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## Report of the Working Group on Marine Habitat Mapping (WGMHM)

10–13 May 2011

Calvi, France



**ICES**

International Council for  
the Exploration of the Sea

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## Executive summary

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The Working Group on Marine Habitat Mapping (WGMHM), chaired by Jacques Populus, France, convened at the Stareso (Liège University) in Calvi, Corsica, from 10–13 May 2011.

Although a long list of ToRs had been adapted by the group at last year's meeting (with a view to accommodating any topic brought about by any member), it was decided in the course of the year to focus the 2011 meeting on habitat modelling. This was motivated by the number of developments on modelling reported in the literature and at conferences (e.g. Geohab) and even in other working groups (e.g. BEWG).

The group invited a keynote speaker, Sandrine Vaz from Ifremer, expert in fish habitat modelling, to give a lecture on the various regressive modelling methods, namely GLM, GAM and quantile regressions. Experts also presented their modelling works that were discussed by the group in the light of the lecture. The important topics dealt with were the choice of the models, the choice of the environmental descriptors variables and the relevance of their scales, the calibration and validation of the models. The ground-truthing strategy for properly collecting response variable data was also touched upon.

Another key topic was the webGIS hosted by the ICES Data Centre. This WebGIS is developed as a tool to provide the wider user's community with a view at a glance of habitat maps coverage throughout ICES. The group intends to use this WebGIS to report annual progress (along with written national status reports) in a geographic form, with provision of metadata managed by the Geonetwork software.

The expert group also discussed ToRs and decided on a restricted list of ToRs with more “flesh” in them. While the usual ToRs a) and b; respectively international and national mapping programmes) are maintained, only two other ToRs are maintained for 2012, namely on “Spatial distribution of errors” (related to confidence assessment) and “Mapping for the MSFD and Marine spatial planning”.

There were recent contacts between three EGs, namely BEWG, WGEXT and WGMHM to start dealing with overlapping issues. A telephone conference could be organized in the near future, following by a liaison meeting at ASC Gdańsk.

Lastly, as the Chair Jacques Populus is standing down this year, a first round of nominations was organized by the group. The following members were nominated: Fergal MacGrath, Pål Buhl-Mortensen, Martin Isaeus, Fernando Tempera and Dieter Boedeker. A vote was then organized and the group unanimously elected Pål Buhl Mortensen from IMR (Norway) as new Chair.

The venue for the 2012 meeting will be Isle of Vilm, on the German Baltic coast, following a very kind offer made by Dieter Boedeker (BfN).

## **1 Opening of the meeting**

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The Working Group on Marine Habitat Mapping (WGMHM) meeting was held at Stareso, the marine research station near Calvi, Corsica from 10–13 May 2011. The meeting was attended by 21 delegates from 11 countries.

Apologies were received from Helen Ellwood, Kerstin Geitner, Brigitte Guillaumont, Peter Lawton, Mike Robertson, James Strong, and Brian Todd.

## **2 Adoption of the agenda**

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The meeting agenda (Annex 3) was reviewed and accepted by the group.

## **3 Progress in international mapping programmes – ToR a)**

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### **3.1 EUSeaMap project update**

#### **Jacques Populus - Ifremer**

The EUSeamap project, funded by the EU DG/MARE, is one of the Emodnet preparatory actions to set the way for a European marine data repository. The project started in February 2009 and its main phase was concluded in December 2010. After this 22 month period, the project has now entered a maintenance phase for another year or so where the only action will be to maintain the website.

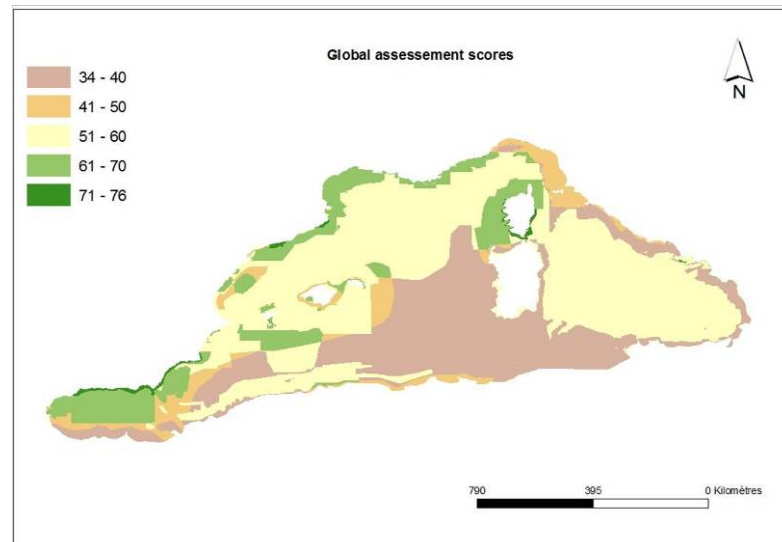
EUSeaMap general objective was to provide broad-scale maps of seabed habitats, using common functional mapping methods, for the Baltic Sea, Greater North Sea, Celtic Seas and Western Mediterranean and to determine what further steps are required to improve their usefulness and coverage. More specifically the following sub-objectives were the following

- 1 ) Review existing broad-scale marine habitat mapping efforts
- 2 ) Prepare a broad-scale seabed habitat map
- 3 ) Make data available online
- 4 ) Assess benefits
- 5 ) Respect INSPIRE principles
- 6 ) Assess next steps
- 7 ) Carry out maintenance

The key project output is a global map of the physical seabed habitats for the four above mentioned marine basins. The habitats are expressed in the Eunis classification and they span the level 2 to level 4 ranges according to the available data. A limitation to level 2 occurred for example in the Mediterranean where suitable energy data were not available to fit with the nominal resolution of 250m adopted for the maps. Therefore rocky habitats could not be expressed in level 3 where energy at the seabed is required.

A lot of efforts were allocated to converting habitats (-e.g. the Barcelona habitats in the Mediterranean) to Eunis classes and to assess the relevance of the thresholds of these classes. As an example, properly defining the depth zones such as the lower limit of infra- or circalittoral requires dealing with statistical data on light reaching the seabed or finding a slope break line.

Another key issue of EUSeaMap, because the maps are made from existing data without collection of any new data, is the confidence associated with them. This assessment is based on the confidence in the underlying data. Two key layers were assessed, namely the depth and substrate ones, and further assembled into a weighted score from 0–100% to reflect the quality of the source data. An overview of the quality maps is given in the figure below for the western Mediterranean.

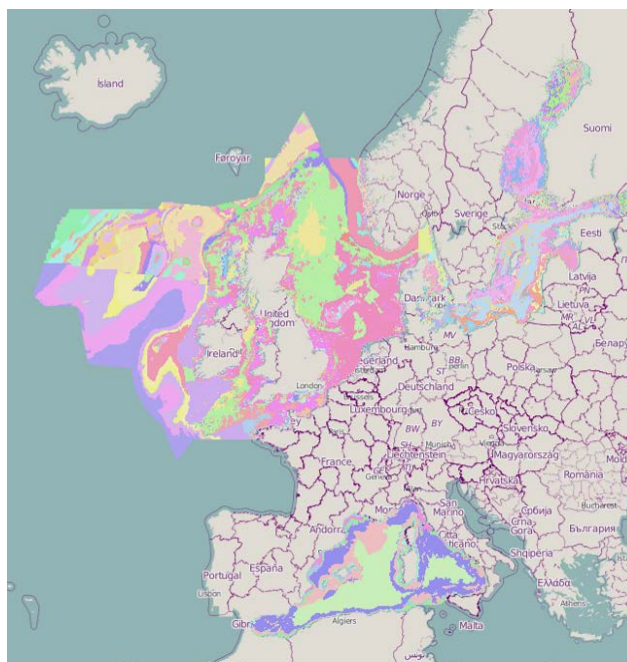


#### **Mediterranean EUSeaMap quality assessment.**

Applications of the maps are sought in the following domains.

- Essential Fish Habitat
- Network of Marine Protected Areas
- Potential sites for sand and gravel extraction
- Potential sites for wind farms
- Tourist facilities
- Assessment of multiple uses in spatial planning
- Marine Strategy Framework Directive Initial assessment

In particular the physical habitat maps are thought to be used for the initial assessment of the MSFD. Whether their current resolution of 250m is enough to provide a monitoring basis is still an outstanding question, hence the likely need for a resolution enhancement as mentioned here below.



#### Overview of the current EuSeaMAP coverage.

Lessons learned were basically the following:

- Making a global sediment layer may be an issue when samples are not available
- Current and waves models are still insufficient both in terms of spatial resolution and in the time span they cover. Several years of runtime are necessary to provide reliable climatologies.
- More work is needed on defining thresholds (biological habitat samples along with their physical properties)
- Lastly stakeholders' endorsement of the maps remains to be confirmed.

The follow on strategy concerns:

- The extension of the map over the rest of Europe (keeping in mind that SW Europe is covered by the MeshAtlantic project), i.e. the Eastern Mediterranean and Black Sea
- The assessment of costs to fill major data gaps (both geographic and thematic)
- Increase the amount of validation data to reduce uncertainty (this could be within the remit of the Emodnet biology lot)
- Improve resolution (e.g. go for 100m, as was done already in France on a national basis)
- Possibly incorporate biological data to reach levels 4 to 5

The Incorporation of biological data into the physical map is an idea developed by Ifremer, Vliz and JNCC. A meeting is planned in Ostend (Belgium) in June 2011 to possibly bring together a proposal for a new project to be submitted to DG/MARE. This would imply a) the collation of habitat sample data (through Emodnet biology lot) consisting in recent as well as historical survey data (including epifauna data from fisheries surveys), b) designing a methodology to integrate these data into the maps with special focus on poor data areas.

### 3.2 Mesh-Atlantic update

#### Jacques Populus - Ifremer

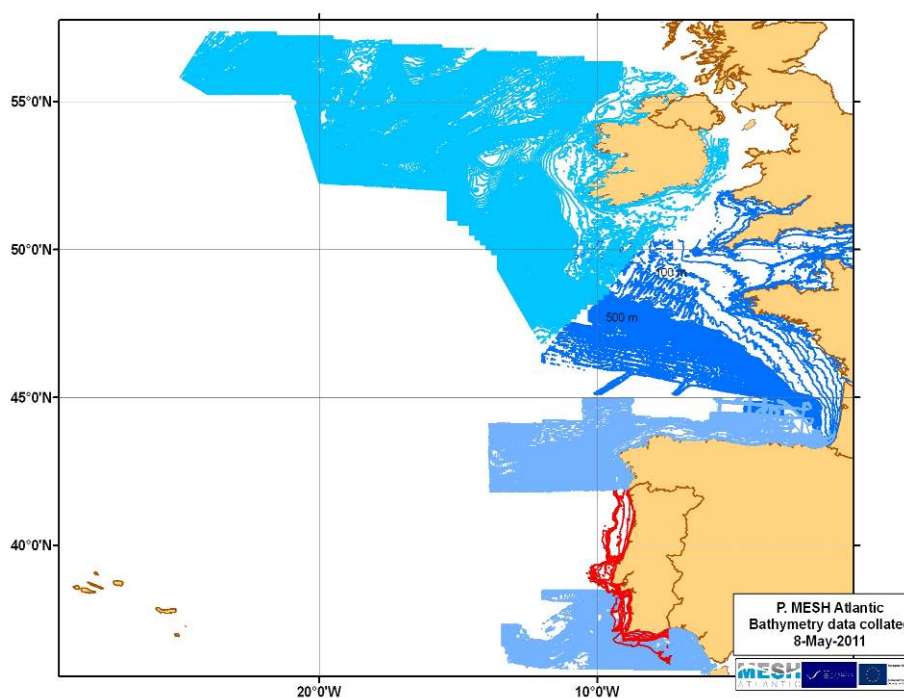
The MeshAtlantic team (with partners from Ireland, France, Spain and Portugal, see <http://www.meshatlantic.eu/>) is now one year into the project.

The key outputs of the project are basically three different sets of maps made homogeneous across the area in the Eunis classification. The first set is a collation of existing habitat maps across the four countries which may need enhancement and harmonization into Eunis. The second set is a collection of detailed bespoke maps covering a limited set of Natura 2000 sites which are going to be made from surveys. The third set is a broad-scale modelled map quite similar to the EUSeaMap (see EUSeaMap description in this report; <http://jncc.defra.gov.uk/page-5020>) applied to southwest Europe.

The following table gives a summary of the number of historical maps concerned in the four countries.

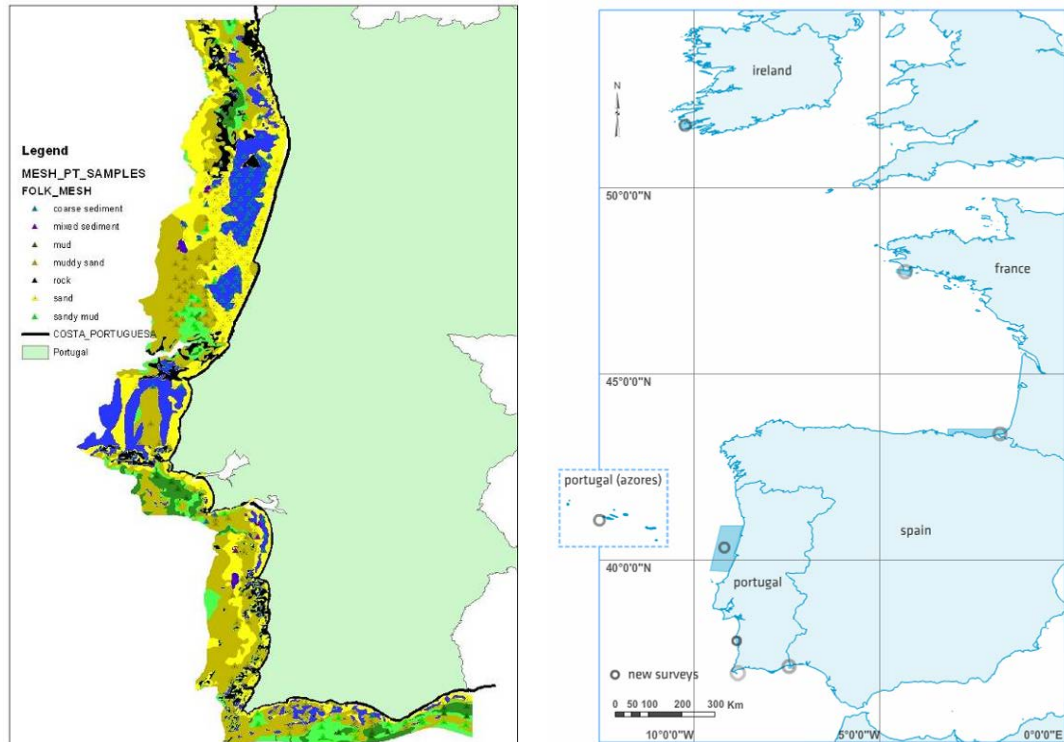
Available habitat maps have been identified and the digitizing and translation work is currently underway. The collation of the base layers for the broad scale maps – namely depth and substrate types- has been completed quite recently and mosaics for each countries have been handed out to IEO to be stitched across borders into a 250m common grid. An example of availability of depth data throughout the area is given in the figure below.

Work on the energy layer is still pending. It is made more difficult by the fact that the project does not directly imply physical oceanographers, hence making it necessary to mobilize other people outside the project. Another limitation is the need for climatology, which means hydrodynamical models on waves and currents that have been running for a long enough period to be representative of an average behaviour.



Collated bathymetry coverage as of April 2011.

Concerning surveys, 2011 is the peak survey year and several Natura 2000 sites will be under strong scrutiny. The survey synopsis appears on the map below. A workshop was organized in Galway last November with focus on a survey scoping document (SOW or Scope of Work) designed to be used by project partners. Expectations are high in the project in terms of harmonized efforts and common surveying practise.



Collated sediment for Portugal as of April 2011 (left) and synopsis of MeshAtlantic survey sites (circles, right).

### 3.3 PREHAB – Spatial PRediction of benthic HABitats in the Baltic Sea: incorporating anthropogenic pressures and economic valuation

Ulf Bergström – Aquabiot

The Prehab project, which started in 2009, provided an updated report on preliminary results obtained until May 2011. Of particular relevance to the group is work package 2 “Developing methods for spatial prediction”. The aim of this work package is to develop and deliver (a) recommendations for spatial prediction, (b) assessments of how human pressures can be used as quantitative or qualitative predictors and (c) maps of relevant biological properties. The guidelines will be based on criteria such as explanatory power, costs and predictive performance. To this end, the first task under work package 2 consists of a comparison and Baltic wide synthesis of the performance of different techniques for modelling of benthic habitats. Five different statistical techniques were used for modelling and spatial prediction of species and habitats performed by each project partner. For all partners, techniques and variables together, this amounts to approximately 700 modelling runs. The accuracy of the models was relatively good (generally >0.8 AUC). In case of western part of Sweden (GU) Random forest (RF) was the best model for both classification and regression models followed by GAM, MARS and kriging. Non-spatial models predominated (10

out of 13). GAM models were the most accurate ones for the data of AquaBiota. In case of Lithuanian waters (KU) - the accuracy of regression models based on  $r^2$  was similar among the methods, where RF was the best according to normalized RMSE. The accuracy of classification models based on AUC was relatively high for all models. In general no differences were found among modelling methods, whereas models differed among species from data of the eastern part of Sweden (SBF). Detailed and comprehensive conclusions about efficiency of different techniques, including consequences for their practical application in mapping efforts in the Baltic, will be summarized in a scientific paper as well as incorporated in the web resource which is developed within task 4.2. The web resource is available at [www.prehab.gu.se](http://www.prehab.gu.se).

Additionally, the second task consists of a comparison and Baltic-wide synthesis of the performance of different kinds of environmental predictors for modelling of benthic habitats. Altogether more than 50 predictor variables from different parts of the Baltic Sea region have been modelled. For purposes of overall comparison and synthesis, these have been classified according as either of the following types: location, bathymetry, substrate, exposure, hydrography and biotic. The majority of these have been modelled both quantitatively and qualitatively (presence / absence). According to the preliminary results of habitat modelling, importance of predictors differed among study areas. In case of the western part of Sweden (GU) - substrate and bathymetry predictors were the most important environmental variables in the models, where location predictors were the least significant one. Bathymetry, hydrography and exposure were the most important predictors, whereas water current was the least important in the models of the case study area Östergötland (AqB). In case of Lithuanian waters (KU) - bathymetry and substrate predictors were the most important in both regression and classification models. Hydrography and exposure predictors were more important for classification models than for regression models. Location predictors were the most important, followed by exposure and hydrography predictors in models from eastern part of Sweden (SBF). Detailed and comprehensive conclusions about efficiency of different predictors, including practical recommendations for mapping efforts in the Baltic, will be summarized in a scientific paper as well as incorporated in the web resource.

The third task of particular relevance to the group consists of a comparison and Baltic-wide synthesis of predictability of different types of response variables. A total of 70–80 response variables from different parts of the Baltic Sea region have been modelled. The majority of these have been modelled both quantitatively and qualitatively (presence / absence). Three main groups of response variables were modelled within all the case study areas: individual species, functions of habitats and benthic communities/biotopes. In case of western part of Sweden (GU) - 10 algal species and 3 functional groups were modelled. RF models were the most accurate ones. Six fish species and one functional group were modelled in the Swedish-Finnish archipelago area of the northern Baltic Sea (SBF). RF, GAM and MAXENT models were the most accurate ones. In case of Lithuanian waters (KU) - 23 zoobenthos, 1 macrophytobenthos species and 6 functional groups were modelled. RF, MARS and kriging models were the most accurate ones. Detailed and comprehensive conclusions about predictability of different response variables, including practical recommendations for mapping efforts in the Baltic, will be summarized in a scientific paper as well as incorporated in the web-resource.

A fourth task under work package 2 of particular relevance to the group deals with quantitative assessment of selected human pressures and their capacity as predictors



of benthic habitats. A specific case study was presented and is described later in the report.

Preliminary results from work packages 1, 3 and 4 were also presented. The first work package has, among other results, summarized a literature review regarding species-environment relationships and the potential of distribution modelling in coastal waters of the Baltic Sea region. In total, 137 peer-reviewed studies covering 3 decades and 6 regions in the Baltic Sea were synthesized. The review focuses on fish, macro-invertebrates and macro-vegetation as response groups and summarizes earlier research regarding environmental descriptors of species distributions. Results are expected to be of importance for future efforts on modelling species and habitats distributions in support of marine spatial planning and management. The third work package focuses on developing tools for economic valuation of goods and services related to habitats. In collaboration with economists estimation of willingness-to-pay (WTP) for marine ecosystem services in Sweden, Finland and Lithuania has been performed. This has been done by utilizing professional polling companies in respective countries. Three main characteristics of the habitats were investigated; healthy vegetation, preservation of currently pristine areas and fish stock status. Results reveal country-specific differences in WTP for different characteristics. The main output of the fourth work package is a web resource. The web resource will summarize the collected lessons learned in the Prehab project. By using specific scenario studies in combination with background information on mapping and modelling of habitats the web resource will provide valuable guidance aimed at national and local managers, consultants and other stakeholders engaged in habitat mapping and spatial planning. The external web page and resource will be fully operational by the end of 2011, available at <http://www.prehab.gu.se>.

### 3.4 CHARM 3

**Sandrine Vaz – Ifremer**

Presentation of the CHARM3 project

CHannel integrated Approach for marine Resource Management



The project has been selected within the scope of the INTERREG IV A France (Channel) – England cross-border European cooperation programme, co-financed by the ERDF.

The English Channel and the southern North Sea, have, for long, been supporting a range of human activities (fisheries, tourism and leisure, marine aggregate extraction, maritime traffic, international ports and shipping, estuaries, offshore windfarms...) of great economic importance and subjected to multiple user groups who often have conflicting stakes. Despite these pressures, natural resources (fisheries, shellfish, but also minerals) available in these zones remain very prized, at national and European levels. Stakeholders' (e.g. EU and its member states, regional councils, fishers, industries, NGOs, ...) demands in terms of understanding the responses of the marine



ecosystem and its resources to various pressures, including that of climatic change, is acute and continues to intensify.

A deeper understanding of this maritime area is hence needed so as to preserve this fragile marine ecosystem, which is subjected to strong human pressures. It is moreover essential that neighbouring countries share a common vision of the management of this ecosystem for the long-term sustainability of its resources. Hence, an ecosystem-based approach of marine resources management requires the synthesis of existing scientific knowledge and its integration to new research; such an approach will help improving the quality of management and planning advice that is given to decision-makers.

In this context, the Interreg IIIA CHARM projects (phases 1 and 2 – 2003/2009) represented a first multidisciplinary approach in this maritime area through an innovative approach to spatial ecosystem modelling ([www.ifremer.fr/charm](http://www.ifremer.fr/charm)). The CHARM 3 project builds on the results obtained previously so as to pursue an ambitious ecosystem-based approach that will encompass the whole English Channel.

The objectives of the project follow three main themes (*Collection and standardization of information; Information integration; Tools and information dispersal*), that cover 17 actions. The expertise involved range from marine sciences to economy, maritime law, geography, statistics, conservation and information technology and should offer decision-makers a status report of the English Channel ecosystem and a range of tools based on scientific knowledge for the sustainable management of living marine resources.

### 3.5 MESMA

#### Ibon Galparsoro – Spain

MESMA is an FP7 project on Monitoring and Evaluation of Spatially Managed Areas. The project consortium is integrated by 21 partners from 13 countries. It started in November 2009 and will last for 48 months.

MESMA, in consultation with stakeholders, will develop integrated management tools (a generic framework, guidelines, data systems and models) for monitoring, evaluation Spatially Managed Areas (SMAs).

MESMA will produce guidance and tools to support the implementation of spatial planning in Europe's seas. These will include advice, tools and information on human uses, biotope classifications/distributions (including examples of geospatial data systems), governance processes and different approaches to conflict management.

The main tasks of MESMA are information analysis, the development of a generic framework, the testing and evaluation of this framework through case-studies and the development of management tools that contribute to the sustainable use of European seas. All these actions are tackled in different work packages. The case studies cover the whole of Europe: Southern North Sea, Pentland Firth and Orkney Waters, Barents Sea and Lofoten area, Celtic Sea, Basque country continental shelf (SE Bay of Biscay), Strait of Sicily, Inner Ionian Archipelago and adjacent gulfs, Baltic Sea and Black sea.

MESMA's work will benefit governments, local authorities, the whole range of stakeholders, managerial bodies for planning and decision-making and the public in general.

MESMA will provide a firm basis for the further design and implementation of marine spatial planning policies, particularly the Marine Strategy Framework Directive, in which marine-related economic and social activities have to be considered.

More information at <http://www.mesma.org/>

## 4 National programmes (National Status Report) – ToR b)

### 4.1 National reports

#### 4.1.1 National programme report for Germany

Dieter Boedeker – BfN

presented the NSR for Germany. There are no major changes to the habitat mapping situation in Germany since the 2009 report to this group.

#### Sediment maps

Sediment maps at different scales and different age exist for German waters, and the Federal Maritime and Hydrographic Agency (BSH) is continuing a national programme of large-scale sediment distribution mapping. The following maps and shapes are already available and can be purchased from BSH ([http://www.bsh.de/de/Produkte/Karten/Geologische\\_Karten/index.jsp](http://www.bsh.de/de/Produkte/Karten/Geologische_Karten/index.jsp)):

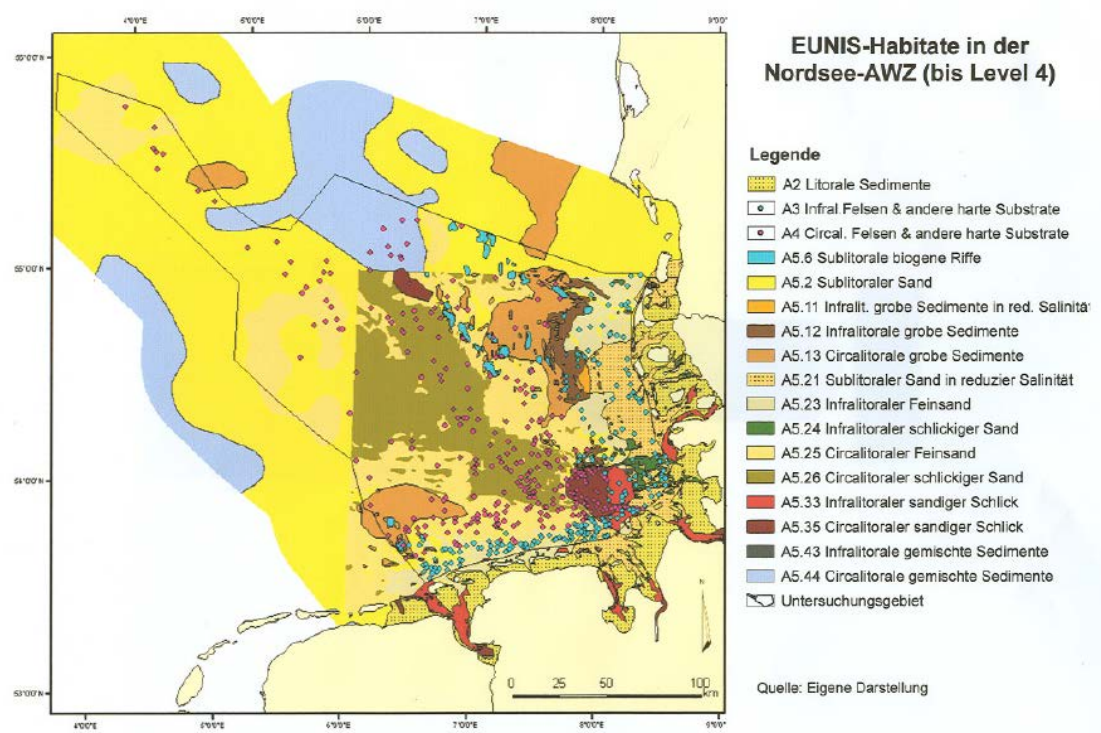
2900 Sedimentverteilung in der Deutschen Bucht

2901 Meeresbodensedimente in der westlichen Ostsee, Blatt Darß

2902 Meeresbodensedimente in der westlichen Ostsee, Blatt 1 und 2

2903 Digitale Karte der Sedimentverteilung in der Deutschen Bucht (Format: ESRI Shapefile).

There also exists a draft map of EUNIS habits (level 4) of the German North Sea.



Draft map of EUNIS Habitats in the German North Sea down to level 4 (Source AWI MarNet).

### Natural habitat types as of Habitats Directive Annex I

The German (coastal) state authorities are responsible for identifying these habitat types inside the Territorial See (12 nm zone), the Federal State beyond (EEZ). In the EEZ only the natural habitat types “sandbanks covered by seawater all the time” and “reefs” occur. These habitat types are defined in the EU Interpretation Manual (EUR27: [http://ec.europa.eu/environment/nature/legislation/habitats\\_directive/docs/2007\\_07\\_im.pdf](http://ec.europa.eu/environment/nature/legislation/habitats_directive/docs/2007_07_im.pdf)).

The official map presenting the distribution of habitat types and species relevant to SCI<sup>1</sup> nominations in the German North Sea EEZ (28 April 2004) can be viewed at: [Karte2 FFH Schutzgueter.pdf](#) for the North Sea and at [Karte7 FFH Schutzgueter.pdf](#) for the Baltic Sea. For the 12 nm zone no official map of habitat types and species relevant to SCI nominations exists so far. The German Federal Agency for Nature Conservation (BfN) had developed common standards to map sandbanks and reefs in the EEZ<sup>2</sup>.

### Draft maps on marine landscapes and biotopes in the German North Sea and Baltic Sea

Dieter Boedeker (Germany) presented updated draft maps on marine landscapes and biotopes in the German North Sea and Baltic Sea produced for BfN by BioConsult Schuchardt and Scholle GbR. The biotope maps are based on the BfN biotope classification given with the German Red List of Biotopes<sup>3</sup>. These maps were compiled by using existing data from different sources; hence, parts of the map contain more detailed data, whereas other parts are less precise. Several variables have been used in the classification, e.g. distance to coast, tidal range, depth, sediment, salinity, geomorphology, currents, oxygen, temperature, etc, and also some biota such as blue mussel beds in the Baltic Sea and eelgrass-beds in the Wadden Sea. The maps can be viewed at: <http://www.bfn.de/habitatmare/de/downloads-marine-biotope.php>.

The landscape maps contain marine landscapes and include expert opinions on natural habitat types according to Annex I of the Habitats Directive and all Water Bodies as demanded by the Water Framework Directives.

### Legally Protected Biotopes in Germany

Apart from the “Annex I – Habitats” additional marine habitat types enjoy general legal protection in the German marine area<sup>4</sup>:

- Eelgrass meadows and other marine macrophyte stands
- gravel, coarse sand and shell gravel biotopes
- Muddy biotopes with burrowing megafauna.

These habitat types are derived from respective HELCOM and OSPAR lists of threatened and/or declining species and habitats. Definitions can be viewed at:

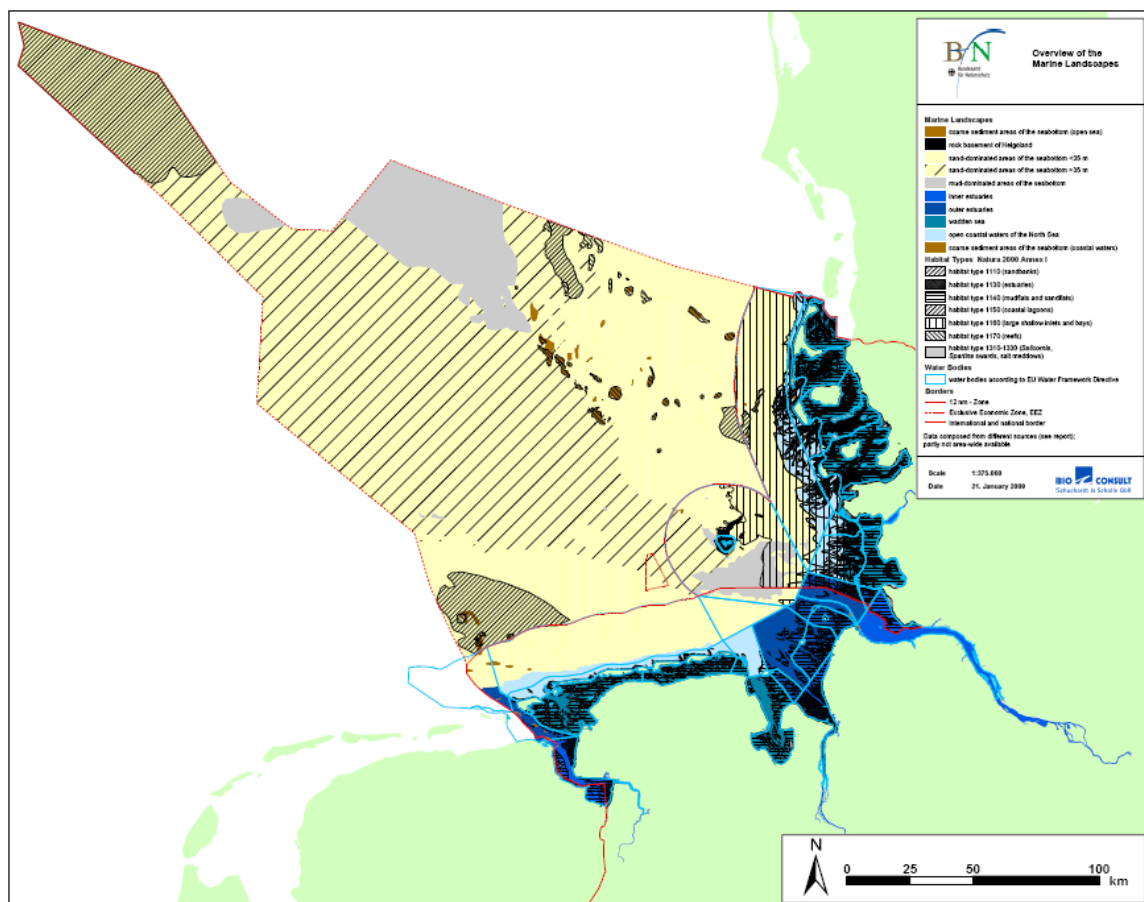
<sup>1</sup> Site of community importance according to the Habitats Directive

<sup>2</sup> Henning von Nordheim, Dieter Boedeker and Jochen C. Krause (Eds.) 2006. Progress in Marine Conservation in Europe – Natura 2000 in German Offshore Waters. Springer, Heidelberg 263pp.

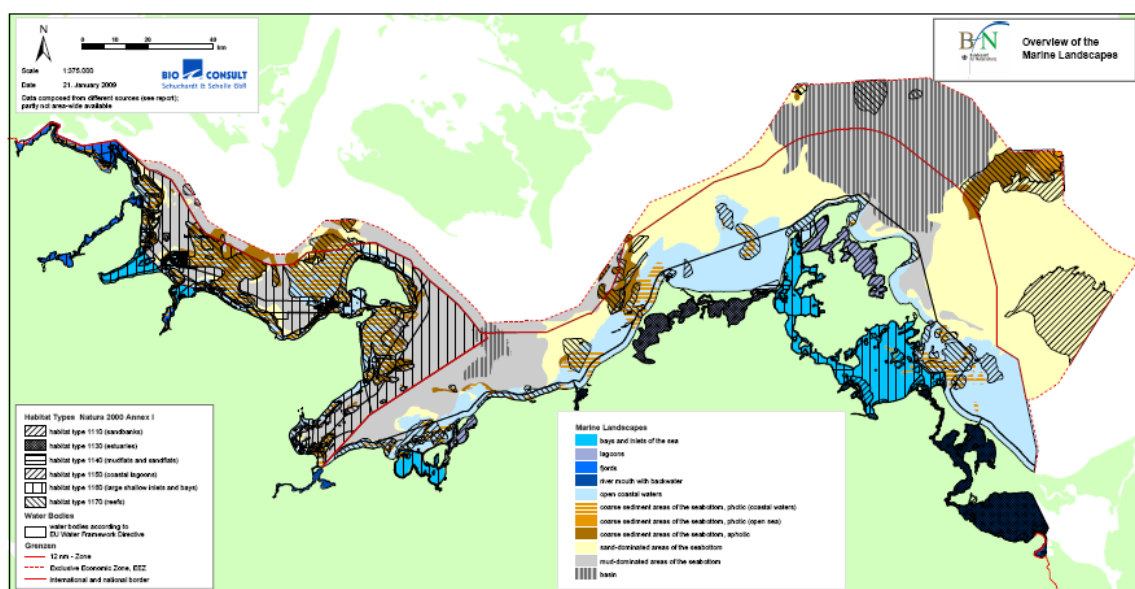
<sup>3</sup> RIECKEN, U., FINCK, P., RATHS, U., SCHRÖDER, E., and SSYMANK, A. (2006): Rote Liste der gefährdeten Biotoptypen Deutschlands. Zweite fortgeschriebene Fassung 2006. Naturschutz und Biologische Vielfalt 34

<sup>4</sup> Act on Nature Conservation and Landscape Management (Federal Nature Conservation Act – BNatSchG) of 29 July 2009

[http://www.helcom.fi/environment2/biodiv/endangered/en\\_GB/fact\\_sheets/1.%20Biotopes/habitats](http://www.helcom.fi/environment2/biodiv/endangered/en_GB/fact_sheets/1.%20Biotopes/habitats) and:  
[http://www.ospar.org/documents/dbase/publications/p00358\\_case\\_reports\\_species\\_and\\_habitats\\_2008.pdf](http://www.ospar.org/documents/dbase/publications/p00358_case_reports_species_and_habitats_2008.pdf).



Draft marine landscapes in the German North Sea.



Draft marine landscapes in the German Baltic Sea.

The habitat type “eelgrass meadows and other marine macrophyte stands” of the German North Sea occurs only in shallow coastal waters, whereas in the Baltic Sea it exist also on offshore banks (not eelgrass meadows) and in association with the natural habitat type “reef” as of Habitats Directive Annex I.

National definitions and mapping guidelines are under preparation.

#### Future activities

In future the focus will be on mapping biotopes, rather than mapping landscapes, i.e. including more biota in the mapping efforts. At a first stage it is planned to conduct a comprehensive biotope mapping within the German Natura 2000 sites in the German EEZ, and in a second step to map the remaining parts of the German EEZ. This programme is closely linked to the national programme of large-scale sediment distribution mapping of BSH.

#### 4.1.2 National programme report for Belgium

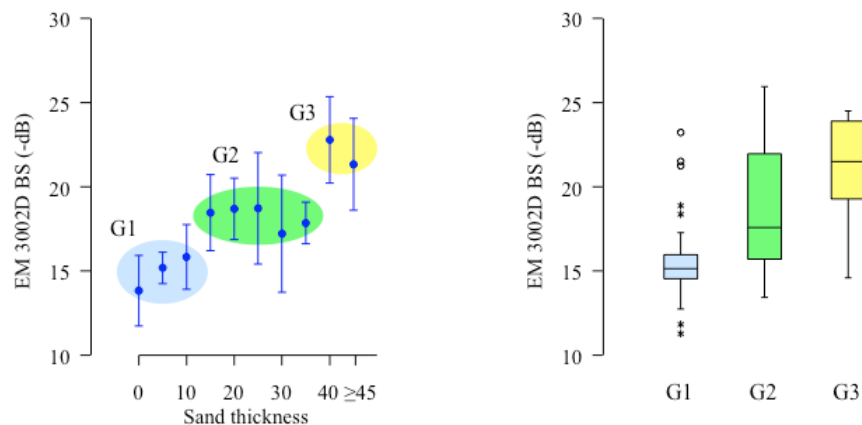
A. Norro, J. S. Houziaux, J. Haelters and V. Van Lanker (RBINS – MUMM)

##### The CALMUL Project

Calmul (Calibration of BS multibeam data) is collaboration between MUMM and the fund for sand extraction of the Belgian FPS Economy.

*In-situ* sand thickness measurements have been compared with BS data obtained from survey made by the multibeam EM3002 on the sandy and gravel beds of the Hinderbanks zone located in Belgian North Sea.

Clear correlation is obtained and three classes of sediments can be highlighted. Ground-truthing using only video images cannot permit to differentiate these three classes.



Three classes of reflectivity are identified (STD represented on right graph).

##### 4.1.2.1 Reference

Degrendele, K., Houziaux, J.-S., Norro, A., and Roche, M. 2010. Intérêt de la plongée scientifique pour la caractérisation de visu et le contrôle des classes acoustiques définies par sondeur multifaisceaux. Bilan général des campagnes de mesures 2004–2010 et perspectives. Novembre 2010. MUUM report. 53 pp.



### Historical seabed composition

A reconstruction work has been undertaken on historic sediment data held at the Royal Belgian Institute of Natural Sciences and dating back to the first decade of the 20<sup>th</sup> century (the Gilson's archive; Houziaux *et al.*, in Press). This work enables consideration of the long-term component for subtidal habitats of the Belgian part of the North Sea as well as the Dutch waters of the Westerschelde mouth. Most interestingly, a macrobenthic survey was carried out in the same target area, at the same period, which will permit an enquiry on the macrobenthos – sediment relationship by then. Proper long-term analyses still have to be developed now on both compartments. We can however state that maritime access works have altered the dynamics of fin-grained sediments in the area since then (see Fettweis *et al.*, 2009); larger mud levels were to be found in the nearshore zone from Nieuwpoort to Zeebrügge and further to the Dutch border compared to the present day.

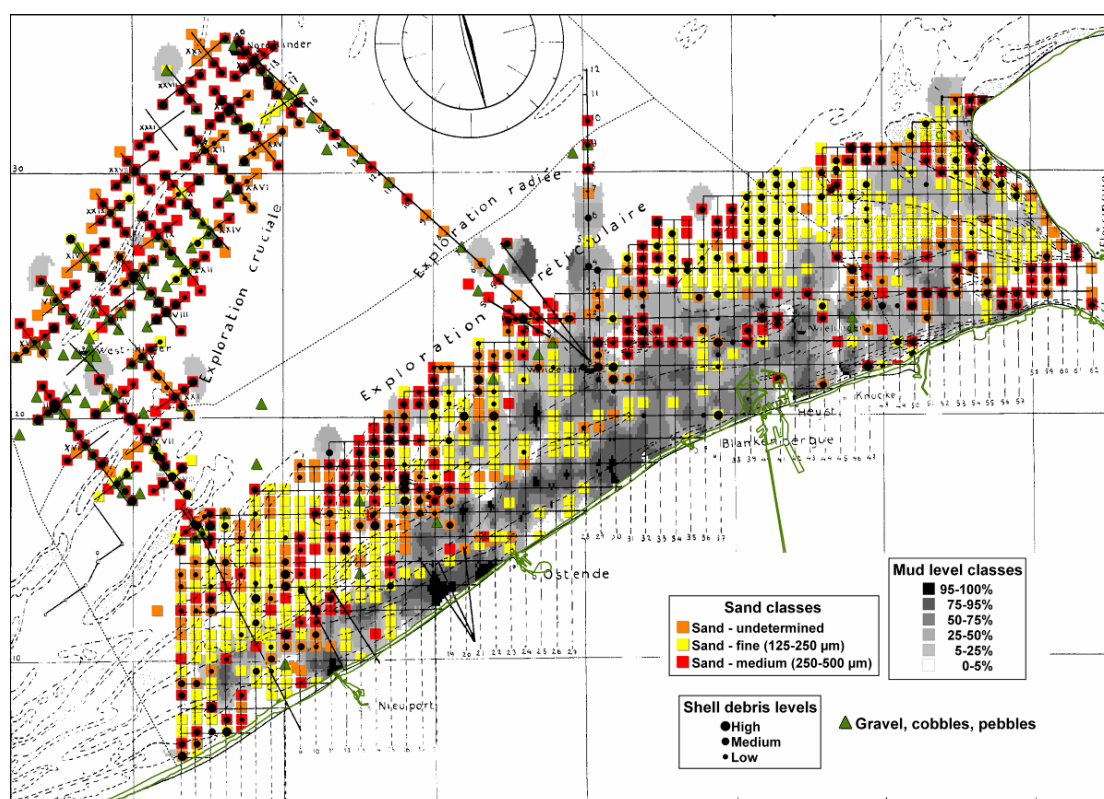


Figure: integrated map of raw sediment parameters extracted from sample descriptions and calibrated by means of grain size analysis. See Houziaux *et al.* in press for details.

In the offshore gravels of the Hinder banks area, which were, somehow, 're-discovered' through processing the historical dataset, a rich specific macrofauna existed and is still found in the present-day, although heavily affected by chain-mat trawling. Our research on historical macrobenthic data thus also ascertained that wild beds of the European oyster used to occur on these gravels until the late 1860s, when they were targeted by Essex "deep sea oyster" dredgermen. The amounts of oysters extirpated from the area point at the probable existence of biogenic 'reefs'. In this area, acoustic surveys combined with underwater video and sampling with a small beam trawl evidenced in 2005 the existence of refuge areas for the fauna sensitive to trawling. These refuges are gravel patches located between the sand-waves of the Oosthinder bank, where trawling is reduced.

Research is ongoing targeting determination of long-term changes in various soft-bottom coastal habitats.

#### 4.1.3 References

Fettweis, M., Houziaux, J-S., Du Four, I., Van Lancker, V., Baeteman, C., Mathys, M., Van den Eynde, D., Francken, F., Wartel, S. 2009. Long-term influence of maritime access works on the distribution of cohesive sediment: Analysis of historical and recent data from the Belgian nearshore area (southern North Sea). *Geo-Marine Letters*, 29, 321–330. doi:0.1007/s00367-009-0161-7

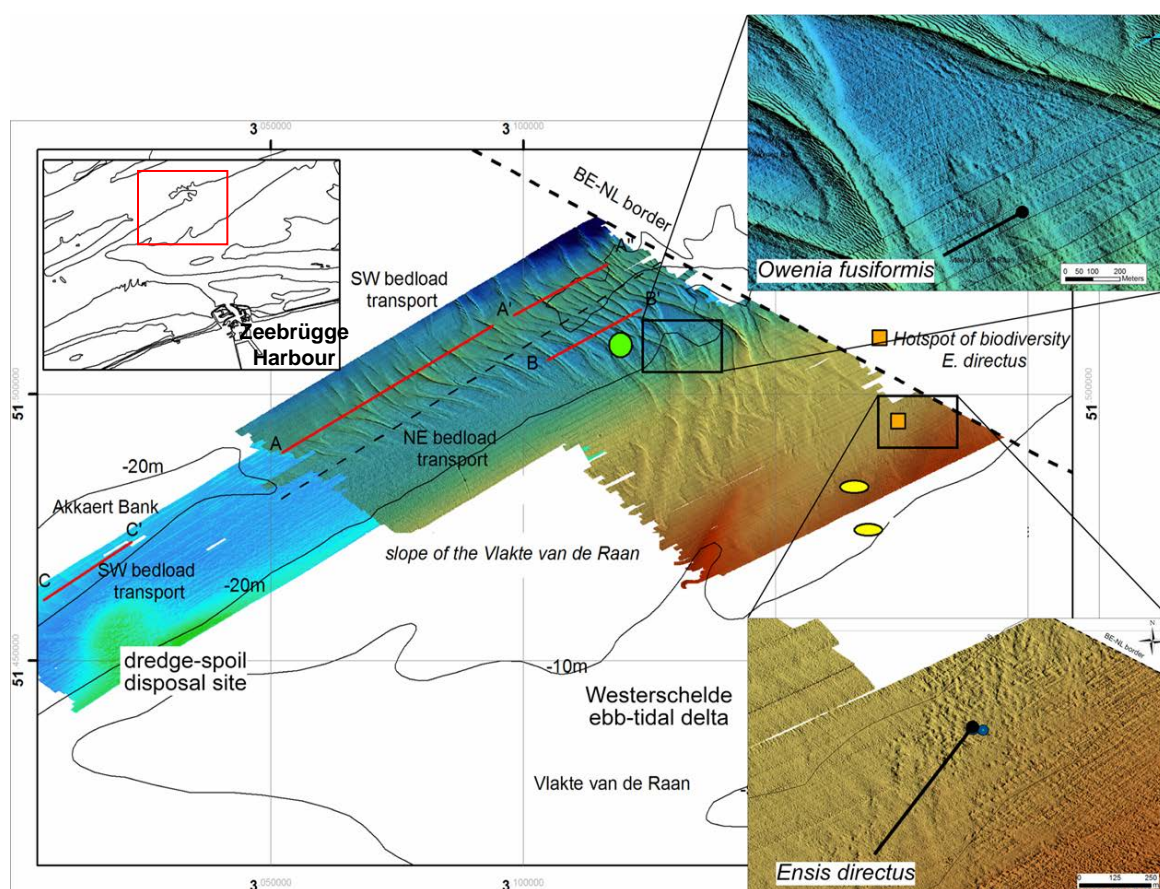
Houziaux, J.-S., Fettweis, M., Francken, F. and Van lancker, V. (In press). "Historic (1900) sea-floor composition in the Belgian-Dutch part of the North Sea: A reconstruction based on calibrated visual sediment descriptions". *Continental Shelf Research*.

#### QUEST4D Project

"Quantification of Erosion/Sedimentation patterns to trace the natural vs. anthropogenic sediment dynamics (<http://www.vliz.be/projects/quest4D/>)". Belgian Science Policy Research Programme Science for a Sustainable Development (2006–2011).

Within the project, observations and modelling combine to reconstruct ecosystem evolution along the Belgian part of the North Sea over the last 100 years, both naturally and anthropogenically induced. The sediment and sediment transport system is targeted, as also its contribution towards the prediction of the occurrence of macrobenthos. One of the results indicates that changes in the amount of suspended particulate matter, through time, caused shifts in the occurrence and characteristics of macrobenthic communities. Furthermore, aggregations of the tubeworm and ecosystem engineer *O. fusiformis* were mapped with very-high resolution multibeam (RV "Belgica", Kongsberg Simrad EM3002, 300 kHz).





Habitat mapping along the delta front of the Westerschelde ebb tidal delta. At the extremity of the flood channel north of the delta, dense aggregations of the tubeworm *Owenia fusiformis* occur ( $> 1000 \text{ ind/m}^2$ ). With decreasing depth along the delta front, dense aggregations of both *O. fusiformis* and the razor blade *Ensis directus*, the most important invasive species in Belgian waters, are observed. Both give a distinct acoustic facies. Relationships with sediment dynamics are being investigated (Van Lancker *et al.*, 2011).

#### EnSIS: Ecosystem sensitivity to invasive species

Belgian Science Policy Targeted Action Science for a Sustainable Development (2009–2011)

The introduction of invasive species is considered a major problem to marine ecosystems. The American jackknife clam *Ensis directus* represents a well-investigated and -documented example of such invasion in Northwest European coastal waters. Apart from extensive sampling of the species, its habitat has been acoustically characterized in areas where high densities prevail. Very-high resolution multibeam was acquired during 3 periods (RV “Belgica”, Kongsberg Simrad EM3002, 300 kHz) and will allow to characterize the habitat in detail ( $< 2 \text{ m}$  resolution). The measurements relate to the depth and the backscatter of the acoustic signal. Full-coverage recordings were obtained to situate the occurrence of *E. directus* in its broader spatial environment. Seabed samples were taken for validation. Results assist in the set-up of habitat suitability modelling of the species.

#### Geo-Seas

Pan-European Infrastructure for management of marine and ocean geological and geophysical data (<http://www.geoseas.eu/>). EU-FP7 Infrastructure (2009–2012).

Within Geo-Seas, one of the subtasks focuses on standardization in seabed habitat mapping (RBINS-MUMM lead). Efforts relate mainly to sediment and topography parameterization and classification. Case studies will be provided on the scales 500m, 50m and <5m.

### **EMODNET-Geology - European Marine Observation and Data Network**

(EU-DG MARE, 2009–2012 - [http://ec.europa.eu/maritimeaffairs/emodnet\\_en.html](http://ec.europa.eu/maritimeaffairs/emodnet_en.html))

Pilot project aiming at delivering geologically related GIS data layers. One of the deliveries is a continuous seabed substrate map for the Baltic Sea, Greater North Sea and Celtic Sea, on a scale of 1:1 million. The map includes an index map that identifies initial data layer patches and provides information on metadata: variation in remote observation, interpretation and ground-truthing methods. The current map is collated from 208 separate seabed substrate maps and can be viewed at <http://www.onegeology.org>. The existing substrate classifications were reclassified / translated to a system that is supported by EUNIS. The EMODNET reclassification scheme consists of four substrate classes defined on the basis of the modified Folk triangle (mud to sandy mud; sand to muddy sand; coarse sediment; mixed sediment) and three additional substrate classes (boulder, diamicton, rock). This map feeds into EMODNET-Habitat (EUSeaMap).

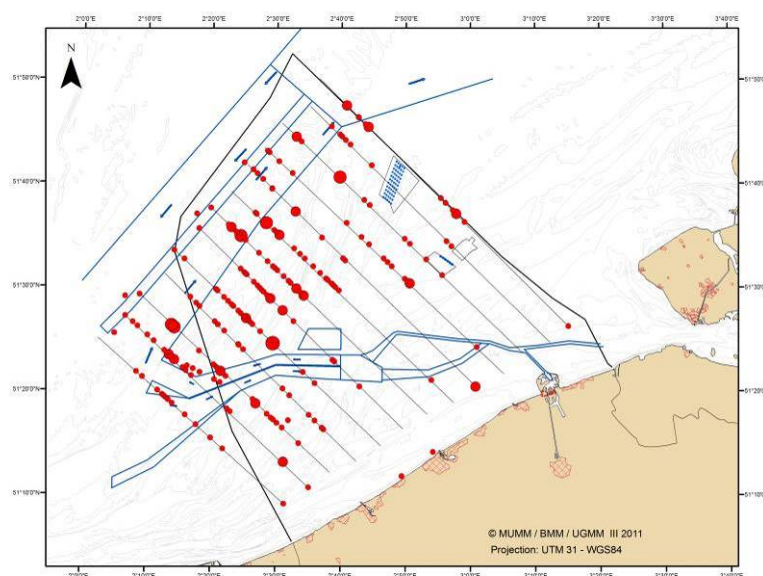
### **Relevant publications**

- Van Lancker, V., Baeye, M., Du Four, I., Degraer, S., Fettweis, M., Francken, F., Houziaux, J. S., Luyten, P., Van den Eynde, D., Devolder, M., De Cauwer, K., Monbaliu, J., Toorman, E., Portilla, J., Ullman, A., Liste Muñoz, M., Fernandez, L., Komijani, H., Verwaest, T., Delgado, R., De Schutter, J., Janssens, J., Levy, Y., Vanlede, J., Vincx, M., Rabaut, M., Vandenberghe H, Zeelmaekers, E, and Goffin, A. 2011. *QUantification of Erosion/Sedimentation patterns to Trace the natural versus anthropogenic sediment dynamics (QUEST4D)*. Draft Final Report, January 2011. Science for Sustainable Development. Brussels: Belgian Science Policy, 93 pp. + Annex
- Van Dijk, T. A. G. P., van Dalfsen, J. A., van Overmeeren, R., Van Lancker, V., van Heteren, S., and Doornenbal, P. J. (in press). Benthic habitat variations over tidal ridges, North Sea, Netherlands. *In: Seafloor Geomorphology as Benthic Habitat: GeoHab Atlas of seafloor geomorphic features and benthic habitats*. Ed. by Harris, P., and Baker, E.K. Elsevier Insights.
- Van Lancker, V., Moerkerke, G., Du Four, I., Verfaillie, E., Rabaut, M., and Degraer, S. (in press). Fine-scale geomorphological mapping for the prediction of macrobenthic occurrences in shallow marine environments, Belgian part of the North Sea. *In: Seafloor Geomorphology as Benthic Habitat: GeoHab Atlas of seafloor geomorphic features and benthic habitats*. Ed. by Harris, P., and Baker, E.K. Elsevier Insights.
- Van Lancker, V., Breine, N., Baeye, M., Janssens, R., and Rabaut, M. 2011. Soft substratum biodiversity hotspots in shallow waters, role of sediment dynamics and anthropogenic influence? GeoHab 2011 (*Marine Geological and Biological Mapping*). 10th Anniversary. Helsinki (FI), 3–6/5/2011.
- Van Lancker, V., Carrara, G., Elvenes, S., van Heteren, S., Kupschus, S., Lepland, A., O'Leth, J., Mason, C., Monteys, X., Moussat, E., Schmitt, T., Selboskar, O.H., Thinon, I., Thorsnes, T., and Verbruggen, K. 2011. Standardisation and Harmonisation in Seabed Habitat Mapping: How can a geological data infrastructure project contribute? GeoHab 2011 (*Marine Geological and Biological Mapping*). 10th Anniversary. Helsinki (FI), 3–6/5/2011.

#### Estimation of the number of harbour porpoises in Belgian waters

In the framework of the possible effects of the construction and exploitation of off-shore windfarms, the RBINS (MUMM) undertakes research on the harbour porpoise. The methodology used is similar as the one in neighbouring countries, making comparisons possible.

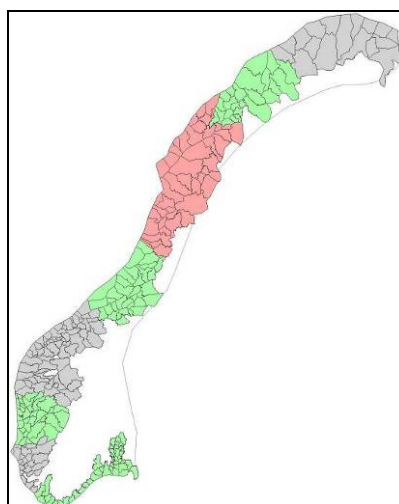
Densities of porpoises during early spring 2011, estimated on the results of dedicated aerial surveys, were estimated at more than 2 animals per km<sup>2</sup>. During this period of the year, the total number of harbour porpoises in Belgian waters, with a surface of almost 3.600 km<sup>2</sup>, can be estimated as more than 8.000. The figure presents the survey tracks and the sightings of groups of porpoises.



#### 4.1.4 National programme report for Norway

Trine Bekkby (NIVA) and Pål Buhl-Mortensen (IMR)

The National Program for Mapping and Monitoring of Marine Biodiversity



The program started in 2003 and is funded by the Ministry of the Environment, the Ministry of Fisheries and Coastal Affairs and the Ministry of Defence, with a yearly

budget of about 1.3 M€. The scientific part of the program is coordinated by the Norwegian Institute for Water Research (NIVA), and mapping is carried out by NIVA, the Institute of Marine Research (IMR) and the Geological Survey of Norway (NGU). In northern Norway Akvaplan-niva (NIVAs Daughter Company) is doing the field mapping on behalf of NIVA. This program (which started in 2007) focuses on mapping a selection of these: large kelp forests, ice marginal deposits, soft sediments in the littoral zone, loose calcareous algae, eelgrass/seagrass meadows, carbonate sand, oyster areas, dense scallop occurrences and spawning areas for fish. By the end of 2011, 12 of the 17 counties with coastline will be mapped (green areas in the figure on the left). In 2011 we start mapping Nordland (red areas in the figure on the left). Mapping this region is planned to take five years. The program is planned to be finished mapping all counties in 2015. However, this depends on funding, which is decided from year to year.

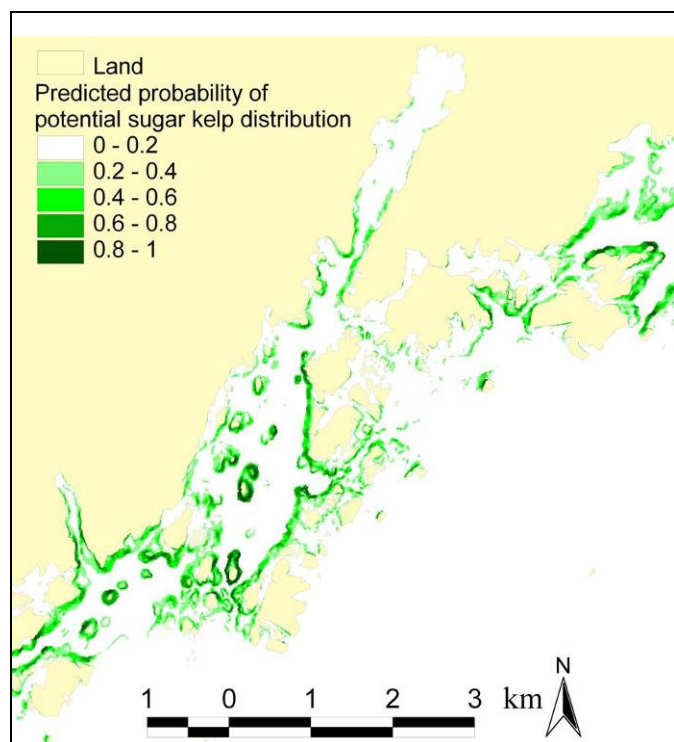
#### **NiN – Nature types of Norway, a new classification system**

NiN (Nature types of Norway) is a new classification system to be used by all municipalities in Norway. It is theoretically developed system for both land, freshwater and ocean. Nature type classes are modelled at a 100 m spatial resolution for the whole country. Norway has been classified only at a very coarse level, marine system even more coarsely classified. IMR and NIVA involved in the marine part. Practical classification is tested in the terrestrial environment in Nordland County (northern Norway) in 2011, and discussions are going on a further classification of the strand-flat area, i.e. down to about 50 m, using wave exposure and depth. We like to coordinate this with EUNIS, so that classes are comparable. See <http://www.artsdatabanken.no/artArticle.aspx?m=243> (in Norwegian).

#### **Nature index for Norway**

The aim with the Nature index for Norway (a project coordinated by Directorate for Nature Management) is to give an indication on the development of the biodiversity in Norway and identify knowledge (mapping and research) needs. The index is build on a series of indicators that combined will give a representative picture of the ecological status. The Nature index requires knowledge of reference conditions. Some of the indicators are habitat maps, and the projects uses information, data and methodology develop by e.g. the National mapping program. As a part of the Nature index project, NIVA has developed area representative maps of reference values for various biodiversity and sensitivity indices for the Norwegian coast. This we consider as a great improvement over earlier deliveries in which the same reference value was used in all regions, counties and municipalities in Norway.

### Sugar kelp natural distribution and loss in Skagerrak



Sugar kelp (*Saccharina latissima*) forests have an important ecological function in the coastal zone, as they inhabit a large number and a specific composition of fauna. In 2002, a large-scale disappearance of sugar kelp was observed in Skagerrak and parts of the southwest coast of Norway and the perennial sugar kelp forests were replaced by opportunistic and ephemeral filamentous algae. For management purposes, including identifying areas for restoration initiatives, maps of where sugar kelp forests are supposed to be found and where and under what conditions they have disappeared are needed. Based on modelled and field-measured geophysical variables and presence/absence/loss data of sugar kelp, NIVA has developed spatial predictive probability models (i.e. maps) for sugar kelp potential distribution under natural conditions (see figure in text) and areas of kelp loss in the Skagerrak. These models were developed into maps presented to the managers.

**MAREANO (Marine AREA database for NORwegian coast and sea areas)**

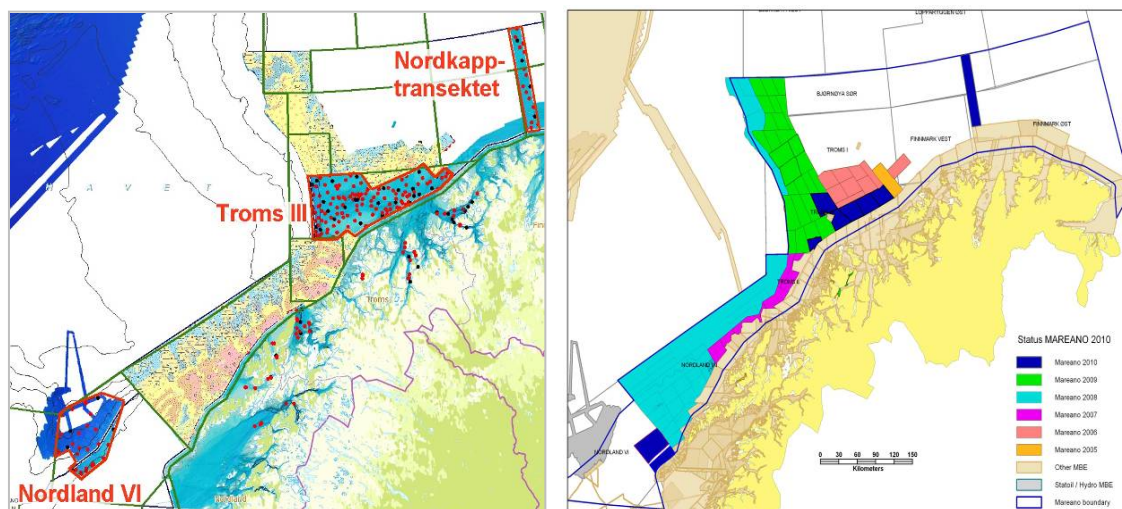
**Pål Buhl-Mortensen, IMR**

MAREANO is a multidisciplinary seabed mapping programme, focusing on offshore areas in the southern Barents Sea and the northeastern Norwegian Sea. The programme started in 2005 as one of the tools for the process of developing a plan for the integrated management of the marine environment of the Barents Sea.

MAREANO aims to map terrain, sediments, benthic habitats, species diversity and sediments pollutants. It is a multidisciplinary collaboration between the Institute of Marine Research (IMR), the Geological Survey of Norway (NGU), and the Hydrographic Service (SKSD). In addition to collecting new data, the partners collate existing information and present it integrated in the web portal [www.mareano.no](http://www.mareano.no). The project is financed by the ministries of the Environment, Fisheries and Coastal Affairs, Trade and Industry and the Research Council of Norway.



In 2010, 16 000 km<sup>2</sup> was sampled with respect to sediments, fauna and pollutants during two cruises. In the period from 2005 to the end of 2010 MAREANO has undertaken a total of 9 sampling surveys (sediments, fauna and pollutants), and 67 000 km<sup>2</sup> has been mapped by multibeam surveys. For 2011, three new cruises (57 days of ship-time) are scheduled.



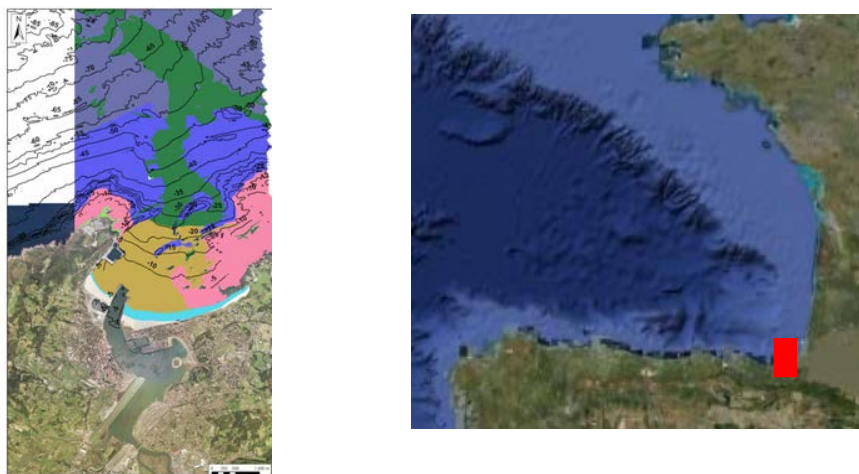
Areas surveys with video transects (red dots) and sampled with different sampling tools (black dots) in 2010 (left figure). Areas mapped with multibeam echosounder in the MAREANO area and elsewhere in Northern Norway (figure to the right).

The coverage of video-transects is close to 1 per 100 km<sup>2</sup> and for sampling stations 2 per 1000 km<sup>2</sup>. Faunistic results from seabed videos are used to classify sampled locations. Together with predictors derived from multibeam echosounder data (terrain variables and backscatter) these results are used to predict biotopes and habitats. The choice of scale is important for the outcome of the biotope prediction. Therefore, the results from processing of the video records are stored in a database format enabling subsampling of videotransects at different regular intervals or based on changes in sediment composition.

#### 4.1.5 National programme report for Spain

##### Habitat mapping in the Hendaye and Txingudi bays

This habitat mapping programme was co-funded by the Regional Governments of Aquitania and Basque Governments in the period 2006 to 2008. The partnership was composed by Ifremer, AZTI-Tecnalia, Laphy and IMA. Main of the projects was the biological characterization of the Basque continental shelf; for that, Txingudi bay was established as training site (Figure 1). The specific objectives were: (i) habitat classification and mapping using integrated methodologies; MBES, LiDAR, grab sampling, video, diving and (ii) the analysis of the EUNIS applicability (adaptation of the description-species, new habitats, etc.).



#### Study area and classified habitat map.

The main results of the project includes final habitat map at different EUNIS classification up to level 5 (Figure 2) and the description of the habitats including the characteristic species of the study area and that there were not included in the EUNIS habitat descriptions. Moreover, characteristic habitats not included in EUNIS were found. This project resulted in a publication by G. Chust, I. Galparsoro, Á. Borja, J. Franco, A. Uriarte, 2008. Coastal and estuarine habitat mapping, using LIDAR height and intensity and multi-spectral imagery. *Estuarine, Coastal and Shelf Science* (78) 633–643.

#### LIFE+ INDEMARES

##### LIFE+ "Inventory and designation of marine Natura 2000 areas in the Spanish sea"

The main objective of the LIFE+ INDEMARES project is to contribute to the protection and sustainable use of the biodiversity in the Spanish seas through the identification of valuable areas for the Natura 2000 Network. The project actions will be carried out from 1 January 2009 to 31 December 2013. The budget is € 15.4 million, and the European Commission will co-finance 50% of the project. Coordinated by Biodiversity Foundation, the project will have a participatory approach, and will include all of the relevant institutions in management, research and conservation in marine environments: Environmental, Rural and Marine Affairs Ministry, (through the Secretary General of Sea Affairs), the Spanish Institute of Oceanography (IEO), the Spanish Council for Scientific Research, ALNITAK, the Coordinator for the Study of Marine Mammals, OCEANA, the Society for the Study of Cetaceans in the Canary Archipelago, SEO/BirdLife and WWF Spain.

The project will study 10 areas in the Atlantic, Mediterranean and Macaronesic regions with the aim of including them in the Marine Natura 2000 Network. These areas are: Cañón de Avilés, Banco de Galicia, Chimeneas de Cádiz, Seco de los Olivos, Isla de Alborán y conos volcánicos, Delta del Ebro-Columbretes, Cañón de Creus, Canal de Menorca, Banco de la Concepción y Sur de Fuerteventura.



Study area location.

### Study of the Spanish Continental Shelf and Slope

This Project started in 1999 by the Secretaría General del Mar and, at present, is being conducted by TRAGSATEC. Surveyed area includes Atlantic and Mediterranean continental shelf between 10–130 m water depths (Figure 4) by means of multibeam echosounder and grab sampling. The main objective of the programme is to produce base cartographic information for nature conservation, fisheries and other activities management such as pipelines installation.

The techniques used include swath bathymetry, backscatter, seismic, ground-truthing with grab samples and underwater photo and video.

Final results were in GIS format and paper maps are being edited at 1/50000 and 1/100.000 scales.





Surveyed area in the Study of the Spanish Continental Shelf and Slope.

Within the collaborative framework signed between the Secretaría General del Mar and AZTI-Tecnalia, in spring and summer of 2010, new multibeam surveys were conducted in the Basque country continental shelf. During 2011, new surveys are planned with the final aim of finishing the seabed cartography of the Basque continental shelf up to 200 m depth.

#### **CARPEMA Project**

This Project was conducted by Instituto Español de Oceanografía – Secretaría General de Pesca Marítima during 2002 and 2007. Surveyed area was North of Alboran Sea between Málaga and Almería between 120–2,000 m water depth. Gathered data include: seismic profiles, swath bathymetric data and sediment data.

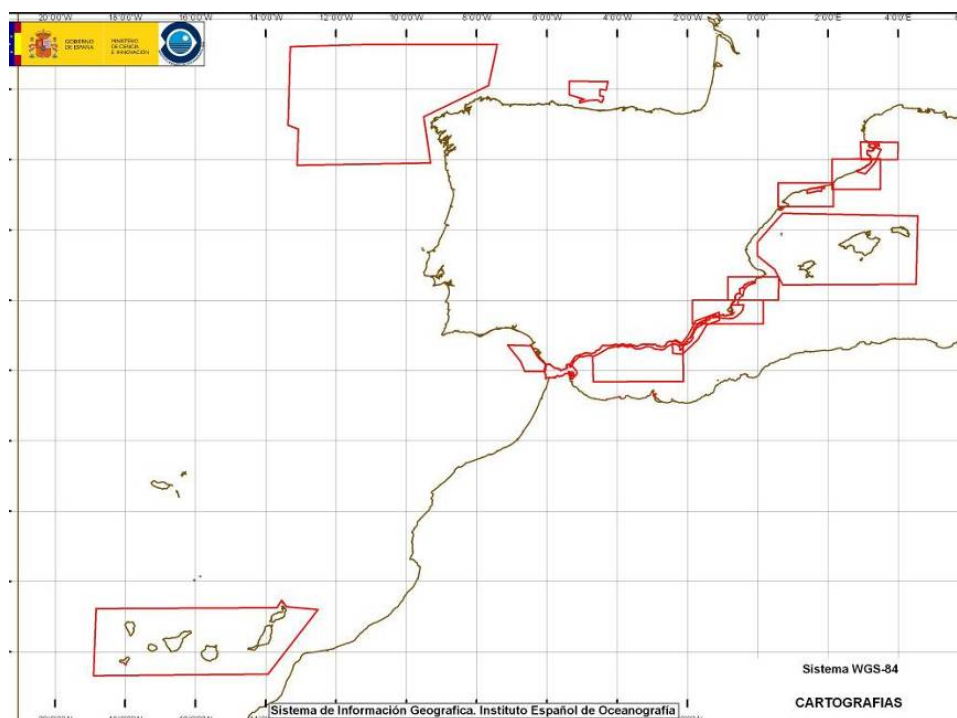
#### **ZEE Española**

This project was conducted by Instituto Español de Oceanografía - Instituto Hidrográfico de la Marina in 1999. The objective is the systematic survey of the geological composition of the seabed within the Spanish marine territory and Exclusive Economic Zone (EEZ). Fieldwork was conducted during 1995–1998 in the Balearic Islands continental margin, from 2000 to 2003 on the Canary Islands continental shelf and since 2005 northwest Iberian margin is being surveyed.

Swath bathymetry, backscatter, seismic, marine gravimeter and marine magnetometer techniques are being used.

#### **Marine ecocartographies**

It was conducted by the Dirección General de Costas in 2002. Surveyed areas were the continental shelves of Canary Islands, Málaga, Alicante and Valencia in the range of depths between 0 to 100 m water depths. Main objective of the project was to map of geological, hydrographic, and any biological characteristics of Spanish continental shelf and littoral zone, for environmental, management and planning purposes. Paper maps were produced at 1:25,000 and 1:50,000 scales.



Location of the main cartographic programmes surveys.

### Marine Information Web Map Service

Developed and hosted by Spanish Institute of Oceanography In IEO (in IEO web: [http://mapserver.ieo.es/website/WMS\\_IEO/viewer.htm](http://mapserver.ieo.es/website/WMS_IEO/viewer.htm)) there is a compilation of thematic information such as: administrative borders, bathymetry, fishing grounds, etc.

### Habitat mapping and seabed characterization of the Basque continental shelf

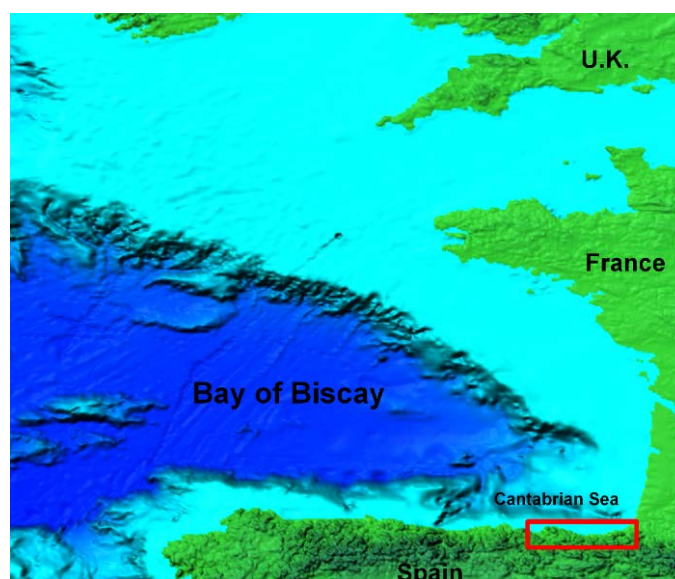
This programme was funded by the Department of Environment, Regional Planning, Agriculture and Fisheries of the Basque Government. It started in 2005 and finished in 2009 (Galparsoro *et al.*, 2009). The main objective was to generate seabed cartography, defining and delimitating marine habitats, and identifying the main species associated to each habitat type, within the continental shelf up to 100 m water depth. The specific objectives were:

- obtain high resolution bathymetric data;
- characterize different seabed types (including geologic and geomorphologic features);
- determine habitat distribution pattern, in relation to environmental factors;
- produce habitat maps (intertidal and subtidal zones);
- classify habitats (European Natural Information System (EUNIS)); and
- identify and locate habitats of Community Interest.

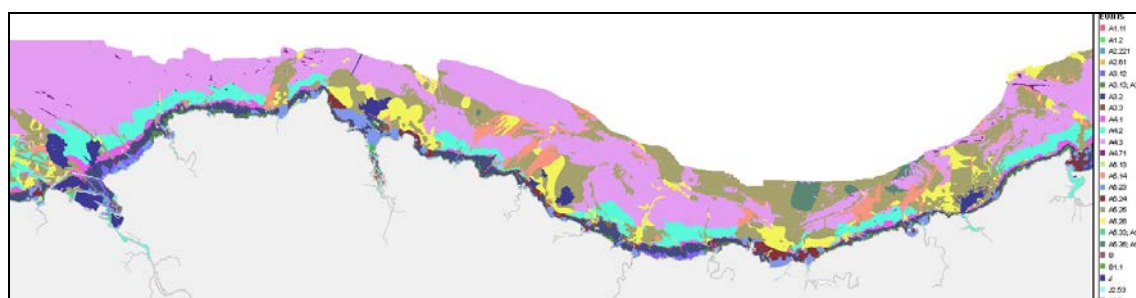
This investigation integrates different remote sensing techniques, such as multibeam echosounder (operating from approximately 10 to 100 m water depth), topographic LiDAR (terrestrial land to mid-intertidal zone), bathymetric LiDAR (up to 20 m water depth) (Galparsoro *et al.*, 2010), and aerial photography (Chust *et al.*, 2007; 2008), to cover a continuum from land to deep-water environments.. In situ samples correspond to biological benthic data which includes 423 grabs from soft-bottoms in the

period 2003–2008, and 405 samples from rocky seabed, taken by divers (Galparsoro *et al.*, In press).

Habitat modelling assessment was carried out to relate the sedimentological and oceanographical conditions to the species distribution. Most of the variability on species composition was explained by the sedimentary composition and the sedimentary resuspension produced by wave action. This result was used for habitat classification and their spatial delimitation by environmental information layer combination in a GIS environment. Moreover, the Pan-European EUNIS habitat classification was used as base classification for management and conservation purposes, but it was adapted to the specific characteristics of the Basque continental shelf biological communities and habitats.



Study area within the Bay of Biscay.



Intertidal and subtidal benthic habitat map distribution based on EUNIS classification.

#### 4.1.6 References

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- Galparsoro, I., Á. Borja, I. Legorburu, C. Hernández, G. Chust, P. Liria and A. Uriarte, 2010. Morphological characteristics of the Basque continental shelf (Bay of Biscay, northern

Spain); their implications for Integrated Coastal Zone Management. *Geomorphology*. 118, (3–4), 314–329.

Galparsoro, I., Á. Borja, J. G. Rodríguez, I. Muxika, M. Pascual and I. Legorburu, In press. Rocky reef and sedimentary habitats within the continental shelf of the southeastern Bay of Biscay. Insights into Seafloor Geomorphology as Benthic Habitat: GeoHAB Atlas of Seafloor Geomorphic Features and Benthic Habitats. P. T. Harris and E. K. Baker (Eds.). pp.

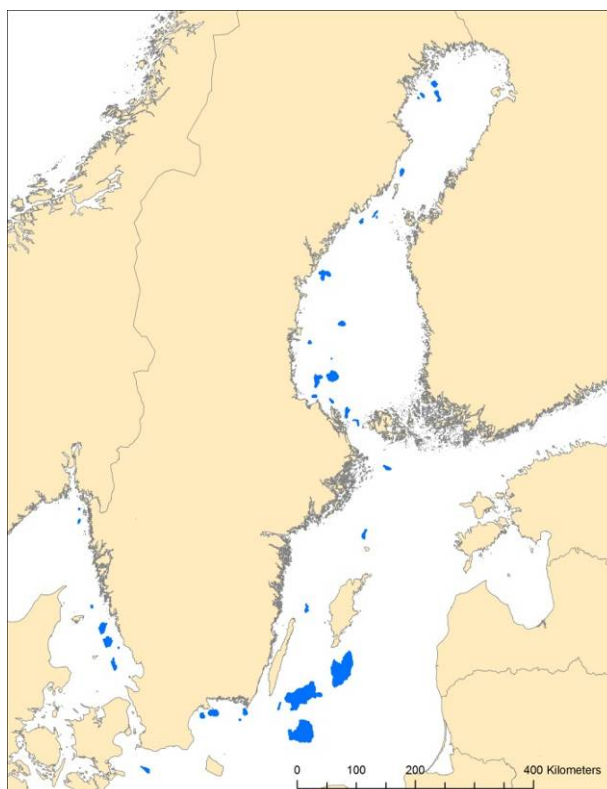
Galparsoro, I., G. Rodríguez, Á. Borja and I. Muxika, 2009. Elaboración de mapas de hábitats y caracterización de fondos marinos de la plataforma continental vasca. Informe inédito elaborado por AZTI-Tecnalia para el Dirección de Biodiversidad; Viceconsejería de Medio Ambiente; Departamento de Medio Ambiente, Planificación Territorial, Agricultura y Pesca del Gobierno Vasco, 74 pp. pp.

#### **4.1.7 National programme report for Sweden**

##### **Martin Isaeus (Aquabiota) and Cecilia Lindblad (SEPA)**

##### **Swedish offshore bank survey**

In order to raise awareness of the Swedish offshore marine environment the Swedish Environmental Protection Agency was given the task to continue the mapping of offshore banks, with the addition to also include inventories of seabirds and fish. The first mapping of the offshore banks (U1) was conducted in 2003–2005 (EPA Report 5576, 2006), while the continued mapping (U2) was conducted from December 2007 to 2010, and reported here. Within the framework of the two surveys 42 offshore banks have been surveyed with a total area of 5452 km<sup>2</sup>, or about 3% of Sweden's maritime areas.



**An overview of the 42 offshore banks surveyed during the project.**

The work within U2 included fish, seabirds, bottom flora, and bottom fauna (invertebrates), respectively.

This report presents, at first hand, the results of the field surveys conducted within U2. For some of the reported sites data from earlier surveys, conducted in other projects, were made available. The results are also presented as maps of predicted species distributions, constructed through spatial modelling. The mission was designed to incorporate the development of an assessment system for the biological and ecological conservation values of offshore banks on the basis of national and international recommendations. An important ambition has been to base the assessment on empirical field data rather than on subjective opinions. The conservation value of the banks was assessed in relation to other offshore banks, not comparing them to the rest of the marine environment. It is important to remember that all offshore banks have general values that are not, or only partly, included in the assessment. Since the banks are located off the coast, they are less affected by human activities, which means that in many cases they function as refuges for species dispelled from coastal areas by human influence. Offshore banks can thus serve as important source sites for recolonization if conditions in the coastal areas improve. Furthermore, offshore banks are rare features compared to coastal areas and surrounding soft bottoms and therefore have a high value for the criterion of uniqueness. The assessment of biological and ecological value covered the all so far investigated offshore banks, i.e. all banks within both U1 and U2, and was carried through separately for fish, seabirds, and benthic flora and fauna. To some extent, the assessment also included marine mammals, for which data were taken directly from expert evaluations of seals and porpoises.

All three banks that were investigated in the Skagerrak were interesting from a conservation perspective. Svaberg, outside Smögen, has high conservation values for both its benthic flora and fauna. The values are primarily associated with a large number of algal species and endangered invertebrates, as well as the occurrence of rare and endangered habitats maerl beds and exposed shell gravel banks. Persgrunden, within the Kosterhavet National Park, is characterized by a high diversity of invertebrates. Benthic surveys also imply that the diversity of fish is high on this bank, but a more targeted fish survey is necessary to adequately compare the banks in the Skagerrak with regard to their relative value of fish. Makrillbåden is less important for algae and has smaller proportion shell gravel, but hosts a large proportion of red-listed invertebrates.

Of the banks in the Kattegat, Fladen was given the highest conservation values with regard to both fish and invertebrates, as well as high values of benthic flora. The bank is designated as Natura 2000 area containing the habitat types Reefs (1170) and Sandbanks (1110), and has a high diversity of fish, invertebrates, and algae as well as a large quantity of rare and endangered species. Both the abundance of kelp forests and large catches of juvenile cod indicate that this offshore bank is likely an important nursery grounds for fish. The bank is also of international importance for seabirds. Also Lilla Middelgrund has high conservation values for all the investigated organism groups. The bank is designated as Natura 2000 area containing the habitat types Reefs (1170) and Sandbanks (1110). The diversity of algae is even slightly higher than at Fladen and the prevalence of kelp and maerl beds is similar to that at Fladen. Diversity of fish and invertebrates are lower than at Fladen, but again many rare and endangered species were found here, as well as indications that the bank is important as spawning and nursery grounds for fish. Extensive *Modiolus modiolus* beds, a threatened and declining habitat, were also found at Lilla Middelgrund. Most



of the remaining banks in the Kattegat have high conservation value for at least one of the organism groups. Stora Middelgrund is of international importance for seabirds, and moreover, high densities of porpoises have been recorded here. Also, it has the largest presence of *Modiolus modiolus* beds among the surveyed offshore banks, a large prevalence of exposed shell gravel bottoms and a relatively high diversity of invertebrates and is therefore considered as one of the most valuable banks for invertebrates. Stora Middelgrund also has special importance for life-history stages of fish with a high prevalence of sole. Permission has been granted for construction of a wind farm on Stora Middelgrund. Kummelbank hosts nearly as many red-listed invertebrate species as Fladen and is therefore valuable with regard to this organism group. The conservation value of Vanguard's ground is instead mainly connected to its algal flora, and to the presence of maerl beds which, except for at Fladen and Lilla Middelgrund, only has been found on this bank. The nearby and more coastal Tistlarna, which were surveyed for fish, have high densities and relatively high diversity of fish. The coastal Morups bank has a relatively rich algal flora and especially the shallowest areas (0–20 m depth) are given high conservation value for fish. On the contrary, the small and deep Röde bank was given relatively low conservation values for all the investigated organisms and criteria. Both Morups bank and Röde bank are designated Natura 2000 sites.

In the Baltic Proper the three big offshore banks Hoburgs bank, Norra Midsjöbanken, both of them Natura 2000 sites, and Södra Midsjöbanken have consistently high conservation values. All three banks are of international importance for seabirds due to the high density of wintering long-tailed ducks. Hoburgs bank ranks highest for fish, due to high diversity and high densities of red-listed species. A high density of red-listed fish species was also noted for Norra Midsjöbanken, and this bank is considered as important for the life-history of turbot. Södra Midsjöbanken was not surveyed for fish. Hoburgs Bank and the Midsjö banks are given the highest values also with regard to benthic flora and fauna, mainly due to their large areas of ecologically important habitats and their geomorphological uniqueness. Utklippan is of national importance for birds, since there are several species that nest there. This bank extends up to the sea surface and thus holds the highest diversity of algae among the banks in the Baltic Sea. Hanöreven, Ölands södra ground and Knolls ground are similar to Hoburgs Bank and the Midsjö banks with regard to the unique moraine embankments, but are given a lower value because of their smaller size. They are also less significant for long-tailed ducks. For fish, Ölands södra ground has a relatively high value, whereas Hanöreven has low values. Svenska Björn is given an overall low conservation value compared with the other offshore banks in the Baltic Sea.

In the southern Bothnian Sea both banks of Finngrundén are given high values for fish, algae as well as invertebrates. Of these two banks, higher diversity of both fish and algae are observed for Västra banken. Östra banken, which also is designated as a Natura 2000 site, is rather characterized by the large amount of bladderwrack, this valuable habitat covers a considerably larger area on Östra banken than on any other offshore bank in the Gulf of Bothnia. Both banks are also nationally important for seabirds, primarily as a resting site for long-tailed ducks and several other species. Also Storgrundet obtains high values for fish, algae and invertebrates, with the highest recorded density of herring in the Gulf of Bothnia and a high diversity of algae. However, in contrast to Finngrundén, this more northerly located bank is not documented to be important for seabirds. Of the remaining offshore banks in the southern Gulf of Bothnia Grundkallegrund stands out as interesting with regard to the benthic flora and fauna, with a high diversity of algae and a large prevalence of blue mussels.

The Argos banks and Campsgrund also host relatively large amounts of blue mussels, but none of these small and coastal banks are documented to be important for seabirds. In the northern Gulf of Bothnia, Långrogrunden and Sydostbrotten emerge as internationally important for seabirds. Sydostbrotten is also highly valued for its unique northern extension of the endemic *Fucus radicans*. Vânta litets grund is a dedicated Natura 2000 site, dominated by the habitat type Sandbanks (1110). The bank is given a high conservation value, mainly due to the large amount of blue mussels which is unique as far north in the Gulf of Bothnia. It has not been possible to make a corresponding evaluation of the offshore banks in the Gulf of Bothnia because of the limited knowledge of biological and ecological values in this area. Marakallen was the only bank surveyed for fish in the Gulf of Bothnia and a relatively high density of fish (mainly perch) was noted, but no redlisted species. With regard to benthic flora and fauna Rata Storgrund, Klockgrundet/ Tärnans grund and Marakallen are all relatively equal in presence of species and habitats. Marakallen, which is a Natura 2000 site, has a larger element of hard substrate and thus more benthic vegetation, as well as a greater prevalence of filtering freshwater sponges. Svalans and Falkens grund lie deeper than the other banks and have almost no vegetation. If biological values exist on these banks they are likely associated with infauna of sandy substrate, but this element has not been investigated in the current offshore surveys. For marine mammals, data from environmental monitoring show that the highest densities of ringed seals (*Pusa hispida*) in late winter are found in the northeastern part of the Gulf of Bothnia. For Marakallen a slightly higher density of ringed seals has been observed, compared with the other investigated banks in the Gulf of Bothnia.

Thanks to the inventories and access to good environmental data, such as high resolution depth data, it has been possible in U2 to produce maps of the expected distribution of a number of macroalgae, benthic invertebrates and habitats through predictive modelling. For some banks it was possible to create predictions for many species while for other banks only one or a few species could be successfully modelled. The differences in outcome have mainly been due to discrepancies in the quantity and quality of the underlying data. The predictions should be viewed as a statistical description of the distribution of species rather than precise maps of species occurrence. They show the approximate extent of the species' distribution (i.e. is the species common or rare, well-dispersed or confined to a small area) and which parts of the bank that are the core areas for the distribution. They should therefore be used for general descriptions of the banks or for creating a comprehensive picture of the prevalence of a particular species, species group or habitat at a bank. Maps for hard substrate and hard-substrate species can be used to identify areas of probable occurrence of the Natura 2000 habitat type Reefs (1170). Since the maps do not show the exact distribution of species or habitats, they are not intended to be used for detailed planning of work on a bank. However, they may constitute a first basis for further studies and provide guidance on areas of concern for deeper investigation on a certain bank. The continued survey of offshore banks U2 has contributed significantly to raising the awareness of the presence of fish, seabirds and benthic life on our offshore banks, although several banks still remain to be surveyed for certain groups of organisms.

Thanks to the surveys there is now a better understanding of the natural assets in terms of species and habitats in the Swedish offshore areas. Also, the systematic methodology used in the field surveys provides a good basis for future follow-up projects. The system for assessment of conservation value is a first step for marine spatial planning and conservation work. However, in order to permanently protect

the unique offshore environment and ensure a representative and viable network of offshore banks, a comprehensive strategic planning is required which takes into account also cumulative effects arising when several banks are exposed to human affect.

### **Collaboration plans**

Collaboration Plans for Valuable Coastal and Marine Areas is a national pilot project initiated by the Swedish Environmental Protection Agency. The project consists of five regional pilot areas that are being conducted during 2008–2011 by the administrative boards of Västernorrland, Stockholm, Östergötland, Blekinge and Västra Götaland counties. Four of the pilot areas are designated as Baltic Sea Protected Areas (BSPA) by HELCOM. Part of the fifth area is designated as a Marine Protected Area (MPA) by OSPAR.

The five project areas vary with regard to their dimensions, populations, knowledge of marine valuable areas, and users' interests. The objective is to develop plans on conservation, protection and sustainable use in order to provide a basis for long-term and sound management fulfilling the requirements according to regional conventions and conducting the achievement of national environmental objectives. The implementation of the Ecosystem approach and ICZM is guiding the process on the development of governance in the area. A strong emphasis is placed on the approval, participation and cooperation with municipalities and stakeholders.

One important part in the pilot project has been to increase the knowledge of the sea area through basic mapping of marine environment and develop GIS maps of habitat distribution. Another important part has been to work across geographical and administrative borders to develop a consensus upon values needed to consider for a sustainable development and developing strategies for a sustainable management in collaboration with stakeholders. Where Open standards ([www.FOOnline.org](http://www.FOOnline.org)) for adaptive management has been used as a tool to systematically precede the process.

### **Mapping human activities**

A national program has finalized to map human activities along the coasts of Swedish. The project was funded by Swedish environmental protection area and performed by Metria miljöanalys.

The report *Mapping and analysis of disturbance factors in the marine Environment (NV report 6376, 2010)* presents results from data compilations and GIS-analyses. The purpose was to produce knowledge for national environmental goals, and for national, regional and local strategies for protection measures and permits for coastal construction and exploitation. Digital GIS data has been combined and analysed for the purpose of estimating the affect on the environment and on various key habitats. The compilation of nationally covering GIS datasets giving direct or indirect indication of disturbance on the marine environment, mainly in shallow areas.

The area of analysis encompasses marine waters; shallow area the depth interval is 0–10m and for other analyses the Swedish EEZ is used. The results comprise nationally GIS datasets that describe potential physical disturbance. From these datasets, regional and national statistics has been compiled based on different administrative boundaries, marine protected areas as well as water districts according to the Water Framework Directive.

The datasets describe:



- Jetties, harbours and bathing sites along the Swedish coast
- Navigation lanes and traffic intensity for various vessel categories
- Fish farms and commercial fish catch
- Guest harbours and naturally sheltered bays used by leisure traffic
- Marine constructions such as cables and dolphins
- An exploitation indicator for the coast
- Disturbance potential of shallow areas (0–10m)

The results are accompanied with recommendations on how to use the material either as statistics or geographically, e. g. in marine spatial planning, zoning of protected areas or as background information for EU Directives.

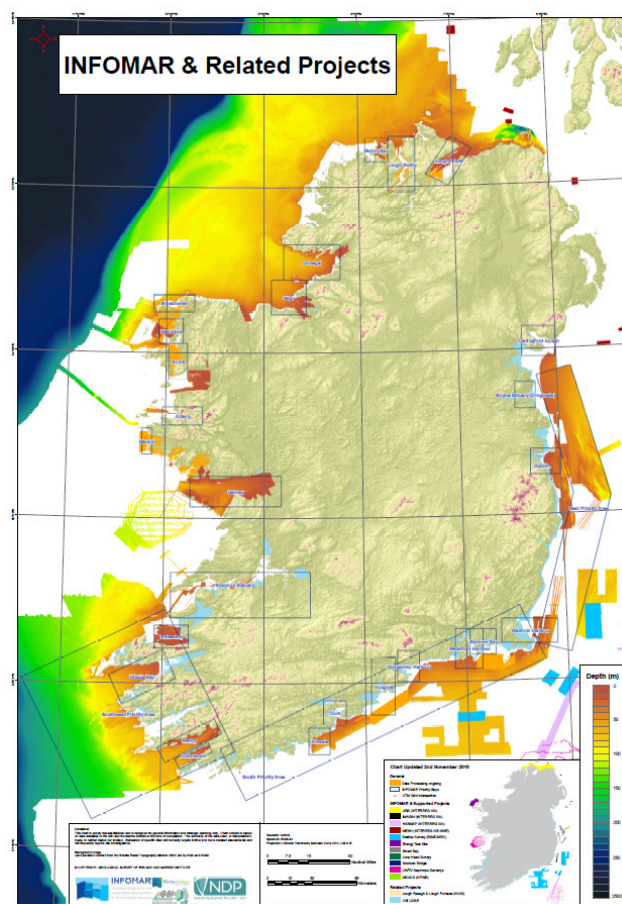
#### **4.1.8 National programme report for Ireland**

##### **Fergal McGrath (INFOMAR Programme)**

presented an overview of the work currently being undertaken in Ireland

##### **National Mapping Programme - INFOMAR**

INFOMAR (Integrated Mapping for the Sustainable Development of Ireland's Marine Resource) was launched in 2006 as a follow on the successful Irish National Seabed Survey (INSS) which ran from 1999 – 2005. The INSS mapped over 80% of Ireland's offshore EEZ using MBES, sub-bottom profiler, gravimeter and opportunistic sampling. The current coverage map, comprising INSS and INFOMAR is presented below:



INFOMAR is a joint venture between the Marine Institute and the Geological Survey of Ireland ([www.infomar.ie](http://www.infomar.ie)). Current annual funding for this programme is €2.9m. INFOMAR is a 20-year programme, which aims to carry out integrated mapping over the entire shelf and coastal waters of Ireland. Through extensive stakeholder consultation 26 Priority Bays and 3 Priority Areas have been identified for mapping during the first 10 – year phase of the project (2006–2016). There will be a mid phase 1 review end 2011 / start 2012. The programme has achieved its target metrics for this period.

The mapping programme includes acquisition of multibeam bathymetry and backscatter data together with a comprehensive geological sampling programme. Equipment used includes EM3002, EM1002, EA400, OLEX, Hull Mounted Pinger, Magnetometer, GeoSpark 200, underwater video, ROV, boxcorer, grab, and vibro-corer. Mapping outputs from the project include bathymetric data and geological maps. All results and raw data from INSS and INFOMAR are available for download and can be accessed at [www.infomar.ie](http://www.infomar.ie).

### INFOMAR Activities

A new 'Priority Bays and Areas Graphic' has been designed and approved by the programme board. This graphic presents the actual outer delimitation of the priority bays and priority areas as opposed to the schematic representation used up until now. The limits are based on existing Special Areas of Conservation (SAC), Marine protected Areas (MPA), and UKHO Chart limits.

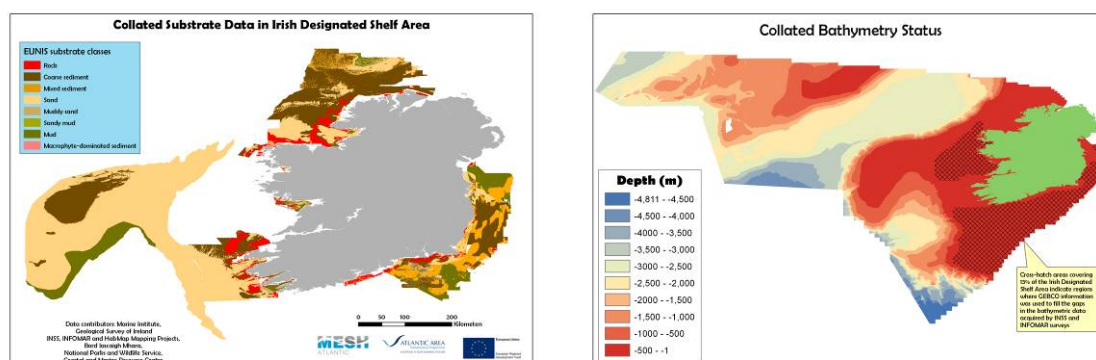
In 2010, INFOMAR acquisition comprised 12 survey legs (Ship/LiDAR). The RV "Celtic Voyager" surveyed in 2010, six (6) priority bays and (2) priority areas were partially surveyed. MBES (EM3002) data were acquired using the Celtic Voyager in

two (2) priority areas. MBES (EM3002) data were acquired using the RV “Keary” in five (5) priority bays LiDAR data were acquired in four (4) priority bays.

<b>Name</b>	<b>Acquisition</b>	<b>Platform/Dates</b>
West Coast	MBES / Vibrocoring	Celtic Voyager – 03/2010
Blacksod Bay	LiDAR	Peledryn – 04/2010
Mannin / Clifden Bay	LiDAR	Peledryn – 04/2010
Achill Bay	LiDAR	Peledryn – 04/2010
Lough Swilly	LiDAR	Peledryn – 04/2010
Irish Sea. East Priority Area	MBES	Celtic Voyager – 04/2010
Dublin Bay	MBES	Keary – 05/2010
Galway Bay / Aran islands Nephrops Survey - Aran Grounds	UWTV / MBES	Celtic Voyager – 06/2010
Kinsale Bay	MBES	Keary – 06/2010
Celtic Sea. South Priority Area	MBES	Celtic Voyager – 07/2010
Mannin / Clifden Bay	MBES	Keary – 08/2010
Blacksod Bay	MBES	Keary – 09/2010
Celtic Sea. South Priority Area	MBES	Celtic Voyager – 09/2010

## Habitat maps

Through the Mesh Atlantic project, comprehensive collation and standardization of existing bathymetric data and existing substrate data in Ireland is being carried out. Existing seabed classification maps created by the INFOMAR programme are being collated and translated into EUNIS classification. This will facilitate integration into the final Mesh Atlantic habitat map which is a deliverable of Mesh Atlantic requirements.



## Other Programme Activities

**MESH Atlantic:** Mapping Atlantic Area Seabed Habitats for Better Marine Management. The Marine Institute is participating in this Ifremer led INTERREG IV project. There are 10 European partners in the project, which started in May 2010 and is due to be completed by April 2013. The general objective of Mesh Atlantic is to provide harmonized seabed habitat mapping over the coastal and shelf zones of the Atlantic Area in order to help informed spatial planning and management.

**INIS Hydro:** Ireland, Northern Ireland, and Scotland Hydrographic Survey. The Marine Institute is participating in this MCA led INTERREG IV project. There are 6 European partners in the project, which started in March 2011 and is due to be completed by April 2013. The objective of INIS Hydro is to provide a standardized seabed survey specification, and high-resolution seabed mapping data in key geographical areas, sensitive bays and inlets on the coasts of the bordering regions. It will also serve up the freely available results via the web.

**EMODNET:** European Marine and Observation and Data NETWORK. This project, funded by DG Mare aims to develop EU wide thematic marine maps under three different modules. It is currently assembling marine data into interoperable and publicly available data streams for complete maritime basins.

**GEO-SEAS:** This project funded through the FP7 infrastructure fund, is a Pan-European Infrastructure for Management of Marine and Ocean Geological and Geophysical Data. It will represent a network of interconnected ecological/geophysical data centres. The Geological Survey of Ireland and the Marine Institute of Ireland are participating in this (both INFOMAR joint programme managers).

**NEPHROPS Fisheries Surveys:** INFOMAR acquired EM3002 MBES data (bathymetry and Backscatter) on Celtic Voyager during an annual nephrops assessment survey in the Aran Grounds off the west coast of Ireland. OLEX was also deployed on the survey. Provision of ground discrimination equipment for use during annual programmes will result in added value acoustic and ground-truth data being collected at no cost to INFOMAR, in Phase 2 Areas.

#### **4.1.9 National programme report for the Netherlands**

##### **Jan van Dalfsen - Deltares**

Jan van Dalfsen (Deltares) updated the group in his presentation about the status of marine habitat mapping work and related projects in the Netherlands.

##### **Netherlands Continental Shelf. Update of surface and subsurface geological map (Geological survey)**

Seabed and resource mapping in the Netherlands is the responsibility of two organizations: the Geological Survey of the Netherlands and Deltares. The Geological Survey manages queries and analyses the central geological database, whereas Deltares has extensive expertise in the areas of geophysical monitoring and numerical modelling. Using a new data analysis method an updated surface and subsurface geological map of the entire Netherlands EEZ and the territorial sea has been produced based upon the existing seismic information

##### **Shellfish related mapping**

Annual surveys of marine shellfish communities are performed in the Dutch coastal zone to calculate the total stock and distribution of the various species. In the Wadden Sea inventories are made annually on the distribution and abundance of intertidal mussel beds. The mapping is done with aerial inventory followed by detailed mapping by site visits using GPS. Annual mapping of sublittoral mussel beds and intertidal cockle densities is conducted in the Wadden Sea to locate and estimate the total stock of sublittoral seed mussels and cockles.

The information is used for fisheries management. Development of littoral mussel beds is followed over the years.

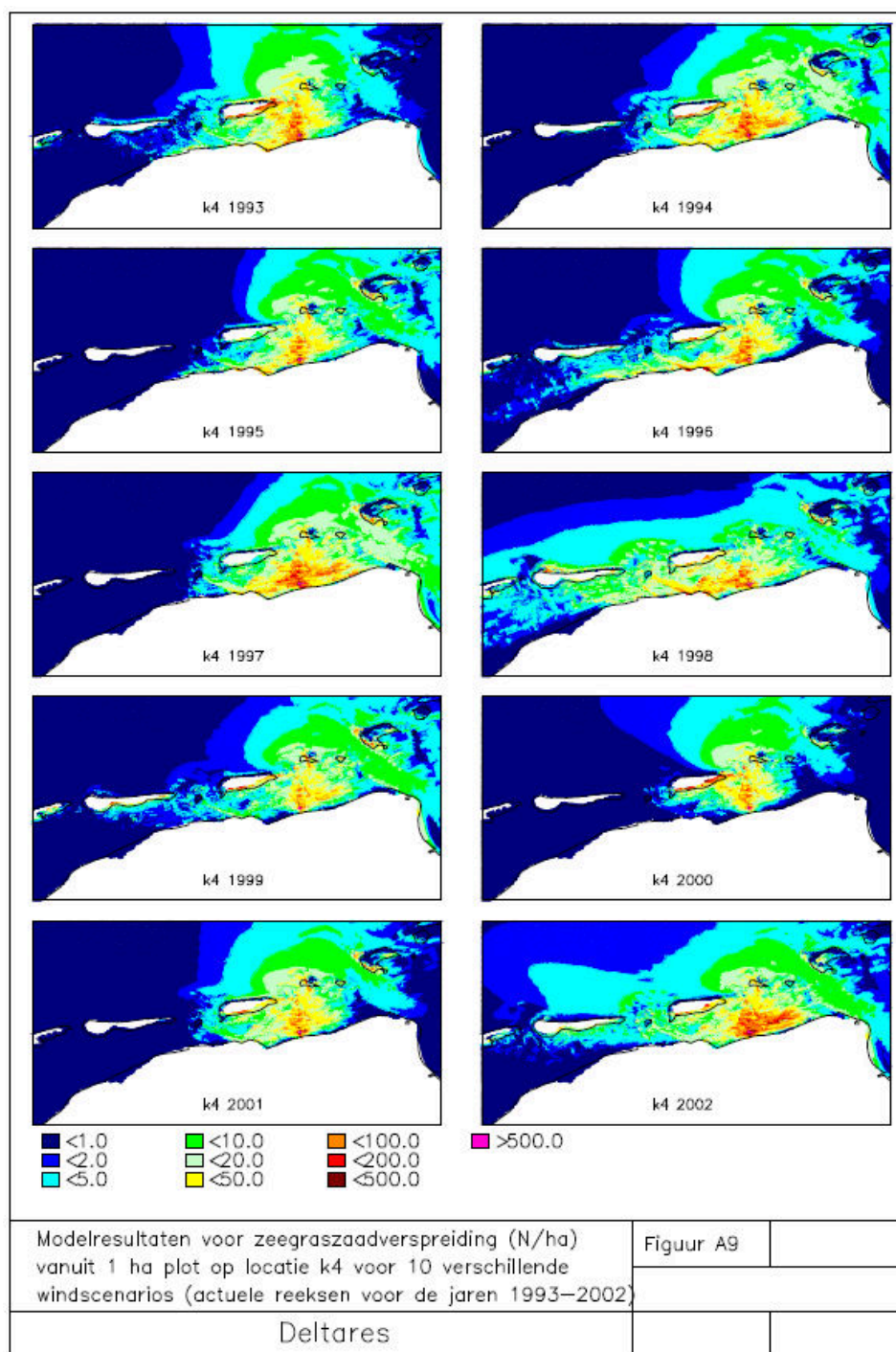
##### **Mapping of Pacific Oysters Oosterschelde**

Pacific oysters have become invasive in the Dutch coastal waters. In the Oosterschelde the species have reached high densities and they have an effect in the functioning of the ecosystem by providing hard substrate and filtering phytoplankton from the water column. Using habitat modelling, habitat suitability maps are produced for predicting the potential distribution of Pacific oysters in the southwestern delta area and for various shellfish species in the coastal area of the North sea; mussel beds and seed mussels. The distribution and coverage of Pacific oysters is furthermore followed on an irregular basis using aerial photography and ground-truthing.

##### **Wadden Sea seagrass restoration prediction map**

In 2010 Rijkswaterstaat initiated a project to restore the seagrass community in the Wadden Sea. Seagrass was an important environment in large parts of the shallow Wadden Sea, but has disappeared completely from the Dutch marine waters after a disease in 1930 seagrass. Natural recovery did not happen possible related to large environmental changes that have occurred in the following decades, such as the building of the Afsluitdijk and eutrofication in the following decades. Several attempts were made to reintroduce seagrass but these were unsuccessful, although slight recovery occurred naturally on one site in the Eastern Wadden Sea. Based on the HABITAT model and the ecotope description of the species a potential habitat map was produced for the Wadden Sea. This map indicates areas with high potential of successful introduction by seeding including the potential of further dispersion from these test seed sites. The project is planned to start in 2011, with a total length of

4 years. Within the project is foreseen to have two seeding experiments at three locations (Balgzand, Schiermonnikoog en Groninger Wad).



Modelled seagrass seed distribution maps.

### Projects

Related to different sand extraction and coastal nourishment projects several environmental seabed descriptions have been made. These include e.g. the **Zeeland Bank** which is recognized as an ecological valuable area and is considered to become a Marine protected area under Natura 2000. Also large coastal areas of the Netherlands are assessed on the possible affects of the construction of Maasvlakte 2, the enlarge-

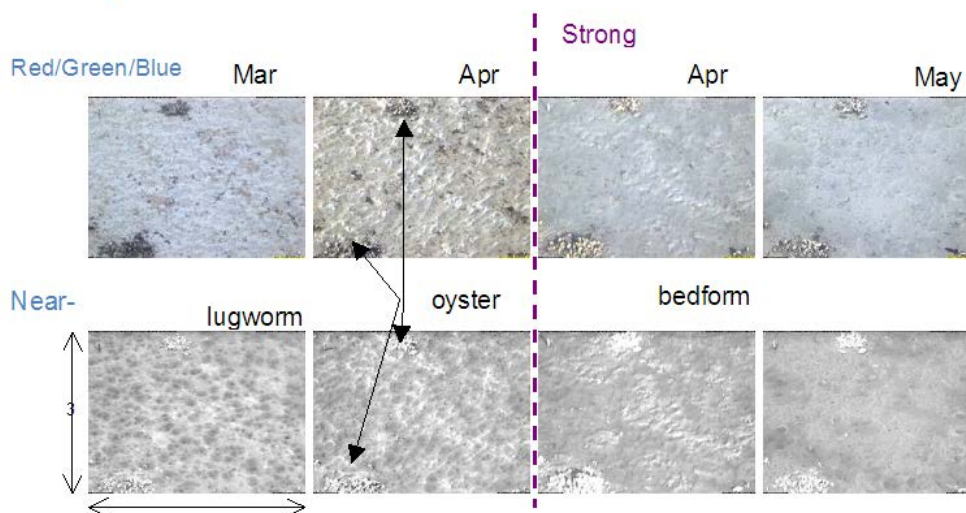


ment of Rotterdam harbour. Measurements are done on bathymetry, sediment composition of the seabed, diversity and biomass of benthic fauna, underwater noise as well as changes in the amount of suspended matter in a broader area and the influence of these changes on the timing of the yearly algae bloom. Results and conclusions are expected in 2011 and 2012.

Next to the monitoring campaign for Maasvlakte 2, an additional campaign is coupled to an experiment with ecological landscaping. The aim of the project is to create ecologically valuable habitats through sand extraction and ecological landscaping. Models will be developed aimed to predict benthic infaunal, epifaunal and demersal fish abundance and assemblage (biomass and species diversity) in landscaped extraction sites. The data of the Maasvlakte 2 landscaping experiment will be used to validate the outcome of the model. This research is part of the **“Building with Nature” program**, a public-private initiative which aims at developing hydraulic engineering infrastructures while creating opportunities for nature at the same time.

Within the Building with Nature program a study is conducted in which a high resolution remote monitoring system is being developed and tested to study the biogeomorphology of intertidal areas. This system uses a high resolution camera system to make observations on morphodynamics, benthos and birds. Furthermore the system is used to calibrate fine scale hydrodynamic and sediment transport models (more info at <http://argus-data.wldelft.nl/sites/galg/2011>).

### Multispectral camera



Multispectral camera imagery.

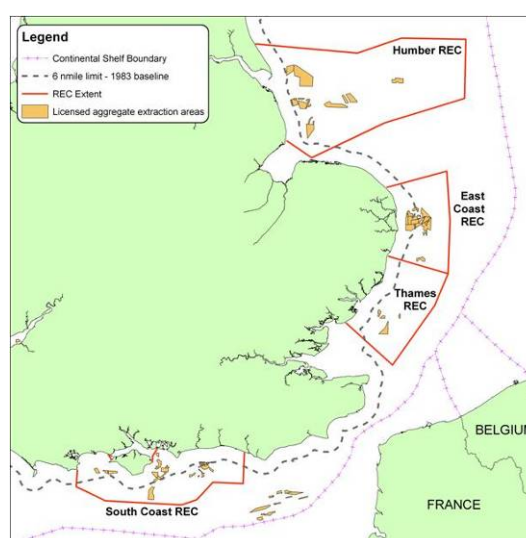




In Europe marine habitat maps will be useful in the implementation of EC policy such as the Marine Strategy Framework Directive, the Bird Directive (79/409/EEC) and the Habitats Directive (92/43/EEC). Spatial information is also needed to apply to the OSPAR Convention which is guiding international cooperation on the protection of the marine environment of the Northeast Atlantic. More and more habitat maps are being used to support marine spatial planning and integrated management plans aimed at sustainable development and management of marine areas.

#### 4.1.10 National programme report for UK-England

##### Regional Environmental Characterization Surveys (REC)

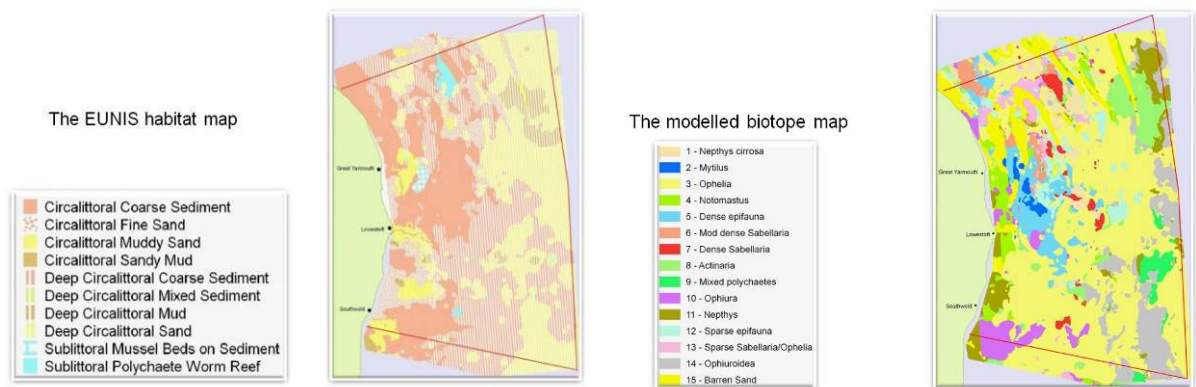


In 2007 a series of regional characterization surveys were funded through the Marine Aggregate Levy Sustainability Fund around the East and South Coast of England. The areas were situated around areas where aggregate extraction takes place and aimed to provide regional scale geological, biological and archaeological context. Large amounts of acoustic and ground-truthing data were collected during the course of the surveys. Different partnerships of UK research organization and companies delivered the reports for these surveys. All reports are presented in similar formats and were delivered by early 2011.

All surveys were required to deliver a EUNIS habitat type map. Cefas led the East Coast REC project and produced a EUNIS habitat type map using traditional approaches using photic zone, wavebase and seabed sediment data layers. The EUNIS habitat type map could only be developed to EUNIS Level 4, not incorporating any of the biological data collected during the survey, as there was little agreement between both datasets.

Therefore the East Coast REC also adopted a bottom-up approach to mapping biotopes. The mapping units were distinct faunal communities defined by statistical analysis of the sampled benthic assemblage. Correlations between communities and physical variables were used to extrapolate the distribution of communities beyond point samples using 5 different modelling approaches. A consensus map is built from the results of different modelling approaches.

The bottom up approach gives more biological detail than top-down approach (EUNIS) as it is not constrained by predefined habitat type categories. It is up to managers and decision-makers to choose maps that are fit for purpose.



### Habitat mapping for conservation purposes

Over the last year the Joint Nature Conservation Committee (JNCC), Natural England (NE) and Cefas have worked together on several projects to characterize the habitats within areas proposed as SACs under the EU Habitat Directive. Full multi-beam surveys were undertaken at several sites along the coast off SW England and at one site offshore in the Celtic Sea. Additional ground-truthing was undertaken using grabs and video.

Within the Lyme Bay to Torbay cSAC area, Natural England commissioned a full multibeam bathymetry and backscatter survey, together with the Maritime and Coastguard Agency. The area is designated for rocky and stony reef, but the extent of the SAC area was contested by local stakeholders. The recent survey data were integrated with available ground-truthing data and Annex I habitats were spatially delineated. The acoustic data did not allow differentiating between rocky and stony reef.

At the meeting an update was also provided on the Marine Conservation Zone (MCZ) projects currently underway in England. The UK Government is committed to „creating a UK-wide ecologically coherent and well-managed network of MPAs as a key element of its wider work to recover and conserve the richness of our marine environment and wildlife“. MCZs will be designated under the Marine and Coastal Access Act 2009. The work is being delivered through four Regional Projects who will work with sea users and interest groups to identify Marine Conservation Zones and provide recommendations for sites within their regions to Government. No new habitat mapping surveys are undertaken as part of this work, but existing surveyed and predicted habitat maps (UKSeaMap2010) are play a major role in the selection process.

### Review of marine seabed survey needs

Unlike countries such as Ireland and Norway, the UK currently has no large-scale or coordinated programme of seabed surveys. Several proposals have been made to Government but none have been taken forward to date. The lack of understanding of how this work helps to deliver the Government's current and future requirements was identified and a project was commissioned to identify the Government's need for seabed maps and the policy drivers. The project also set out to identify the information needs and current data gaps, and come up with recommendations for the way forward for seabed mapping.

A review of all policy frameworks identified that the Marine and Coastal Access Act, Marine Strategy Framework Directive (MSFD) and the Strategic Environmental Assessment (SEA) Directive were key policies requiring knowledge derived from habitat maps. Few mention habitat mapping explicitly, but the need is implicit in many of the frameworks. A review of available data confirmed previous findings that the seabed habitat data currently available is too sparse, patchy and variable in quality to make sound decisions.

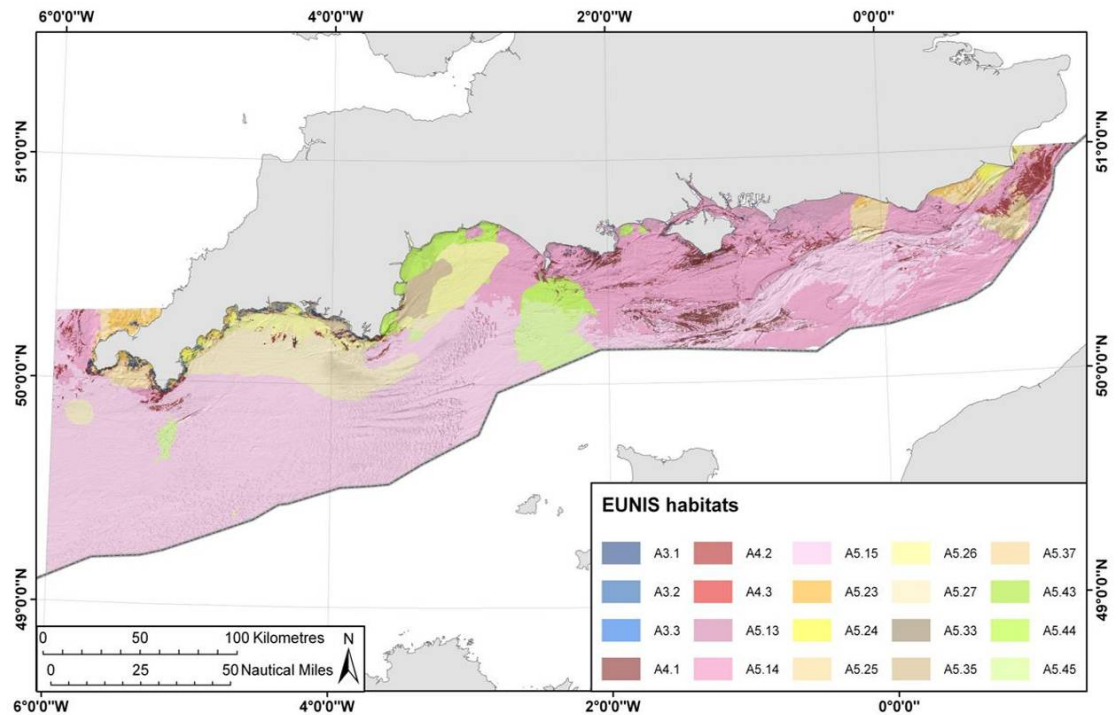
A series of recommendations was developed with the key ones listed below, providing a way forward for the seabed mapping work in the UK.

- Improved use of existing data: e.g. Existing multibeam data from the other Government organizations could be further utilized in a more systematic and coordinated approach for the development of seabed maps;
- Better use of existing survey effort: multidisciplinary and multi-agency integration of marine surveys should be encouraged; and
- Coordinated future survey strategy: Existing processes in UKMMAS, MSCC and MEDIN should be used to ensure there is no duplication in future data collection and commissioning.

It should be noted that these are recommendations to Government and at present have not yet been adopted.

#### **Improving predictive habitat modelling base layers**

In absence of habitat maps for large parts of the UK continental shelf areas based on survey data, efforts are underway to develop predictive habitat maps. Traditional approaches make use of data layers developed in the 1970's and 1980's, which were not developed with habitat mapping and marine spatial planning in mind. Efforts are therefore underway to improve the quality of key base layers such as seabed sediments and bathymetry. State-of-the-art modelling approaches are used to develop more accurate seabed sediment maps from raw sediment data, rather than the classified maps developed 4 decades ago. Similarly, significantly improves bathymetry data layers, derived from historical single beam surveys, and are incorporated in the analysis. The results so far suggest are encouraging compared to the predictive modelling approaches using the historical datasets, and outputs should be more useful for managers and planners.



#### 4.1.11 National programme report for France

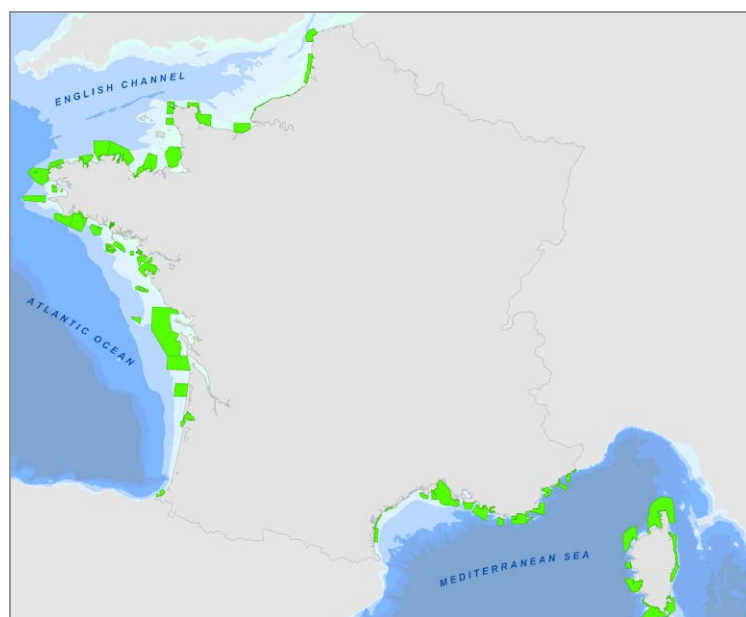
##### Implementation of Marine Natura 2000 in France

The establishment of Natura 2000 is related to the application of two Directives: The first concerns the Birds directive in 1979 with the designation of Special Protection Areas. The second is Habitats directive in 1992 which required designation of Special Areas of Conservation.

Habitats Directive represents a key challenge for EU biodiversity policy in the coming years. The objective is to maintain species and habitats in a good state of conservation. This directive has been transposed in French law in 2001. The main commitments of the French State towards the European Commission regarding the implementation of the habitats Directive concern:

- The designation of sites completed in 2008. Relevant areas were identified on a scientific basis,
- The elaboration of marine sites conservation management plans have been started. It must be finished in 2012,
- The development of specific sustainable objectives in the aim to maintain the conservation and/or the restoration of the natural and species habitats taking into account economic, social and cultural activities,
- The application of the specific Natura 2000 site commitments identified in the conservation management plan,
- The development of monitoring methods to evaluate the implemented actions in the aim of habitats and species conservation.
- Initially, the French Natura 2000 network covered only littoral and shallow water areas. European Commission has estimated that network was insufficient and claims its extension to integrate deeper zones. The final French Marine Natura 2000 Network is shown by the followed figure. 207 among

the 750 total sites are entirely or partly marine sites. They concern 40 000 km<sup>2</sup> that represent about 12% of French territory.



#### French Natura 2000 network.

In 2009, a national marine habitats inventory was launched by the Marine protected Areas Agency, commissioned by the French ministry of ecology. Sites were grouped into twenty lots. They were awarded to several providers by geographic location. The main objective is habitat mapping to provide habitats and species biological inventory of community interest. Additional studies were also asked. They are related to:

- Marines ZNIEFF (rare or protected species, species with economic value, indicator of environmental quality species, remarkable habitats),
- Habitats functionalities (nursery, spawning and transition habitats),

Recognized habitat classification systems at European (EUR27 EUNIS), national (Cahiers d'habitats) and regional level (Brittany and Mediterranean) as well as ERMS (European Register of Marine Species) taxa reference system had to be used.



In general, the mapping strategy applied consists firstly on existing data on the sites synthesis. Data collation concerns both the physical data such as bathymetry, currents, sedimentary and biological data for habitats and species. This work enables the sampling plan establishment. New survey acquisitions included acoustic imaging with the implementation of side scan and multibeam sonar. Effort is concentrated on areas that requires improved knowledge or with high natural heritage value. Field observations were also acquired. On the soft substrate areas grabs and dredges were used. On the rocky areas, diving, video and ROV tools have been implemented. The newly acquired data will be integrated into a GIS with existing data to produce updated map.

For now, the mapping work is underway and results are expected in 2012. Pending, some improvements of habitats and species knowledge's are to be noted.

In Brittany region, new maerl and *Zostera* beds were discovered. Subtidal *Sabellaria* reef were observed and Haploops beds were identified.



In the Mediterranean, two new species of crabs were discovered. The *Spicara maena* nests image illustrate the interest of the study presented in this inventory to highlight the functionality of certain habitats often, and wrongly, poorly regarded, such as sandbanks slightly covered by seawater (1110). Same as *Cymodocea nodosa* seagrass which was observed to several locations along the Var coast to over 37m depth. The presence of the seagrass at such a depth had been observed in Corsica. It is found normally in fine sand up to 10 m deep.

	
<p>Haploops sandy muds habitat (Plateau du Four, TBM/HOCER).</p>	<p>Spicara maena Spawning at -55 m (Cap Martin. Andromède-Océanologie-AAMP-2010).</p>

### Deep sea habitats in the Bay of Biscay (EU CoralFISH project, Ifremer, France)

The European CoralFISH project aims to study the interaction between Cold Water Corals (CWC), fish and fisheries through an ecosystem-based approach. One of the objectives is to provide a comprehensive characterization of CWC habitats based on geophysical and ground-truthing data.

### Compilation of existing data on Bay of Biscay margin

Over a hundred and thirty canyons in the Bay of Biscay, 85% of them are within French jurisdiction. An inventory of main available data coming from previous expeditions, as reported in maps and databases, has been made for the French waters and integrated into GIS.

The environmental data collected include a 200–3000m bathymetric synthesis from acoustic data with a grid spacing of 125m (Figure 1), sediment sampling from the Ifremer Database Banque de Géologie Marine (57 grab and 15 corers ) and near bottom-water characteristics collected from the Ifremer database SISMER (CTD and ADCP measurements, Water chemistry).

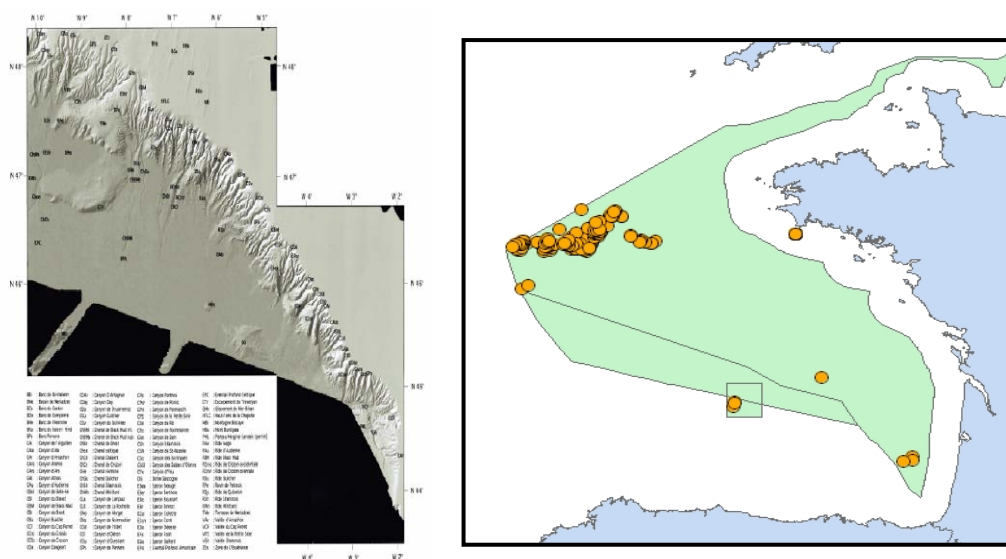
Bay of Biscay campaigns related to deep-sea benthos studies archived in Ifremer database SISMER have been identified and localized as well as data on benthos fauna stored in Ifremer database BIOCEAN (Figure 1). The first synthesis of localizations of scleractinian corals done by Reveillaud (2008) have been completed for *Lophelia pertusa* and transmitted to OSPAR (July 2008, Figure 2). Still photographs and video available from previous surveys, ranging from 150 to 2000m depth and using various underwater systems (ROV, Nautilie and Cyana), have been collected and previewed.



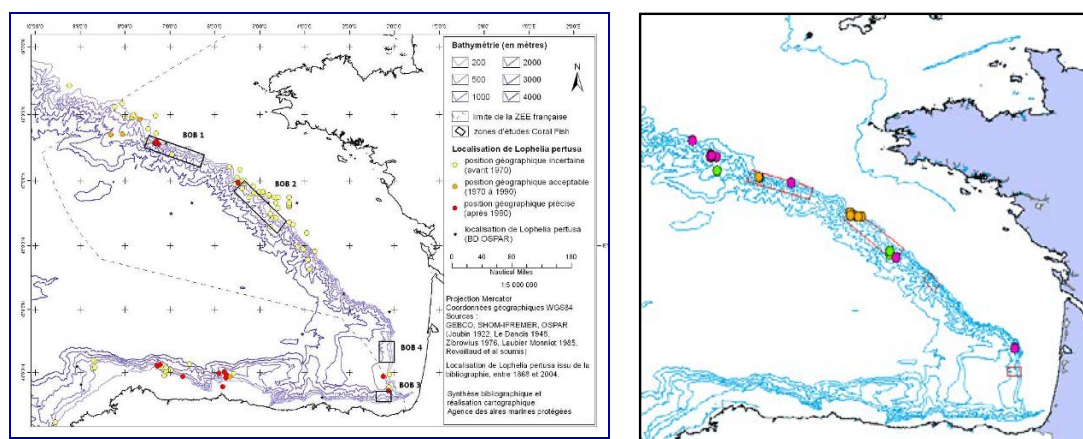
### CoralFISH surveys 2008–2009

Four cruises, focusing on cold water corals, have been done to record information on the seabed nature, morphology and associated fauna of the upper slope.

High resolution seabed acoustic data have been acquired at water depths ranging between 200 and 2200 m over thirty-four canyons during the BoBGeo1 cruise (October 2009), using 24 and 100 kHz Multibeam Echosounders on-board the RV *Pourquoi pas ?* as well as subsurface geological layers. Two boxes Bob1 (4000km<sup>2</sup>) and BOB2 (3000 km<sup>2</sup>) have been covered. The level of resolution of the resulting DTM (15 to 20m grid spacing) enables to see details such as scarp, slides, and cliffs. During EVHOE-2008 (October 2008), BobGeo1 and EVHOE-2009 (November 2009) cruises 24 dives with the towed camera SCAMPI have been done, allowing 4 thousand images. 4 dives with the ROV “Hollande”, equipped with a HDTV front camera and a vertical camera, have been done during the joint NUIG/Ifremer CE0908 survey on-board Celtic explorer (April-May 2009). Vulnerable habitats have been recognized including living *Lophelia pertusa*-*Madrepora oculata* reefs, deep cliffs with *Enallopsammia rostrata*, bamboo fields, deep seapens and burrowing megafauna communities, Cerianthid anemone fields, Crinoids and Brisingids aggregations and sponge grounds. Affects of trawling have been observed in many areas above 1000m depth. A draft for cold water coral habitat classification has been prepared.



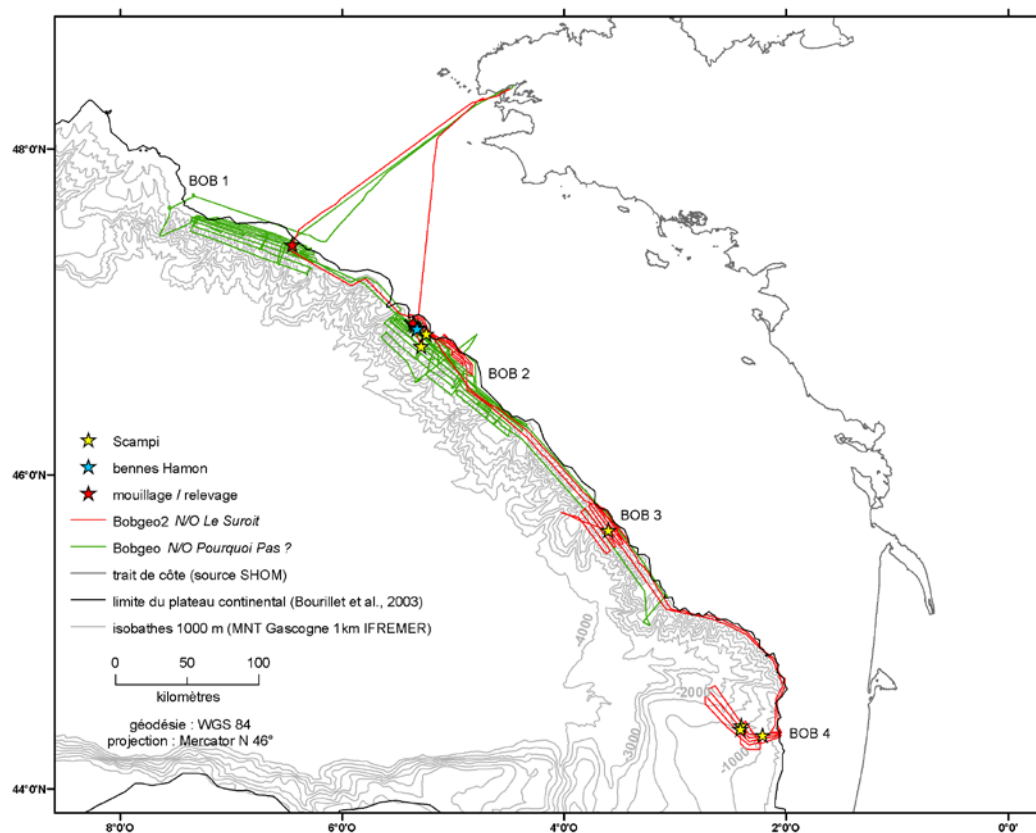
Bay of Biscay margin: bathymetric synthesis, grid spacing of 125m (left, from Le Suavé R. *et al.*, 1999), data on benthos fauna stored in Ifremer BIOCEAN database (right).



Bay of Biscay: *Lophelia pertusa* locations (left, data transmitted to OSPAR, July 2008), location of still photographs and video transects from previous surveys (right).

#### Results from 2010–2011 surveys

The Ifremer BobGeo2 (figure 3) campaign (Bay of Biscay GEOlogy) on RV “Le Suroît”, 18–25 of July 2010 (Bourillet *et al.*, 2010) complements the previous campaign BobGeo1, on areas BOB1 and 2 held in October 2009. It aimed at mapping two other areas (BOB 3 and BOB4) characterized by a succession of canyons and interfluvies within the Bay of Biscay.

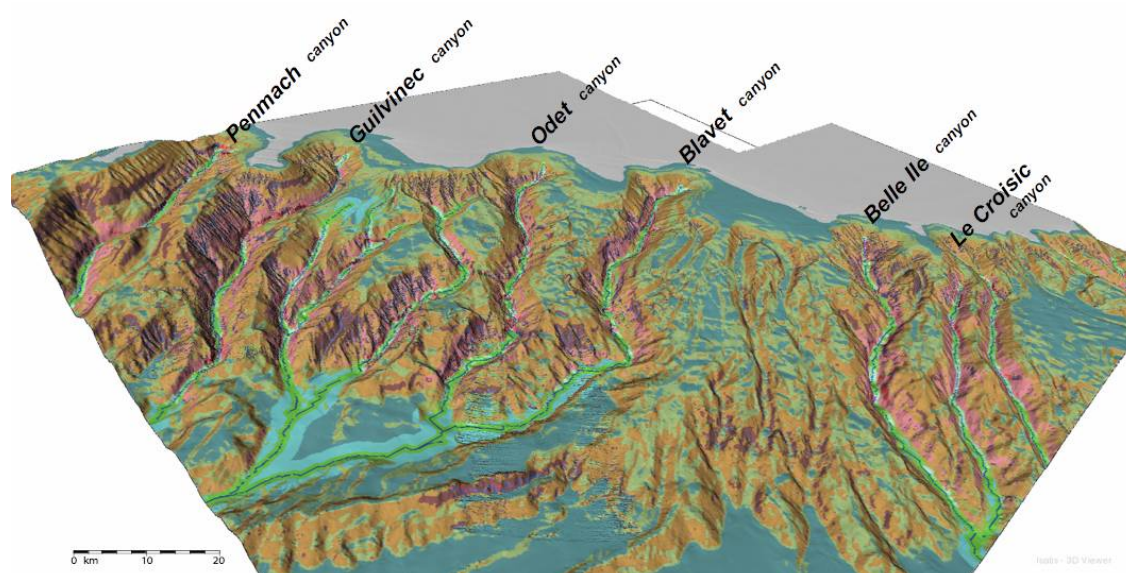


Bay of Biscay BobGeo2 campaign: Red line: Location of the 2 new surveyed areas Bob3 and bob4; Yellow star: towed camera; Blue star: grab, Red star: mooring. The Green line corresponds to the BobGeo campaign.

The work plans included high resolution seabed mapping of these two sectors with 30 and 100 kHz Multibeam Echosounders (bathymetry and backscatter). The areas Bob3 and Bob4 were chosen to characterize the South part of the Bay of Biscay where historical records of CWC are less numerous. Both EM302 and EM1000 multibeam echosounders on-board the RV “Le Suroit” were used. These systems provided numerical terrain model with 15 to 25 m grid spacings at water depths ranging between 200 and 2200 m.

Narrow and steep canyons characterize the area Bob3. Canyons present an incised morphology but more gentle than those in areas Bob1 and Bob2. Flanks are constant, with sediment and gullies. Thalwegs are continuous with gentle banks. A major difference with the Bob1 and Bob2 areas is the absence of flat and escarpment, or steep banks and falls, favourable to coral settlement. Arcachon canyon in the Bob4 area presents a quite different morphology with a broader canyon floor, very gentle flanks, and neither gully nor escarpment. It looks like a channel-levee system.

A classification methodology based on combination of several morphological attributes is applied to the DTM (Bourillet *et al.*, 2011). Attributes derived from DTM and used to initiate the automated classification are local slopes at different scales, residual bathymetry, drainage network and distances to the thalwegs. It allows delineating the megageoforms and next delineating smaller scale geoforms thanks to a specific morphological analysis. Meso-geoforms such as canyon beds and banks, falls, escarpments, flanks, crests, and other as mounds present in the interfluvial areas will be defined together with the method(s) for automatic identification from the DTM attributes. The corresponding codes of the Coastal and Marine Ecological Classification Standard are also considered.



Ten new dives using the towed camera SCAMPI have been acquired during BOB-GEO2 and Ifremer EVHOE 2010 cruises all along the margin. A small area of living *Lophelia-Madrepora* reef have been observed in small canyons on BOB2, coral rubble have been observed and sampled in the southeast of Guilvinec Canyon head and debris have been detected on the upper part of the BOB3 dive. Soft coral and Hexactinellids grounds have been observed in BOB4. 3 ROV dives have been acquired during the “Belgica” 10/17a cruise conducted by RCMG/Univ. Ghent on Guilvinec

Canyon, 7–16 June 2010, confirming the presence of CWC reefs and large reef affected areas.

A methodology to promote standardization of annotation has been proposed by Ifremer and improved by CoralFISH partners (Guillaumont *et al.*, 2011a). It is based on common knowledge tables with a hierarchical structure where necessary. These tables have been defined taking existing references such as Worms Register, EUNIS and CMECS into consideration. New CWC habitat types have been defined. The first results from image analysis (Guillaumont *et al.*, 2011 b and c) have allowed the identification of various habitats dominated by coral or sponges. *Lophelia pertusa* and *Madrepora oculata* compound mixed reefs occurring until 1100m depth in association with a large variety of antipatharian, some gorgonians and hexactinellids sponges. Coral rubble and areas of trawl affects have also been recognized. The stony coral *Enallopsammia rostrata* occurs as a dominant species on vertical cliffs around 1500m. Some localized areas of hard bottom substrate are colonized by demosponge beds or by coral gardens.

On the soft sediment, the two main pennatulid habitats are dominated by *Kophobol-emmon* and by *Funiculina quadrangularis* (in association with burrowing megafauna). Bamboo fields are also well represented on soft bottom with *Acanella arbuscula* or others Isididae, sometimes associated with stalked sponges. The sponge grounds with *Pheronema carpenteri* are present in various localities.

#### 4.1.12 References

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- Bourillet, J-F., de Chambure, L., Guillaumont B. 2011 Geomorphological classification of cold water coral seabed (Bay of Biscay – NE Atlantic), Geohab, 3–6 May 2011, Helsinki, Finland.
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## 4.2 ICES web GIS and WGMHM habitat maps

**Hans Mose Jensen (ICES Data Centre) and Jacques Populus (Ifremer)**

### 4.2.1 ICES GIS developments

In the last decade the need to support marine spatial planning and integrated area based science has been steadily growing. This development is also promoted by the implementation of the INSPIRE Directive (2007/2/EC), establishing the spatial infrastructure in Europe and the Marine Strategy Framework Directive (2008/56/EC) that necessitates an integrated, area based ecosystem approach. In ICES a joint ACOM/SCICOM strategic initiative on area-based science and management was established last year. An outcome of this initiative was the workshop on the science for area based management: coastal and marine spatial planning in practice (WKCMSPP) that was held last year. Another outcome was the establishment of a strategic initia-

tive group (STIG-MSP) that will identify approaches to facilitate and encourage integrated analysis and exchange of spatial data within and between expert groups.

In order to support the developments towards marine spatial planning and integrated area-based science, the ICES Data Centre (ICES DATA CENTRE) in cooperation with STZ Geoinformatik in Rostock, has developed a web GIS system that can capture spatial layers including metadata and make them discoverable and accessible for all users. The web GIS developments within the ICES Data Centre are now capable of showing the WGMHM habitat map outlines and metadata. The ICES web GIS is a generic application designed to serve all of the ICES community, but it has added functionality for showing habitat map metadata related to a habitat map outline polygon. The ICES web GIS system was shown as a prototype system at the WGMHM 2011 meeting and will be officially launched in June 2011.

The integrated viewer has some added functionality for habitat maps making it possible to select a polygon in one of the three layers generated for habitat maps (Modelled habitat maps, Surveyed habitats maps and Substrate maps) and display the related metadata (See figure 1). It has been important to use best practices and widely accepted standards in the system. The metadata are stored in the ISO19115/19139 format, but the required information has been kept to a minimum due to the wide scope of layers and uses expected in the system.

The main infrastructure components of the ICES web GIS application are:

**GeoServer** (see <http://map.ices.dk/geoserver>)

Open source software that allows users to share and edit geospatial data (rendering). Excellent software for format transformations.

**GeoNetwork** (see <http://geo.ices.dk/geonetwork>)

Open source software for capture of metadata and for making them discoverable (search and display).

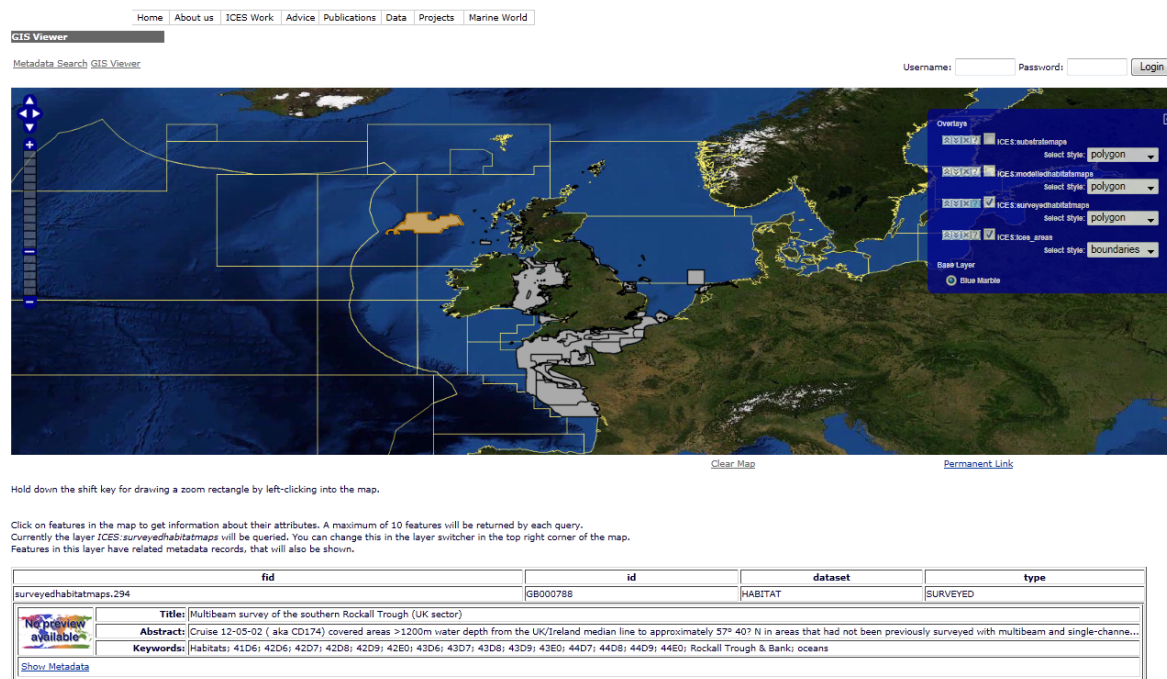
**MS SQL Server**

Database used for storage of geospatial data (used by GeoServer) and metadata (GeoNetwork database). Other databases can be used by GeoServer and GeoNetwork, but MS SQL server was chosen for good integration with other data systems in the ICES DATA CENTRE.

**ICES web GIS application**

The developed system builds on GeoServer (web map services) and GeoNetwork (metadata handling) that are both open source tools. The system integrates their functionalities and creates the important linkage between the spatial datasets and their metadata.





**ICES GIS viewer showing habitat maps and metadata.**

The spatial layers and metadata are to be generated primarily by the ICES community, but it can also be generated by other users. The spatial datasets can be grouped into 3 categories:

- Spatial reference layers. This includes both maps that are maintained by ICES (e.g. ICES statistical areas and ICES ecoregions), but it can also be maps that are maintained outside ICES (e.g. OSPAR regions).
- Spatial layers and metadata generated by expert groups in the ICES community. An example of this is the collation of marine habitat map outlines generated by the ICES Working Group on Marine Habitat Mapping. The expert groups in ICES produce various kinds of spatial products that are included in reports etc. In many cases the usability and value of these layers can be increased by making them discoverable and accessible in a spatial data infrastructure.
- Spatial layers generated as topic/indicator views from existing data collections held in ICES.

The system is a web application with open access for all users, but in order to upload data and metadata the user will have to be registered. The collection of spatial layers can be searched based on geographic extent, keywords, category, title, etc. The GIS viewer allows layers to be viewed one at a time or in combination with the possibility to explore the attribute information of the spatial objects in the layers. All layers can be accessed as web map services or downloaded for use in various GIS applications and map viewers.

The new web GIS system increases the use and usability of spatial layers being generated by ICES expert groups and it promotes increased exchange of spatial data between ICES expert groups and the marine community in general.

#### 4.2.2 Metadata capture and import

The WGMHM national representatives can insert metadata of their own in GeoNetwork using the instruction created for the use of WGMHM. The WGMHM metadata template is a subset of ISO19115/19139 having mandatory fields and some optional. In the GeoNetwork environment it is possible to select any field of the full ISO19139 xml in the metadata description. Important for the linkage between metadata and outline polygons is the 'alternate title' being the key linkage field to the attribute ID of the spatial polygons. The ID should be unique and have the form of a 2 letter country code (ISO 3166-1) plus 6 digits (e.g. GB000001). Each metadata description should be categorized in one of the three categories created in GeoNetwork for WGMHM habitat maps 'modelled habitat metadata', 'surveyed habitat metadata' and 'substrate metadata'. This will facilitate searching for specific habitat maps.

Metadata has been imported from the MESH project distributed as:

- 207 Surveyed habitat map metadata records
- 8 Modelled habitat map metadata records
- 42 Substrate habitat map metadata records

Corresponding map layers for each of the categories has been loaded into the GeoServer and can be utilized as a web map service (<https://map.ices.dk/geoserver/wms>). The attribute ID of the polygons matches the imported metadata records. In the ICES web GIS system the metadata description for a polygon is displayed when selecting a polygon from these map layers.

#### 4.2.3 Metadata capture use feedback

A few test users from WGMHM have been testing the metadata capture environment following the instructions. Users were able to insert metadata and there were some comments for improvements. Some of the fields could be better explained in the instruction and the metadata template created for WGMHM should perhaps consider INSPIRE mandatory fields. INSPIRE is using a subset of ISO19139, but the fields considered mandatory differs from the ISO standard and in some cases the definition differs.

#### 4.2.4 Summary and conclusions

- MESH habitat study areas metadata and polygons have been imported into the ICES GeoNetwork and GeoServer installations.
- The ICES GeoNetwork installation is ready as a capture environment for insertion of additional habitat maps metadata. This should be done by the national contact points making sure that unique ID's are used. Corresponding update of the map layers (modelled, surveyed and substrate habitat maps) should also be done with input from the national contact points.
- The new ICES web GIS application integrating GeoServer and GeoNetwork functionality will be implemented during June. The application has added functionality for viewing habitat maps.

ICES EGs are invited to use the ICES web GIS to share their map products and use the spatial resources when the system has been implemented in June.



## 5 Modelling – ToR c)

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### 5.1 Habitat modelling lecture

Sandrine Vaz - Ifremer

#### 5.1.1 Introduction

The analysis of relationships between a species and its habitat – defined here as the set of environmental factors required for presence, survival, growth and reproduction of a given species - has always been a central issue in ecology. The study of these relationships represents the core of predictive geographical modelling in ecology.

#### 5.1.2 Habitat modelling methods

A large number of statistical modelling techniques are available to predict species distribution from environmental conditions. The majority of species distribution modelling approaches in current use are based on estimation of mean or median (central tendency) species response (abundance or presence probability) to environmental factors<sup>5</sup>. This is the case for Generalized Linear or Additive Modelling (GLM, GAM), which describes and predicts the «preferential habitat», i.e. the portion of the potential habitat that is used on average over time, or, in the case of presence/absence species data, the «probable habitat», i.e. where the species may be present. Such techniques describing the mean or median are very useful but do not properly estimate the limiting effects of the environment on species distribution<sup>6</sup>. Indeed, the real response of a species to a given limiting factor can only be quantified if all other factors occur at non-limiting levels. This is known as Liebig's law of limiting factors which predicts that the growth-rate of a species is determined by the most limiting resource<sup>7</sup>. This situation (all other factors occur at non-limiting levels) being unlikely to occur in the natural world, the meaningful determination of the limiting effect of environmental variables on species response requires the use of non-standard statistical methods. In quantile regression (or Regression Quantiles, RQ), any relative limit of the observed data distribution ( the  $q$  quantile describing the value above or equal to  $q\%$  of the observed data or, in other words, the upper bound of  $q\%$  of the observed data) may be modelled rather than the mean<sup>8</sup>. Therefore, RQ is a suitable technique to estimate the effects of limiting factors on species abundance response and the study of the upper-bounds of species abundance response to environmental factor enable to describe its "potential habitat" rather than is "preferential habitat". Thus, predictions from upper RQ models overestimate species abundance to illustrate the spatial distribution of the species maximum abundance in ideal environmental conditions<sup>9</sup>. As such, RQ tend to describe potential spatial patterns or the "potential habitat" of species, i.e. all possible areas with conditions suitable for the presence or high abundance of a species. Both statistical model types (GLM and RQ) are very efficient tools to describe the habitat of a considered species, but while GLM describes the average probable or preferential habitat, RQ can in theory describe the maximum or potential habitat. Maps showing potential habitats are less likely to underestimate

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<sup>5</sup> Oksanen & Minchin, 2002

<sup>6</sup> Cade et al., 1999

<sup>7</sup> Hiddink & Kaiser, 2005

<sup>8</sup> Koenker & Bassett, 1978; Cade & Noon, 2003; Yu et al., 2003; Koenker, 2005

<sup>9</sup> Vaz et al., 2008

species responses' to the environment, and hence the value of the habitat, and therefore have potential benefits for precautionary management of living resources. In the context of habitat conservation and sustainable fisheries management, an approach based on the use of these techniques for describing and comparing potential (maximum) species abundance (RQ models) to average species abundance (GLM models) and observed distribution (geostatistical interpolation), the latter that may be updated annually, can be very useful. Besides their usefulness for ecological research, predictive geographical modelling may also be useful to assess the affect of accelerated human utilization of resources and other environmental change on the distribution of species, to improve faunistic atlases<sup>10</sup> or to set up conservation priorities.

### 5.1.3 Assessment of habitat models

Model performances may be assessed using datasets internal or independent to their development, by simply comparing observed and predicted values of species abundance. The bootstrap procedure may be used to generate estimates of standard errors and confidence intervals for a wide variety of statistics without resting on any parametric assumption; this approach may be used to produce a more robust validation of the habitat models. Spearman's Rank Correlation Coefficient ( $r_s$ ), a non-parametric correlation measuring correspondence between two variable rankings, may be used to compare observed and predicted values and is often preferred to that of Pearson as it does not assume a linear relationship between the variables. For GLM and GAM habitat models, a paired Wilcoxon signed-rank test, a statistical test that compares means of paired data (here observed vs. predicted) without assumptions about the form of the distribution of the measurements, may also be applied. When the p-value was  $>0.05$ , the null hypothesis is accepted and the means are judged to be similar thus validating the model prediction. In the case of RQ models, a correct classification test, defined by the proportion of observed values in the validation dataset that fall below those predicted<sup>11</sup> was used. So, for example, if a predictive species distribution model was developed from the 90th quantile of the abundance distribution, correct classification would require at least 90% of all observed abundance values for this species to fall below and at most 10% above those predicted.

However, all these tests being very permissive, the relative prediction or model error (defined as the absolute difference between observed and predicted species abundance and/or probability of presence relative to the maximum observed value) may also be computed to spatially illustrate the model adjustment. For RQ, however, the error was set to zero if the observed value was lower than the predicted value (which is the expected behaviour of that type of model). The spatial distribution of the model error ratios was mapped for each model, the value of 1 corresponding to the maximum possible prediction error. The model prediction error can thus be interpreted as a percentile of model uncertainty.

### 5.1.4 Discussion and issues on modelling

The following modelling issues were raised during the discussion:

- Response variable, sampling strategy;
- Environmental descriptor variables: selection and scale;
- Model selection;

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<sup>10</sup> e.g. Carpentier et al., 2009

<sup>11</sup> Eastwood et al., 2003, Vaz et al., 2008

- Model validation.

### **Sampling the response variable**

There should be considerable *a priori* consideration of the scale, quality and management value of response variables employed in species distribution modelling. The sampling strategy of the response variable should be geared to encompass a complete range of environmental descriptors. Sampling limitations should be addressed in terms of size and variability of the dataset and problems of autocorrelation carefully considered, especially when samples are opportunity or historical ones (e.g. using Optimal allocation analysis (e.g. Strong J. and Service M., 2011. Using Optimum Allocation Analysis to Improve Seed Mussel Stock Assessment. Journal of Shellfish Research 30(1):1–6). Where biological attributes that better inform the spatial marine planning process can be collected and modelled at little extra effort (e.g. percentage covers) this should be a ground-truthing consideration. The issue of sample independence was raised by Goren and Fernando and certain routines (executable through R scripts) were mentioned. This has particular relevance when data are obtained along survey transects (video or ROV) where a minimum distance between samples needs to be defined to ensure sample independence.

The sampling scheme should be adapted to the scale of the study. Small-scale sampling in areas of high spatial heterogeneity may not integrate sufficiently the information for larger scale modelling. On the contrary, spatially integrative sampling (such as haul) may not be suited for fine scale modelling as they may overlap on many habitats. The sampling gear should be appropriate to detect low abundance area. Absence data are needed to address suitability modelling (realized vs. non-realized habitats).

### **Choice of descriptors**

Environmental descriptors are mostly selected according to professional advice and published literature. They often reflect underlying hypotheses about the driving forces of the spatial distribution of the species of interest (i.e. the response variable). They may be direct descriptors of these drivers or well defined proxies. The number of variables may be restrained by the results of multivariate statistical analysis.

The spatial scale of environmental descriptors is usually imposed by data availability, e.g. light or exposure data are usually available at low resolution. The scale on which environmental factors drive the presence of habitats should be better assessed. For example temperature would not normally be a relevant factor in a bay but rather at regional level, unlike exposure which strongly varies at a local scale according to topography.

### **Model selection**

Model selection is based on the relative advantages and drawbacks of each model (e.g. robustness, parsimony). GLM and GAM are usually reported to yield very close results, therefore the choice is not easy. The latter has a stronger smoothing effect which may be desirable in some cases but difficult in some cases to explain ecologically. Because of the large number of zeros in the response data, these models are run in two steps, firstly for presence-absence, secondly for abundance. Quantile regressions do it all in one step but the choice of the right quantile is a long process. This technique however has the advantage to produce a selection of the limiting factors of the response distribution and predict the optimum habitat of the response. This may

be useful if the species has not been sampled adequately or if it is suspected not to occupy its whole preferential habitat (in case of exploitation).

### **Model assessment**

Several methods may be used to compare observed and predicted values: cross-validation, AIC or LogL may be used during model calibration. Tests such as Spearman or Wilcoxon's; or measure of the adjusted  $r^2$  may also be used *a posteriori*. Independent datasets should be sought for validation. Their range has to be stable (identical or within that of calibration samples) to avoid extrapolating the model prediction outside the calibration range. Another issue lies with the true independence between calibration and evaluation dataset. It is almost impossible to obtain truly independent observations (both spatially and temporally) unless sampling is repeated several times and samples used for model calibration and evaluation are distant enough in time. Autocorrelation of observation will tend to yield overfitted model with poor predictive power and not very general outputs.

Modelling errors are usually high in areas with poor sampling replication and in those with relatively high abundance, as models based on central tendency are generally unable to reproduce extreme abundance values. It is generally recommended that model outputs include a spatial expression of errors along with a general score. This will provide an indication to spatial planners about the confidence of model predictions in a spatially explicit context.

### **5.1.5 Conclusion**

In conclusion, models are generally good at predicting when a response variable is not present, yet not so good at predicting relative abundance. The environment may drive the occurrence of a given species but other processes (linked to trophic interaction or population dynamics) may be driving the abundance level.

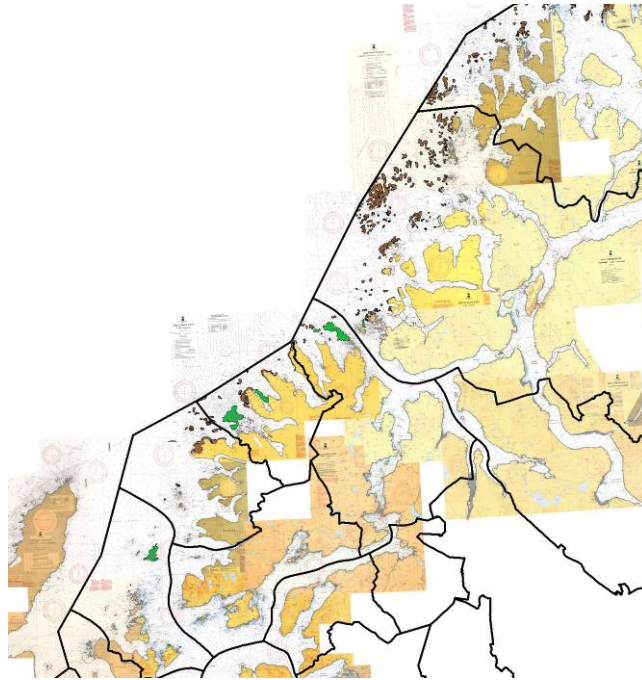
## **5.2 The National program for mapping and monitoring of marine habitats in Norway – A mapping program using spatial predictive modelling as a tool**

**Trine Bekkby (1), Eli Rinde (1), Heidi Olsen (2), Reidulv Bøe (2), Henning Steen (3), Nina M. Jørgensen (4), Frithjof Moy (3). (1) Norwegian Institute for Water Research, (2) Geological Survey of Norway, (3) Institute for Marine Research, (4) Akvaplan-niva.**

The UN Rio convention (1992) commits all countries to know and protect the biodiversity. To develop plans and make decisions, we need information (maps) on where different habitats are found. In 2003, the Norwegian program for mapping and monitoring the biodiversity started, the field mapping started in 2007. The selected habitats and key areas were large kelp forests, ice marginal deposits, soft sediments in the coastal zone, loose calcareous algae, eelgrass meadows and other seagrass meadows, carbonate sand, oyster areas, large scallop occurrences and spawning areas for fish.

Norway has a 83 000 km long (and complex) coast line, and mapping all areas is too big a task. The different habitats require different methodology for mapping. As the Norwegian coast is so long and complex, modelling is a helpful tool, that has been applied with success for *Laminaria hyperborea* kelp forests and carbonate sand. Here, the work carried out on kelp forest in Troms (northern Norway) is presented. This is an area with a high level of sea urchin grazing of the kelp forest in moderately exposed and sheltered areas. GIS layers on depth, slope, wave exposure, basin and cur-

vature is available for the whole country at a 25x25 m spatial resolution. For the Troms area, a current speed model was available at a 500x500 m resolution.



Kelp forests are mapped using underwater camera, UWC (collecting point data), modelling, field validation and model improvement. We used GAM, AIC model selection (in GRASP) and spatial prediction to develop probability maps that again was developed into maps of kelp forest (see figure in text). The relationships between modelled probability and field recorded densities (classified into one of four classes, see box plot) was used to set the limit for kelp forest occurrence. Some areas were digitized manually. The habitat occurrences (polygons) are given a value A, B or C according to criteria.

This work exemplifies that modelling kelp forest distribution in a sea urchin grazed area is difficult, and NIVA has several research projects to learn more about the kelp-sea urchin dynamic. More detailed models on current speed are needed.

### 5.3 Predictive modelling of Laminarian kelp forests within the temperate waters of Brittany

Daniel Gorman – Ifremer

#### 5.3.1 Introduction

Understanding species distributions is key to marine spatial planning, but obtaining such information at the scale of regional or national management programs (i.e. 10's - 1000's kilometres) can be challenging. This has led to the increasing popularity of predictive habitat models as a cost-effective means of deriving such broad-scale distributions. Predictive models offer the potential of efficient large-scale mapping within coastal environments where field-collected data are limiting. Predictive habitat models typically integrate ground-truthing data (direct surveys of biological attributes), high resolution environmental data (known *a priori* to be important to species occurrence) and statistical routines (e.g. generalized additive models) to produce maps of probabilistic distribution.

Kelp forests represent some of the most diverse and productive natural systems but our understanding of their distribution remain surprisingly fragmentary. The aim of this study was to test the applicability of models that predict kelp forest attributes over spatial scales relevant to management.

### 5.3.2 Data and methodology

The rationale for selecting biological field-data sites was to employ a stratified sampling design (Gorman, *et al.*, 2011). Data quantifying the occurrence and relative covers of kelp forest were extracted from underwater video footage obtained during two vessel-based field survey missions (April and June, 2010). Diver-based field sampling was done to collect species biomass data, validate video observations (i.e. covers) and collect samples from areas that were too shallow to sample with a vessel.

Predictive species models are limited by the precision and physiological relevance of the variables from which they are developed. We used high resolution data describing abiotic variables that have direct physiological roles in limiting the distribution and structure of kelp forests. The final horizontal resolution of predictor raster layers was 5m.

We used Generalized Additive Models (GAM's) to model three biologically relevant attributes of kelp forests within the temperate waters of Brittany. These were probability of occurrence, forest covers and biomass. Predictor datasets were initially investigated for normality and heterogeneity and transformed where necessary. All models were run initially using the R package 'gam' (Hastie and Tibshirani, 1990) which employs Akaike's information Criterion (AIC; Burnham and Anderson, 2004) to select the best model term (termed 'stepwise selected model'). Fitted models were used to create maps by automating the model work flow with the 'ModelBuilder' interface using the Marine Geospatial Ecology Tools; 'Predict Rasters' tool in ArcGIS. The performance of the binomial probability model was tested by plotting a Receiver Operating Characteristic (ROC) curve using the R function in the 'rocr' Package (Sing *et al.*, 2005). We assessed confidence in modelled results through analysis of performance statistics including standard error outputs, ROC plots, residuals and Q-Q plots.

**Table 1.** Summary of environmental predictor variables; codes used in this report (model terms); horizontal resolution of data layer; and source, year of coverage and derivation.

Predictor	Code	Resolution	Data source, year, derivation
<i>Benthic terrain</i>			
Bathymetry (m below MHWS)	BATHY	Grid raster, 5	IFREMER, 2010, LIDAR and acoustics used to produce a Digital Terrain Model (DTM)
<i>Light</i>			
Photosynthetically active radiation	KPAR	Grid raster, 250	EU Sea Map, 2005-2009, derived from MERIS reflectance data (see Saulquin et al. in review)
Hill shade	HSH	Grid raster, 5	IFREMER, 2010, geoprocessing of DTM raster layer using the ArcGIS Spatial Analyst tool
<i>Exposure</i>			
Average wave height	HS	Grid raster, 370	PREVIMER (ARMOR 370m), 2009-2011, points interpolated into ArcGIS raster layer
Wave deviation	WDEV	Grid raster, 5	PREVIMER (ARMOR 370m) - 2009-2011; IFREMER, 2010, geoprocessing of DTM to produce an aspect layer from which the deviation from average annual wave direction was calculated using the ArcGIS Spatial Analyst tool
<i>Seabed characteristics</i>			
Slope	SLOPE	Grid raster, 5	IFREMER, 2010, geoprocessing of DTM raster layer using the Benthic Terrain Modeller extension to ArcGIS Spatial Analyst tool
Benthic Position Index	BPI	Grid raster, 5	IFREMER, 2010, geoprocessing of DTM raster layer using the Benthic Terrain Modeller extension to ArcGIS Spatial Analyst tool
Rugosity	RUG	Grid raster, 5	IFREMER, 2010, geoprocessing of DTM raster layer using the Benthic Terrain Modeller extension to ArcGIS Spatial Analyst tool
Rock substrate	ROCK	Polygon shapefile, 5	IFREMER, 2010, LIDAR, side scan sonar interpretation
Sediment proximity	SED	Grid raster, 5	IFREMER, 2010, geoprocessing of rocky substrate layer using the ArcGIS Spatial Analyst tool

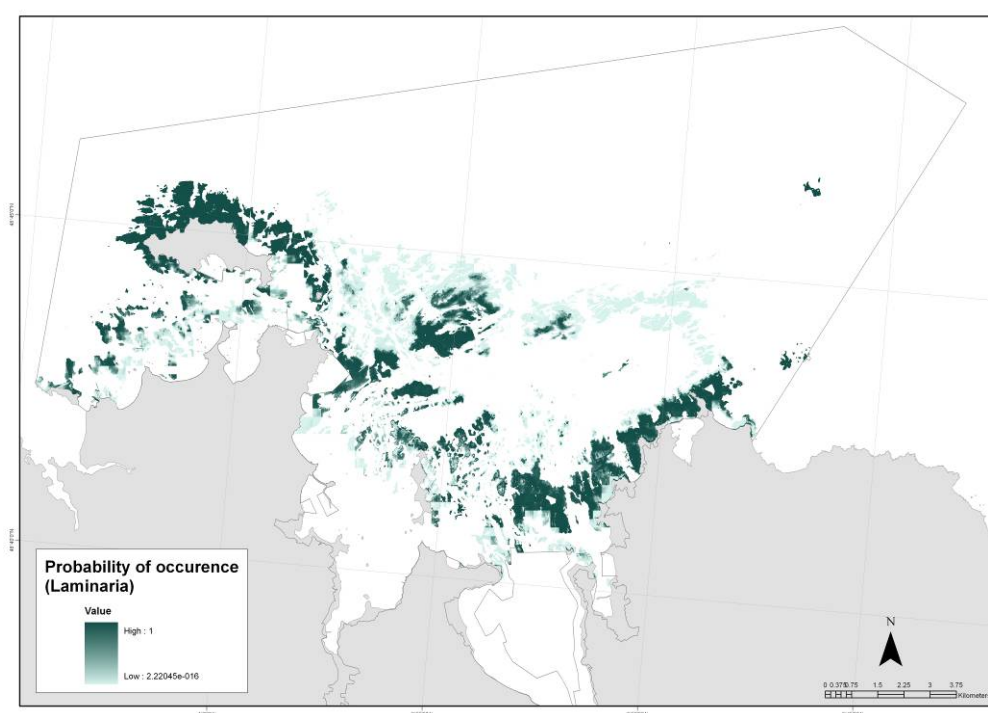
Notes: IFREMER: Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploitation of the Sea). LIDAR: Light Detection and Ranging. PREVIMER: a project managed by Ifremer and supported by funds from the European Union, with SHOM and Météo-France as principle partners. EUSaMap: mapping European seabed habitats (<http://www.jncc.gov.uk/page-5020>).

### 5.3.3 Results

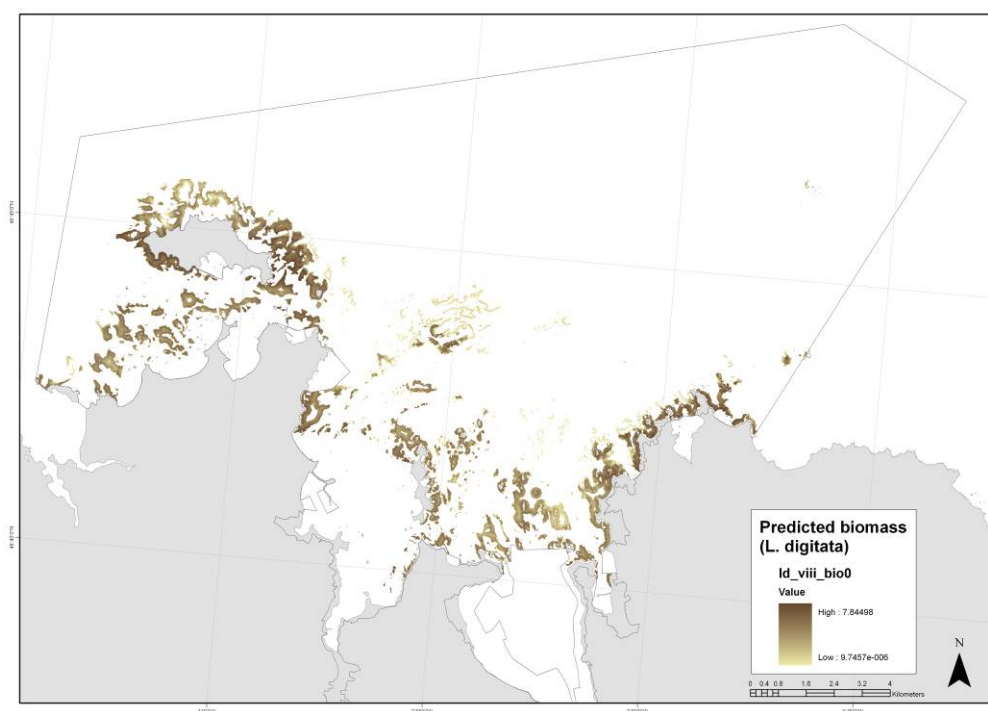
The probability of kelp forest occurrence was modelled using 2619 observations. We fitted a binomial Generalized Additive Model that predicts the occurrence of kelp forest as an additive multiple regression of bathymetry, ln(slope), wave height, photosynthetically active radiation, seabed deviation from swell orientation hillshade, rugosity and benthic position index fitted with a smoothed spline logarithm. The equation was inferred as the best 'stepwise selected' model using Akaike's Information Criterion (AIC) and explained 71.4% of the variance in presence and absence observations. The probability of kelp forest occurrence was negatively related to bathymetry at depths greater than 30 meters

The biomass of kelp forests were modelled using 80 ground-truthing sites. We fitted a binomial Generalized Additive Model that predicts the biomass of *Laminaria digitata* as an additive multiple regression of bathymetry, ln(slope), wave height, seabed deviation from swell orientation and benthic position index. The equation was selected as the best model using Akaike's information Criterion (AIC) and explained 60.8% of the deviance in pooled biomass observations of *Laminaria digitata*. We fitted a binomial Generalized Additive Model that predicts the biomass of *Laminaria hyperborea* as an additive multiple regression of bathymetry, ln(slope), wave height and hillshade. The best model explained 80.9% of the variance in biomass observations.

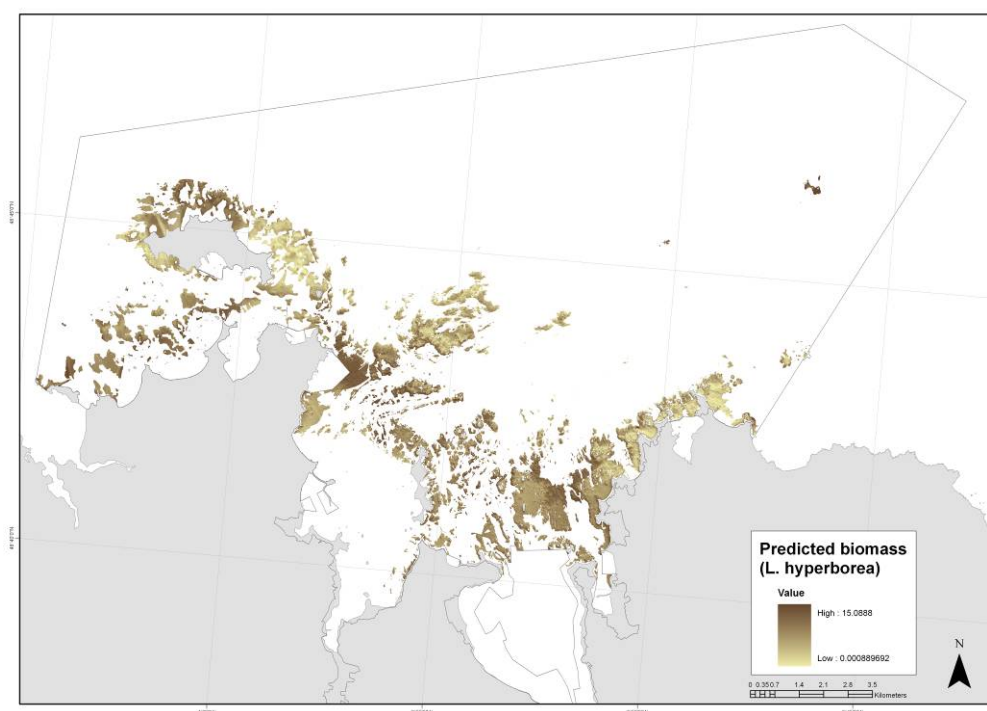




Predicted occurrence of Laminarian algae (species pooled) across the Baie de Morlaix study location (defined by Natura 2000 zoning) plotted as a relative probability between 0 – 1. Modelling was done using a binomial Generalized Additive Model (GAM).



Predicted biomass of *Laminaria digitata* across the Baie de Morlaix study location (defined by Natura 2000 zoning) plotted as estimates of wet weight ( $\text{kg} \cdot \text{m}^{-2}$ ) derived through Gaussian GAM.



Predicted biomass of *Laminaria hyperborea* across the Baie de Morlaix study location (defined by Natura 2000 zoning) plotted as estimates of wet weight ( $\text{kg m}^{-2}$ ) derived through Gaussian GAM.

### 5.3.4 Discussion

We produced accurate, spatially explicit maps of the distribution, relative cover and biomass of forests that match the results of field-based studies. The key environmental variables for predicting these attributes were bathymetry, light and wave exposure. Nevertheless, our results also highlight the need to consider other less obvious variables such as sediments and swell direction. Model responses revealed normality in residuals and near linear responses between sample and theoretical quantiles (Q-Q plots) giving confidence in the approach. Not only did our outputs match the results of ground-truthing data and independent surveys, but they also identified forests (validated through field observations) in areas previously not described. We thus contend that predictive habitat modelling is a useful tool for coastal managers as well as an effective approach for investigating the major drivers of marine benthos distributions.

Predictive habitat models have been criticized because of historically poor resolution and because they do not adequately describe the temporal variability inherent in natural systems. Our use of very high resolution spatial data (i.e. raster grid cell size of 5m), averaged over a number of years, should allay some of these concerns. Nevertheless, in practice the value of modelling programs will depend on how well researchers and managers understand the limitations of the models and the geographic and species based modelling inferences.

On an increasingly human-dominated planet, the effects of anthropogenic change on species distributions are becoming increasingly important. To aid the global management of kelp resources research should be aimed at understanding how human stressors (e.g. harvesting, pollution, etc.) and environmental change (e.g. global climate change; Gorman *et al.* in review) may affect the abiotic variables that define kelp forest distribution and structure.

### 5.3.5 References

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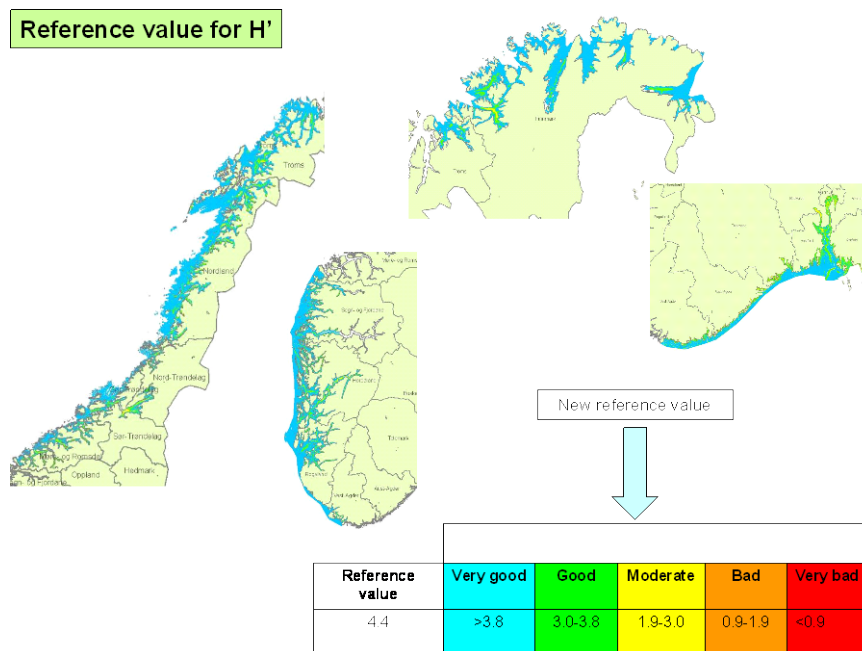
## 5.4 Nature index of Norway – Modelling soft sediment indicators (of natural state) of coastal water

**Trine Bekkbu, Hege Gundersen, Karl Norling, Eivind Oug, Mats Walday, Norwegian Institute for Water Research**

As a part of the Nature index project, NIVA has developed area representative maps of reference values for various biodiversity and sensitivity indices for the Norwegian coast. The two big questions are:

- 1 ) does an area diverge from natural conditions or not?
- 2 ) do we have to take action or not to gain good environmental status according to the EU WD?

Macrofauna composition and diversity in soft sediments are commonly used as “health indicators” and is one of the main quality elements in the EU Water Directive. Norway only has one reference condition value for the whole country, and this is not considered sufficient for management. Consequently, NIVA has developed method for production of area representative maps of reference values for various indices. This is considered as a great improvement over earlier deliveries in which the same reference value was used in all regions, counties and municipalities in Norway, and we suggest that the results from this project may be included in the next delivery to the nature of the index. Through the Norwegian Coastal Monitoring Programme (1990–2010) and other projects, NIVA have available data with high spatial and temporal coverage from a period of more than 30 years. Five different indices are estimated based on these data: Shannon–Wiener diversity index ( $H'$ ), species richness (ES100), Indicator Species Index (ISI) and the Norwegian Quality Index 1 and 2 (NQI1 and NQI2). The data are specified to ecoregion (Skagerrak, North Sea, Norwegian Sea, and Barents Sea) and important geophysical predictor variables: depth, slope, wave exposure, terrain-, and basin structures) in GIS.



We considered the models as being relatively good, but could with advantage also have been evaluated qualitatively by persons with local knowledge. A possible improvement of the models could be a further differentiation between different types of water bodies as well as including other relevant explanatory variables (e.g. a current speed model).

On the basis of the work we have done in this project, we strongly recommend using the same or similar methodology for preparation of reference values with full geographic and habitat-specific representation, where adequate data exists.

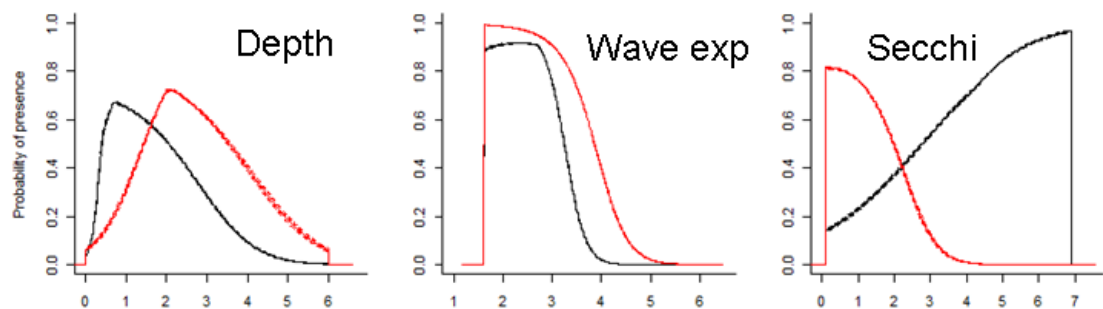
### 5.5 Evaluating management scenarios using predictive habitat modelling – effects of eutrophication mitigation in the Baltic Sea

Ulf Bergström<sup>1</sup>, Göran Sundblad<sup>1,2</sup>, Anna-Leena Downie<sup>3</sup>, Martin Snickars<sup>4</sup> and Mats Lindegärth<sup>5</sup>

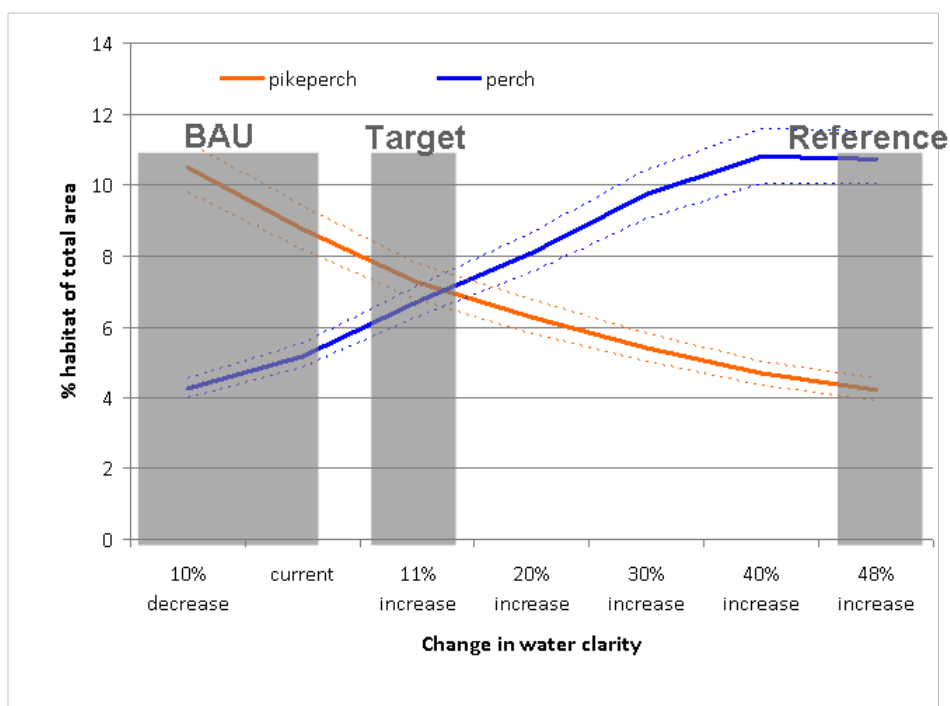
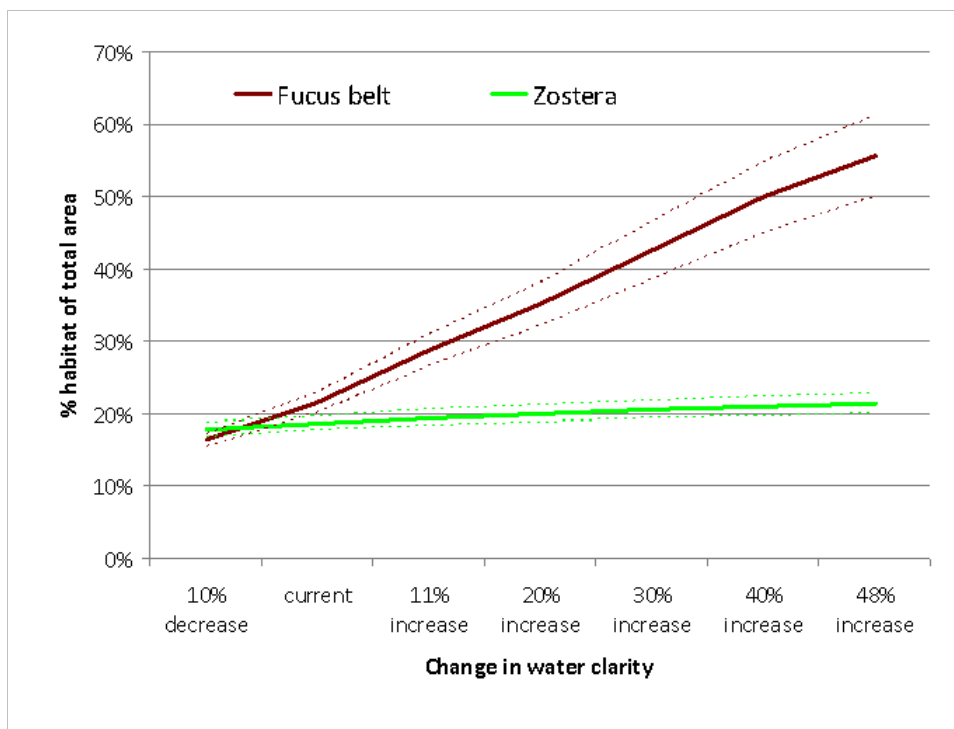
1 Swedish Board of Fisheries, 2 AquaBiota Water Research, 3 Marine Centre, Finnish Environment Institute, 4 Åbo Akademi University, 5 Göteborg University.

An example of how predictive habitat modelling may be used for scenario analysis was provided by the Prehab project. In the study, potential habitat effects of eutrophication mitigation in the Baltic Sea have been explored. Eutrophication in the coastal zone reduces water clarity, which can be expected to have important effects on the distribution of both macrophytes and fish. The Baltic Sea Action Plan (BSAP) sets out targets for a decrease in eutrophication by 2021, using Secchi depth as the main status indicator. However, potential effects of these targets on the distribution of ecologically important species and habitats have not been assessed. In the study, we use habitat modelling to assess the effects of changing eutrophication on the distribution of habitats of some of the dominating vegetation and fish species of the coastal zone. The studied habitats were recruitment habitats for perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*), and stands of bladderwrack (*Fucus vesiculosus*) and eelgrass (*Zostera marina*) in the vast archipelago of the northern Baltic proper. Species distributions were statistically related to water depth, wave exposure and Secchi depth using maximum entropy modelling (see figures). By changing the Secchi depth

according to a set of scenarios corresponding to business as usual, BSAP target level and BSAP reference level, the effects on the spatial distribution of these habitats were explored. Increased Secchi depth, i.e. reduced eutrophication, led to increases in perch recruitment areas, while reducing the recruitment areas of the commercially important pikeperch (Fig. XX), which is consistent with prior knowledge of the species-specific differences in effects of visual conditions on feeding and predator avoidance behaviour. For vegetation, increasing Secchi depth led to different levels of increase in the areas suitable for eelgrass and bladderwrack. The highly species-specific responses to a change in Secchi depth illustrates the importance of detailed studies for understanding how marine ecosystems may respond to management actions. The importance of including the pressure variable as a predictor variable in the model and of a direct effect of the pressure variable on the study species was discussed. It was concluded that using habitat modelling for evaluating management scenarios is a promising approach, although much work still remains to develop the methodology.



Response of perch (black) and pikeperch (red) to the variables depth, wave exposure and Secchi depth used as predictors in the MaxEnt models.



Predicted changes in cover of bladderwrack, eelgrass and recruitment habitats of perch and pikeperch with changes in water clarity of the northern Baltic Sea archipelago region. Shaded areas represent different scenarios: BAU represents change in water clarity if current trends continue (business as usual), Target is the target level for Secchi depth, which is the main indicator according the Baltic Sea Action Plan, to be reached by 2021, and Reference is the long-term reference level of the Baltic Sea action plan.



## 6 Standards and protocols – ToR d)

### Ground-truthing of multibeam backscattered signal by in-situ sand thickness measurements

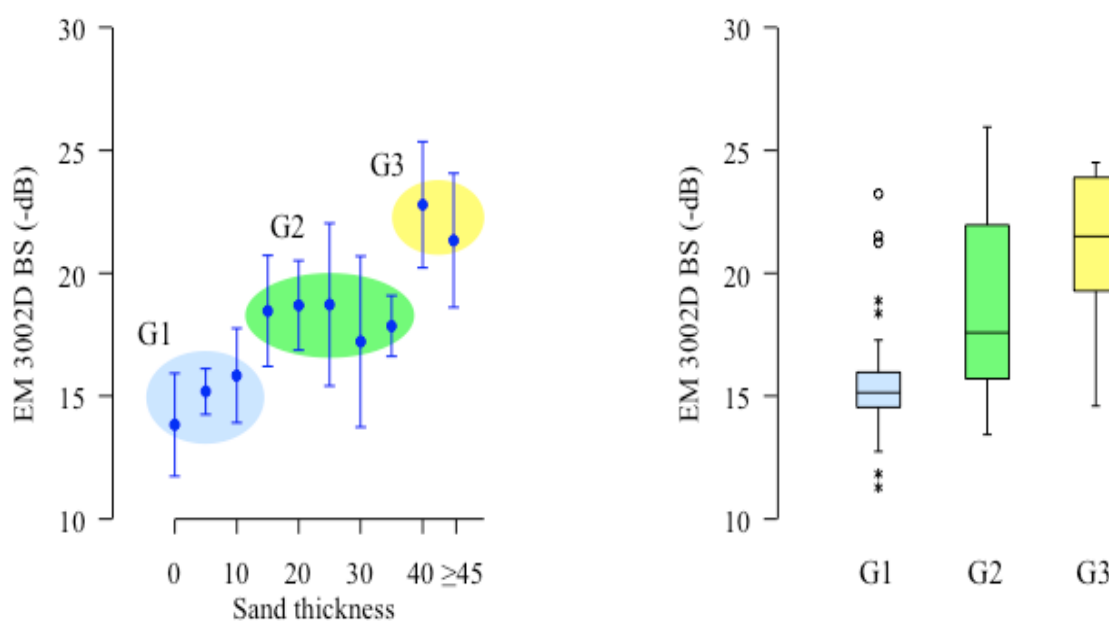
A. Norro<sup>1</sup>, K. Degrendele<sup>2</sup> and M. Roche<sup>2 -1</sup> RBINS-Mumm, Gulledelle, 100, B-1200 Brussels. <sup>2</sup>Fund for sand extraction. Belgian FPS Economy

Multibeam surveys have been conducted over the Belgian continental plate for bathymetric purposes. Backscattered (BS) signal have been recorded as well for sediment classification purposes. Starting in 2005 for 5 years, 23 tracks were surveyed by scientific divers taken video images as well as direct measurements of sand thickness on reported geo-referenced points. The method used for geo-reference as well as the inter-calibration made using GAP Xseausbl system was presented at the last year WGMHM meeting (WGMHM 2010). The accuracy of the positioning is better than 10m.

The 23 dived tracks have been surveyed using Multibeam less than 2h after the end of the dive for BS signal. Using Sonarscope (Ifremer) a 1m\*1m mosaic of BS has been created post-treatment included the masking of the central (specular, -20°,20°) and the external sectors (-78°, -70 and 70°-78°) as well as a compensation of the BS vs. the angle mean curve.

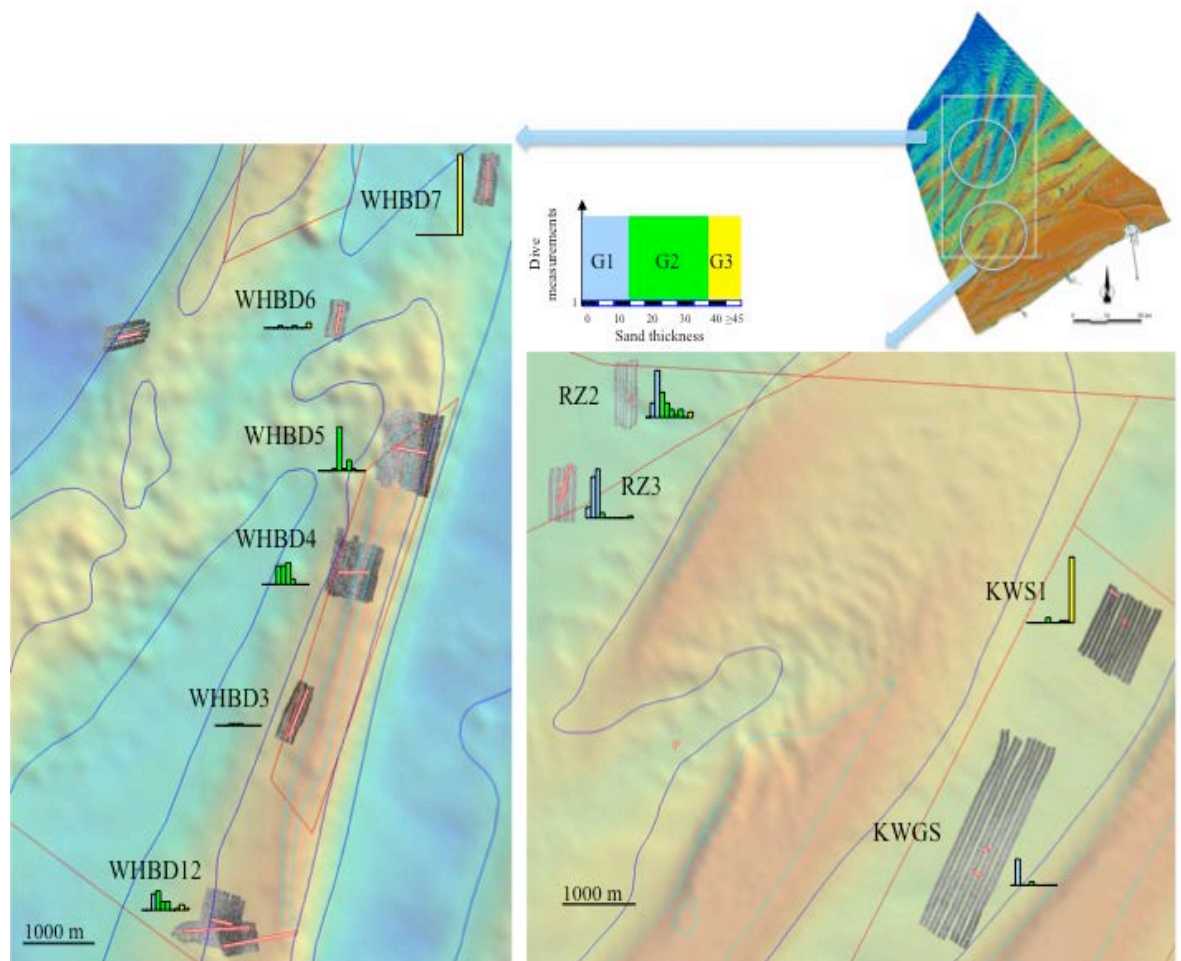
A mean value as well as a standard deviation of BS has been obtained on a 10m diameter circle taken on every available *in-situ* sand thickness measurement point.

The correlation existing between BS and sand thickness is presented at Figure 1



Correlation between backscatter (BS) signal and the *in-situ* sand thickness measurement. Standard deviation shown on the left panel.

Three classes of BS can be isolated from the analysis. They correspond to a sand thickness ranging from 0–15 cm from 15–35 cm and from 40cm. They are featuring different zone of the Belgian continental plate. Video images cannot differentiate clearly between these zones and therefore will associate very different BS signature to similar sediment appearance. Moreover, use of van Veen grab in order to ground-truth such environment is not possible for the zone of very thin sand cover (0–15 cm) and direct measurement of sand thickness is seen here as an improvement in ground-truthing permitting the differentiation (see Figure 2)



**Zone of the North Sea Belgian continental plate featuring the 3 different classes of sediment as differentiated by BS signal calibrated by direct sand thickness measurement.**

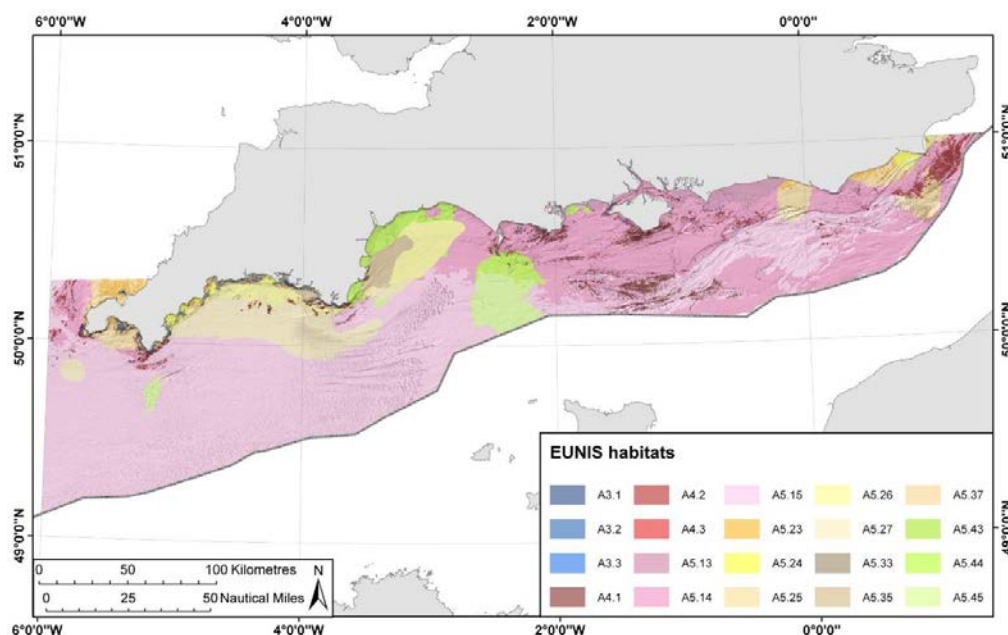
Figure 2 shows two zones of the Belgian North Sea continental plate featuring different sediment type. Zone referenced as RZ2 and RZ3 are featuring coarse sediment with numerous boulders that are covered by thin sand layer while zone KWS1 is featuring the deep end of the sand ridge.

## 7 Data interpretation – ToR e)

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### **Developing improved base layers for predictive habitat modelling in the Eastern English Channel**

Worldwide, the oceans and marginal seas are under increasing pressure from human activities and there is an ever greater need for good habitat maps, both to underpin environmental and socio-economic affect assessments and to help in the development of effective management measures that will contribute to our responsible stewardship of the marine environment and the sustainable use of its resources. The development of habitat mapping is now driven more by specific policy needs than our innate desire to explore our world. For example, the European Union's Marine Strategy Framework Directive requires better habitat maps than exist at present to support assessments of the status of the seabed and the proportion of each habitat significantly affected by human activities. We report on methodological developments that can be applied to provide better predictive habitat maps. We present a case study to develop an improved habitat map for the British part of the English Channel. At its heart is a more realistic representation of seabed substrate types than has been available in standard seabed sediment maps. We have used geostatistical predictions and terrain modelling techniques, validated against observational datasets, to map seabed substrata and used this to model the distribution of rock and sediment habitats. A new habitat map of the British part of the English Channel according to the EUNIS (European Union Nature Information System) classification. We applied a hybrid spatial prediction model to map sediment composition using both spatial autocorrelation and correlation with auxiliary predictors (bathymetry and derivatives thereof, wave and tidal shear stress, etc.). The proportion of sand, mud and gravel were then analysed to classify the sediments according to Folk textural classes and the EUNIS habitat schema. Morphologically distinct bedrock outcrops were extracted from a detailed bathymetric dataset (30 m by 30 m bins). Several measures of rugosity were tested using a training dataset for their ability to discriminate between rock and non-rock. The Vector Ruggedness Measure was selected for use, applying a cut-off value to discriminate flat from rugged terrain. The latter class included subaqueous dunes and sandbanks which were subsequently separated from rock outcrops. The sediment predictions and the bedrock layer were unified to yield a substrate map. This layer was finally intersected with modelled biological zones (infralittoral, circalittoral and deep circalittoral) and hydrodynamic energy at the seabed to derive the EUNIS habitat model.



## 8 Uses of habitat mapping for management – ToR g)

### 8.1 Seabed habitat mapping in support of marine renewable energy developments and Marine Protected Areas in Scottish waters

Marion Harrald – Marine Scotland Science (MSS), Megan Linwood – Joint Nature Conservation Committee (JNCC), Ben James – Scottish Natural Heritage (SNH)

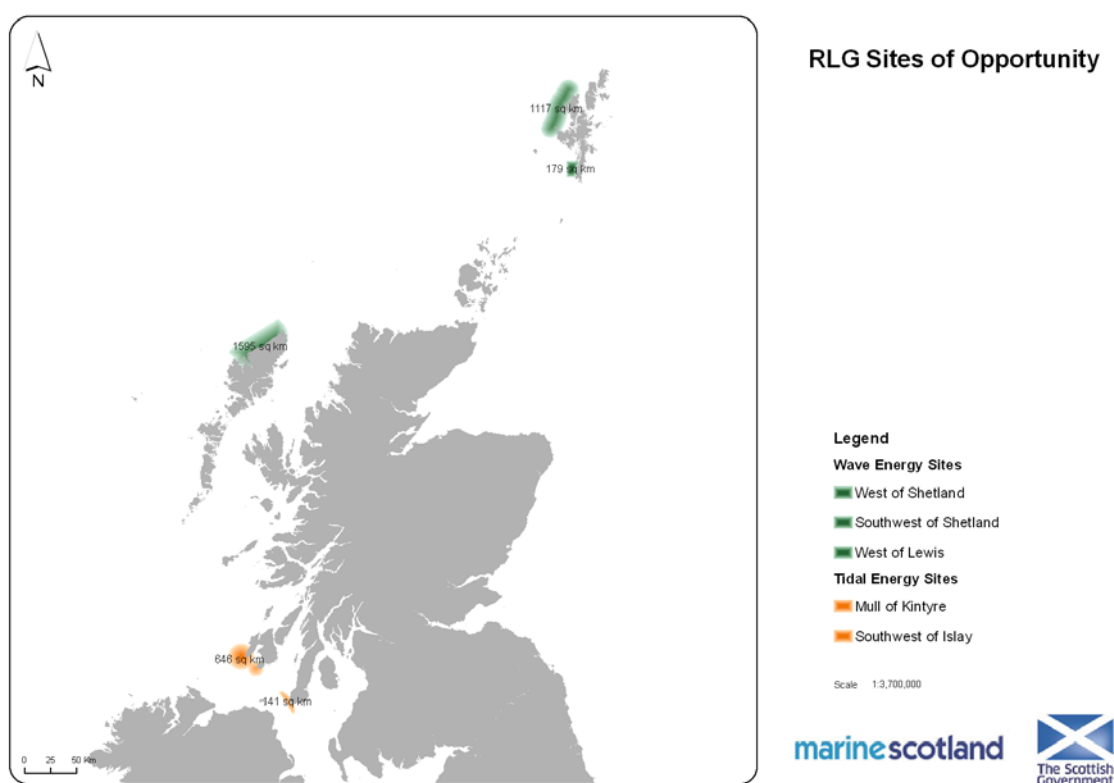
#### 8.1.1 Introduction

Bathymetric and seabed habitat mapping is becoming increasingly important in Scottish waters. This is firstly to provide regional data in areas of interest to the wave and tidal stream energy industry and secondly to provide evidence to justify the locations of new Marine Protected Areas (MPAs). The locations for the renewables orientated mapping have been determined in line with recent marine spatial planning work specifically for wave and tidal stream energy in Scotland. The outputs from this work, in terms of the bathymetry and seabed facies are being made freely available on the Marine Scotland website, Marine Scotland Interactive. The Joint Nature Conservation Committee (JNCC) and Scottish Natural Heritage (SNH) are putting considerable effort into habitat mapping surveys in support of commitments to establish a network of MPAs in inshore and offshore waters. The JNCC has also progressed its collaborative seabed mapping and data dissemination projects, MESH and UK Sea-Map.

#### 8.1.2 Marine renewables

##### Marine Spatial Planning

Much attention has been given to management of the siting of new wave and tidal stream energy developments in Scottish waters. In March 2010 leases were awarded for wave and tidal developments in the Pentland Firth and Orkney waters, an area with particularly high tidal currents. Following the success of this project, Scottish Government launched the Further Scottish Leasing Round in order to open up areas of the Scottish coast out with the Pentland Firth and Orkney waters.

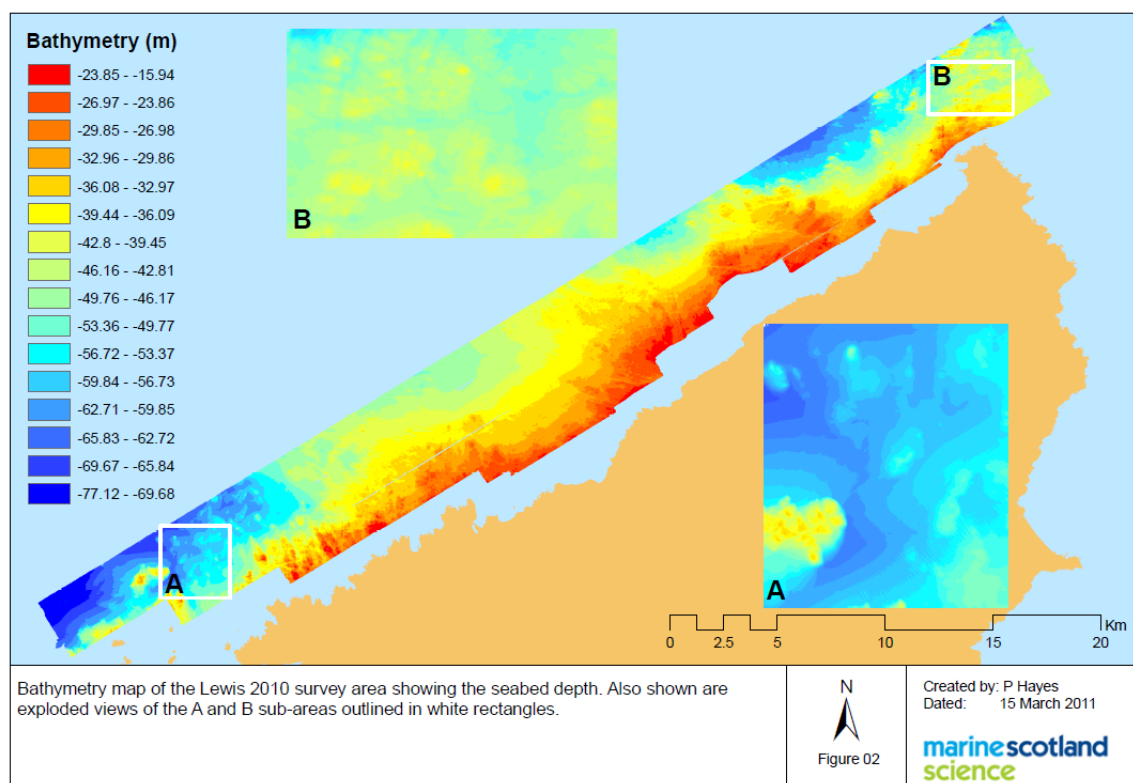


**Sites of opportunity for wave and tidal stream power development in the Further Scottish Leasing Round (Saltire Prize projects) identified in the Regional Locational Guidance.**

Marine Scotland Science (MSS) was tasked with advising on site suitability for this leasing round. We used a multi-factorial spatial modelling approach to identify sites with high development potential but which avoided sensitive areas and minimized interactions with other users. We used a GIS-based tool developed by The Crown Estate, known as the Marine Resource System (MaRS), to explore the levels of constraint in areas of interest to the industry. Six areas were identified from the MaRS analysis (Harrald and Davies 2010). These were put forward for stakeholder consultation and further investigation in the form of Regional Locational Guidance (RLG; Harrald, Aires and Davies 2010). In this publication we explored the resource potential, bathymetry and depth, proximity to infrastructure, environment and conservation importance and other uses, in each of the sites under consideration. On conclusion of the RLG and taking account of stakeholder view-points, 5 sites were put forward in September 2010. The success of this spatial planning approach may be assessed through the interest shown by developers in new projects in these areas.

### **Seabed mapping for marine renewables**

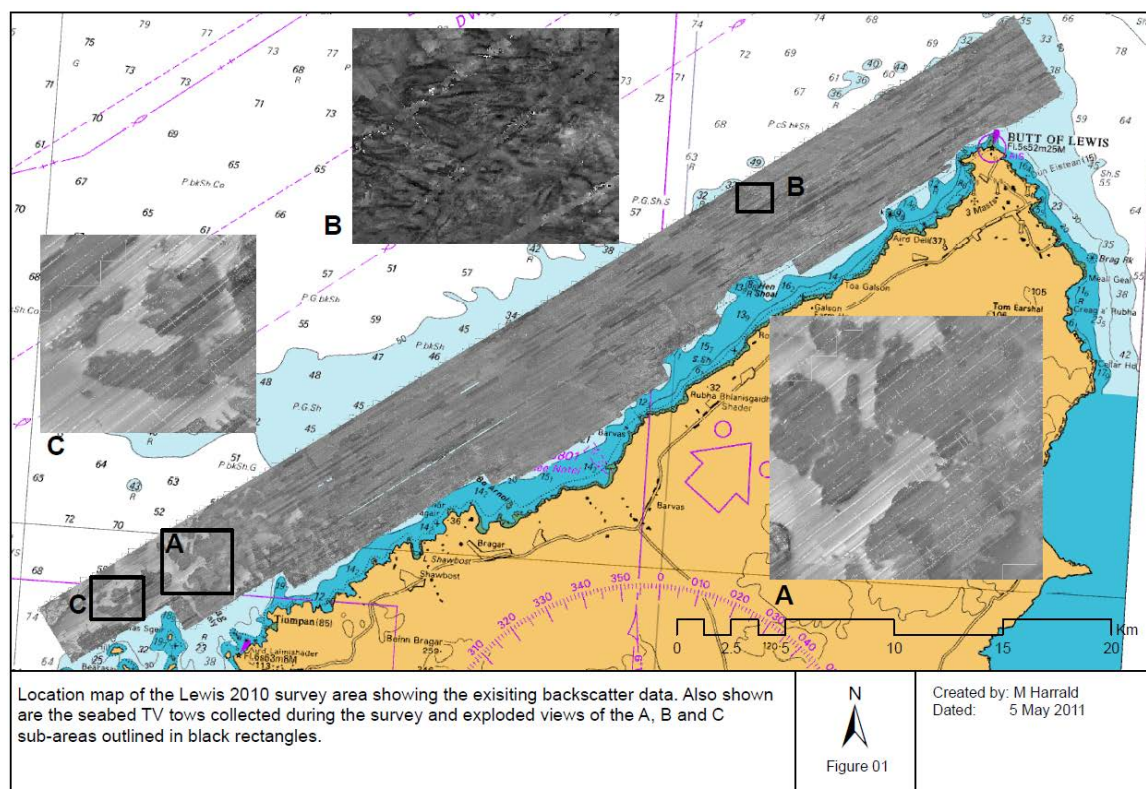
As a part of Scottish Government's drive to encourage renewable energy, MSS has been providing regional scale bathymetry and habitat maps in areas of interest to the wave and tidal stream energy industry. In 2009 we surveyed 230 km<sup>2</sup> in the Pentland Firth, and provided detailed bathymetric maps of a large component of the area under consideration for leasing. This is reported in the ICES WGMHM in 2010. We are now focusing on areas identified in the Further Scottish Leasing Round. In 2010 we surveyed an area to the west of Lewis in the Outer Hebrides and in 2011 we are planning a survey to the southwest of Shetland (see Figure 1).



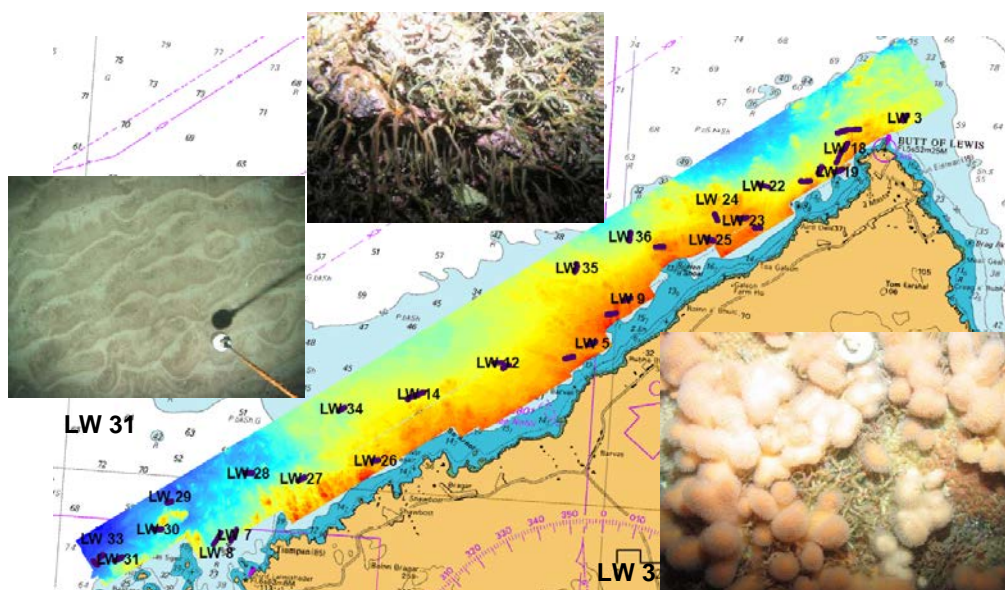
**Bathymetry of the West of Lewis 2010 survey area.**

Inshore waters to the west of the Isle of Lewis contain one of the best wave resource areas in the UK and had not previously been surveyed using multibeam. Bathymetric data were collected using the FRV “Scotia” with a Reson Seabat 7125-B multibeam echosounder system together with ground-truthing data collected using a dropframe TV. In total, 260 km<sup>2</sup> of hard and soft ground were surveyed, 36 seabed TV tows were completed and over 600 digital stills were collected to the west of Lewis from 21 July to 6 August 2010. The bathymetry and backscatter data were post-processed using industry standard software. An integrated approach was applied in which bathymetric, backscatter and derived datasets were used to identify changes in the seabed facies. Subsequent ground-truthing using the footage from a drop frame TV is enabling the compilation of a regional seabed habitat map leading to an assessment of the conservation interests in the area.





Backscatter data from the West of Lewis 2010 survey area.



Locations of drop frame camera tows (purple lines) used for ground-truthing the bathymetry and backscatter data and examples of the sediment and rocky habitats.

### Spatial data dissemination

The maps and TV footage are of great interest to the marine renewables industry for use in site selection. In recognition of the diversity of interest in the datasets, we have set up a spatial data sharing website, Marine Scotland Interactive ([www.scotland.gov.uk/marinescotlandinteractive](http://www.scotland.gov.uk/marinescotlandinteractive)), in which our data and the software needed to view it are made freely available to all. Viewers can download bathymetry and other derived datasets in multiple formats in 2D and 3D where pos-

sible. The datasets are best viewed in Google Earth or ArcGIS Explorer, in which the viewer can overlay the paths of the TV footage on the bathymetry layer. A bubble box appears with a link to the photographs in Picasa, the videos in You Tube and a description of the biotopes observed on the TV tow. Industry and others have shown great interest in this resource and it is continually being expanded and updated with new data.

### 8.1.3 Marine protected areas

#### Seabed habitat mapping for MPAs

The UK is committed to delivering an ecologically coherent and well-managed network of MPAs by 2012. The network of MPAs will ensure we meet our commitments under the Convention on Biological Diversity and contribute to measures aimed at achieving Good Environmental Status across Europe's seas by 2020 under the EU Marine Strategy Framework Directive. JNCC is responsible for the identification of MPAs in UK offshore waters (out-with 12 nm) while Scottish Natural Heritage is responsible for inshore waters. This role includes providing advice to Government on the selection of Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Marine Conservation Zones in England and Wales (MCZs) and Scottish MPAs. In Scotland a large programme of surveys has been initiated to chart the abundance, quality and distribution of habitats and species of high conservation importance, known as Priority Marine Features (PMFs). Certain PMFs (MPA search features) will be used to support the selection of nature conservation MPAs.

The JNCC and SNH are planning to create habitat maps from a combination of their own acoustic survey work, backscatter data collected by the **Maritime and Coast-guard Agency** (MCA), diving and video surveys.

Habitat maps will be created for the following areas in Scotland using the MCA backscatter data and other data available to provide ground-truthing:

#### Territorial sea areas:

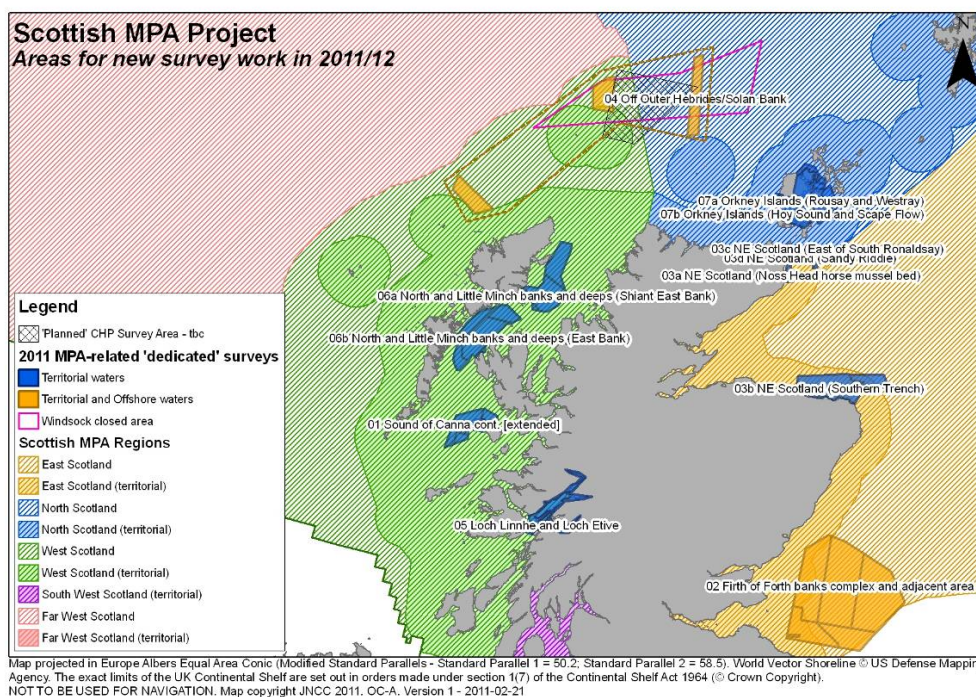
- HI 1297 Western approaches to the Small Isles Block 5
- HI 1299 Canna to Point of Sleet Block 2

#### Offshore areas

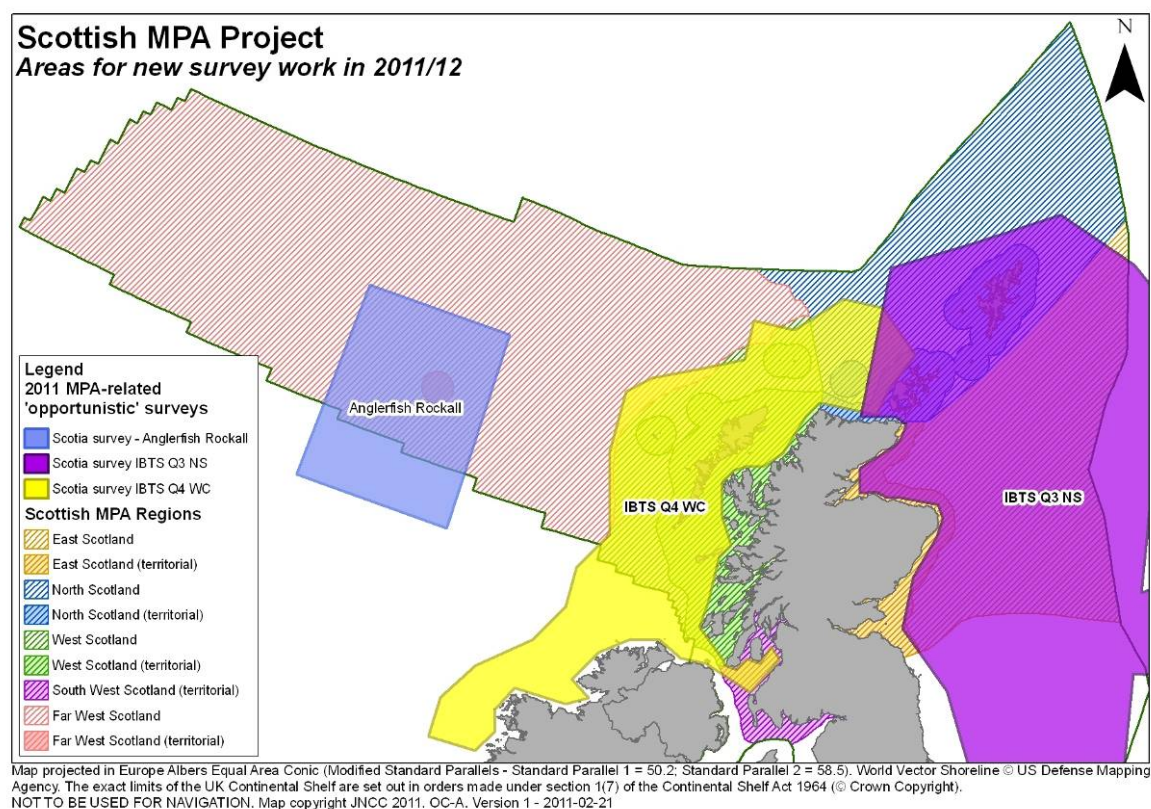
- HI 1072 - Solan Bank to Fair Isle Channel
- HI 1137 - Eastern Approaches to Sanday and Stronsay (Block 2)
- HI 1137 - Eastern Approaches to Sanday and Stronsay (Block 3)
- HI 1151 - Approaches to the Firth of Forth
- HI 1152 - Wee Bankie to Gourdon (A)
- HI 1137 - Orkneys Eastern Approaches to Sanday and Stronsay

A compilation of all the new dedicated and opportunistic survey work planned for 2011 and 2012 is illustrated in Figures 5 and 6 respectively. In some cases this work may be split into multiple surveys.





Areas for new dedicated survey work in 2011/12 for Scottish Marine Protected Areas.



Areas of opportunistic survey work in 2011/12 for Scottish Marine Protected Areas.

## Data compilation and dissemination

### UK SeaMap

To fill the gaps between small and detailed habitat maps, broad-scale predictive habitat maps have been produced based on broad physical categories. The UKSeaMap 2010 project has recently updated a seabed habitat map for the entire UK continental shelf area using this method. UKSeaMap 2010 used the EUNIS habitat classification system to classify seabed habitats, with some new proposed habitat classes for the deep-sea area, which are currently being considered as part of the JNCC's work on marine habitat classification for Britain and Ireland as part of the EUNIS scheme.

The UKSeaMap 2010 final report and technical appendices are in the final review stage and are not yet publically available. However, due to popular demand, the JNCC have launched the online interactive map ahead of the release of the report. This allows users to view and download the data layers used and produced in the UK SeaMap 2010 project, [www.jncc.gov.uk/page-5534](http://www.jncc.gov.uk/page-5534). For more information on the UKSeaMap 2010 project visit, [www.jncc.gov.uk/UKSeaMap](http://www.jncc.gov.uk/UKSeaMap).

### 8.1.4 References

- Harrald, M., and Davies, I. M. 2010. Further Scottish Leasing Round (Saltire Prize Projects): Scoping Study. Scottish Marine and Freshwater Science, Volume 1, 7.
- Harrald, M., Aires, C., and Davies, I. M. 2010. Further Scottish Leasing Round (Saltire Prize Projects): Regional Locational Guidance. Scottish Marine and Freshwater Science, Volume 1, 18.

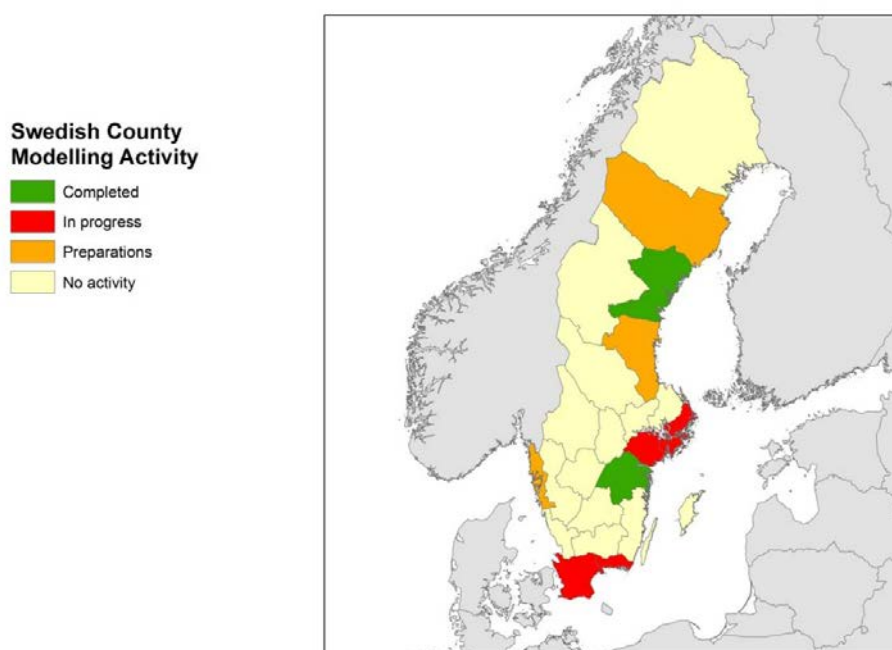
## 8.2 Marine regional mapping of Swedish marine areas

Starting in 2009 Swedish marine areas are mapped county by county. The mapping has been finalized in the first two counties Östergötland and Västernorrland, and mapping projects in four counties are in progress (Figure 2).

The projects are funded by the Swedish Environmental Protection Agency, in Skåne and Blekinge co-funded by LIFE+ project MARMONI. The mapping projects are lead by AquaBiota Water Research in collaboration with the County Administration Boards, Swedish Maritime Board, Swedish Geological Survey and the municipalities in the counties. The projects include the following main work packages (some variation between counties):

- Collating and management of existing field data.
- Oceanographic modelling of salinity and bottom currents in 50 m resolution.
- Modelling of surface sediments based on surveyed marine geology and environmental parameters.
- Digitizing old depth measurements, and interpolating them into a bathymetry grid.
- Complementary biological sampling for calibration and validation of models. Drop-down video is mainly used.
- Modelling of distribution of phytobenthic species distributions. About 50 different probability maps were produced showing the distribution of benthic species and assemblages in 25 m resolution.

- Modelling of distribution of zoobenthos species distributions. Twelve different probability maps were produced in Västernorrland showing the distribution of species in 25 m resolution.
- Accuracy calculations of environmental layers and species predictions. The validating was performed using independent field data.
- In collaboration with managers at national, county and municipality level selected probability maps were converted into polygons showing *preliminary areas of biological significance* of special importance for management. The areas displayed important areas for Blue mussel (*Mytilus edulis*), High vascular plants, Perennial redalgae, Bladderwrack (*Fucus vesiculosus*) and Eelgrass (*Zostera marina*).



The completed mapping projects in Östergötland and Västernorrland are displayed in green. Similar projects are in progress in Stockholm, Södermanland, Blekinge and Skåne (red), and preparations for a project is conducted Västerbotten, Gävleborg and Bohuslän (orange).

The report by Carlström *et al.* 2010 (in Swedish with English abstract) can be downloaded from [www.aquabiota.se](http://www.aquabiota.se).

## Annex 1: List of WGMHM 2011 participants

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## **Annex 2: WGMHM 2011 terms of reference**

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It was decided by WGMHM members that the list of ToRs as it stands is best to accommodate any contributions from members. It is therefore decided to leave this list in its present form. The ToRs are reproduced below:

WGMHM will meet in Calvi, France (at the Stareso Marine Station) from 10 to 13 May 2011 to:

### **International programmes – ToR a)**

- a) Report on progress in international mapping programmes (including OSPAR and HELCOM Conventions, EuSeaMap, EC and EEA initiatives, CHARM, Prehab, Sesma and Mesh-Atlantic projects)

### **National programmes (National Status Reports) – ToR b)**

- b) Present and review national habitat mapping activity during the preceding year, providing National Status Report updates according to the standard spreadsheet reporting format and in geographic display in the ICES webGIS and focusing on particular issues of relevance to the rest of the meeting

### **Modelling – ToR c)**

- c) Evaluate recent advances in marine habitat modelling techniques

### **Protocols and standards for habitat mapping – ToR d)**

- d) Report on advances on survey strategy and data collection and develop guidelines for data collection by completing the list of recommended operating guidelines (ROGs) produced by Mesh (with particular emphasis on, but not limited to grabs, sonar interferometry, PSA etc.)

### **Data interpretation – ToR e)**

- e) Report on progress in post-processing and interpreting data (e.g. Sonar-scope)

### **Accuracy and confidence – ToR f)**

- f) Review methods for accuracy and confidence assessment on both modelled maps and interpreted maps and initiate production of written guidelines.

### **Uses of habitat mapping for management – ToR g)**

- g) Review practise about the use of habitat maps in different countries for various purposes.

## **Annex 3: WGMHM 2011 agenda**

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### **Progress in international mapping programmes - ToR a)**

- EUSeaMap, UkSeaMap (JPO)
- Mesh-Atlantic (JPO)
- Prehab (GSU)
- CHARM 3 (SVA)
- CoralFish (FTE)
- Mesma (IGA)
- Any other?

### **National programmes (National Status Reports) - ToR b)**

- National status report : short presentation (10' to 15' for each country – N, S, D, NL, B, UK, F, P, E) by national delegates
- A regional approach to marine mapping and modelling in Sweden (MIS).
- Actual and future activities on mapping marine biotope types in the German EEZ of the North and the Baltic Seas (DBO).
- Regional seabed habitat mapping contributing to planning for marine renewable energy development (MHA).
- MHM in Belgian water using BC data obtained by multibeam and verified by in situ data (ANO).
- Using the ICES WebGIS for discovery of habitat maps: presentation and guidelines - ICES IT survey (HMO)

### **Modelling - ToR c)**

- Lecture on modelling (SVA)
  - Introduction to habitat model concepts
  - The statistical models in use (GAM, GLM, RQ)
  - Presentation of example datasets
  - Habitat modelling application using delta GLM
  - Model parameters : interpretation
  - Evaluation of models, model uncertainty
  - Habitat modelling application using delta GAM
  - Model parameters : interpretation
  - Evaluation of models, model uncertainty
  - Building habitat maps in GIS
- Evaluating management scenarios for eutrophication in the Baltic Sea using predictive habitat modelling (UBE)
- Process-driven habitat mapping - the “Kostylev approach” - (IGA).
- The National program for mapping and monitoring of marine habitats - a mapping program using spatial predictive modelling as a tool (TBE).
- Nature Index of Norway - modelling soft sediment indicators (of natural state) of coastal water (TBE).
- Kelp modelling on the coast of Brittany (DGO).
- Lecture on modelling (continued) - Quantile Regressions (SVA)

- Model parameters : interpretation
- Evaluation of models, model uncertainty
- Open discussion: a collaborative paper?

**Election of new Chair and choice of 2012 meeting venue.**

## **Annex 4: WGMHM 2012 terms of reference**

The **Working Group on Marine Habitat Mapping** (WGMHM), chaired by Pål Buhl Mortensen\* Norway, will meet on Isle of Vilm, Germany, 22–25 May 2011 to:

### **International programmes – ToR a)**

- a) Report on progress in international mapping programmes (including OSPAR and HELCOM Conventions, Emodnet, EC and EEA initiatives, CHARM, Prehab, Sesma and Mesh-Atlantic projects).

### **National programmes (National Status Reports) – ToR b)**

- b) Present and review national habitat mapping activity during the preceding year, providing National Status Report updates according to the standard spreadsheet reporting format and in geographic display in the ICES webGIS and focusing on particular issues of relevance to the rest of the meeting.

### **Habitat modelling / Accuracy and confidence – ToR c)**

- c) Evaluate recent advances in marine habitat modelling techniques and address the spatial distribution of errors. Make final review of collaborative report or paper on habitat modelling.

### **Uses of habitat mapping for management – ToR d)**

- d) Review practise about the use of habitat maps, and more specifically “Mapping for the MSFD and marine spatial planning”.

WGMHM will report by 20 June 2012 (via SSGSUE) for the attention of SCICOM and ACOM.

### **Supporting Information**

Priority	This Group coordinates the review of habitat classification and mapping activities in the ICES area and promotes standardization of approaches and techniques to the extent possible.
Scientific justification	<p>The working group provides an important forum to discuss international and national seabed mapping programmes, along with their relevance to Regional conventions and European directives and more specifically among them the MSFD.</p> <p>The MSFD required better knowledge of the seabed, both from a biodiversity but also an integrity point of view. WGMHM examines techniques with a capacity to address these issues, whether for direct mapping or through modelling.</p> <p>Habitat suitability modelling is a key emerging technique as it allows addressing large areas of the seabed using field data and environmental parameters or their proxies, limiting the need for survey data. Mapping physical habitats is also a promising approach.</p> <p>The compilation of National status reports remains an important tool to show progress in knowledge on our seabed. This extends to interpreted and modelled maps as well as substrat maps.</p>
Scientific justification, ToR d	This ToR is of paramount importance in view of the many developments and impacts occurring in the coastal, shelf and even deeper zones and because of the MSFD requirements where a link is sought between the ecology and the pressures. However linking science and usages remains a difficult task and hopefully some members will be keen to address this at 2012 meeting.

Participants	Representatives from Member Countries with experience in habitat mapping and classification. Participation of the Baltic countries is quite active that from USA and Canada would need to be resumed. The participation of members of BEWG, WGEXT, WGDEC, and WGMPCZM would be helpful in developing appropriate linkages to other areas of ICES work, however it does not happen because of work overload.
Linkage to advisory committee	ACOM
Linkages to other committees or groups	BEWG, WGEXT, WGDEC, WGMPCZM
Linkages to other organizations	OSPAR, HELCOM, EEA

## Annex 5: Recommendations

Recommendation	For follow up by:
1. The National Status Report has to be made by each national representative (even if they are not showing up at the meeting) both geographically and semantically, which means by capturing metadata through the specific interface made available by ICES Data Centre and submitting shapefiles of the map outlines to the same. This will provide the wider community with a geographic view of the status of habitat maps coverage throughout ICES.	WGMHM, ICES Data Centre
2. Based on recent progress habitat modelling it is planned that the group will review a paper on that topic being drafted in 2011 (deadline Christmas) under the lead of the WGMHM Chair, with potential feedback from Theme Session G at ASC Gdańsk, Poland, with a view to submission in early 2012 to the ICES Journal. BEWG could also be requested to review the paper.	WGMHM, BEWG
3. There is a growing need to make habitat maps available for spatial planning. An effort should be made by WGMHM to come up with informed examples on how habitat maps are being used (e.g. probability maps). It is suggested to liaise with three expert groups on this topic: the WGMPCZM, WGEXT (contacts have been taken with the Chairs) and STIGMSP. The use of maps within both MSP and MSFD perspectives will be addressed as a ToR at 2012 meeting.	WGMPCZM, STIGMSP, WGEXT