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

21–24 May 2013

ICES Headquarters, Copenhagen

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Contents

Executive summary

The Working Group on Marine Habitat Mapping (WGMHM), chaired by Pål Buhl-Mortensen, Norway, convened at the ICES Headquarters in Copenhagen, Denmark, from 21–24 May 2013.

Two new ToRs were introduced to the group shortly before the meeting (f and g). These ToRs were reported separately immediately after the meeting, as well as in this report. Experts also presented statuses on both on national and international mapping projects (ToR a and b).

There have been recent contacts between three EGs, namely BEWG, WGEXT and WGMHM to start dealing with overlapping issues. These were also discussed during the meeting.

WGMHM chaired by Pål Buhl-Mortensen, Norway, will meet at AZTI-Tecnalia in San Sebastian, from 19–23 May 2014.

1 Opening of the meeting

The meeting was held at ICES headquarters, in Copenhagen, Denmark from 21–24 May 2013. The meeting was attended by 10 delegates from six countries.

Apologies were received from several of the members that were not able to attend.

2 Adoption of the agenda

The meeting agenda (Annex 3) was reviewed and revised at the start of the meeting before it was accepted by the group.

3 Progress in international mapping programmes – ToR a)

3.1 MeshAtlantic status report

Jacques Populus (Ifremer)

a) Broad-scale map

Over the last year the MeshAtlantic (www.meshatlantic.eu) partners spent significant resources in improving the broad-scale map thresholds, in other words testing cut-off values of the layers defining the EUNIS categories (sediment type, depth zones, energy at seabed) as a function of biological features. Some of these values do change with the biogeography and the prevailing conditions of each marine basin. This is particularly the case with energy at the seabed, which exhibits very different amplitude in a macrotidal basin such as the Channel and the Mediterranean for example.

The collation of depth and substrate data for the Atlantic Area has been completed in 2012 with main updates from Ireland and the Azores. The final run to produce the map has been performed and the map is now ready.

In Figure 1, only the area where seabed substrate data – currently the limiting factor - was in existence is shown. Empty parts (UK and central Ireland) had already been covered with historic data by EUSeaMap (http://jncc.defra.gov.uk/euseamap/) so now it is just a matter of stitching together MeshAtlantic and EUSeaMap outputs to arrive at a continuous broad-scale map from the Baltic Sea to Gibraltar. The stitching is currently being examined jointly by Ifremer and JNCC, the custodian of the unified Mesh/MeshAtlantic webGIS. Note that the final map will be visible on the two websites (http://www.searchmesh.net/default.aspx?page=1974) and available for download by the end of the year.

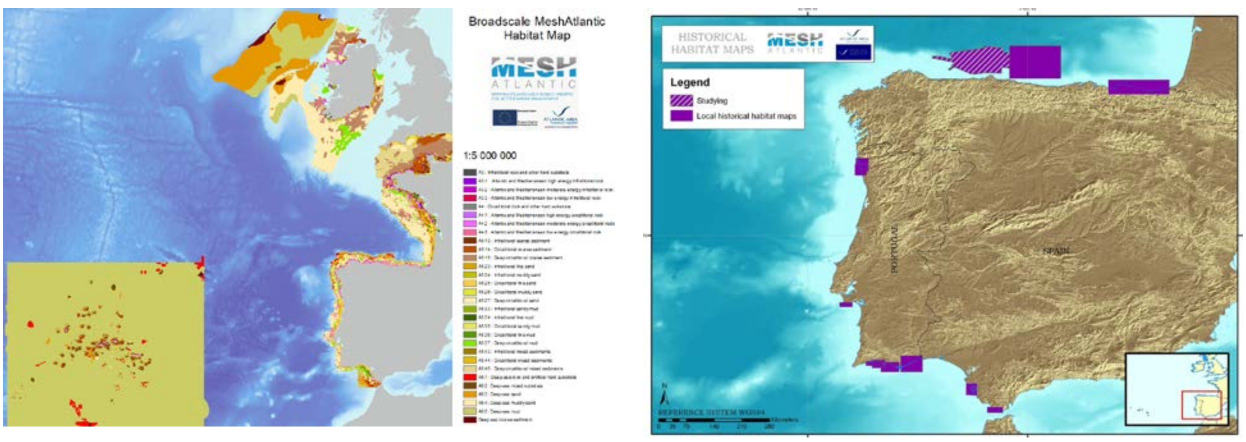


Figure 1. Left, broad-scale map; right, habitat maps collated in the Iberian Peninsula.

b) Progress with historic map collation and creation of new maps

During the project the partners conducted two activities of map generation:

i) a collation of about 38 historic maps in the Atlantic Area of the four participating countries. These maps go from very local maps (Arrabida MPA in Portugal to regional maps such as that of El Cachucho seamount in the Cantabrian Sea, North Spain).

ii) 27 bespoke surveys applied to eleven study sites (including the Azores) to collect data and make detailed habitat maps. Several of the maps are readily available and about to be uploaded to the common (http://www.searchmesh.net/webGIS) Mesh / MeshAtlantic webGIS and it is expected that by the end of the project (November 2013) all of them will be there. Maps are uploaded with their metadata (captured in Geonetwork format in the ICES habitat map discovery site) and their confidence map. The table below shows the detailed confidence assessment of eleven maps in Ireland using the MESH project's assessment method.

GUI	RemoteTechnique	RemoteCoverage	RemotePositioning	RemoteStdsApplied	RemoteVintage	BGTTechnique	PGTTechnique	GTPositioning	GTDensity	GTStdsApplied	GTVintage	GTInterpretation	RemoteInterpretation	DetailLevel	MapAccuracy	Remote score	GT score	Interpretation score	Overall score
IE001000	2	1	3	3	1	3	2	3	3	3	1	3	3	2	2	66,67	86,67	83,33	79
IE001001	2	1	3	3	1	3	2	3	3	3	1	3	3	2	2	66,67	86,67	83,33	79
IE001002	2	1	3	3	1	3	2	3	3	3	1	3	3	2	2	66,67	86,67	83,33	79
IE001003	2	1	3	3	1	3	2	3	3	3	1	3	3	2	2	66,67	86,67	83,33	79
IE001004	3	3	3	3	2	1	3	3	3	3	2	1	2	1	2	93,33	75,00	50,00	73
IE001005	3	3	3	3	3	1	3	3	1	3	2	1	2	1	2	100,00	65,00	50,00	72
IE001006						1	2	2	3	2	1	1		1	1	0,00	56,67	25,00	27
IE001007														1	1	0,00	0,00	16,67	6
IE001008	3	3	3	3	3	1	3	3	3	3	3	1	2	1	2	100,00	80,00	50,00	77
IE001009	3	3	3	3	1	1	3	3	3	3	1	1	3	1	3	86,67	70,00	66,67	74
IE001010						3	2	1	2	2	1	3		2	1	0,00	66,67	50,00	39
IE001011	3	3	3	3	3							1	2	1	2	100,00	0,00	50,00	50

Figure 2. Confidence rating for 11 maps collated in Ireland (MESH confidence assessment).

3.2 The EUSeaMap2 project

Jacques Populus (Ifremer)

In April 2013 the EUSeaMap2 project was awarded to an Ifremer-led consortium including the following partners: NIVA (NO), DCE/Uni. Aarhus (DK), JNCC (UK), IEO (ES), ISPRA (I), HCMR (GR), IO-BAS (BUL) and Geoecomar (RO). The objectives of the project are (i) primarily to extend the broad-scale map to central, eastern and east Mediterranean and the Black Sea, with focus on European waters, and also to the Atlantic marine frontiers (Macaronesia, Norwegian Sea), (ii) engage on a reflection about EUNIS and improve the thresholds for the various basins by using adequate biological datasets, (iii) help collate existing habitat maps and store them in a central European repository for habitat maps.

3.3 EMODnet-Geology

Vera Van Lancker (Royal Belgian Institute of Natural Sciences)

EMODnet-Geology (DG-MARE) was a three year project (2009–2012), coordinated by the National Environmental Research Council and the British Geological Survey. The project provided web-accessible, interoperable geological spatial datasets for the Baltic Sea, Greater North Sea and Celtic Sea. Information was collated from datasets of 14 partners (national Geological Surveys, mainly), together with datasets that were publicly available. Themes were seabed sediments, seabed geology, geological boundaries and faults, rate of coastal erosion and sedimentation, geological events and event probabilities, seismic profiles; and minerals including aggregates, oil and gas. Interpreted maps have been compiled into GIS map layers at 1:1 million scale, stored on the OneGeology-Europe portal (http://onegeology-europe.brgm.fr/geoportal/viewer.jsp).

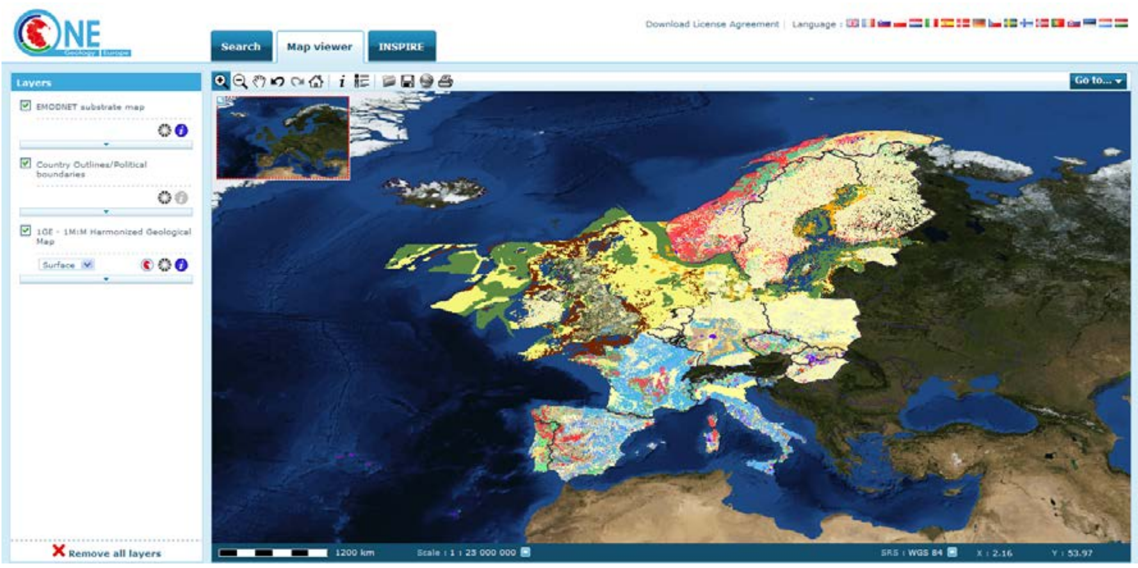


Figure 3. EMODnet-Geology seabed sediments map visualized into the OneGeology-Europe portal.

DG-MARE granted a second phase of the EMODnet projects. Phase 2 of the Geology Lot will likely start in September 2013. The EC have extended the geographical area to include, for example, the Mediterranean and Black seas, and have increased the resolution of compiled information to 1:250 000 scale.

Together with other environmental variables, the EMODnet-Geology seabed sediments map was used to model broad-scale habitats (EMODnet–Physical Habitats, EUSeaMap; http://jncc.defra.gov.uk/page-5020). Biological data have been incorporated into the modelling process, through the development of ecologically relevant thresholds.

3.4 Geo-Seas

Vera Van Lancker (Royal Belgian Institute of Natural Sciences)

The Geo-Seas project was an Integrated Infrastructure Initiative (I3) of the Research Infrastructures programme within EU FP7 (2009–2013). An e-infrastructure was set-up of 26 marine geological and geophysical data centres, located in 17 European maritime countries. Users are enabled to identify, locate and access pan-European, standardized and harmonized marine geological and geophysical datasets (e.g. boreholes, sediment samples, multibeam, seismics, magnetometry) and derived data products through a single common data portal (www.geoseas.eu). The aims of Geo-Seas are aligned with European directives and recent large-scale framework programmes on global and European scales, such as GEOSS and GMES, EMODnet and INSPIRE. Geo-Seas has expanded the existing **SeaDataNet** (www.seadatanet.org) marine and ocean data management infrastructure that merely focuses on oceanographic data.

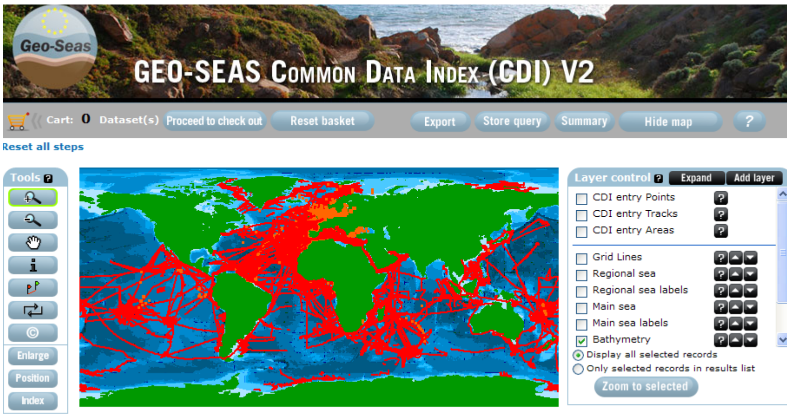


Figure 4. Overview of geological and geophysical datasets, as made available through the FP7 Geo-Seas project.

Data products and services that were developed include: Digital Terrain Model and 3D viewing software; Digital Terrain Model and 2D viewing service; Borehole Viewer software; Low resolution seismic viewing service; High resolution seismic viewing service; and Standardization in seabed habitat mapping.

For Standardization and Harmonization in Seabed habitat mapping, 2 extensive reports were produced: one on sediment characterization, another one on terrain characterization. Both reports have a similar structure and comprise a review of sediment/geomorphic structures that are relevant to habitat mapping and the extent to which they are mentioned (e.g. European Directives; Habitat classification systems); main methodological approaches and classifications; investigations on how different data resolutions affect the sediment and/or terrain characterization and recommendations.

Case studies were provided on 500, 50 and 5m resolution. For sediment the following cases were illustrated (1) Multiple geological datasets used for inferring the distribution of the lesser sandeel (*Ammodytes marinus*) in the North Sea; (2) Using sediment data from the Geo-Seas database to examine the effects of sediment on the species composition in beam trawl samples in the Western English Channel; (3) Seabed characterization in shallow waters using multibeam backscatter data; and (4)

Revisiting the spatial distribution of EUNIS Level 3 North Sea habitats in view of Europe's Marine Strategy Framework Directive. Cases on terrain characterization included: (1) Terrain characterization in NE North Sea and the Skagerrak, as well as the northern part of Kattegat comprising Danish, Norwegian and Swedish water; (2) Submarine canyon system at the Celtic margin, offshore Ireland; and (3) Habitat and species mapping in sandbank environments, Belgian part of the North Sea.

3.4.1 References

Dolan, M., Thorsnes, T., Leth, J., Alhamdani, Z., Guinan, J., and Van Lancker, V. 2013. Standardisation and harmonisation in seabed habitat mapping: role and added value of geological data and information. Part B: Terrain characterisation. Deliverable 10.5. Geo-Seas Pan-European infrastructure for management of marine and ocean geological and geophysical data (EU Grant Agreement Number: 23895), 63 pp.

Stevenson, A., Kotilainen, A., Kaskela, A., Alanen, U., Asch, K., Schubert, C., van Heteren, S., van de Ven, T., Thorsnes, T., Verbruggen, K., Robinson, A., Guinan, J., Glaves, H., and the Project Team 2011. Final report EMODnet-Geology. Preparatory Actions for a European Marine Observation and Data Network. Lot No 2 – Geological data. **EC** Contract No. MARE/2008/03.

Stevenson, A., Kotilainen, A., Kaskela, A., Alanen, U., Asch, K., Schubert, C., van Heteren, S., van de Ven, T., Thorsnes, T., Verbruggen, K., Robinson, A., Guinan, J., Glaves, H., and the Project Team 2012. EMODnet-Geology Project Maintenance Report. Preparatory Actions for a European Marine Observation and Data Network. Lot No 2 – Geological data. EC Contract No. MARE/2008/03, 44 pp.

Van Lancker, V., and van Heteren, S. (eds.) 2013. Standardisation and harmonisation in seabed habitat mapping: role and added value of geological data and information. Part A: Sediment characterisation. Deliverable 10.5. Geo-Seas Pan-European infrastructure for management of marine and ocean geological and geophysical data (EU Grant Agreement Number: 23895), 100 pp.

4 National habitat mapping programmes (National Status Reports) – ToR b)

4.1 National programme report for Belgium

Vera Van Lancker (Royal Belgian Institute of Natural Sciences)

In 2012, integrated results became available from a process-based habitat mapping study along the delta front of the ebb tidal delta of the Westerschelde Estuary, Belgian and Dutch part of the North Sea (Van Lancker *et al.*, 2012, Van Lancker *et al.*, 2013). In this area, dredged material is disposed of at a regular basis, though in the far-field of it high abundances of some benthic species are found.

To understand variations in habitat and species distributions, fine-scale seabed mapping (<5 m resolution; e.g. surficial sediments, morphology and benthos) was conducted, together with measurements of currents and turbidity throughout 13-hrs cycles and with sediment transport modelling results. From the results, hypotheses were formulated stating that highest abundances of some ecosystem engineering species (e.g. the tubeworm *Owenia fusiformis*, and the razor clam *Ensis directus*) occurred near bedload convergence zones resulting from a mutually evasive flood- and ebb-dominant channel system. Such zones are at the end of the channels, hence also fine-grained sediments, food and larvae are trapped. The combination of the coarser-grained bedload with the deposition of fines is likely the optimum for a lot of suspension and detritus-feeders. Still, highest abundances occur at the fringes of such a system where stress levels are intermediate. Those insights are important to assess changes in seabed integrity and hydrographic conditions, two descriptors to define Good Environmental Status within Europe's Marine Strategy Framework Directive.

Hypotheses were successfully tested along the Dutch coastal-zone. Here, mapping was performed using very-high resolution multibeam technology (ship-borne Kongsberg Simrad EM3002, 300 KHz) and sidescan sonar (Marine Sonic 900 and 1800 kHz) mounted in an Autonomous Underwater Vehicle (AUV REMUS Hydroid 100, Belgian Navy).

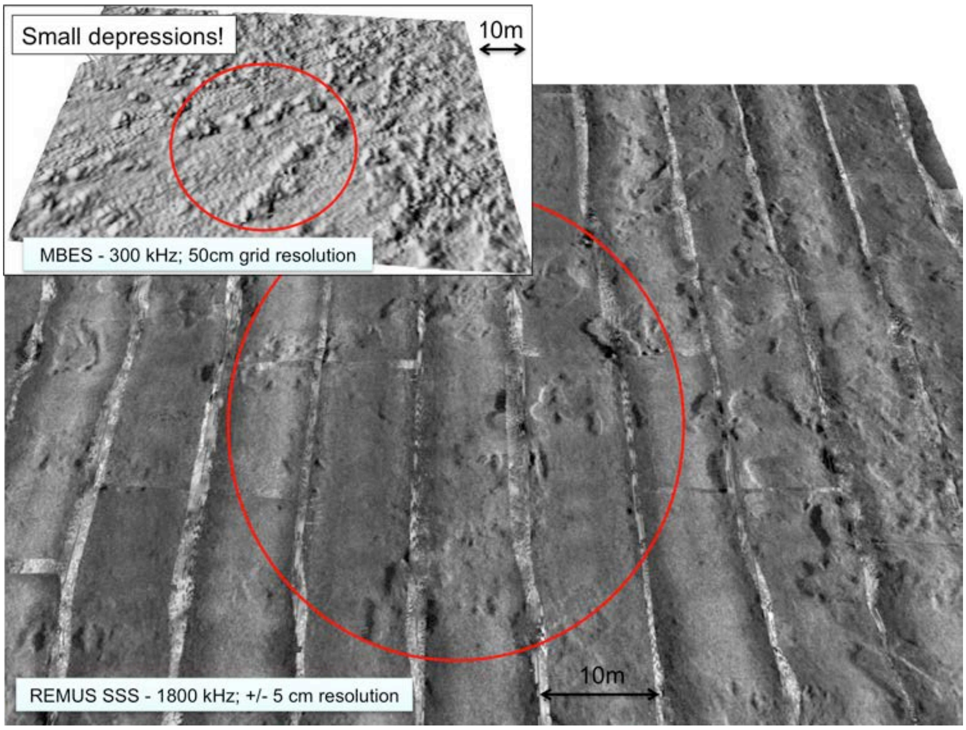


Figure 5. Visualization of bioturbated surfaces from shipborne multibeam bathymetry (300 kHz; upper left) and AUV-mounted sidescan sonar (1800 kHz). Analyses showed small depressions of 20-30 cm relief differences. It is hypothesized that these are caused by fluidization of the sediment, caused by burrowing of high densities of E. directus. Red circle is the common visualization area of multibeam and sidescan sonar (Van Lancker and Baeye, 2012).

In the period 2013–2017, habitat mapping approaches will be reviewed and refined within the Belgian Science Policy funded project **TILES** (Transnational and Integrated Long-term Marine Exploitation Strategies). TILES will provide tools for integrating, visualizing, analysing, and managing available geological marine data of the Belgian and southern Dutch part of the North Sea. A 3D geological voxel model (volume blocks of information) will be developed and coupled to 4D sediment dynamic process models. Advanced, easily adaptable multi-criteria evaluation techniques for the attributes of the 3D subsurface models will facilitate *a.o.* analyses and prediction of habitat extent and refine the input to habitat suitability modelling, a critical research data product assisting monitoring and management (e.g. EU Marine Strategy Framework Directive). Linked data on subsurface characteristics and natural and man-made sediment fluxes will support research on how human activities change the seabed sediment, alter the associated habitat extent and thus potentially deteriorate the integrity of the seabed.

4.1.1 References

Van Lancker, V., Houziaux, J. S., Baeye, M., Van den Eynde, D., Rabaut, M., Troost, K., Vermaas, T., van Dijk, T. A. G. P. 2013. Biogeomorphology in the field: bedforms and species, a mystic relationship. In: Van Lancker, V. and Garlan, T. (Eds). MARID 2013: Fourth International Conference on Marine and River Dune Dynamics. Bruges, Belgium, 15–17 April 2013. VLIZ Special Publication, 65: pp. 277–283. (http://www.vliz.be/imisdocs/publications/246049.pdf)

Van Lancker, V., Baeye, M., Du Four, I., Janssens, R., Rabaut, M., Legrand, S., and Van den Eynde, D. 2012. Annex 3. Long-term disposal of dredged material alters significantly prevailing hydrographic conditions? A discussion based on the Vlakte van de Raan, Belgian-

Dutch coastal zone. *In:* Van Lancker, V. *et al.* Quantification of erosion/sedimentation patterns to trace the natural versus anthropogenic sediment dynamics "QUEST4D": final report, Annexes. Brussels Belgian Science Policy Office, pp. 31–50. (http://www.belspo.be/belspo/ssd/science/Reports/QUEST4D_FinRep_Annexes_AD.pdf)

Van Lancker, V., and Baeye, M. 2012. Use of multibeam for the mapping of *shellfish beds* in the North Sea. Presentation at the IMARES Acoustics Workshop. Texel (NL), 5/9/2012.

4.2 National programme report for Denmark

4.2.1 Mapping of marine aggregates and nature types in the Danish Kattegat and Skagerrak and Western Baltic 2011

Thomas Kirk Sørensen (DTU Aqua)

English summary excerpted from the report: GEUS/ORBICON 2012. Marin råstof- og naturtypekortlægning I Kattegat og vestlige Østersø 2011. 452 p.

Available here: http://www.naturstyrelsen.dk/Udgivelser/Aarstal/2012/Kortlaegning_raastoffer_naturtyper.htm

Mapping of raw materials

"A consortium consisting of GEUS and Orbicon has in the summer of 2011 carried out a mapping of raw materials in the Kattegat, Great Belt region and western Baltic Sea region. The geophysical and biological surveys was initiated and funded by the Danish Nature Agency, partly in connection with an overall national mapping of raw materials and partly in connection with the implementation of the EU Sea Directive. The aim of the mapping of raw material was to provide an overview of locations, volumes and composition of available raw materials in the Kattegat, Great Belt region and western Baltic Sea region. The mapping of raw materials must be seen in the context of a long-term supply and extraction policy that secures offshore raw materials in an environmental sustainable way.

Raw materials were mapped using a combination of bathymetric profiling with echosounder, sidescan sonar mapping of the seabed surface, as well as shallow seismic mapping of geological units in the seabed. The acoustical data collection was followed by vibrocores for the purpose of sediment characterization and raw material quality evaluation. On the basis of acoustical interpretation of the seabed sediments, positions for biological verification with ROV (Remotely Operated Vehicle with video) and HAPS-sampling were selected.

The geological interpretation of the collected data are presented in a geological model that includes the Kattegat, Great Belt region and western Baltic Sea region. This model is used as a basis for an evaluation of potential areas with raw materials. The model shows that a number of stratigraphical units contains potential raw material from melt water deposits from the Weichselian glacier retreat to drowned coastal deposits and sand waves, of which some are still active.

The interpretation of seismic data are presented in two maps which presents the Holocene marine sand and gravel resource areas, exposed on the seabed (Map A 5.1) and the Pre- Holocene sand and gravel resource areas, partly super positioned by the Holocene resources (Map A 5.2). No full coverage maps are available, but line maps that are gridded in a 300 m wide zone along the survey lines, generally in a grid of 1 x 5 km.

To estimate volumes of the individual areas, overall maps of the thickness of the raw materials have been produced. The volumes are only guiding figures. In order to select potential inter-

esting areas for future detailed surveys for raw materials, it is advised to contact the Danish Nature Agency who is the administrator of marine raw materials.

In addition to potential raw materials, the geological units are closely linked to the seabed biotopes. The reporting of the geophysical data has been optimized by the use of a HTML report structure (http://www2.naturstyrelsen.dk/habitatkortlaegning/), which provides easy access to data. It offers the possibility to combine the presentation of map themes with line and point information on a digital map of the surveyed part of North Sea. A click on the different sample positions will give the reader access to acoustical examples, coring data and grain size analysis.

Mapping types of substrate and flora/fauna

The substrate- and nature type mapping was carried out for the Danish Nature Agency in the Danish part of Kattegat, the Great Belt region and the western Baltic Sea (Phase 1 and 2). The aim of the project was to collect basic information on seabed characteristics and biological parameters, to provide information about substrate- and nature types, to be used in the implementation of the EU Sea Directive and management of Natura 2000 areas in relation to the Habitat Directive.

In the summer of 2011, about 7000 line kilometres were surveyed with echosounder and sidescan sonar, as well as chirp and sparker (seismic instruments). The acoustic data has been used to interpret surface sediment composition, and has been verified visually by 355 ROV dives (Remotely Operated Vehicle) and 55 HAPS bottom samples. A further 550 line kilometers from an existing survey of the raw material mapping area Moselgrund (Orbicon 2009) has been incorporated into the data, including 60 ROV dives and 39 HAPS samples. By using this combination of surface sediment data, visual verification and bottom samples, the seabed sediment types have been classified and presented in a number of substrate type maps (maps A6.R1 – A6.Na18).

The geophysical data demonstrates a clear correlation between the distribution of seabed geological units and substrate types. It is therefore an example on how essential the understanding of the geological development of the seabed in Kattegat, the Belts and the western Baltic Sea, is in combination with present sediment transport patterns, as background information for nature type mapping.

The nature type mapping includes elements from the Natura 2000 classification defined by the EU Habitat Directive as well as the EUNIS classification constructed with the purpose of harmonizing habitat types across Europe. The classification types are both based on bottom substrate types, supplemented by information on morphology, depositional environment, salinity and light intensity as well as information on the floral and faunal communities, which inhabit the different substrate types.

In order to verify the floral and faunal communities, 22 supplementary previously verified localities within the study areas were included in addition to the 2011 surveys and the existing data from Moselgrund. In combination, this provided a verification foundation of 437 ROV dives and 94 HAPS samples. Based on these data, nature type maps and EUNIS maps which cover both phase 1 and 2 areas have been constructed.

Reporting of geophysical and biological data has been optimized by the use of an HTML report structure, which provides easy access to all data. It offers the possibility of combining presentations of map themes with line and point information on a digital map of the surveyed areas in the Danish part of Kattegat and the western Baltic Sea. A click on the various sample positions will give the reader access to acoustic examples, sediment data, video documentation and descriptions of flora and fauna."

Comments

Nature type mapping has resulted in several maps of Natura 2000 sites that deviate enormously from existing official maps based on anecdotal and historical data and knowledge. This fundamental development in the knowledge surrounding the precise locations of habitats represents a challenge to the Danish Ministry of Food, Agriculture and Fisheries who have been in the middle of a process of developing fisheries management plans for Natura 2000 sites, incl. proposed buffer zones and consultation with fishing industry representatives, NGO's etc.

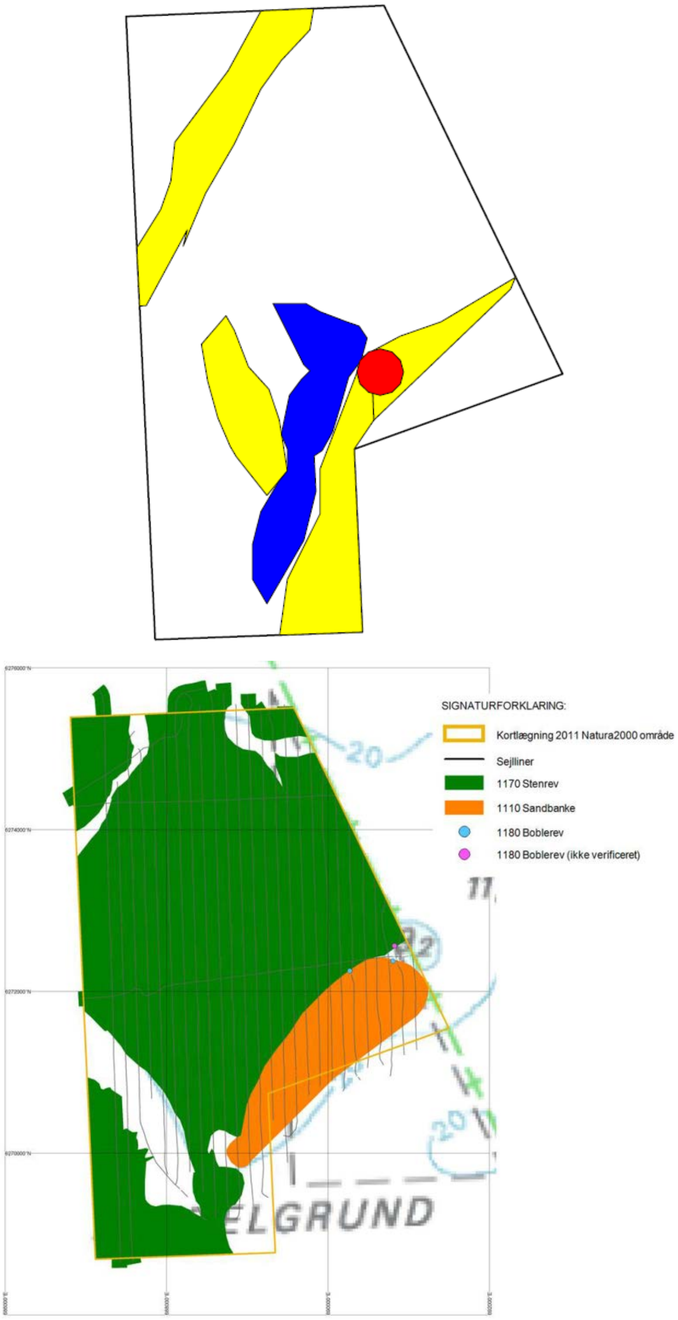


Figure 6. Danish Natura 2000 site Store Middelgrund. Left: old map of the site. Yellow: sandbanks; Blue: reefs; Red: "bubbling reef". Right: new map of the site. Green: reefs; Orange: sandbanks; Blue dot: "bubbling reef"; Pink: "bubbling reef" (not verified).

In addition, there has been some controversy surrounding a decision to only categorize a substrate type with scattered (<10%) boulders >10cm as “reefs” when directly adjacent to actual reefs consisting of substrate types with stones covering more than 25% of the area, i.e. when found in isolation the aforementioned substrate type is not considered to be “reef”.

4.2.2 Natura 2000 project – Denmark

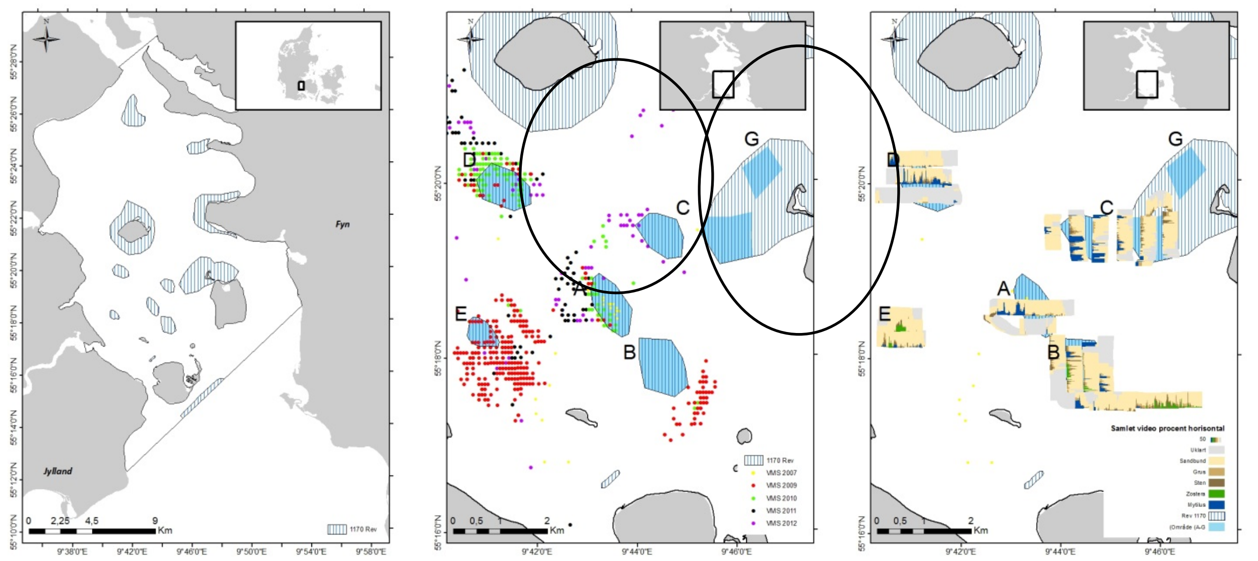
Kerstin Geitner (Technical University of Denmark)

The Danish project "Fisheries management in Nature 2000 areas" has the objective of building a knowledge foundation and the development of a concept for Environmental Impact Assessments of fisheries in Nature 2000 areas. In addition, the objective of the project is gaining knowledge of specific interactions between fisheries and the species/habitats protected by the Nature 2000 areas.

As a part of that project the following tasks were performed; 1) Mapping of the geographical distribution of reefs in the Nature Type Reef (1170) in the Little Belt, 2) Examination of the complexity of reefs in the area 3) Identification of possible fishing activity and exploitation of this habitat 4) Developing of analysis and methodology for habitat mapping with a combination of side scan, mapping with video and diving.

The individual reefs were mapped with different level of detail; with Sidescan sonar stones, macroalgae/eelgrass and trawl tracks were mapped, a video slide was used to monitor species and habitats. Fishing nets with different mesh sizes were used to investigate the fishing fauna and divers were used to conduct the density and the size of stones and occurrences of macroalgae.

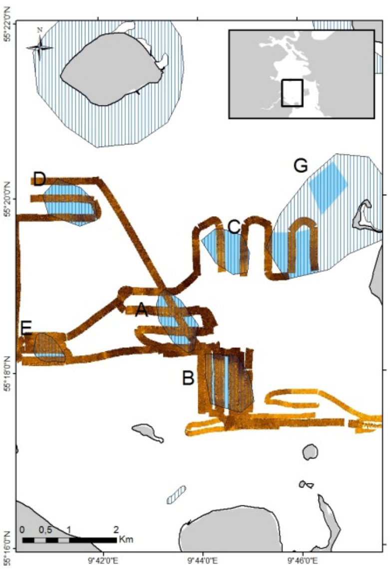
The study area is situated in the Natura 2000 area Little Belt in Denmark; see the map on the left below, with the nature type reefs symbolized in blue. With the help of VMS data for the fishing fleet, the areas investigated were divided into two groups, one where fishing has taken place during recent years (D+E) and one where no fishing has occurred (G+B; see the map in the middle below).

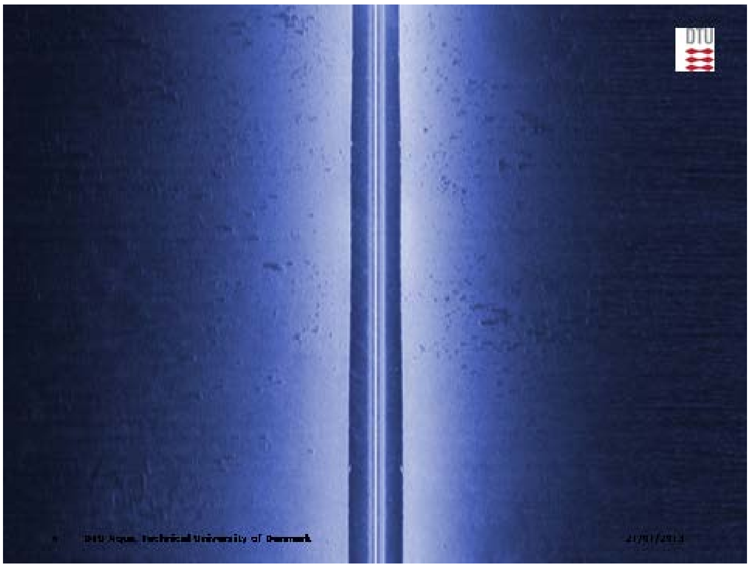


Results

The map to the right above shows the results of the video monitoring. The different colors symbolize percentages of sandy bottom (light brown), gravel (brown), stones (dark brown), eelgrass (green), blue mussels (blue) and cloudy (grey).

The map on the left below shows the area that has been monitored with sidescan sonar, the right shows a waterfall picture of the sediment where stones can be detected.





Other results show that the occurrence of stones and boulders is much lower in the reef areas that have been exposed to fishing, compared to the areas where no fishing has occurred. Red algae clearly dominate stones up to 25 cm, whereas both red and brown algae are found on rocks between 25 and 45 cm while brown algae dominate the largest of the stones.

Conclusions

In the period 2005–2012 fishing occurred to greater or lesser degree within the reef habitat. Stones were observed in 6–52% of the reef habitat while mussels were observed in 6-43%. Eelgrass was observed in 0–29%. There was a significant variation in habitat and fish fauna between the individual reefs. Less density of rocks and stones occurred in fished areas compared to not fished areas. A clear dominance of red algae was found on smaller stones while brown algae dominated large stones. A possibility to increase the quality of the reefs in the Little Belt would be habitat restoration.

4.3 National programme report for France

Jacques Populus (Ifremer)

The EUSeaMap broad-scale map concept was adapted in a French context and taken to a higher resolution of 100m enabled by the general availability of depth and substrate map to this scale (see historic substrate maps below). However, as this resolution is not reached everywhere, a confidence map was produced to advise the user on the local quality of the map. This map was used as background information by the consultants who produced the Cartham map (Natura, 2000) reported below (Figure 7). The figure illustrates the two sets of EUNIS codes relevant in the Atlantic and Mediterranean.

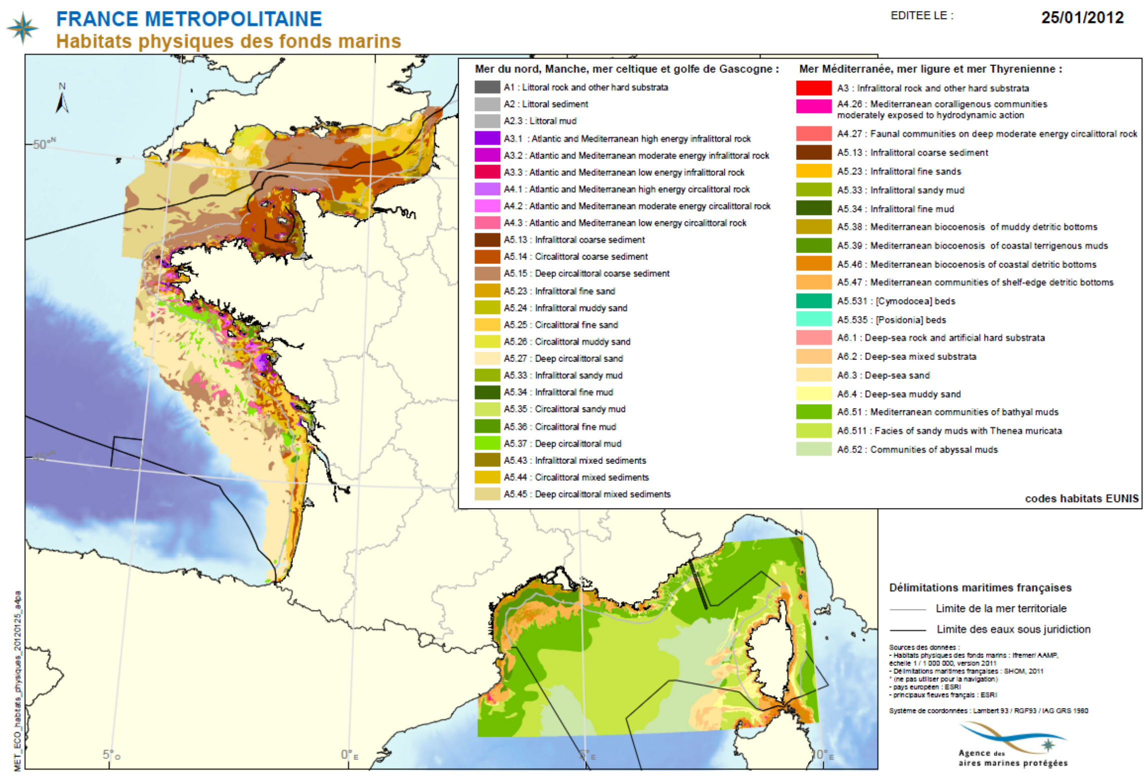


Figure 7. Distribution of seabed habitats in the French metropolitan area.

The Natura 2000 Cartham initiative

The main event in 2012 was the start of the delivery (also extending in 2013) of the 2009-launched Cartham results. This 7M€ mapping project managed by the MPA Agency had the ambition of catching up with Habitat Directive reporting obligations because France had got a lot of ground to make up on this front. There were 20 lots summarizing the 66 Natura 2000 sites (Figure 8, left) and covering 20000 km² in total.

Figures for the ratio of acoustic coverage are not known yet but it is anticipated that this ratio will be very low and that only a few small sites could be comprehensively covered with acoustics. In the case of the big sites – the majority of them - contractors mostly resorted to sampling and observing the seabed with video. The total figures for the Atlantic and English Channel are the following: for the subtidal 2635 "stations" broken down into 362 grabs, 1050 trawls and dredges, 143 dives, 1080 video frames, plus 6820 intertidal observations.

Map delivery can be checked at:

http://cartographie.aires-marines.fr/?q=node/43

It is expected that the habitat maps and point habitat data will be fully quality checked and stored on this site within a couple of years.

On top of the Natura 2000 Cartham project, there is another initiative – in Brittany only – called Rebent that has delivered two habitat maps over the period, one for Baie de Morlaix and the other for Les Abers in north Brittany. Another two maps are expected in 2013 before this programme draws to a close after being up and running for seven years. To view all the maps collated or made during the Rebent programme see http://www.rebent.org/cartographie/index.php.

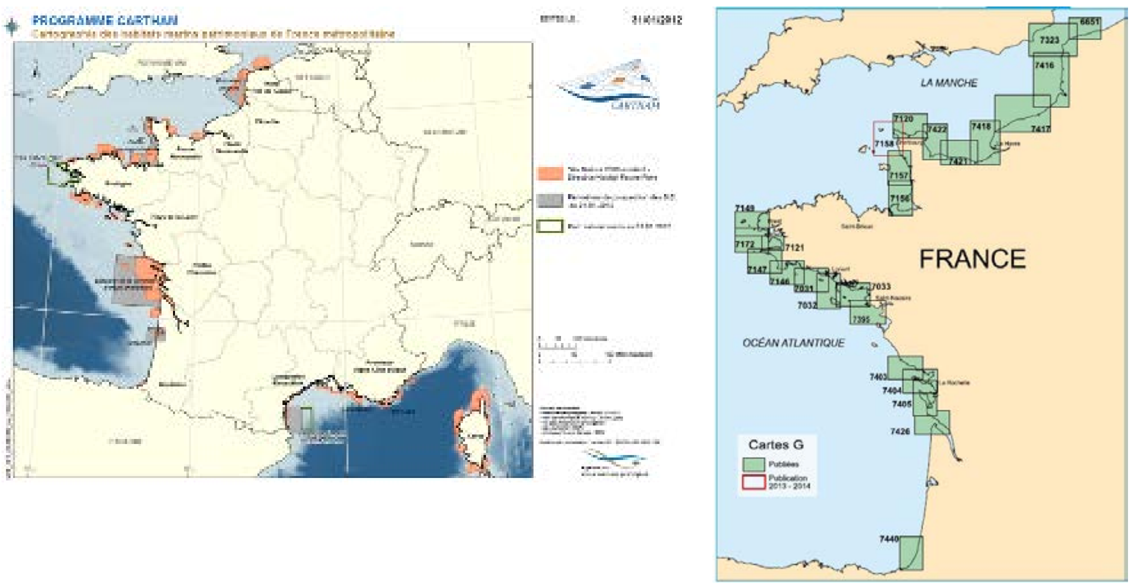


Figure 8. Left, Cartham (Natura 2000) sites; Right, status of seabed substrate maps at French SHOM.

Publication of historic substrate maps

We report here on the progress with substrate maps (cartes G) series produced by the French hydrographic office SHOM because they are a key product for the seabed mapping community. On one hand they provide us with ancillary data when it comes to scoping the work for detailed habitat mapping. On the other hand they contribute to producing a continuous seabed substrate layer used in broad-scale modelling. In particular, they enabled us to refine the EUSeaMap concept to a resolution of 100m for French coastal waters. It can be seen on the figure above that from year-to-year the coverage of these maps slowly comes to completion; with two important blocks needing additional efforts (North Brittany and Languedoc).

4.4 National programme report for Germany

Roland Pesch (University of Vechta)

4.4.1 Mapping and Registration of marine Biotopes in Germany's Exclusive Economic Zones

In order to meet the requirements of environmental policy in marine offshore areas benthic biotope maps are needed. Such maps should enable to sufficiently describe benthic biotopes of the German Exclusive Economic Zones (EEZ) in the Baltic and the North Sea in terms of abiotic and biotic characteristics. Hence, the German Federal

Agency of Nature Conservation has started a project in 2012 aiming at mapping biotope maps in Germany's EEZ areas by use of empirical data on benthic species and sediments as well as on bathymetry, geomorphology and other information relevant to benthic biology. The project comprises of four phases. Within the first phase the ten marine protected areas according to the EU Habitats Directive are to be mapped until the end of 2014. The biotope mapping is to be done according to classification criteria given by the Red List Biotopes by Riecken *et al.* (2006), EUNIS and mapping recommendations regarding three §30 biotopes[1]. Another goal is to extend the given classification systems in terms of additional biological classification levels.

The project is subdivided into two subprojects A and B. Subproject A thereby focuses on the biological investigations, the data management and the biotope mapping and is carried out by the University of Vechta (Coordination, Data administration, Biotope modelling), the Leibniz Institute for Baltic Sea Research, Warnemünde (Benthic sampling Baltic Sea) and the company Bioconsult (Benthic Sampling North Sea). Subproject B aims at the sedimentological mapping by use of hydroacoustical data and is performed by the Federal Maritime and Hydrographic Agency of Germany, Hamburg, in cooperation with the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research Bremerhaven, the Institute of Geosciences, Christian Albrechts-University of Kiel and Senckenberg by the Sea, Wilhelmshaven.

Since the beginning of the project hydroacoustical and benthic biological investigations were performed in the Natura 2000 sites *Sylter Außenriff* und *Borkum-Riffgrund* (North Sea), as well as *Fehmarnbelt* und *Kadetrinne* (Baltic Sea). The biological sampling was done by use of a 10 km x 10 km raster. Further abiotic and benthic biological geodata were acquired and integrated into a GIS registry *Biotope Mapping*, holding all relevant information regarding biotopes in the German North and Baltic Sea. Regarding the Baltic Sea additional EUNIS level 5 and 6 were applied on the available benthic data by use of a draft version of a modified EUNIS classification for the Baltic Sea. Regarding the North Sea a concept was developed enabling to structure given regions regarding their benthic biological environment. The concept depends on statistical modelling techniques and was applied on data coming from environmental impact studies regarding the installation of offshore windfarms in terms of a pilot project. In the near future, the concept developed will be applied on data available for Natura 2000 sites and for regions identified as EUNIS habitats down to level 4. In this way, the extension of EUNIS in terms of additional biological classification levels may be assisted.

4.4.2 Red List of biotopes

For nature conservation in Germany, marine biotopes are to be classified according to the German Red List of Biotopes developed by Riecken *et al.* (2006). The red list comprises both threatened and unthreatened biotopes and is the basis for biotope mapping and legal biotope protection in the German North and Baltic Sea. Generally, protected marine biotopes as in § 30 of the German Nature Protection Law are derived from this list. Further, it informs which biotopes are considered to equal or be part of the Habitats Directive's Annex I natural habitat types. In Riecken *et al.* (2006) marine biotopes are grouped according to bathymetry and the distance to the coastline. In a second step these are furthermore differentiated with respect to the sedi-

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[1] *legally protected biotopes according to §30 of the Germany's Federal Nature Conservation Act (BNatSchG)*

ment compositions and (where possible) representative species. Bioconsult (2010) tried to map the marine biotopes for the entire German North Sea and Baltic Sea. One important result is that in many cases there is not enough data available in order to map more than the highest hierarchical level of the classified red listed biotope types.

4.4.3 References

BioConsult. Marine Landschaftstypen der deutschen Nord- und Ostsee. F+E-Vorhaben im Auftrag des Bundesamtes für Naturschutz (BfN), FKZ: 3507 85 080. Bremen; 2010.

Riecken, U., Finck, P., Raths, U., Schröder, E., Ssymank, A. **Rote Liste der gefährdeten Biotoptypen Deutschlands. Zweite fortgeschriebene Fassung.** In Na Bi V **34**. Edited by Bundesamt für Naturschutz. Bonn; 2006:318.

4.5 4.5 National report for the Netherlands

Jan van Dalfsen (Deltares), Jeroen Wijsman (IMARES), and Narangerel Davaasuren (IMARES)

4.5.1 Habitat mapping in the Dutch Wadden Sea

a) Development of twelve individual intertidal mussel beds

In the governmental research project WOT-IN a study is included on the long-term development of mussel beds and factors that influence the survival of these beds. For this purpose IMARES studies twelve individual beds, three of these are followed since 1997, one since 1998, two since 2002, one bed since 2003 and five since 2006. The contours of these mussel beds are mapped every year to document the location, size and yearly changes in mussel cover. Besides these basic measurements also data on the characteristics of the mussel beds is collected. The size classes and biomass of the mussels, the percentage of other organisms living on the bed and the sediment are measured.

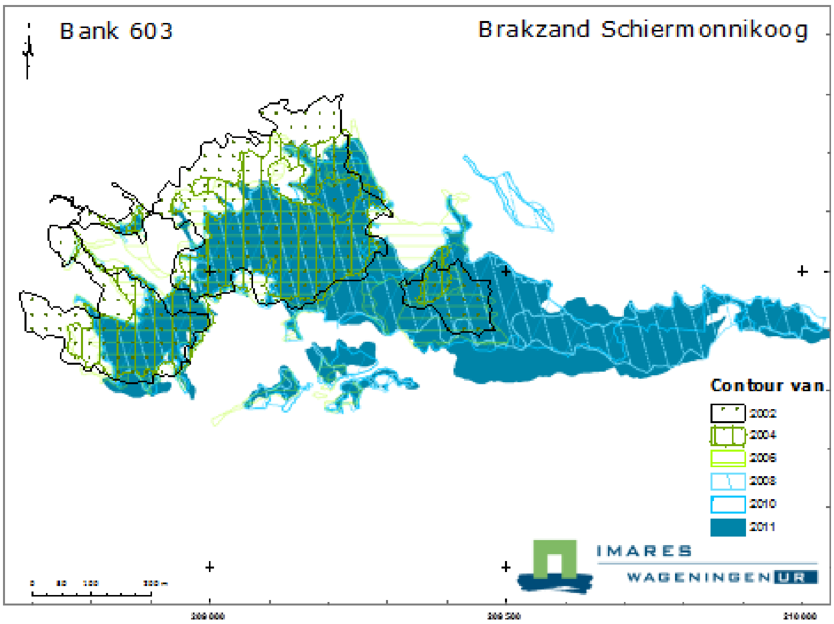


Figure 8. Location of twelve individual intertidal mussel beds in the Dutch Wadden Sea.

b) Mapping of intertidal flats and mussel and oyster beds

It is the yearly project since 1997 is to map the several individual intertidal mussel beds (Reference: Development of selected mussel beds in the Dutch Waddenzee; situation 2011, Frouke Fey, Norbert Dankers, André Meijboom, Piet-Wim van Leeuwen, Martin de Jong, Elze Dijkman en Jenny Cremer. IMARES report C101.11).

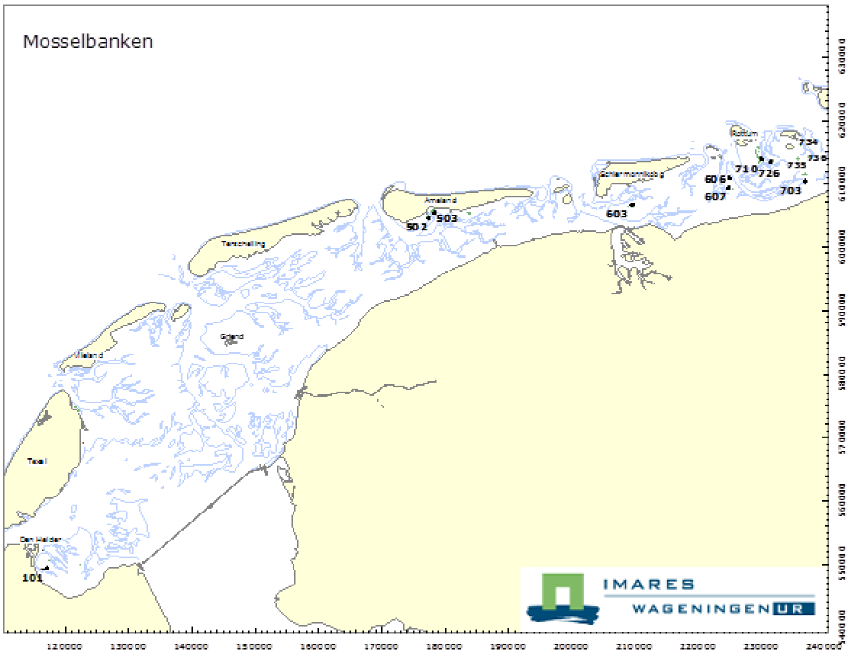


Figure 9. Mapped location of mussel beds around Ameland, Schiermonnikoog and Rottumerplaat.

c) Effects of fisheries in protected areas (VIBEG) project

A spatial zoning of fishing activities has been implemented in the Dutch Wadden Sea, the Natura 2000 areas (co-called 'VIBEG-agreement', acronym in Dutch, which translates to Fishing in Protected Areas), to evaluate and to facilitate the nature protection and impact from fishing activities. The project will end in 2018 and before its end; the project will deliver the scientific expertise and knowledge required for such assessment.

The map below shows the average number of Mollusc species (mainly bivalves) encountered in benthic dredge samples taken as part of the WOT Shellfish-survey (years covered 2006-2012). As such this is a picture of shellfish biodiversity along the Dutch coast. The coloured area shows (roughly) how far out to sea the sampling program stretches. The designated zones are:

- Zone I- fully closed for fisheries,
- Zone II- closed for bottom-touching fisheries gears,
- Zone III- only open to 'innovative' gears and
- Zone IV- no restrictions.

Innovative gear has a relation with Best Available Technology (BAT), but no present and clear definition of what might qualify for access to zone III. Across the zones IMARES is involved with monitoring the changes (or lack thereof) that are expected to develop over the next years. The ViBEG-zones were made official, legally came into force, on 29-04-2013 when they were published in the 'Staatscourant'.

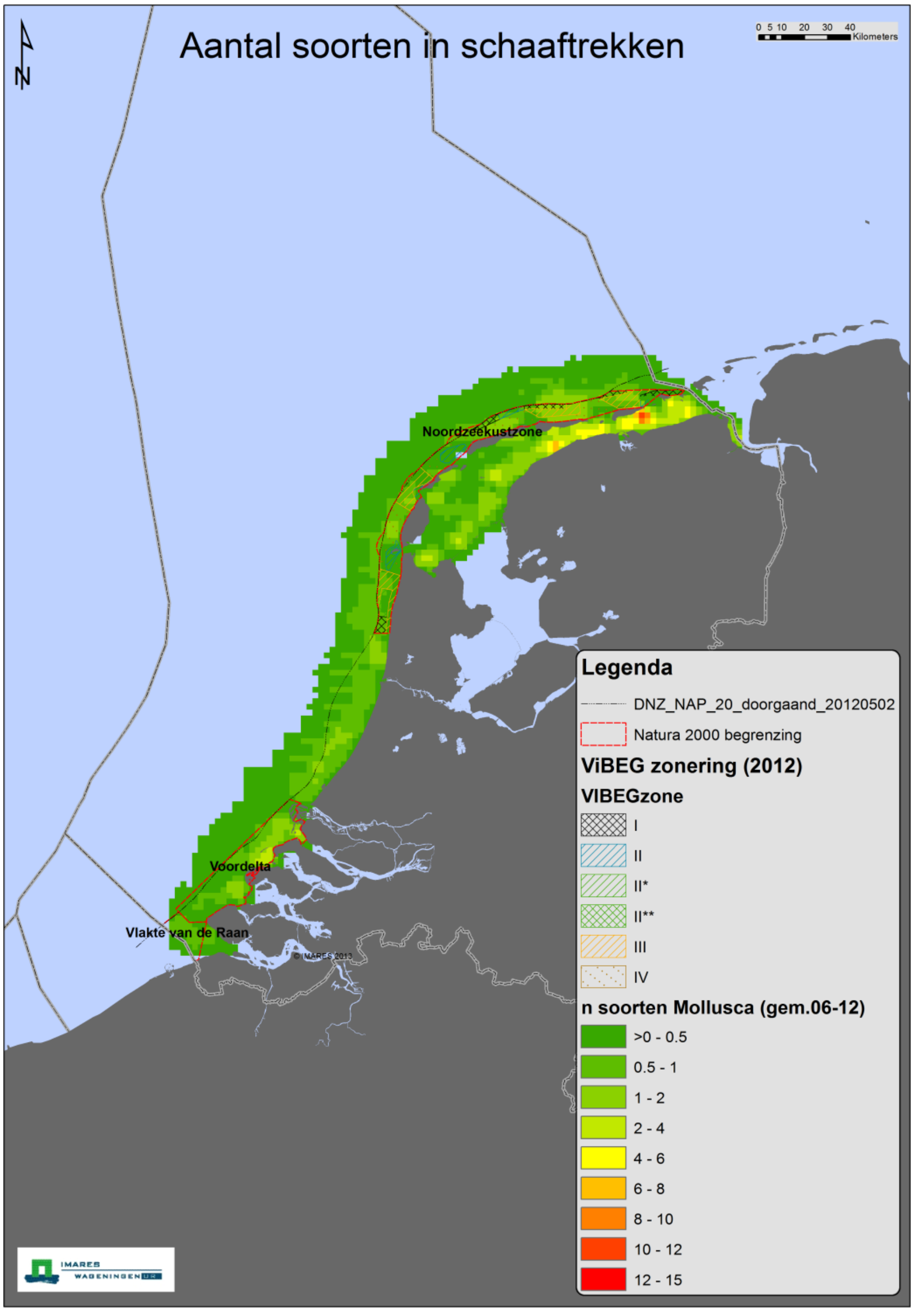


Figure 10. The average number of Mollusc species (mainly bivalves) encountered in benthic dredge samples taken as part of the WOT Shellfish-survey (years covered 2006–2012).

d) Development of automated tools for detailed monitoring of mussel and oyster beds using satellite data: spatial, temporal and vertical development.

The main focus of this research is to develop the application of a novel technique in mapping of mussel and oyster beds using remote sensing, which can be combined this with regular field monitoring to obtain an optimal monitoring strategy. Intertidal areas between Ameland, Schiermonnikoog and the main land were selected for a study to optimize classification of mussel and oyster beds from satellite images and to search for techniques to determine the elevation of mussel and oyster beds from satellite images and to detect changes over time (Reference: IMARES report, 2012, KB-14-005-025).

The classification followed the steps: first- atmospheric correction of FORMOSAT-2 image; second- using IMARES survey data identification of known location of mussel and oyster beds, by overlaying the shape file from the field survey into satellite image; third– choosing the classification parameters, such as the probability filter (selecting from known location the spectral property, color and shape of the objects identified as mussel and oyster beds). Finally, doing the classification – segmenting the image, using the selected classification parameters. The result from classification is shape file, showing the location of the mussel and oyster beds (Figure 11).

Figure 11. Shape file of mussel and oyster beds (red polygons) classified using Imagine Objective tool on FORMOSAT-2 image, date of acquisition 08 August 2012.

The project proposed design of mussel classification tool (IMuCT), integrated in ArcGIS (Figure 12).

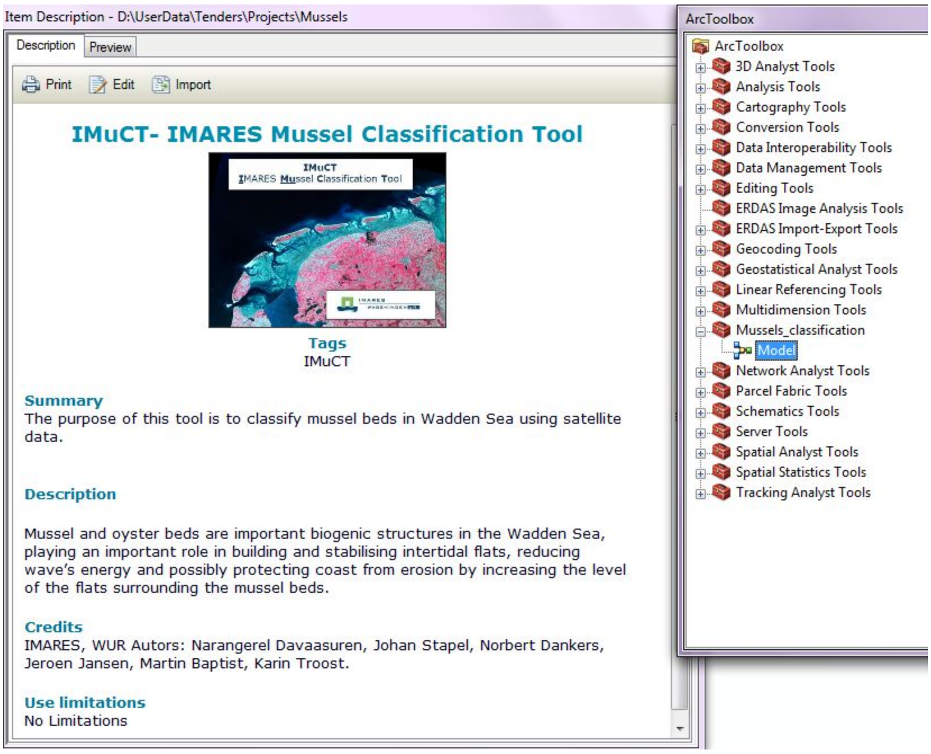


Figure 12. Proposal on mussel classification tool (IMuCT), integrated in ArcGIS.

e) KBWOT 2012: the use of an acoustic technique in mapping beds of razor clams (Ensis sp.)

Acoustic techniques are increasingly applied for seabed mapping and optimum allocation techniques for stock assessments. In the framework of the Belgian Science Policy project EnSIS multibeam technology was successfully used to find an acoustic signal representative of dense Ensis sp. aggregations in Belgian waters. For the survey of shellfish in the Dutch coastal zone (WOT Ensis), a fixed stratified sampling grid is used. Stratification is based on expectation of occurrence, for which previously observations by Spisula fishers were used. Spisula subtruncata has largely disappeared and was replaced by Ensis sp.

However, the stratified sampling grid is still mainly based on expected occurrence of Spisula. The quality of the data would be improved with an entirely independent basis for the stratification. An improved accuracy of stratified sampling grids will increase the efficiency of the WOT surveys and will also increase the confidence level of stock assessments. This will benefit management of shellfish stocks and fishery and will also enhance the reliability of environmental impact assessment studies (Reference: KB-14-012-020).

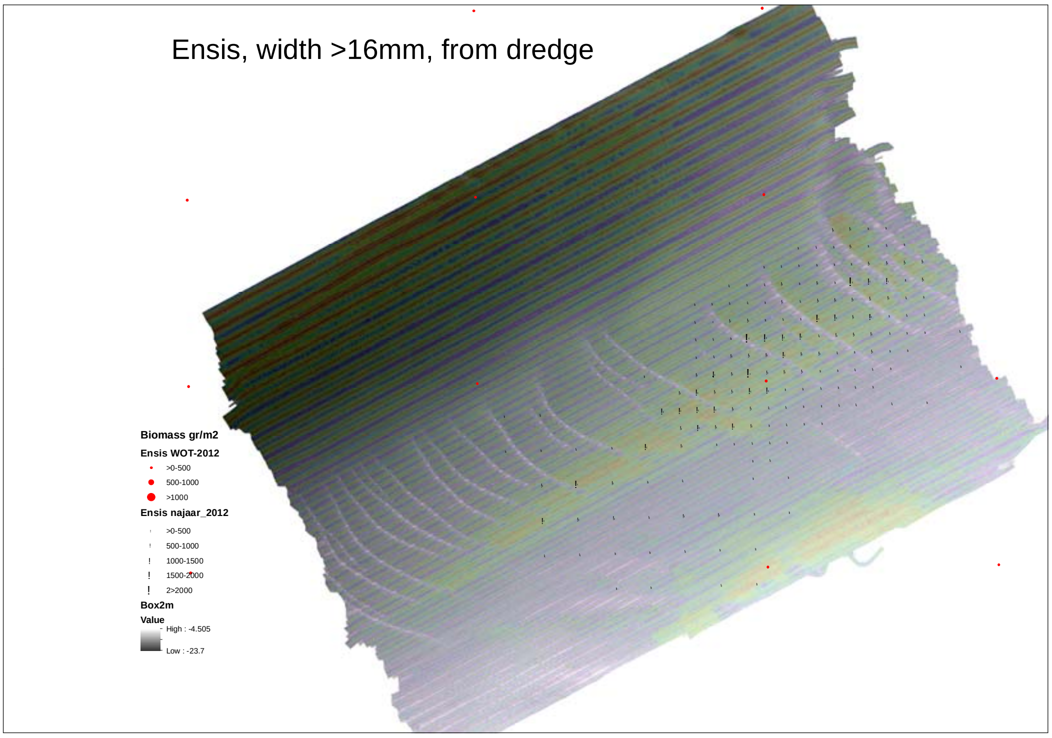


Figure 13. Distribution of large Ensis (width>16 mm), sampled by towed bottom dredge, projected on a combined map of depth (m) and backscatter (dB).

f) High resolution Worldview-2 satellite data for classification of oyster/mussel beds and coastal change detection around Schiermonnikoog and Rottum islands

The study area covered by WorldView-2 images includes the Frisian (Dongeradeel) and northwestern part of the province of Groningen, adjoining the Wadden Sea, partly including Schiermonnikoog and Rottum islands (Figure 14). The image acquired on July 21, 2006 covers Frisian Dongeradeel and northeast of Groningen, De Marne (Reference: 2012, scientific paper under submission).

Supervised classification of sediments showed good separation sediments in high water (mud, mix of sand and mud, sand and sand mix) and lower water (sand and coastal land; Figure 14). The training areas were collected from field data. The classification followed Parallelepiped non-parametric and Maximum Likelihood parametric rule. The separation of sediments was distinct because of tone, content of water and silt, mud and sand, size (areas) and association (located along the islands and close to the shore line; Figure 15).

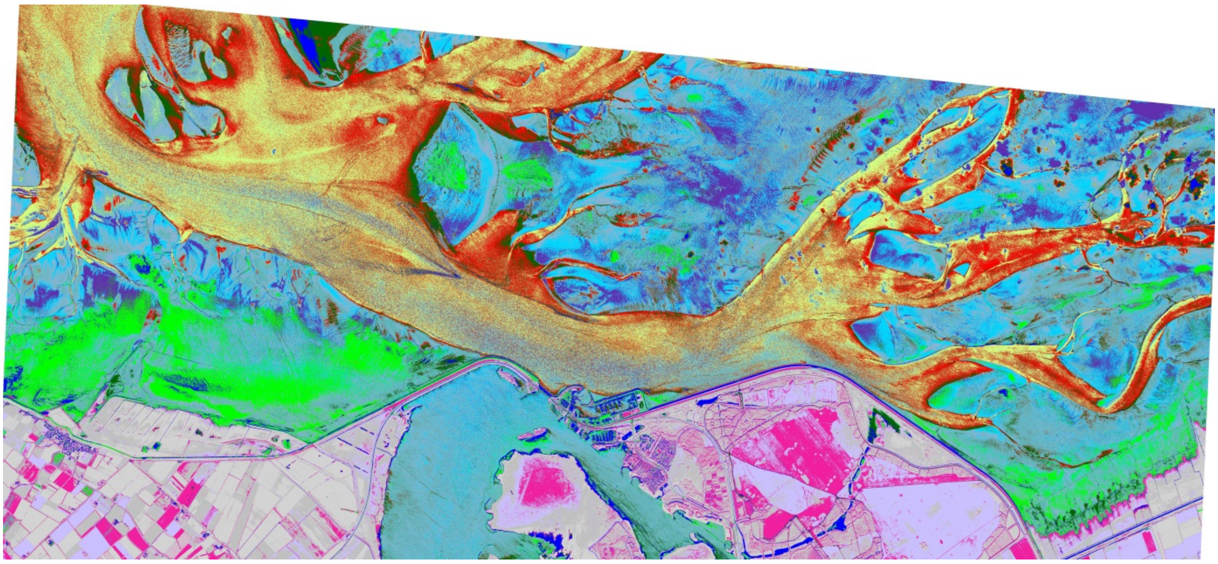
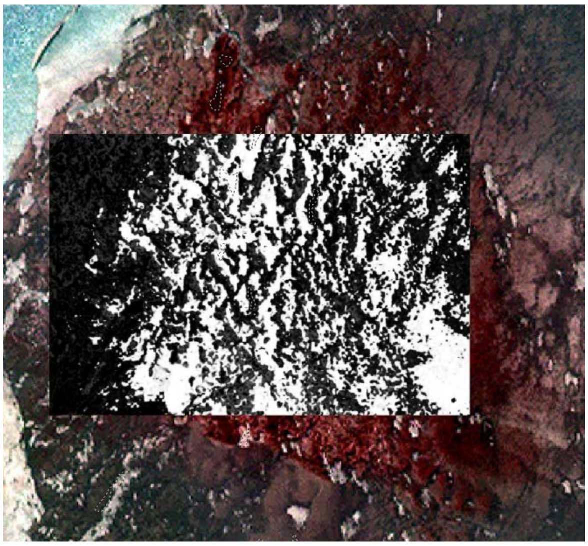


Figure 14. Supervised classification of sediments, image from 21 July 2006.

Color	Class_Names	Area
	Unclassified	1230.96
	Coastal land	171.36
	Dry land	166.281
	Mussel/oyster beds	715.273
	Mixed mud	793.04
	Sand	1409.82
	Sand mix1	1645.15
	Sand mix2	1382.3
	Shallow water	1830.02
	Deep water	1371.59
	Sand mud mix	490.28
	Mud1	61.0404
	Coastal land2	315.174
	Coastal land3	661.377
	Coastal land4	779.58
	Clastal land5	645.646

Figure 15. Legend of classified image. Area of classified features in hectares.

Classification of mussel/oyster beds followed Object Oriented Image Analysis from Imagine Objective module. The spectral signatures of the mussel/oyster beds identified using in-situ data, and generated by Pixel Probability Layer. The computation of NDVI index to detect mussel/oyster beds not covered by macrophytes was not very useful, as it is mainly indicated vegetation on the coast and according to field data there are not much mussel beds covered by macrophytes in this area (Figure 14).



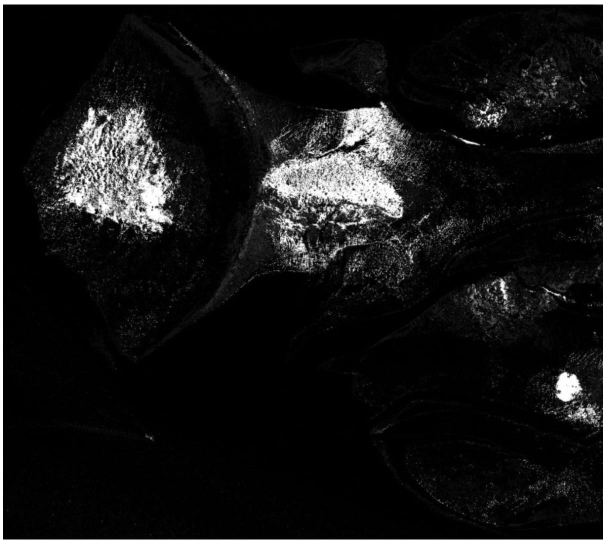


Figure 16. Multi-spectral image with Single Feature Probability (SFP), black and white (right), image with computed probability metric (left).

g) PRODUS (2008– 2012)

In this project the carrying capacity of the benthic ecosystem of the Wadden Sea is investigated to assess the possible impacts of the installation of seed mussel collectors (SMC). Studies on sub tidal mussel beds are laborious as the object of study is situated underwater. The PRODUS project (dp 3: sub tidal nature values) studies the effects of mussel seed fisheries on the development of sub tidal mussel beds. Sidescan sonar and imaging is used to reveal bed structure, mussel distribution and mussel bed contours in research plots. The project successfully completed in end 2012, and results communicated to stakeholders, and scientific community.

h) Mussel seed and cockle survey

Annual mapping of sublittoral beds is conducted in the Wadden Sea to locate and estimate the total stock of sublittoral seed mussels. The information is used to make a management plan for the fishery on seed mussels. Development of littoral mussel beds is followed over the years. Mapping of the beds is done with GPS. Also a yearly the cockle stocks at intertidal areas in the Wadden Sea and Delta area are investigated based on ground-truthing information. From the data the total stocks are calculated.

4.5.2 abitat mapping in the North and European seas, Dutch experience

a) Suitability mapping for aquaculture

COEXIST is an EU FP7 Framework project that uses a broad multidisciplinary approach to evaluate interactions between competing activities and protection in the coastal area, focusing on fisheries and aquaculture in particular. COEXIST consists of thirteen European countries, coordinated by the Norwegian Institute of Marine Research and is funded by the European Commission Seventh Framework Programme (COEXIST 2011). The project has been divided into a number of work packages.

The six Case Studies of the project are dealing with marine areas in the Hardangerfjord of Norway, the Atlantic Coast of Ireland and France, the Algarve coast of Portugal, the Adriatic Sea of Italy, the coastal North Sea of the Netherlands, Germany, Denmark and the Baltic Sea of Finland.

The objective of suitability mapping for aquaculture is to produce map(s) of Europe showing which coastal areas (marine ecosystems) are, based on physical characteristics, suitable for different aquaculture activities. The suitability maps presented in this report show the suitability of areas for selected species, in three categories:

- Highly suitable for the species of interest for aquaculture or
- Moderately suitable and or
- Not suitable.

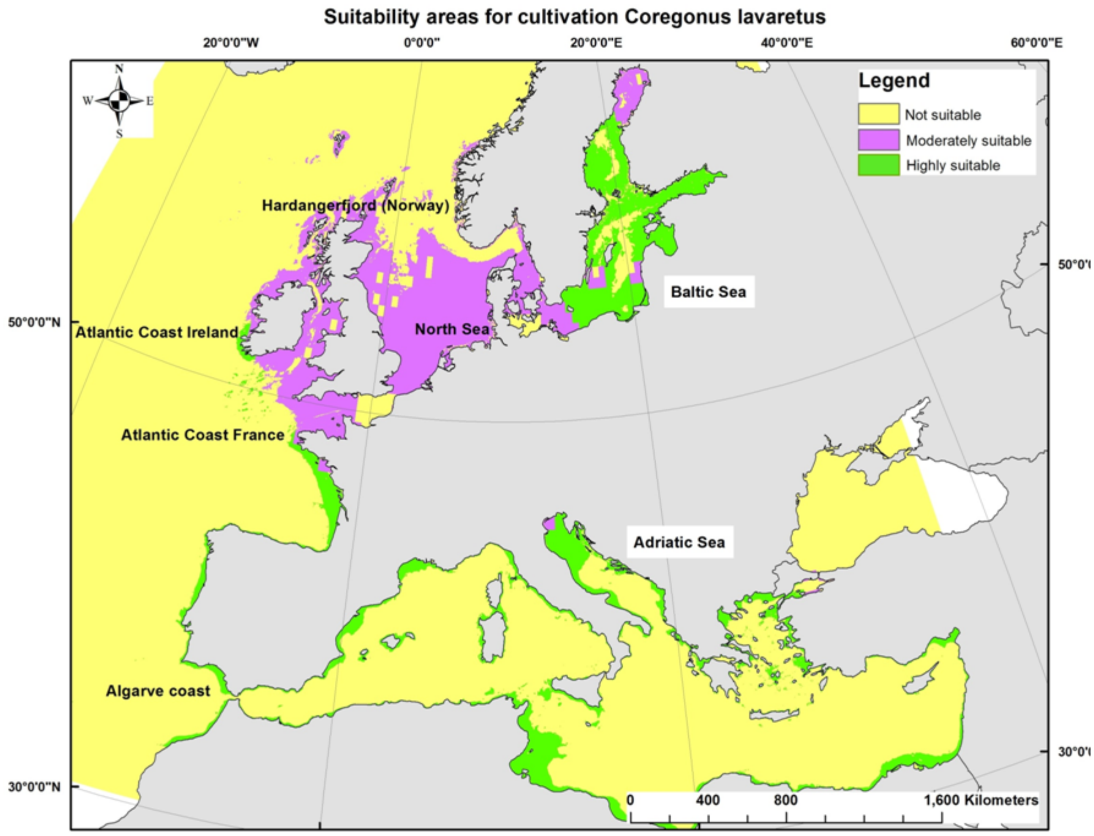


Figure 17. Suitability of areas for cultivation of Coregonus lavaretus, European white fish. (Reference: Project number: 245178, Deliverable D1.4).

b) Annual Shellfish monitoring Dutch coastal zone

Surveys of marine shellfish communities are performed as part of annual monitoring programmes as well as part of projects. Yearly surveys on the shellfish community are performed in the Dutch coastal zone. Altogether about 800 locations are visited and sampled yearly.

c) Mapping of Ecosystems and their Services in the EU and its Member States (MESEU)

Period: 2012-2013. Contractor Alterra. Involved parties: Alterra, IMARES, CEH, UAM, INBO, FUND P, Utrecht, EAA, ETH-Zurich, ECNC.

The aim of this project is to map and to access the state of the ecosystems and their services in EU member states, using the studies and work already undertaken at EU member states and Member State levels. The main objective of the project is to make cross linkage between national/subnational assessments and the work carried out at EU level.

Some examples are presented below such as Natura 2000 species map Oystercatcher (Figure 18) and Ecosystem services Recreation map (Figure 19).

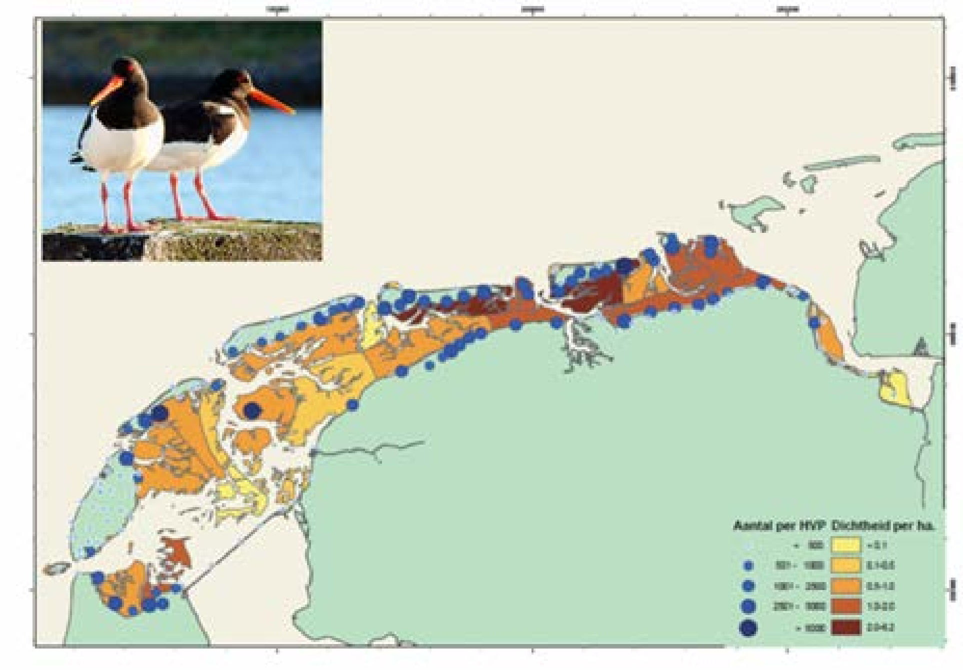


Figure 18. Natura 2000 species map Oystercatcher Wadden Sea.

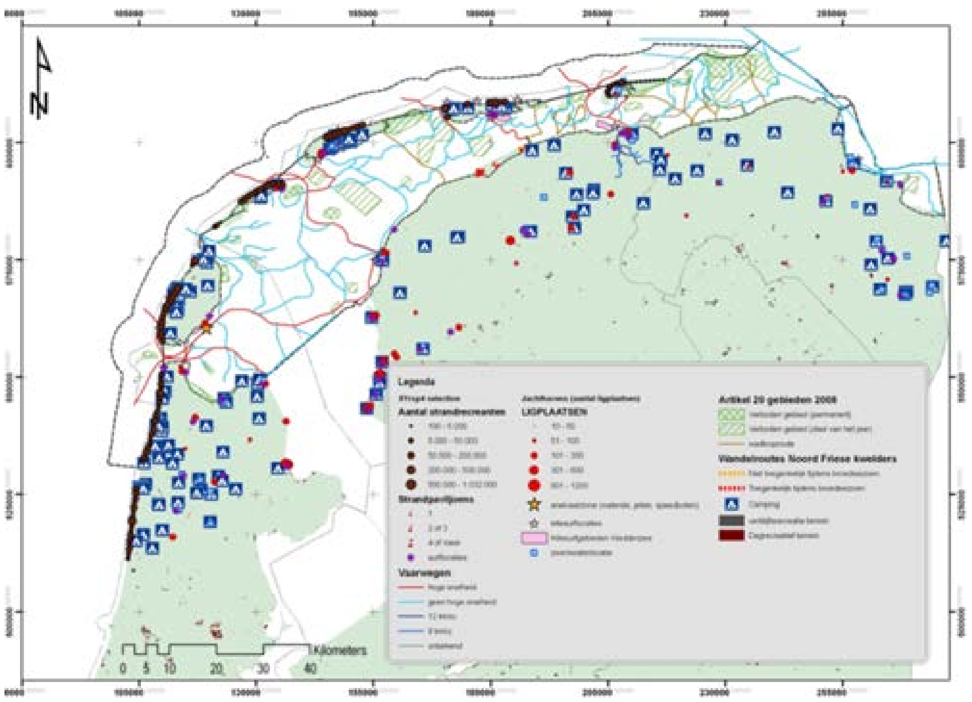


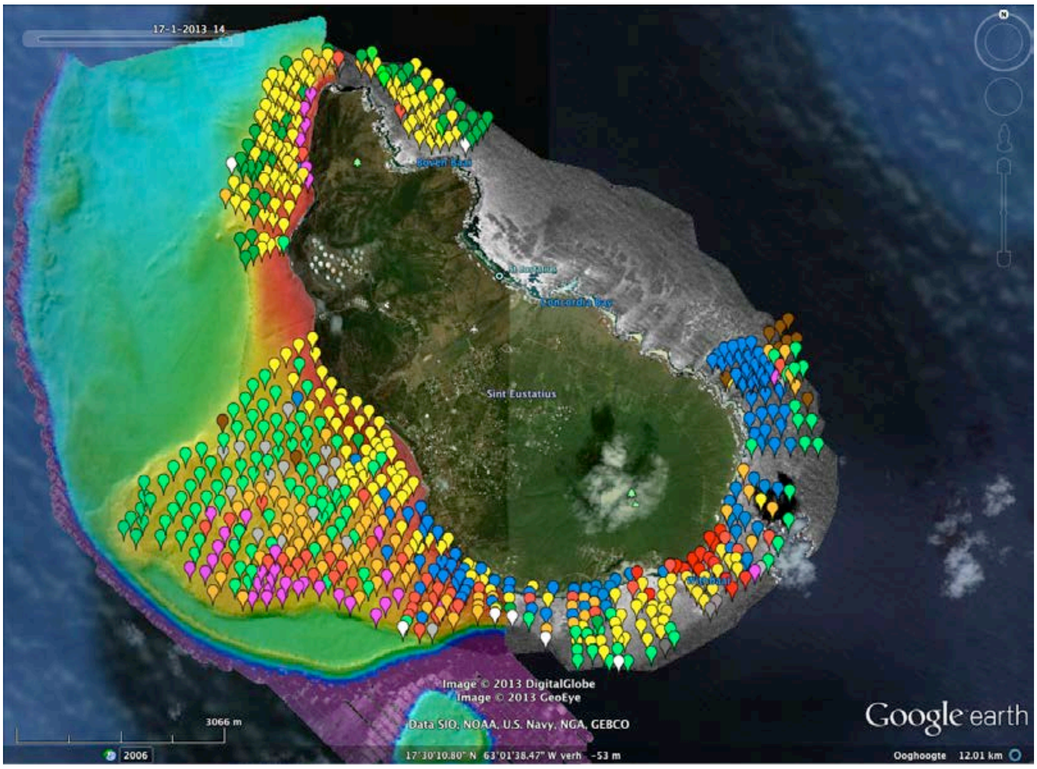
Figure 19. Ecosystem services Recreation map Wadden Sea.

4.5.3 Habitat mapping -Special case: Caribbean Netherlands

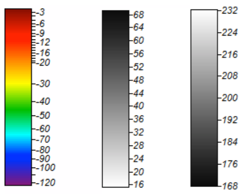
The Caribbean Netherlands refers to a group of three islands that became special municipalities of the Netherlands in October 2010 and are located in the Caribbean Sea: the islands of Bonaire, Sint Eustatius, and Saba, which are also known as the BES islands. Having this special status within the Netherlands there is also a responsibility to maintain or improve among others the nature status of these islands for which the Ministries of Economic Affairs and Infrastructure and Environment have started research.

a) Benthic habitat mapping in the coastal waters of St. Eustatius (2013)

The coastal waters of St. Eustatius are a pristine area with regards to research. Therefore a baseline study was done on the benthic habitats of the coastal waters of St. Eustatius. Similar research has been carried out in the Spaanse Water at Curaçao and in Lac Bay at Bonaire.



Colored dots respectively: sand; rubble; reef 0-33%, reef 33-66%; reef 66-100%, gorgonian reef; algal fields; *Sargassum* sp. and seagrass.



A B C

Legend for depth map:

A = Depth (meter)
B = Analytical Hill shading
C = Calculation [g1/g2]

Figure 20. Benthic habitat en depth map of the coastal waters around St. Eustatius.

The work showed that there are distinct areas with a number of different benthic habitats around the island. This seems predominantly be steered by the prevailing Eastern trade winds, which creates a windward and a leeward side. The wind also affects the wave direction, so that in this way there is also an exposed and protected side of St. Eustatius.

In terms of species composition, rubble habitat is quite diverse, although reef habitat has the highest species richness. The seagrass habitat is poor in the number of species, but the total biotic coverage percentage per 1m2 can be high for the seagrass species.

b) Extent and health of mangroves in Lac Bay Bonaire using high resolution satellite data

The project employed high resolution Worldview-2 (2 meters) and RapidEye (5 meters) satellite data. The RapidEye image acquired on 09 March 2011, with some cloud cover (about 10–15%) in the northern part. The image has 5 multispectral bands in 5 meters resolution (resampled from original 6.5m). The 3 data tiles were merged to cover the entire Bonaire Island with area of 1,000 sq.km. The Worldview-2 data are acquired on 28 October 2010 and have some few cloud patches in the northern part of the Lac Bay.

The main distinction between the red and black mangrove can be done on a basis of specific growth differences of the red and black mangroves. The black mangroves grow close to areas with higher elevation (called dry land), away from permanently flooded areas, or areas with high water content such as mud flats and swamps. The red mangroves occur next to areas with high water content and permanently or frequently flooded areas. Mixed forest areas are represented in small irregular patches. Corals and seagrass classes are included in shallow submerged areas within the lagoon, but according to spectral reflectance, the differences are not so clear.

Figure 21. Black mangrove (left) and Red mangrove (right). Credits: ® Tranquilometro's photostream; Reid Moran.

The mangrove monitoring using Remote sensing can provide detailed information on vegetation characteristics, structural appearance and extent of the spatial coverage. The red and black mangroves were classified using Normalized Vegetation Index, Enhanced Vegetation Index, Atmospherically Resistant Vegetation Index, Vegetation delineation index and unsupervised classification. The health state of the mangroves can be related to chlorophyll content and biomass, which can be detected in red, red-edge and near-infrared channels.

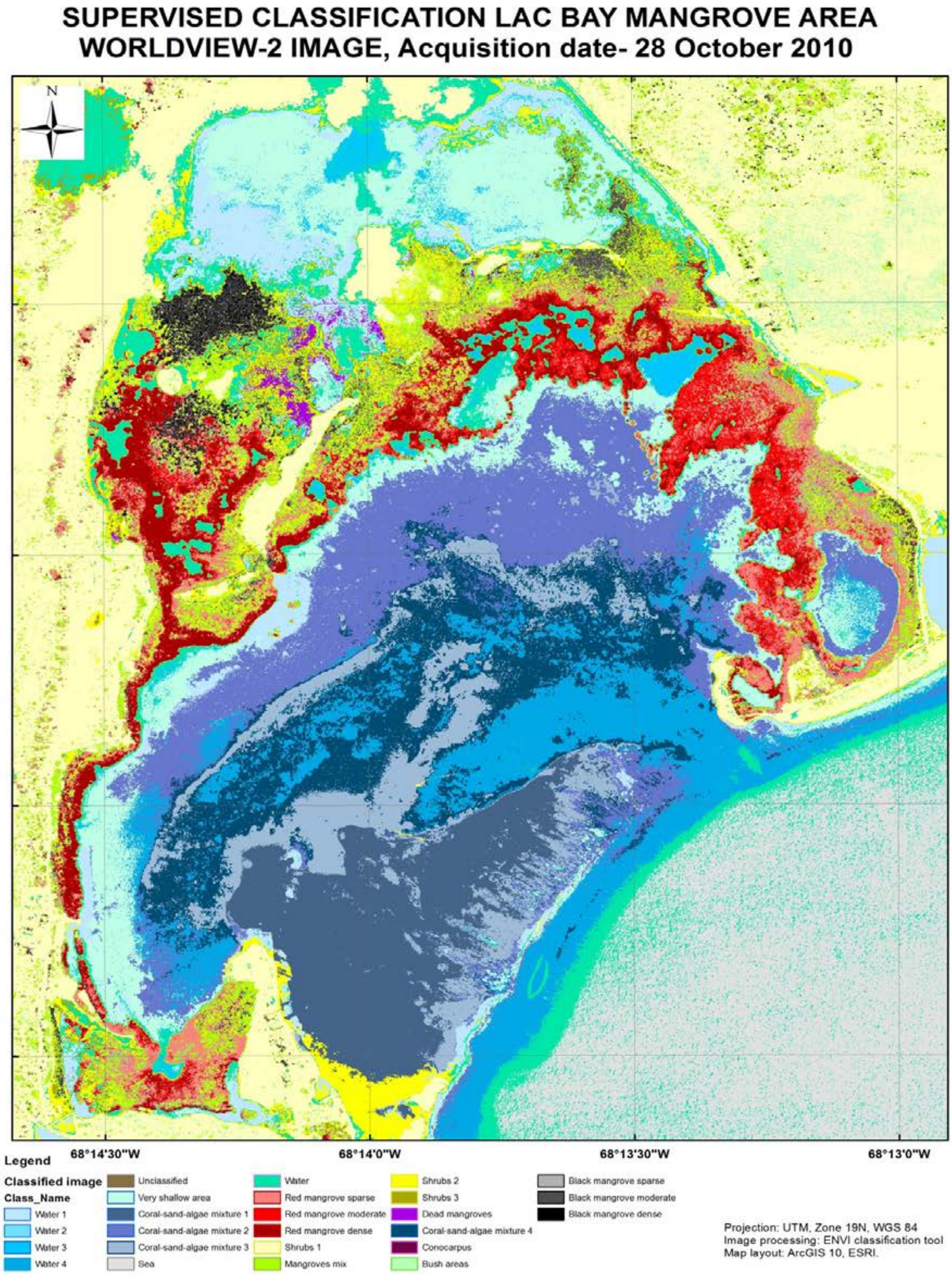


Figure 22. Supervised classification WorldView-2 image.

4.6 4.6 National programme report for Northern Ireland

James Strong (Agri-Food and Biosciences Institute)

2012-2013 has seen the large areas of multibeam echosounder bathymetry gathered in Northern Ireland under the Agri-Food and Biosciences Institute's (AFBI) INIS Hydro and Essential Fish Habitat (EFH) mapping projects. Additional data has been collected for the MCA characterization, both inshore and offshore. These areas have been extensively ground-truthed and broad-scale habitat map production continues. A Civil Hydrography Programme survey of the Ards Pennisula was completed in early 2013 - this information will be available to all the MBES sharing MOU signatures in the UK. Strangford Lough MBES and habitat mapping has also been completed (see below). AFBI has also started an EFH project – see ToR D for summary.

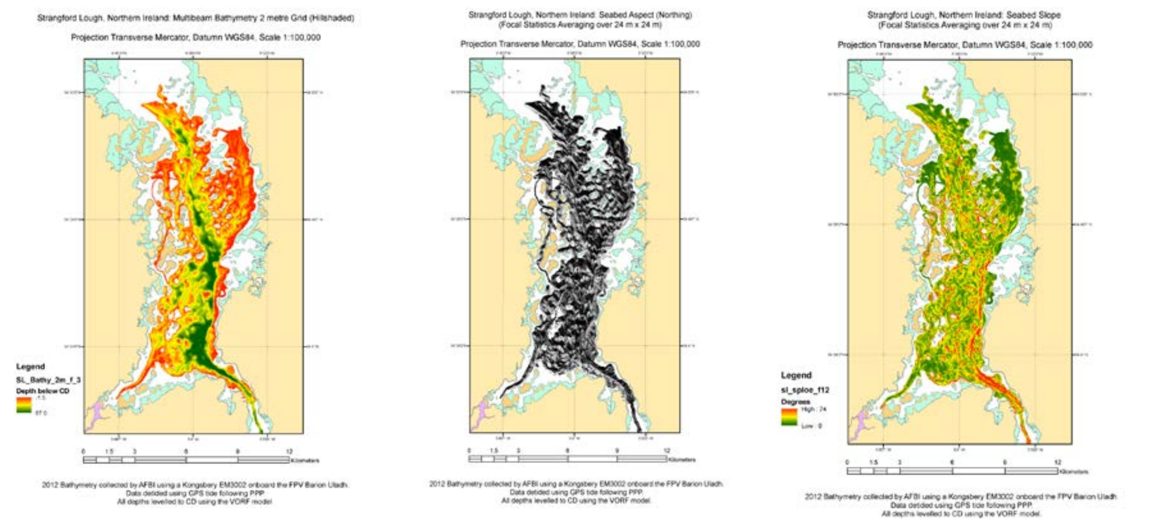


Figure 23, a, b and c. Strangford Lough MBES bathymetry gridded at 2 metres and hill-shaded (left), seabed aspect – northing (middle) and seabed slope (right) for Strangford Lough, Northern Ireland.

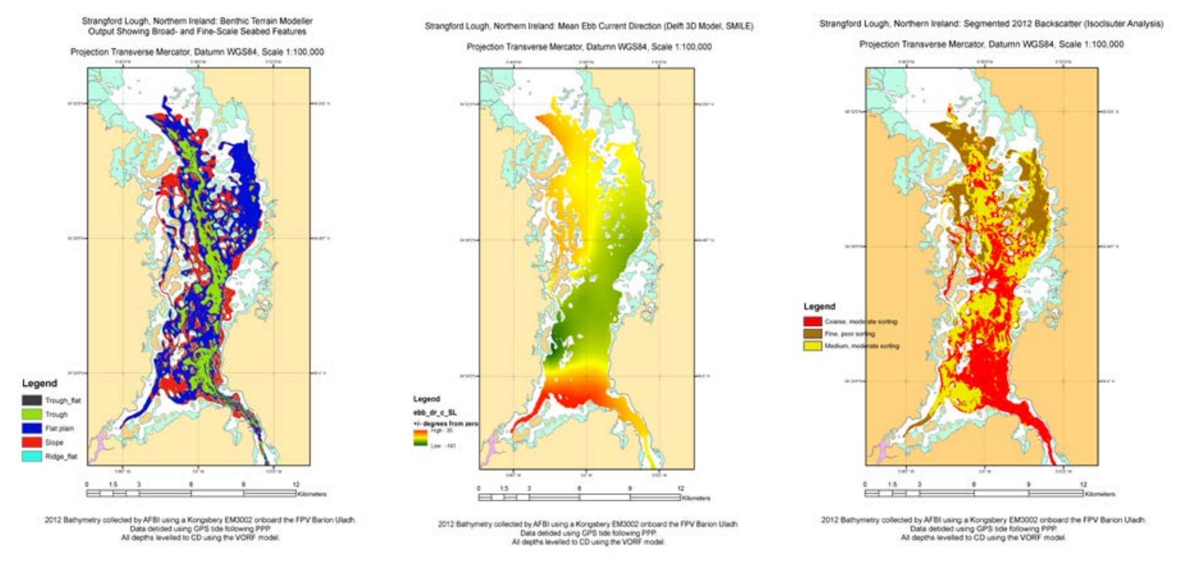


Figure 24a, b and c. Seabed features, as identified by the Benthic Terrain Modeler (left), mean flood speed (middle) and unsupervised classification of AFBI MBES backscatter (right) for Strangford Lough, Northern Ireland.

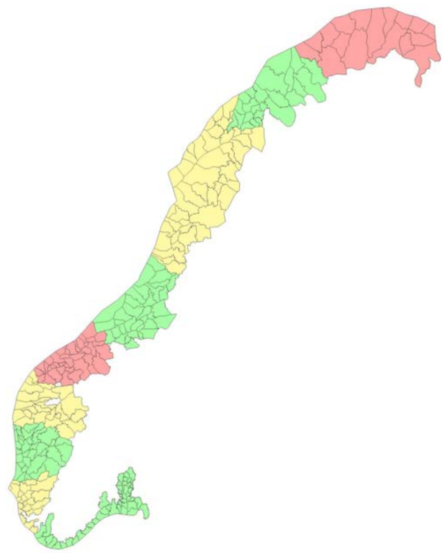
4.7 National programme report for Norway

4.7.1 National program for mapping of marine biodiversity – coast

Trine Bekkby (NIVA/UiO)

The field mapping (which started in 2007) focuses on 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. The figure below shows the status of the mapping (green=finalized, yellow=ongoing, red=not yet started). The program is planned to be finished mapping all counties in 2018. However, this depends on funding, which is decided from year-to-year. Spatial predictive modelling is an important tool for mapping kelp forest, carbonate sand etc. A selection of lessons learned:

- The substrate is important and substrate mapping is needed. A more detailed current speed model is needed;
- The combined effect of wave and current exposure is not fully understood;
- Data resolution – getting high resolution data from the Ministry of Defence is an issue;
- Data coverage and quality – Only 26.5 % of areas 0-20 m are covered by multibeam, there are no holistic land-sea-models; Norway has three different depth reference levels for the coast.



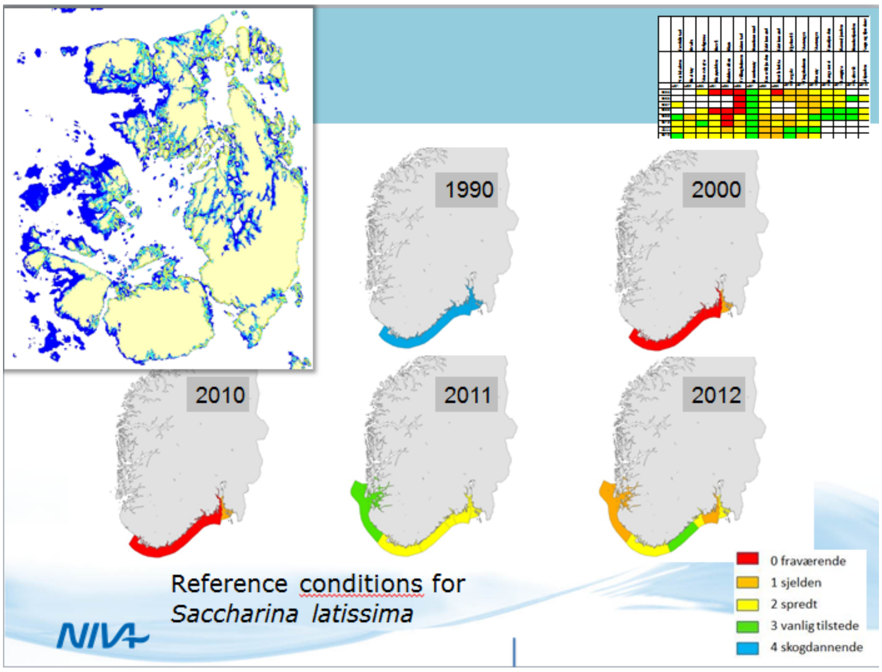
More details on the program can be found in earlier WG reports.

a) Coast-MAREANO, a program in the making

Both nationally and internationally, new methods for the management of marine and coastal areas are implemented, for use in marine spatial planning and management plans. In Norway, the MAREANO project and the National program for mapping of marine biodiversity – coast have shown the value of detailed base data (e.g. on bathymetry) and the development of novel methodology, both for field sampling, statistical analyses etc. There is an initiative now (first workshop in May 2013) for a national collaboration to collect and disseminate management-related knowledge in a cost-effective manner through a "coast-MAREANO". The purpose of the program will be to survey the coastal zone from the coastline and out to where the MAREANO program is mapping. Funding is not yet agreed on, and the process will continue.

b) The Norwegian nature index

The aim of the Norwegian nature index (english.dirnat.no/content/500042128/The-Norwegian-Nature-Index) is to document overall trends for the state of major ecosystems throughout Norway, and to provide a readily available overview of whether Norway is making progress towards its goal of halting the loss of biodiversity. It is calculated using a large number of species and ecosystem indicators. The index is included in the official statistical indices, and methodology inspired by the Natural Capital Index (NCI), the Biological Intactness Index (BII) and the Water Framework Directive (WFD). The index requires knowledge of reference conditions, and NIVA showed several examples of modelling reference conditions as part of the index. Some of the indicators are habitat maps, see figure.



c) Nature types for Norway (NiN)

"Nature types for Norway" (NiN, www.nhm.uio.no/english/research/projects/nin/) aims to summarize knowledge of nature-type variation in Norway. NiN was initiated in 2005 by the Norwegian Biodiversity Information Centre, which also provides financial support for the project. In the first phase of NiN development, from 2006 to 2009, a group of experts, led by Prof. Rune Halvorsen at the Natural History Museum (University of Oslo), elaborated principles for this new system for dividing Norway into nature types and describing variation in Norwegian nature. NiN version 1.0 was published in 2009. A second phase of NiN development was initiated in 2012, and is planned to end with publishing of NiN version 2.0 in 2014. NiN is based on the definition of a nature type in the new Nature Diversity Act of 2009. NiN constitutes the knowledge basis for implementing the instrument 'selected habitat types', and was used as the platform for assessment of nature types for the first issue of the national Red List for Ecosystems and Nature Types, published in 2011. The NiN system is currently increasingly used in a number of areas, i.e. for mapping of natural variation, for monitoring of nature types, and for different research activities.

"Naturtypebasen" (Norwegian only) describes the NiN system and its theoretical basis and includes keys for "determination" of nature types, descriptions of the types and of sources of variation in nature. More than one thousand photographs are included to illustrate the nature types and the environmental conditions that vary within and between the types. A system like NiN will never be finished, but will need continued development and upgrading as we get new knowledge of the Norwegian nature.

Other countries have made local version of EUNIS (e.g. in the Baltic) or developed other methods (e.g. CMECS, MESH). NiN is now tested for the terrestrial environment. The Norwegian Institute for Water Research (NIVA), the Geological Survey of Norway (NGU) and the University of Oslo (UiO) are involved in the marine work. NIVA has, together with Ifremer, Aarhus University (DCE), GeoEcoMar, ISPRA, HCMR, JNCC, IEO and IO-BAS, a project EuSeaMap2 on testing the gradients and borders in EUNIS. NIVA will also apply for a project, to the Norwegian Research Council, comparing NiN, EUNIS and, possibly CMECS, for the Norwegian coast.

4.7.2 MAREANO – progress 2012

Pål Buhl-Mortensen (IMR)

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 sediment 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.

The coverage of video-transects is close to 1 per 100 km^2 and for sampling stations 2 per 1000 km^2. 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.

At the end of 2012, 104 000 km^2 have been mapped with multibeam echosounder, and 95 000 km^2 has been sampled (sediments, fauna and pollutants) using MAREANO's standard density of sampling stations during 15 sampling surveys.

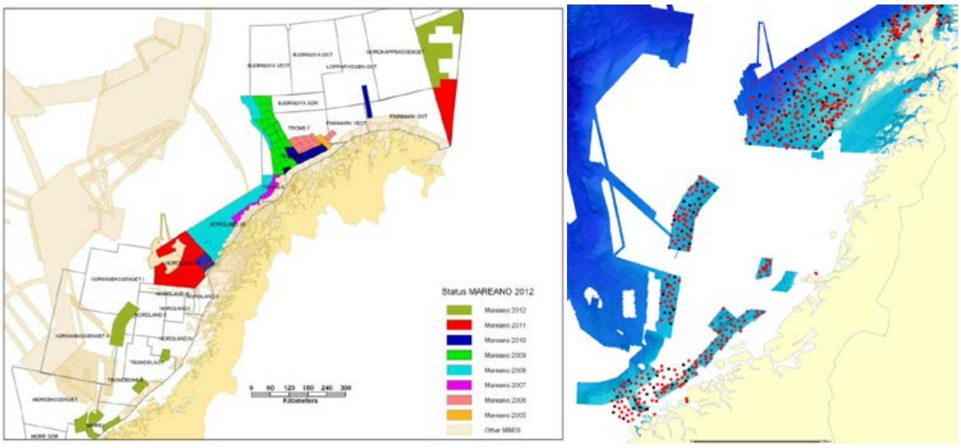


Figure 25. Coverage of bathymetric mapping with multibeam echosounding (left map) and the survey location areas in 2012.

Much effort has been allocated to produce biotope maps (Figure 26) based on classified samples from quantitative video analysis using DCA and Maxent. The challenge is to find a method to combine maps from adjacent regions, which has been analysed separately.

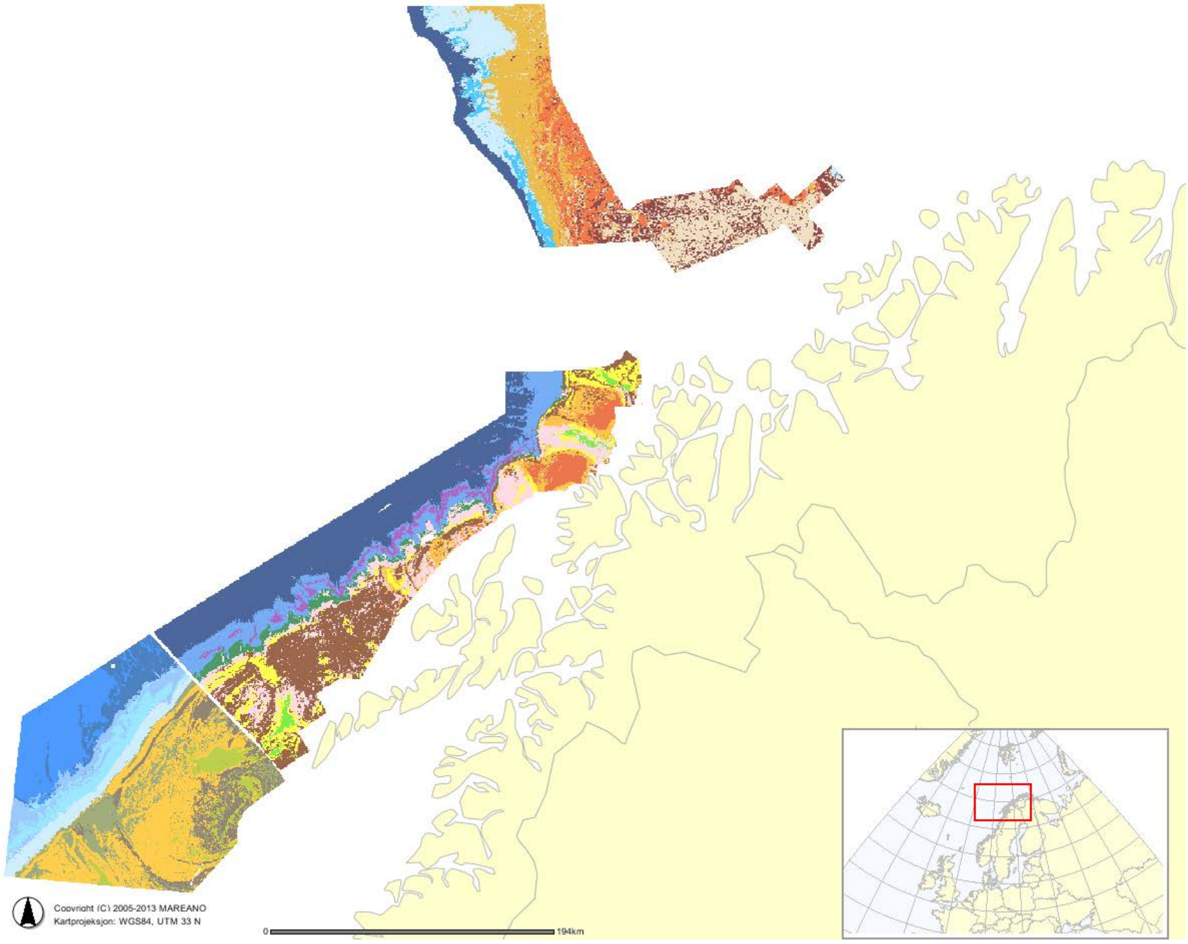


Figure26. Biotope maps for parts of Northern Norway. The areas with different colours represent modelled biotopes from training data identified from grouping patterns in ordination plots (DCA) of quantitative megafauna data from video analysis. (Map from: www.Mareano.no).

5 Evaluate recent advances in marine habitat mapping and modelling techniques, including fieldwork methodology, and data analysis and interpretation – ToR c)

5.1 Experiences with different modelling techniques

Trine Bekkby (NIVA/UiO) and Roland Pesch

Several methods have been used for modelling, e.g. envelope models, decision trees, guided classifications, statistical modelling etc. There is no general "best model", and the choice of model should depend on the data you have and the question you ask. Some models are strong in handling large datasets, others are better with few observations, some methods require both presence and absence data and some need only presence data. Some of the models have a tendency for overfitting, which may be useful if you want the prediction to be as good as possible within the study area. Others are better if knowledge of the ecological response of the predictors is to be transferred to models, and understanding the general patterns is the main issue. The experience of the group is that the results tell more or less the same story if the sampling design is good and the choices made within the methods are comparable and reasonable (e.g. reducing the number of pseudo-absences and modelling extent in Maxent).

The following text presents a selection of modelling techniques and the group's experience with them. There are several other methods that can be used for modelling (e.g. PCA, multivariate adaptive regression splines, MARS etc.) that are not discussed here.

There are also several geospatial tools that we will not discuss, e.g. MGET (http://mgel.env.duke.edu/mget)

5.1.1 GLM, GAM (generalized) and Mixed models

Generalized linear models (GLM) are commonly used, and are a generalization of ordinary linear regression, allowing the response variables to have other than a normal distribution, using a link function. Generalized additive models combine generalized linear models with additive models, and allows for the relationship to have different shapes, depending on the smoothing factor selected. GAM has therefore become very popular, as it allows for more the data to determine the shape of the relationship, without using a predefined shape as GLM does. Overfitting is a potential problem with GAM, and the degree of smoothing has to be selected carefully.

Data are often collected in a way that generated pseudoreplicates, as many samples are often collected at the same location/station. It is then important to use location/station as random factor in the analyses to make up for the pseudoreplication.

GLMs, GAMs can be run for instance through the Package GRASP in R (cran.r-project.org/src/contrib/Archive/grasp/). GLMMs and GAMMS (the mixed versions of the two former, making up for pseudoreplication) is best run through the MuMIn package (cran.r-project.org/web/packages/MuMIn/index.html), an R package for model selection and model averaging based on information criteria (AICc and alike).

5.1.2 Maxent and MaxLike

Maxent is a Maximum Entropy species distribution modelling method, which was first launched in 2004, later improved several times. Maxent is one of the currently most used methods for distribution modelling, and is regarded as a good and robust method, is easy to use, implemented in user-friendly software. Maxent is a freeware, can be run as a separate program (www.cs.princeton.edu/~schapire/maxent) or run through R (cran.r-project.org/web/packages/maxent/index.html) or the Dismo package in R (cran.r-project.org/web/packages/dismo/index.html). However, there have been many discussions on the use of MaxEnt, and the method has a large tendency for overfitting. It is important to remember that MaxEnt is not really a presence-only method; it is a presence-pseudo-absence method, as it generates absences. By default, it generates thousands of pseudo-absences from an area and an extent of environmental conditions that potentially is outside the expected range of the distribution of object (species, habitat etc.) in question. The pseudo-absences are generated in areas that we actually do not have any information, neither presences nor absences, so the pseudo-absences might be incorrect. Also, Maxent generates a lot of interactions that are not necessarily ecologically relevant, maybe not even wanted by the user. However, these interactions are only shown in the Lambda-file. As a result, the few variables used in the analyses by the user will be turned into tens, sometimes hundreds, of predictors, increasing the challenge with overfitting. These are the main reasons that Maxent performs better than other methods. However, if a sensible number of pseudo-absences are selected and the extent of the modelling area is reasonable, the validation of the Maxent model gets more comparable to other methods. Regularization might be used within Maxent to reduce overfitting. It is important to remember that the probabilities delivered by Maxent is not *real* probabilities for finding the species (see discussion under MaxLike).

MaxLike is a newly introduced methods providing a likelihood-based approach to modelling species distributions using presence-only data, as Maxent. MaxLike can be run through R (http://cran.r-project.org/web/packages/maxlike/maxlike.pdf)

MaxLike *claims* to, in contrast to Maxent, to provide estimates of the probability of occurrence (Royle *et al.*, 2012: onlinelibrary.wiley.com/doi/10.1111/j.2041-210X.2011.00182.x/abstract). Some have compared Maxent and LaxLike, finding that MaxLike performs better (see Fitzpatrick *et al.*, 2013: www.esajournals.org/doi/abs/10.1890/ES13-00066.1). *However*, there is a heavy discussion on this, and both Halvorsen (2013, www.degruyter.com/view/j/som.2013.36.issue-1/v10208-011-0016-2/v10208-011-0016-2.xml?format=INT) and Phillips (2012, onlinelibrary.wiley.com/doi/10.1111/j.1600-0587.2011.07285.x/abstract) state that inferring prevalence from presence-only data are not possible. Hastie and Fithian (2013, onlinelibrary.wiley.com/doi/10.1111/j.1600-0587.2013.00321.x/abstract) discuss the ongoing controversy in the use of presence-only data. They state that "one cannot learn the overall species occurrence probability, or prevalence, without making unjustified simplifying assumptions. In this forum article we question the approach of Royle *et al.* (2012) that claims to be able to do this."

Maximum Likelihood Classification (MLC) uses Baye's theorem for decision-making, and is a method available in ArcGIS. Each cell is assigned to one of the classes represented in a signature file. The statistical probability is computed for each class to determine which class each cell belongs to. The most common choice is that a cell is classified into the class to which it has the highest estimated probability to belong to. A confidence raster can also be produced. One of the reasons for the popularity of the method is that it is a part of ArcGIS.

5.1.3 Decision trees (incl. BRT, Random Forest etc.)

Decision tree models are used to identify latent structures in datasets consisting of large numbers of objects that are described by a multitude of variables with, potentially, different levels of measurements according to the theory of scale types (Stevens 1946). Like traditional regression methods, decision tree models aim at computing an explanation or prediction model for a variable of interest (target or response variable) from a given set of variables assumed to have an influence on this variable (predictor variables). There are several decision tree algorithms available like *Classification and Regression Trees* (*CART*; Breiman *et al.*, 1984) or inference statistically based models such as *Chi Square Interaction Detection* (*CHAID*; Kass, 1980). All of these algorithms rely on the consecutive segmentation of a given dataset (root node) into subclasses or sub-nodes. The subdivisions are performed on the basis of the features of the predictor variables with the goal of optimizing a defined statistical target criterion. Thus, decision trees are processed until a maximum tree is reached depending on user specified restrictions, e.g. insufficient number of cases in a produced node or until further splitting is impossible (only one case or identical cases in the node). Smaller trees can be produced by pruning the maximum tree either automatically or interactively by expert judgment. In this way all decision trees result in so called end nodes which are then the product of a hierarchical sequence of decision rules. These may be applied on objects (e.g. raster cells) where information on the predictor variables is given and that on the target variable is missing. With regard to marine habitat mapping an application of decision trees would be to predict the occurrence of benthic species or communities (response variable) by a set of suitable and predicting variables available for the entire region of interest. The result of the mapping then would be spatial units where a certain species or community occur at a high probability. As an example, Pesch *et al.* (2008) and Vetter *et al.* (2012) applied *CART* together with other decision tree algorithms to map benthic biotopes within the extended area of the German North Sea.

Decision tree models like *CART* have advantages when compared to other prediction methods. Their results are easy to interpret and they are robust against outliers. *CART* performs binary splits and can analyse metrically, ordinally- and nominally-scaled data for both target and predicting variables. The method thereby subdivides given nodes by choosing that predictor resulting in the highest increase of homogeneity (improvement) with regard to the features of the target variable. For regression trees (when the response variable is metrically scaled) the calculation of homogeneity is carried out by determining the class-internal variance. The improvement per split then is determined on the basis of the reduction of the variance of the whole sample in relation to the variance of the newly created tree level. The *Gini index* is commonly used when calculating classification trees (when the response variable is nominal), although other options exist (entropy, twoing index).

In order to improve the *CART* method in terms of prediction quality and avoidance of over-fitting ensemble methods were developed. Here, a large number of decision trees are calculated from subsets of the entire sample. The corresponding results are then aggregated in terms of an optimal tree solution. Two ensemble methods can thereby be distinguished: bagging and boosting. Bagging relies on the extraction of random bootstrap samples from the entire dataset, whereas with boosting successive trees are calculated by assigning weights to cases incorrectly classified in pervious steps (Liaw and Wiener, 2002). Breimann (2001) furthermore introduced *Random Forests*, where another random factor is taking into account when calculating an optimal decision tree from a given set of data. Next to taking a bootstrap sample each decision step or split is chosen by taking into account a random subset of all predicting variables available. Hence, each node is split using the best predictors among a subset of predictors randomly chosen at that node. *CART* based on ensemble techniques has recently been tested successfully with respect the prediction of benthic species within the Swedish Baltic Sea (Gonzalez-Mirelis and Lindegarth, 2012).

5.1.4 References

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5.2 Autonomous Underwater Vehicles (AUVs) and Synthetic Aperture Sonar (SAS) - basic principles and experiences

Terje Thorsnes (Geological Survey of Norway)

5.2.1 Autonomous underwater vehicles (AUVs)

AUVs are unmanned underwater vehicles, which can travel underwater without direct input from an operator. The AUV is programmed to survey a specific area, with predefined lines, flying in a predefined height above the seabed. The AUV returns to the surface after completing the mission, or if unexpected contacts with the seabed occur, or if the operator instructs it to do so. AUVs differ from ROVs which are controlled and powered from the surface by an operator/pilot via an umbilical or remote control. AUVs have a far greater capacity to survey large areas than ROVs, but lack the capacity to stop for more detailed investigations, or to physically interact with objects on the seabed. AUVs are widely used for military purposes and offshore industry.

AUVs come in a range of sizes, ranging from small AUVs which are man portable, to large AUVs over 10 meters. The larger vehicles have advantages in terms of battery capacity allowing power consuming instruments to be operated for a considerable time, while smaller AUVs may be simpler to operate in terms of launch and recovery.

AUVs serve as platform for a number of acoustic, visual and chemical systems. Typical instruments may include altimeters, forward looking sonar (to avoid collision), compasses, magnetometers, thermistors, conductivity probes, sidescan sonars, multibeam echosounders, sub-bottom profilers, photo systems and gas sniffers. Recently, some AUVs are equipped with Synthetic Aperture Sonars (see below) which give unprecented coverage and detail, compared to traditional sidescan sonars. In future, Underwater Hyperspectral imaging devices may also form part of the instrument suite of AUVs.

5.2.2 Synthetic aperture sonars – SAS

Synthetic aperture sonars are a type of sonars which use successive pings to build an image with considerably higher resolution than traditional sonars. The SAS moves along a line and a single point is illuminated by several pings. By stacking the pings by sophisticated processing, a synthetic array equal to the length of distance covered by a given number of pings is created. This provides a range-independent along-track resolution. The resolution towards the maximum range of the sonar width may be several orders of magnitude better than traditional sonars.

5.2.3 Experiences from the use of AUVs and SAS

The Geological Survey of Norway has used a HUGIN AUV (Kongsberg) equipped with a wide range of instruments, including SAS (Kongsberg HiSAS1030).

The overall experience is that the combination of AUVs and SAS gives very high resolution data suitable for a wide range of purposes, including detailed habitat mapping. The Synthetic aperture sonar gives excellent possibilities for acoustic documentation of the physical parts of seabed ecosystems. The B/W TFish photo system provided good images of the seabed and megafauna, but even better resolution and colour will be a great improvement.

The investigations have been done in cooperation with Lundin Norway and the Norwegian Defence Research Institute (FFI). The vessel (H.U. Sverdrup II), the AUV (HUGIN HUS) and the instruments belong to FFI. The purpose of the investigations in the Barents Sea has been to investigate the shallow geological system and related seabed features, and to acquire data on environmental aspects of the seabed, including the distribution of sponges and other megafauna.

The HUGIN AUV was equipped with the following payloads: 1) An EdgeTech 2200 high resolution full spectrum chirp sub-bottom profiler (SBP), 2) HISAS, 3) Gas Sniffer, 4) Turbidity sensor, 5) B&W photo camera. The SBP was used to profile interesting features of the immediate subsurface in very high resolution. The HUGIN HUS was flown ~10 m above the seabed at a constant speed giving 50 cm horizontal resolution and a vertical resolution of less than 100 microseconds (~10 cm) with the SBP system.

HISAS 1030 is a high resolution interferometric synthetic aperture sonar system capable of providing very high resolution images and detailed bathymetry of the seabed. The system has a range-independent resolution of approximately 3x3 cm out to a distance of 200 m from both sides of the AUV at a speed of 2 m/s. The data were processed onboard. Raw, unprocessed sidescan sonar data in xtf format were ready within a few hours. Processed high resolution mosaics in geotiff format were available for inspection in Reflection and/or ArcMap within 10 hours of HUGIN recovery.

Multibeam echosounder data were collected by HUGIN using the Kongsberg EM2000 system. Data were stored in .all format for further processing of bathymetry using Fledermaus DMagic and Fledermaus GeoCoder.

The gas sniffer (METS) had a methane sensitive detector located in a detector room in the sensor head. The methane sniffer was used to estimate the amount of leakage at locations where gas flares have been identified from multibeam water column data during previous cruises. In addition to the methane sniffer, HUGIN also carried temperature, turbidity, salinity and visibility sensors. Dataset deliveries included GeoTiff files and ASCII text files. The TFish B&W camera provided very high resolution images of the seabed. The TFish images were available, co-registered with the HISAS data, within hours through the Reflection software system on-board HU Sverdrup II.

The SAS data proved to be a very efficient tool for discovering and documenting seabed structures related to gas seepage, giving clear images of carbonate crust (a product of the gas seepage) fields at the seabed (Figure 27). The gas sniffer provided information about the methane concentration in the water above the gas seepage (Figure 27). The TFish photo system provided photos showing the carbonate crusts, gas bubbles, a large number of rockfish (*Sebastes*) and other seep related features (Figure 28). Trawl tracks are excellently documented by SAS data (Figure 29). Other features, such as whale carcasses (Figure 30), were also documented using a combination of SAS data and TFish photos.

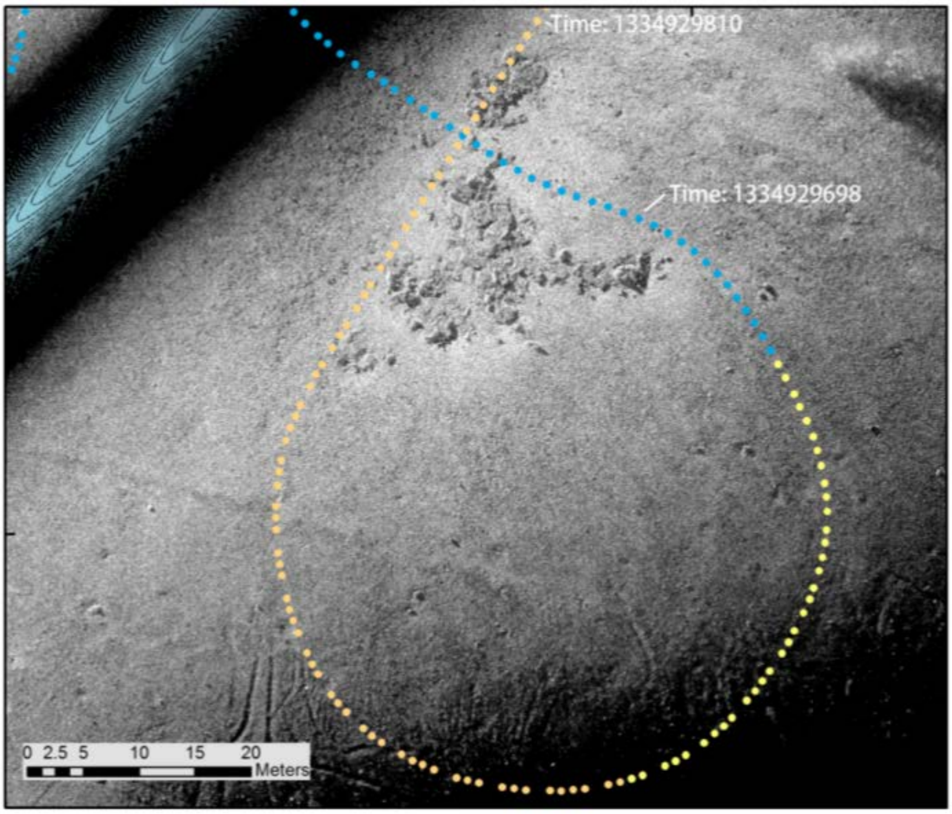

Figure 27. SAS imagery showing the carbonate crust field (central upper part) and the CH4 values from the METS sensor (blue values: below 0.027; yellow dots: 0.027–0.045; orange dots: 0.045-0.060). HUGIN entered the imaged area from upper left and exited the area in the upper central part.

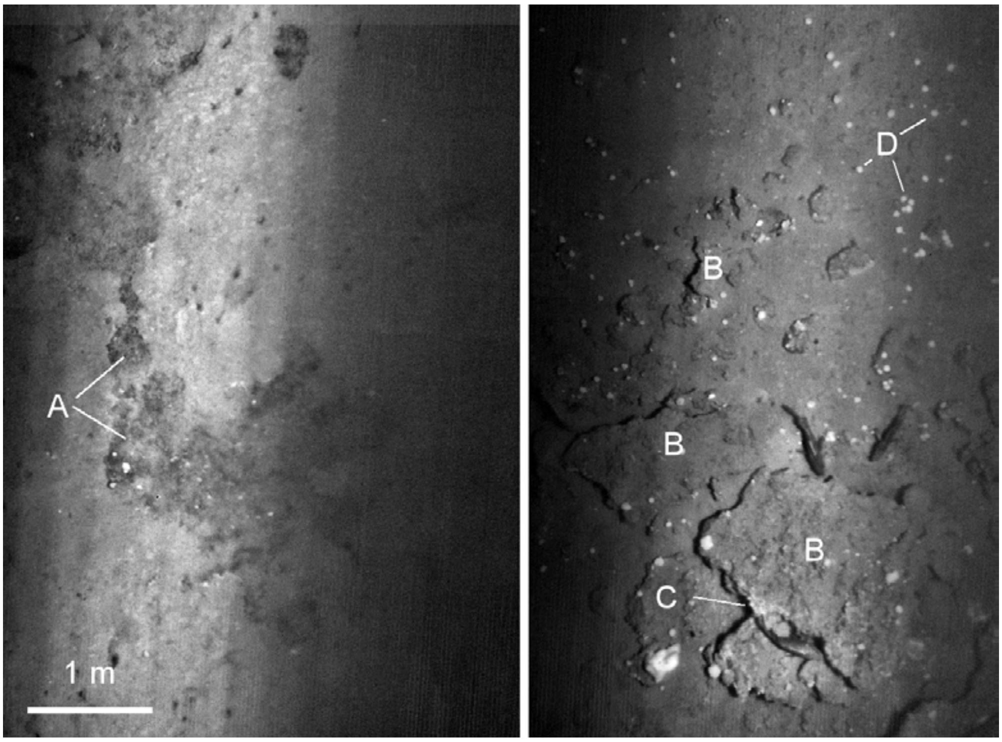

Figure 28. Left photo: Bacterial mats in small depressions (A). Right photo: Carbonate crusts (B), light bacterial mats covering crust (C) and small sponges (D).

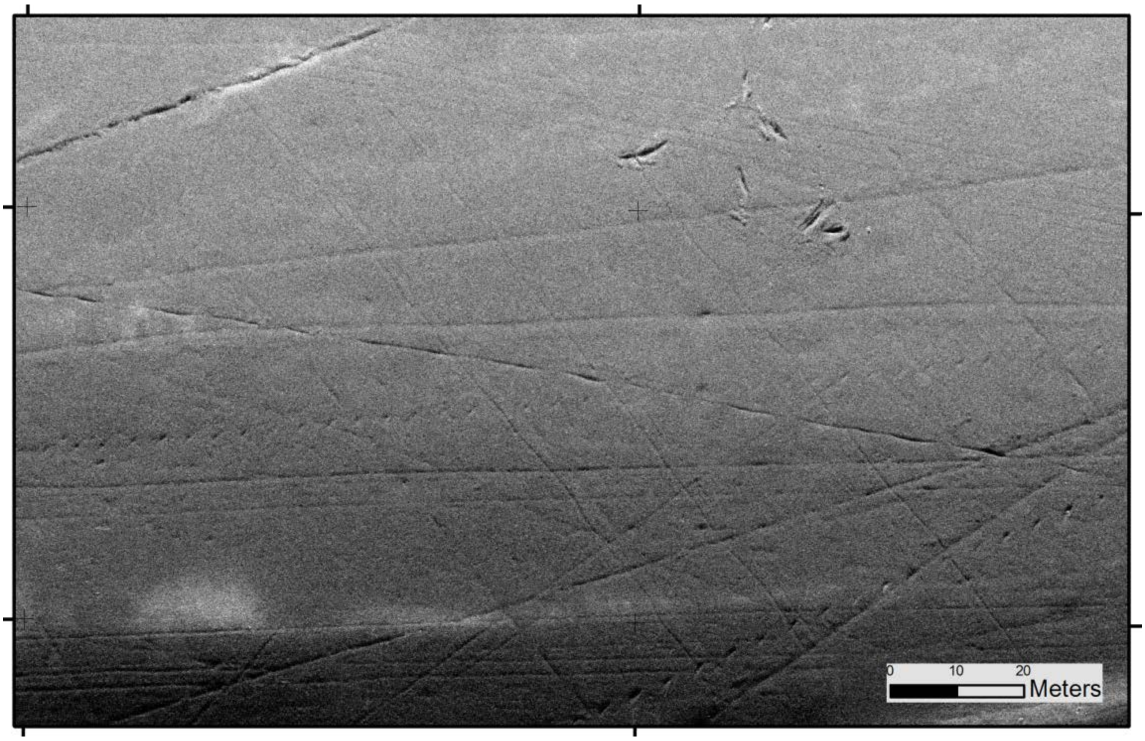

Figure 29. Trawl marks, with probable whale tracks in the upper right corner.

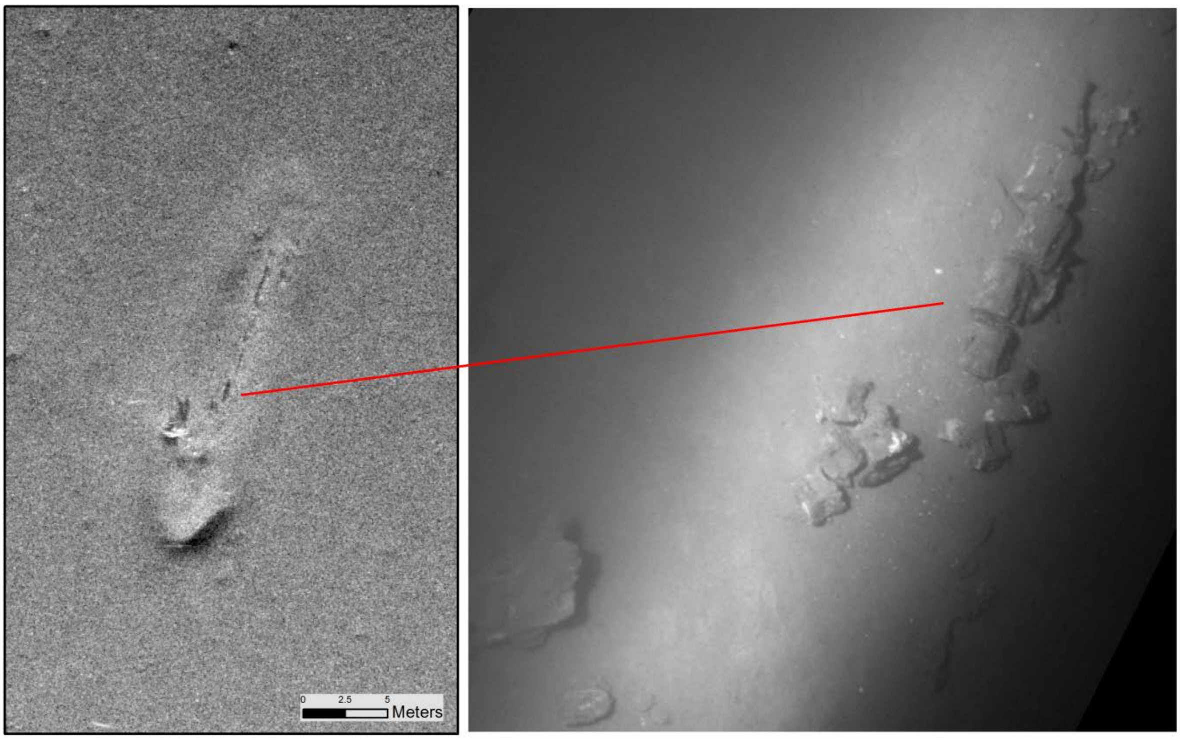

Figure 30. Whale skeleton, imaged by SAS (left) and TFish photo (right, 3 m wide).

5.3 Object Based Image Analysis (OBIA): Benthic habitat mapping for the Fehmarnbelt Fixed Link EIA.

Lars Boye Hansen, and Rasmus Lundgaard Borgstrøm (DHI GRAS A/S, Geocenter Denmark)

As part of the baseline investigations for the Fehmarnbelt Fixed Link EIA a detailed mapping of the benthic habitats in the area was needed. One of the many input datasets in the analysis were acoustic and optical remote-sensing data (multibeam echosounder and aerial photography). A detailed description of the benthic habitat mapping performed for the Fehmarnbelt Fixed link **EIA can be found in the official report from FEMA (FEMA (2013).**

Remotely sensed data (acoustic and optical) can provide vital information about the characteristics of substrate types and benthic habitats. Traditionally, such data types are interpreted by expert judgement by manual delineation and subsequent classification. Whilst this can be an accurate way of interpreting the data it inevitably introduces elements of subjectivity in the analysis. In order to make such analyses more objective and repeatable a computational approach is needed. The concept of object-based image analysis (OBIA) has been developed over the last decades. The principle behind OBIA is to identify segments in the maps with similar characteristics – the segmentation is performed based on a hierarchy of predefined rules taking elements such as spectral response, shape, texture, patchiness etc. into account. The approach is today widely used in the analysis of optical remote-sensing data (Blaschke, 2010) but it is still relatively novel in the context of backscatter data (Lucieer and Lamarche, 2011; Lucieer, 2008).

For benthic habitat mapping for the Fehmarnbelt Fixed Link EIA the OBIA approach was chosen for the remote sensing analyses. In addition to securing repeatability of the data analysis the OBIA approach reduces the needed human interaction significantly and thereby also the cost of habitat mapping. In principle the OBIA approach could be fully automated once the rule set has been established. However, to secure the highest possible accuracy and standards the data processing and labelling of the derived segments were performed in this study in a two-step approach where:

1) The remotely sensed data are segmented following a specifically developed rule set. This is done fully automatically. In this process a first label is established and assigned to the segments.

2) Following the segmentation and first labelling the output is quality checked using expert judgment and available ancillary data. In this process the labelling is adjusted and optimized.

During several test-runs in step 1) the optimal parameters for segmentation were developed. These parameters ensured that areas of similar properties were assigned to one segment following rules related to:

- segments must be as large as possible, with a given minimum dimension in one direction;
- the outer border of an area is more important than the internal structure, i.e. patchy areas are segmented as a whole rather than each patch separately;
- coverage differences in habitats (vegetation density) are not considered, all coverage above 10 % is one habitat;
- The optimum scale parameter (a size controlling parameter for the derived segments);
- The optimum Shape/Colour ratio (controlling the emphasis on either spectral (the colour) or shape information).

In step 2) the segmentation results were finally analysed. The segmentation output had significantly reduced the data elements to app. 8.450 segments (polygons) for the total area covered by the 1100 aerial photos. Since the majority of these could be satisfactorily labeled automatically the need for human interaction was significantly reduced compared to a traditional manual approach.

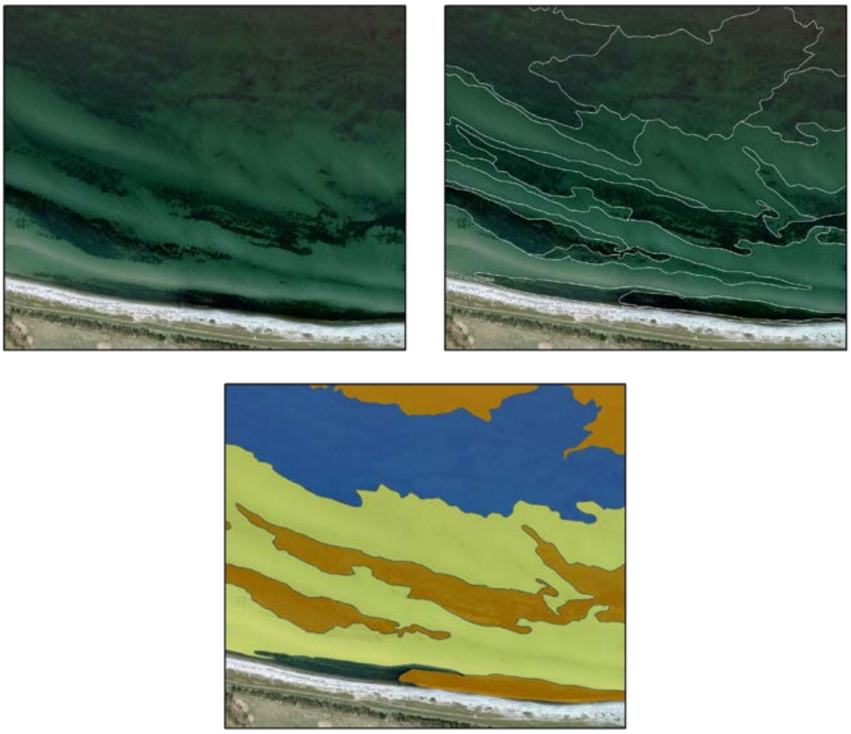

Figure 31. Schematic example of the flow in the OBIA process. To the left: input data (optical or acoustic), middle: Segments have been derived and generalized, right: segments have been aggregated and labelled with the correct habitat class.

The experiences from the performed analyses showed that:

1) OBIA reduces the subjective component of habitat mapping by eliminating the human interaction in the segmentation process.

2) Expert knowledge is still needed to secure a correct classification (input needed both in the rule set development prior to segmentation and in the final labelling of classes following the segmentation).

3) OBIA allows for repeatability of the analyses at a later time.

4) OBIA reduces the cost of habitat mapping as the segmentation and overall labelling of segments is done automatically. In this study input for the optical analysis alone was 1100 aerial photos. Manual digitizing and interpreting of the 1100 images would have been a very lengthy and costly task.

5) Recent advances in very high resolution satellite data means that it is today possible to perform these analyses based on satellite data instead of aerial photos. This further reduces the cost by eliminating the need for dedicated aerial campaigns. The most advanced satellite data today is furthermore providing better spectral information than aerial photos which can significant easy the segregation of the different habitats.

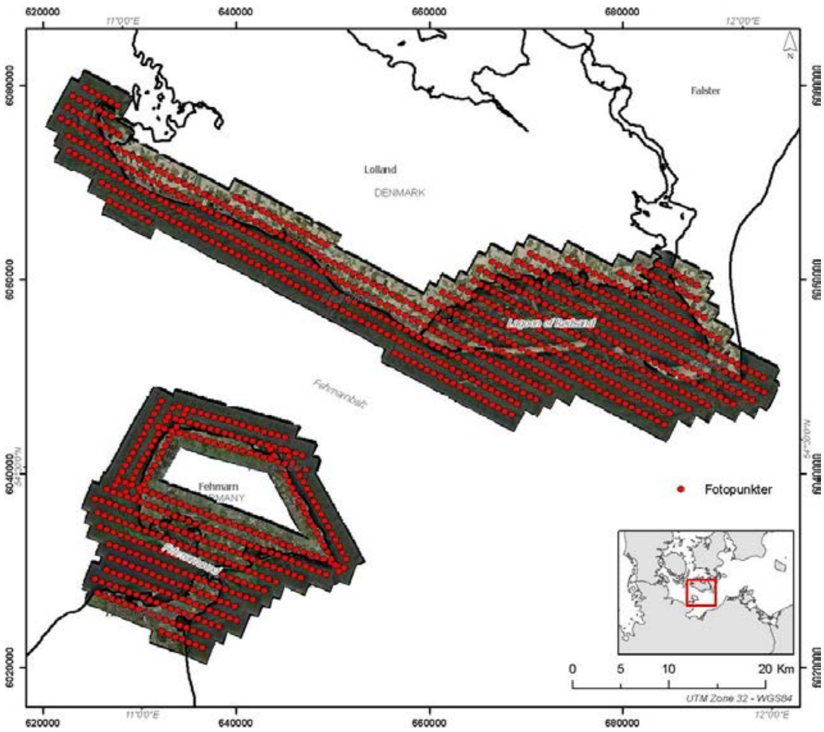

Figure 32. A total of 1100 aerial photos were produced and used as input to the optical OBIA analysis for the shallow water habitat mapping.

5.3.1 Refernces

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6 Review practice about the use of habitat maps, for example Mapping for the MSFD, marine spatial planning, and management of MPAs - ToR d)

In the European Marine Strategy Framework Directive (MSFD, (Council Directive 2008/56/EC, 2008), two important descriptors used in assessing environmental status of marine waters are seabed integrity and biodiversity. "Sea Floor" is interpreted as including both the physical parameters of the seabed - bathymetry, roughness (rugosity), substrate type, etc.; and biotic composition of the benthic community. "Integrity" is interpreted as both covering spatial connectivity, such that the habitats are not fragmented unnaturally, whilst having the natural ecosystem such processes functioning in characteristic ways. "Biodiversity" includes, together with species, population and ecosystem structure, other indicators related to habitat distribution, extent and condition (European Commission, 2010a). Areas of high habitat integrity on both of these standards are resilient to perturbations. As such, human activities can cause some degree of perturbation without serious and lasting harm to the ecosystems (Borja *et al*., 2011; Rice *et al*., 2010; Rice *et al*., 2012; Van Hoey *et al*., 2010).

In Galparsoro *et al*., (2013), an analysis to test the applicability of a process-driven benthic sedimentary habitat model (Kostylev and Hannah, 2007), in the implementation of the European MSFD, in relation to the biodiversity and seabed integrity descriptors for sedimentary habitats (Borja *et al*., 2011; Rice *et al*., 2010; Van Hoey *et al*., 2010) and the MSP approach, was performed. As case study, the Basque continental shelf (Bay of Biscay) was adopted.

The process-driven marine benthic habitat mapping approach, as proposed by Kostylev and Hannah (2007), is based upon ecological theory that relates species life history traits to the properties of the environment (Huston, 1994; Margalef *et al*., 1979; Reynolds, 1999; Southwood, 1977), transforming maps of the physical environment into those of benthic habitat types. This approach is based upon the aggregation of sets of environmental selective factors. The process-driven habitat mapping approach was selected as an insight into biodiversity and seabed integrity assessment, within the MSFD. In this way, the European Commission (2010a) identified 6 indicators as being suitable for seabed integrity assessment, From the 6, 3 can be related to the approach presented in Galparsoro *et al*., (2013): (i) the extent of the seabed affected significantly by human activities (identified using this approach); (ii) the presence of particularly sensitive and/or tolerant species (related to some of the functional traits); and (iii) indices assessing benthic community condition and functionality. Hence, the process-driven approach is related to species composition, structure and function (biodiversity and life-history traits of species) and the main characteristics of the environment (natural and anthropogenic) influencing seabed integrity; these could serve for the environmental assessment, as a complement to other tools proposed or used by van Hoey *et al*. (2010), Borja *et al*. (2011) and Rice *et al*. (2012).

Obtained results indicated that the habitat classes defined in the process-driven model reflected different structural and functional characteristics of the benthos. Moreover, benthic community structure anomalies due to human pressures could be detected also, within the model produced. In the present investigation, the process-driven template was tested for sedimentary habitats (which represent 37% of the case study area); nevertheless, it could be considered as being applicable to other sedimentary environments elsewhere. In addition, the same approach could be developed for hard-bottom substrata.

For the MSFD, when assessing the environmental status, the authors are aware of the possible shortcomings of the method presented; however, it could be considered as a good approach utilizing the available information, which is the criterion required by the MSFD. According to this, the final process-driven habitat map can be considered as being highly useful for seabed integrity and biodiversity assessment, within the European MSFD. Likewise, for conservation, environmental status assessment and managing human activities, especially within the marine spatial planning process.

6.1 Essential Fish Habitat Mapping in Northern Ireland, UK – Summary

Essential Fish Habitat (EFH) refers to specific elements of the habitat, either waters or substrata, necessary to fish for spawning, breeding, feeding, or growth to maturity. It is typically applied to commercial fish species and the purpose of Northern Irish EFH identification is to protect specific habitat elements that ultimately support key fisheries and represent fisheries in Marine Spatial Planning (MSP).

It is important to stress that many of the life-history habitats for commercial species are not vast expanses of open water but intimate associations with particular seabed habitats or physical conditions in pelagic habitats. For example, spring-spawning herring (*Clupea harengus*) shed their eggs inshore, close to the bottom over gravel and shell seabeds. This type of seabed is rare regionally and is typically much less than 4%. The spawning stage for this species has a clear association with a particular seabed habitat. Should this seabed type be modified, extracted or damaged, the ability of this species to spawn, and thereby recruit, would be greatly diminished. Without recruitment, commercial fisheries are effectively unsustainable. Furthermore, fisheries are not stand-alone economic interests but part of a wider ecosystem. Many other commercially important fish species will predate on herring. The loss of herring from these diets could have implications for the productivity of other fisheries. Equally, fish are important processors within marine ecosystems and indirectly generate other ecosystem products and utilities, e.g. gaseous exchange, conversion of wastes, food production that benefit humans.

6.1.1 Initial 2013 Objectives

Identification of EHF for 1) spawning adults, 2) foraging adults and 3) lavaral phases for the 10 species following fish species:

- Dab (*Limanda limanda*; Linnaeus, 1758)
- Cod (*Gadus morhua*; Linnaeus, 1758)
- Haddock (*Melanogrammus aeglefinus;* Linnaeus, 1758)
- Whiting (*Merlangius merlangus*; Linnaeus, 1758)
- Herring (*Clupea harengus*; Linnaeus, 1758)
- Poor cod (*Pollachius pollachius*; Linnaeus, 1758; Pollack)
- Grey Gurnard (*Eutrigla gurnardus*; Linnaeus, 1758)
- Lesser Spotted Dogfish (*Scyliorhinus canicula*; Linnaeus, 1758)
- European Plaice (*Pleuronectes platessa*; Linnaeus, 1758)

The approach used for the mapping of EFH used Generalized Additive Models to predict the spatial distribution of species for three life-history phases. The GAM models combined bathymetry (EMODNET) 400 m grid for Irish and Celtic Seas, rugosity, aspect (northing and easting) and slope. Fine- and broad-scale habitat features were identified with the Benthic Terrain Modeller. Significant slopes and outcrops were selected and 'distance to' layers were made using the Distance tool in ArcMap. Tidal energy (EMODNET) wave and tidal current predictions for the Irish and Celtic Seas region were also included as was water column stratification estimates (EMODNET) and superficial sediments (EMODNET). Finally, MODIS Aqua (4 km grid) – Sea Surface Temperature (SST) 4μ night values, Chlorophyll a concentrations, Euphotic depth (Lee), Particulate Organic Carbon (POC), Particulate Inorganic Carbon (PIC), particulate backscatter at 443 μm and absorption due to phytoplankton at 443 μm were also downloaded for the appropriate month of ground-truthing. Front detection was conducted on temperature and chlorophyll data. The distance tool was used to produce a 'distance to' front layers. Ground-truthing using the Ground Fish Survey Northern Ireland (GFSNI) 2005 data.

To eliminate redundant/collinear environmental variables from the GAMs, ArcMap Exploratory Regressions were run for all species in both seasons. General Linear Models were run for each species and season using biomass as the dependent variable. Once the model expression had been built by the 'GAM Model' (Marine Geospatial Exploratory Tools), the 'GAM predict from rasters' tool was used to predict the distribution of the species/season for the full extent of the AoI.

Each GAM biomass prediction was compared to the observed biomass for that year. As an independent check, the biomass predictions were compared with the observed values for the appropriate season for the following year as well.

6.1.2 Example Project Outputs

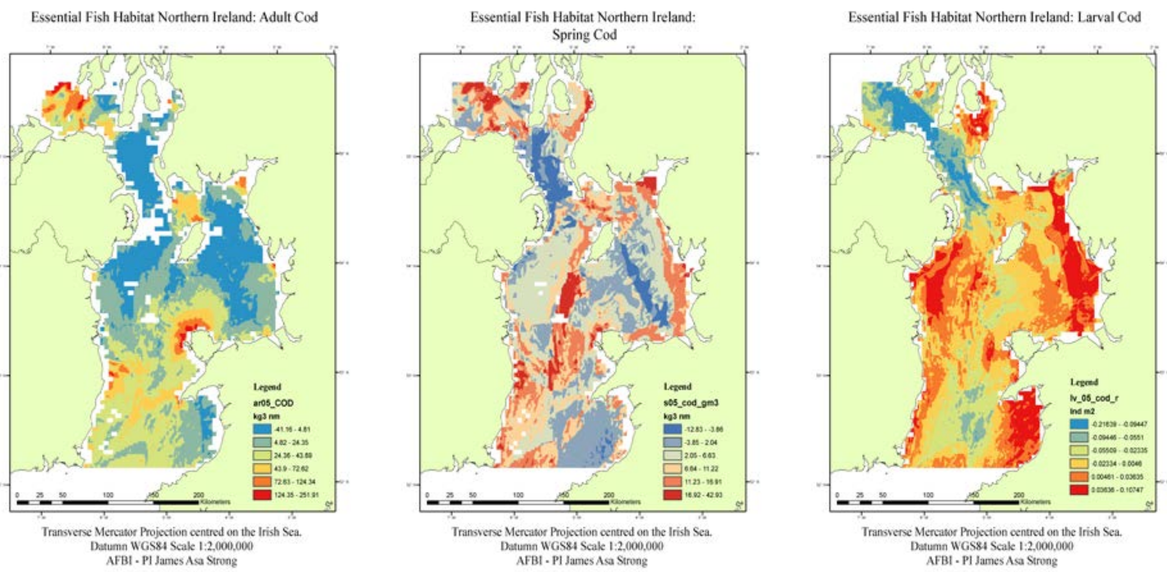

Figure 33. Example outputs - adult foraging distribution of cod (*Gadus morhua*) in the Irish Sea AoI based on 2005 environmental layers with spring and autumn GFSNI data (left), spawning distribution (middle) and larval distribution (right).

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7 Review of existing habitat classification systems and identify commonalities and differences – ToR e)

7.1 General introduction

The diversity of habitat classification schemes and systems has increased over time. WGMHM regard this ToR to be important for better assessing the relevance of different classification systems and communicating between habitat mapping projects.

Habitats need to be defined in any habitat classification system, as a necessary step if habitats are to be shown on maps. Habitats may be defined broadly or narrowly, and hierarchical classification systems such as the European Nature Information System (EUNIS; Davies *et al*., 2004) progresses from broad to more narrowly defined habitats.

The seabed can be characterized and classified at different spatial scales ranging from fine-scale local environment with factors affecting individual organisms, to landscapes and large-scale ecosystems where the substrates, terrain and oceanographic settings influence biological communities and populations. There are several approaches to seascape and habitat mapping. Greene *et al*. (1999) provide a classification scheme for deep seabed habitats where the issue of scale is dealt with in a hierarchy of classes. The same approach is applied in EUNIS. Both classification systems take into account the biological components of the habitat classes. However, whereas the Greene *et al*. (1999) classification scheme uses the biological components as modifiers of geological and geomorphological features at an intermediate level (macro and meso habitats) the EUNIS classification emphasizes taxonomic composition at the lower (finer) levels.

The habitats on OSPAR's list of threatened and/or declining species and habitats vary in the way they are defined. Some of them are defined mainly by abiotic factors, such as terrain and geological features for carbonate mounds and seamounts, or depth and sediment features for intertidal mudflats. For most of the remaining habitats, species composition and density of habitat-forming species are used for their definition.

The characteristics of any marine habitat classification system will depend upon the objectives of the study, but some general features of classification systems include:

- The classification system should be hierarchical to avoid overlap of definitions and duplication of categories at different levels of the system, and ensure that ecologically similar types are placed near to each other and at an appropriate level.
- A classification scheme should be mutually exclusive and exhaustive so that every feature to be classified should fall within one class only.
- Be comprehensive, accounting for all the marine habitats within the region to be mapped. Habitats should be identifiable, repeatable environmental units, divided into types or classes.
- Provide a common and easily understood language for the description of marine habitats.
- Be practical in format and clear in its presentation.
- All types of sampling techniques should result in the same habitat classes or community definitions, although the level to which a habitat can be classified in a hierarchy will be dependent on the resolution of the sampling technique.

- The classification should recognize time-scales over which variables may change. Habitat variables that change over shorter time-scales (*e.g.* biota) should be incorporated at a lower level in the hierarchy than variables that change over longer time-scales (*e.g.* reef substratum).
- It should include sufficient detail to be of practical use for resource managers and field surveyors, but be sufficiently broad (through hierarchical structuring) to enable summary habitat information to be presented at national and international levels or be used by non-specialists.

It should be sufficiently flexible to enable modification resulting from the addition of new information, but stable enough to support ongoing uses. Changes should be clearly documented and where possible, newly defined types need to be related back to types in earlier versions of the classification (Congalton 1991; Booth *et al*., 1996; Kvitek *et al*., 1999; Connor *et al*., 2004).

7.2 The European Nature Information System (EUNIS) habitat classification

7.2.1 Introduction

The European Nature Information System (EUNIS) habitat classification is a pan-European system, developed between 1996 and 2001 by the European Environment Agency. It builds upon the European Commission CORINE Biotopes Project and its successor the Palaearctic habitat classification. In the marine sector it is based on the JNCC Marine Habitat Classification for Britain and Ireland (Connor *et al.,* 2004) and habitat types developed by the Barcelona and Helcom marine conventions (Barcelona Convention, 1998; Helsinki Commission, 1998).

7.2.2 Definitions within EUNIS

EUNIS defines a 'habitat' as: 'a place where plants or animals normally live, characterized primarily by its physical features (topography, plant or animal physiognomy, soil characteristics, climate, water quality etc.) and secondarily by the species of plants and animals that live there', i.e. including both physical and biological components.

Most but not all EUNIS habitats are 'biotopes', i.e. 'areas with particular environmental conditions that are sufficiently uniform to support a characteristic assemblage of organisms'.

7.2.3 Structure

It covers all types of natural and artificial habitats, both aquatic and terrestrial.

The classification, which is strictly hierarchical, forms a key for identification of habitats, analogous to keys for identification of species. The marine classification has 6 levels.

Marine habitats at level 2 are broadly equivalent to terrestrial and freshwater habitats at level 1.

- Level 1 – coastal influence separates coastal and marine realms.
- Level 2 – Substratum (superficial and underlying), aerial exposure, presence of continental shelf and macroalgal separate level 2 classes

- Level 3 – various physical and biological aspects relevant to each level 2 habitat/code subdivide classes at this level.

Higher levels often taken from other existing classifications and are typically driven by biological considerations, e.g. the classification for Britain and Ireland is a bottom–up aggregation of biologically defined habitat types derived from detailed analysis of benthic sample data. The lower levels (5, 6) are aggregated according to similarity in their biological character (level 4) and then into progressively more physically defined upper levels (2, 3 and to some extent 4). Each aggregation up the hierarchy is therefore biologically meaningful, but increasingly reflects the physical structuring of the environment (substratum, depth, salinity etc.). It was intended that this would make the upper levels in the classification more useful for mapping, sensitivity assessment and recognition by non-specialists.

7.2.4 Geographic Extent

The geographical scope is the European mainland, extending east to the Ural Mountains, including offshore islands (British Isles, Cyprus; Iceland but not Greenland), and the archipelagos of the European Union Member States (Canary Islands, Madeira and the Azores). Anatolian Turkey and the Caucasus are included in the classification in principle, although knowledge from these areas is more limited and their habitats are therefore not developed in detail. Marine areas whose habitats are included in the classification are the Northeast Atlantic (including the North Sea), Baltic, Mediterranean and Black Seas.

7.2.5 Value of Classification for Management

All Annex I habitat contained in the EU Habitats Directive are cross-referenced to EUNIS habitats.

Classifications lack quality variations due to disturbance and damage.

7.2.6 Compatibility with Scientific Data

Many levels 2, 3, 4, 5 and 6 have dominant species associated with classes.

Each class has bands for environmental data, e.g. depth bands.

MESH established the potential to have mixed EUNIS codes within a polygon, thereby allowing for scale issues and heterogeneous areas of seabed.

MESH criticized EUNIS for lacking compatibility with acoustic data at the lower levels.

In the light of new habitat mapping initiatives and European directive implementation requirements, a workshop entitled "Using EUNIS habitat classification for benthic mapping in European seas" was organized by AZTI-Tecnalia in San Sebastian (Spain) on 23–24 April 2012 within the framework of the Interreg project MeshAtlantic. The event was focused upon the interchange of scientific knowledge gained in different marine habitat (mapping) programmes around European regions including the Baltic, Atlantic, Mediterranean and North Sea, using the EUNIS habitat classification, together with the experience of scientists using other habitat classification schemes in Norway and the USA. The objective of the meeting was to share experience of different research teams in the current use of the classification, and their perspectives on adaptation and development of the EUNIS classification scheme for present and future needs. Hence, the specific objectives of the workshop were to: (i) bring together scientists with experience in the use of the EUNIS classification, and representatives from the EEA; (ii) agree on enhancements to EUNIS that would ensure an improved representation of European marine habitats; and (iii) establish practices that make marine habitats maps produced by scientists more consistent with the needs of managers and decision-makers. In Galparsoro *et al.,* 2012 the main results and agreements obtained during this workshop is summarized.

During the workshop, it was scientifically agreed that there are a number of issues unique to the development and implementation of broad-scale classification schemes such as EUNIS, and these were also echoed by colleagues in the USA who are developing and utilizing CMECS (Coastal and Marine Ecological Classification Standard). It was commonly agreed that the structure and underlying assumptions of the current EUNIS classification system requires improvements to make it applicable to all regions, more ecologically meaningful and to make it useful when producing map outputs. Nevertheless, several opportunities were identified for modifying the system in order to make it more fit-for-purpose for habitat categorization, and consequently, for marine mapping, implementation of European directives (e.g. Habitats Directive, MSFD, INSPIRE, etc.), management purposes and MSP. The suggested critical improvements could be summarized as (i) inclusion of new habitat classes observed in the field, (ii) revision of the existing habitats to enhance the ecological significance of the scheme and its comprehensiveness, (iii) development of EUNIS below level 4, and (iv) development into less well-represented biogeographic areas such as the deep-sea, the Black Sea and the southwestern European seas (with a particular focus on the Atlantic Area region, specifically the Bay of Biscay and the Azores). Some of the previously cited aspects and developments could be based on, or linked to, national habitat typologies developed by some Member States to suit domestic needs.

It was also suggested the need for a process to propose new habitats, and maintain and update the classification. To propose new biotopes a *pro forma* is needed on the EUNIS website (e.g. http://www.searchmesh.net/default.aspx?page=1864), but it was also suggested that such biotopes should be clearly marked as 'new' (not yet in EUNIS) in any publications/maps.

It was also noted the need for a suitable review mechanism of the proposed new habitats, establishing an effective and timely updating mechanism to accommodate new proposals. The development and revision of the classification requires the input from science and policy/managers, and it would be necessary to define the role of national governments as well as scientists in updating the classification to ensure continuity of classification vs. the revision based on newly available data. In that sense, a clear mechanism/timing in the process is also needed so that old versions of the classification could be related to new versions. For further development, the ETC-BD should bring forward proposals as soon as possible, establishing an editorial group, a marine subcommittee or a more *ad hoc* process. Such reviews and development were found to be crucial to the adaptation of the EUNIS hierarchical habitat classification to the European biogeographic regions and to facilitate the mapping of harmonized biotope data across Europe.

7.2.7 References

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8 Support to the technical specification and application of OSPAR common indicators under D1, 2, 4, and 6 - ToR f)

There was not enough time, given the small number of participants at the meeting (21-24 may), for WGMHM to perform an in-depth review and evaluation of the common biodiversity indicators, and how to maximize the use of existing data for monitoring as requested by OSPAR.

Common for both requests (ToRs f and g) is that relevant information about the habitat is needed as a basement both for selecting good indicators and designing monitoring programmes relating to D6 (Seabed integrity). The use of similar habitat classes is important when comparing values for indicators between regions and countries. Appropriate habitat maps should be used as a basis for designing monitoring programmes. Both the extent and distribution patterns of habitats may to a certain degree control the expected natural baseline level of the indicators.

OSPAR request 2013-4:

Request for the quality assurance/ response to specific questions to support the work of the identification and prioritization of common indicators to support the regional implementation of the biodiversity aspects of MSFD in the Northeast Atlantic. BDC 2012 have requested the submission of first set of common indicators to be presented to BDC 2013 (noting that the relevant ICES groups will meet late February early March 2013). At this time (i.e. first quarter 2013), ICES would be requested to undertake an independent peer review of the technical specifications and proposed operational implementation of the indicators that will be presented. The review should consider, from the perspective of producing a set of common indicators for the OSPAR Region:

For this evaluation of common indicators we have focused on the ecosystem component Benthic habitats, with the five common biodiversity indicators listed below:

BH-1	Typical species composition
BH-2	Multimetric indices
BH-3	Physical damage of predominant and special habitats
BH-4	Area of habitat loss
BH-5	Size frequency distribution of bivalve or other sensitive/indicator species

These indicators have been presented in two reports used as a background for this evaluation: ICG-COBAM (2013a and 2013b).

The OSPAR request presents five questions to be considered:

- Q1) whether the indicators put forwards are appropriate to implement at a regional scale;
- Q2) whether the set of indicators is sufficient as a set to understand GES;
- Q3) identify any gaps;
- Q4) identify where there are difficulties in the operationalization of the indicators, with proposals for how to overcome these.),

- Q5) identify where there are opportunities to cluster indicators that can benefit from shared monitoring/ data collection based on the outcomes of OSPAR request 2013-4 (below; regarding maximizing efficiencies for monitoring of biodiversity. OSPAR request 2013-3.

Questions 2, 3 and 5 relates to all indicators and will be adressed collectively. The other questions will be adressed for each indicator.

8.1 General comments

The technical specifications of the common indicators (ICG-COBAM 2013b) are generic and lack sufficient details to make them operational. Without having access to practical guidelines or "handbook" for the implementation of the different indicators it is difficult for WGMHM to evaluate the indicators in detail. We have therefore discussed the indicators in a more generic way with main focus on how they relate to benthic habitats, and how habitat mapping and classification must be incorporated as a basement for the indicators. A technical specification should refer to publications where relevant standardized methods are described (e.g. EN 16260, ISO 16665, EN ISO 19493, Coggan *et al.*, 2007)

8.2 Habitat maps as a spatial context

Expected natural levels for indicators BH 1, 2, 3 and 4 will vary between habitats and bioregions.

Comparable habitats are more likely to be identified at the lower level of a habitat classification system. Habitats defined at a higher (more generic level) will display more natural variation that will blur any signals from human impact. Habitat maps provide spatial reference for point sampling, and what Typical species composition list (BH1) to use for a particular sample.

Careful considerations need to be made about how sensitive and appropriate indicators are at different habitat classification levels

It is important that the technical specifications for the indicators give clear guidelines for how to relate to a classification system (i.e. EUNIS) in a standardized way.

BH1 – typical species composition

Q1: Typical species composition (TS) relates to specific habitats and bioregions. Otherwise TS will be meaningless or lack power of detecting response of pressures.

Defining TS for habitats and bioregions is a task that cannot be undertaken by different member states separately.

Q4: Comparison of this indicator between habitats is more complex that within one habitat. If there is an aim to combine TS from several habitats within a region, guidelines must be developed. Such comparisons may rely on relative reporting of values and trends (e.g. percentages of species displaying changes in abundance).

Criteria for defining typical species composition should be defined in more detail. TS must be based on quantitative species composition (abundance, biomass or relative composition) and not based on presence absence data. Presence absence data would give too weak responses. This should be stated clearer in the technical specifications (ICG-COBAM 2013b).

BH2 – Multimetric s

Q1: Habitat mapping will provide spatial reference for multimetric indices in a similar fashion as to BH1.

Q4: A practical guideline (technical specification) should give clear advice on for which habitats different indicators are suitable.

BH3 – Physical damage of predominant and special habitats

Q1: Habitats maps provide the baseline for BH3.

Q4: Physical damage may be documented by various techniques. Guidelines for how to document should be addressed (see general comments above).

BH4 – Area of habitat loss

Q1: Habitats maps provide the baseline for BH4. As long as the habitat definitions cover whole regions appropriately, this indicator can be implemented at a regional scale.

Q4: Whether this indicator is operational or not depends on the accuracy of the habitat definitions. For biogenic habitats without clear boundaries , this represents a true problem. For example, for coral gardens it can be difficult to outline the boundary of the habitat because quantitative data on colony density (colonies per area) is needed, whereas for a Lophelia pertusa reef the outline of the reef can in many case be visualized with mulitibeam echosounder data. There are no fixed colony density that represents the treshold value for a coral garden habitat (as well as for many other biogenic habitats). It is therfore important that the treshold values used in each case is reported.

BH5 – Size frequency distribution of bivalve or other sensitive/indicator species

WGMHM does not understand why there is a need to mention bivalves in the title of this indicator. We suggest that the indicator should be named "*Size frequency distribution of sensitive/indicator species*". There is a great potential for video surveys to provide size distribution for attached epifauna of sessile mega-fauna which can be informative for some pressures.

Q1: Size frequency distributions depends on more than human pressures. Mean sizes of Mytilus for instance, will vary with natural environmental gradients, such as salinity. It is therefore crucial that baseline values are defined within relevant environmental regimes.

8.3 Answer to questions relating to all indicators

Q2 and 3: Area of some habitats, e.g. biogenic reef, may deteriota significantly without a change in aeral extent. Many biogenic structures are better monitored through quality indices, such as colony size distribution and percentage cover of live tissue (living colonies).

Q3: The indicators are not specific to individual pressures. We trust that such indicators (e.g. satelite tracking data –VMS) will be viewed together with relevant common biodiversity indicators.

Q5: The oppurtunities to cluster indicators depends to a great extent to which survey techniques are used. For monitoring programmes using benthic sampling of infauna, indicator BH 1, 2 and 5 can be estimated from the same results.

Quantitative results on infauna (which constitute the most common datasets from past surveys) are relevant to estimating multimetric indicies (BH2) and creating list of typical species composition (BH1).

Visual surveys can provide data for all indicators, but the data can not always be used for comparison with results from other survey techniques.

8.3.1 References

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9 Provide advice on maximizing the use of available sources of data for monitoring of biodiversity – ToR g)

OSPAR request 2013-4:

The purpose of this request is to seek ICES advice on the potential sources of data and information that may be available to support the monitoring and assessment of biodiversity in relation to commitments under MSFD so as to maximize efficiencies in the use of available resources, for example where efficiencies could be made to identify where there are monitoring programmes or data sources that can deliver multiple indicators, which may relate to different Descriptors, (e.g. The Data Collection Framework could be used to implement D3 and D1 indicators), or where with a small additional effort existing monitoring could be amplified to deliver a broader set of data. Advice would be sought as to 1) the quality of these potential data sources and how they could be used, including but not limited to the relevance of outcomes identified in chapter 8 of the ICES MSFD D3+ report to Descriptors 1, 4 and 6.

This ToR is treated in the chapter above.

Annex 1: List of WGMHM Participants – 21–24 May 2013

Name	Addres	Telephone/Fax	E-mail
Natalie Askew	Joint Nature Conservation Committee Monkstone House, City Road Peterborough PE1 1JY UK		Natalie.Askew@jncc.gov.uk
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Annex 2: Working Group on Marine Habitat Mapping (WGMHM)

ToR 2013.

The **Working Group on Marine Habitat Mapping** (WGMHM), chaired by Pål Buhl Mortensen, Norway, will meet at ICES Headquarters, Copenhagen Denmark, 21–24 May 2013 to:

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

b) Present and review important results from national habitat mapping during the preceding year, as well as new ongoing and planned projects focusing on particular issues of relevance to the rest of the meeting. Provide National Status Report updates in geographic display in the ICES webGIS;

c) Evaluate recent advances in marine habitat mapping and modelling techniques, including fieldwork methodology, and data analysis and interpretation;

d) Review practice about the use of habitat maps, for example Mapping for the MSFD, marine spatial planning, and management of MPAs;

e) Review of existing habitat classification systems and identify commonalities and differences.

f) Support to the technical specification and application of OSPAR common indicators under D1, 2, 4, and 6

g) Provide advice on maximizing the use of available sources of data for monitoring of biodiversity

WGMHM will report by 21 June 2013 (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	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. 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. 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 approcah. The compilation of National status reports remains an important tool to show progress in knowledge of our seabed. This extends to interpreted and modelled maps as well as substrat maps. 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 2013 meeting. ToR e: The diversity of habitat classification schemes and systems has increased over time. WGMHM regard this ToR to be important for better assessing the relevance of different classification systems and communicating between habitat mapping projects. ToR f) Request for the quality assurance/ response to specific questions to support the work of the identification and prioritization of common indicators to support the regional implementation of the biodiversity aspects of MSFD in the Northeast Atlantic. BDC 2012 have requested the submission of first set of common indicators to be presented to BDC 2013 (noting that the relevant ICES groups will meet late February early March 2013). At this time (i.e. first quarter 2013), ICES would be requested to undertake an independent peer review of the technical specifications and proposed operational implementation of the indicators that will be presented. The review should consider, from the perspective of producing a set of common indicators for the OSPAR Region: 1) whether the indicators put forwards are appropriate to implement at a regional scale; 2) whether the set of indicators is sufficient as a set to understand GES; 3) identify any gaps; 4) identify where there are difficulties in the operationalization of the indicators, with proposals for how to overcome these. Based on the outcomes of OSPAR request 2013-4 (below; regarding maximizing efficiencies for monitoring of biodiversity), 5) identify where there are opportunities to cluster indicators that can benefit from shared monitoring/ data collection. OSPAR request 2013-3. ToR g) The purpose of this request is to seek ICES advice on the potential sources of data and information that may be available to support the monitoring and assessment of biodiversity in relation to commitments under MSFD so as to maximize efficiencies in the use of available resources, for example where efficiencies could be made to identify where there are monitoring programmes or data sources that can deliver multiple indicators, which may relate to different Descriptors, (e.g. The Data Collection Framework could be used to implement D3 and D1 indicators), or where with a small additional effort existing monitoring could be amplified to deliver a broader set of data. Advice would be sought as to 1) the quality of these potential data sources and how they could be used, including but not limited to the relevance of outcomes identified in chapter 8 of the ICES MSFD D3+ report to Descriptors 1, 4 and 6. **OSPAR request 2013-4. Draft of ToRs f and g response by 1 June 2013 to Claus Hagebro, ICES.**
Participants	The Group is normally attended by some 15–20 members and guests. Representatives from Member Countries with experience in habitat mapping and classification.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	ACOM.
Linkages to other committees or groups	BEWG, WGEXT, WGDEC, WGMPCZM
Linkages to other organizations	OSPAR, HELCOM, EEA

Annex 3: WGMHM 2013 agenda

Progress in international mapping programmes – ToR a

- OSPAR and HELCOM Conventions, , EC and EEA initiatives, CHARM, and Mesh-Atlantic, Emodnet, Geo-Seas (Vera van Lancker BE), CoralFish (Anthony Grehan), INISHYDRO (James Strong IE)

National programmes (National Status Reports) – ToR b

- National status report : short presentation (10' to 15' for each country) by national delegates (Thomas Kirk Sørensen DK, Kerstin Geitner DK, Roland Pesch DE, Maria Lambers-Huesmann DE, Trine Bekkby NO, Pål Buhl-Mortensen NO, Vera Van Lancker BE)

Recent advances in marine habitat mapping and modelling techniques – ToR c

- Fieldwork methodology, and data analysis and interpretation (all participants brief review)

Review practise about the use of habitat maps ToR d

- Mapping for the MSFD,
- marine spatial planning,
- management of MPAs

(Hans Mose Jensen DK Wednesday/Friday afternoon?, (Periklis Panagiotidis DK), Vera van Lancker BE, Pål Buhl-Mortensen NO, Thomas Kirk Sørensen DK, Anthony Grehan IE (PROTECT))

Review of existing habitat classification systems – ToR e

- identify commonalities and differences

Support to the technical specification and application of OSPAR common indicators under D1, 2, 4, and 6 – ToR f

Provide advice on maximizing the use of available sources of data for monitoring of biodiversity – ToR g

Other issues

- Venue for next year's meeting
- Next year's TORs

Annex 4: WGMHM terms of reference for the next meeting

The **Working Group on Marine Habitat Mapping** (WGMHM), chaired by Pål Buhl Mortensen, Norway, will meet at AZTI in San Sebastian, from 19–23 May 2014 to:

International programmes – ToR a)

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

National programmes (National Status Reports) – ToR b)

b) Present and review important results from national habitat mapping during the preceding year, as well as new ongoing and planned projects focusing on particular issues of relevance to the rest of the meeting. Provide National Status Report updates in geographic display in the ICES webGIS;

Habitat mapping techniques and modelling – ToR c)

c) Evaluate recent advances in marine habitat mapping and modelling techniques, including fieldwork methodology, and data analysis and interpretation;

Habitat mapping relating to management – ToR d)

d) Review practise about the use of habitat maps, for example Mapping for the MSFD, marine spatial planning, and management of MPAs;

e) Assess the ability to use habitat maps for monitoring of the environment;

WGMHM will report by 21 June 2014 (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	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. 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. 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 approcah. The compilation of National status reports remains an important tool to show progress in knowledge of our seabed. This extends to interpreted and modelled maps as well as substrat maps. 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 2014 meeting. ToR e: It is important to understand the larger environmental context (environmental settings of habitat) when monitoring changes in environmental indicators. This issue was partly covered during the meeting in 2013 but could be further explored during the 2014 meeting.
Participants	The Group is normally attended by some 15–20 members and guests. Representatives from Member Countries with experience in habitat mapping and classification.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	ACOM.
Linkages to other committees or groups	BEWG, WGEXT, WGDEC, WGMPCZM
Linkages to other organizations	OSPAR, HELCOM, EEA