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17–20 April, 2007

Woods Hole, USA

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The Working Group on Marine Habitat Mapping (WGMHM) convened in Woods Hole, USA from 17–20 April 2007 and was hosted by Tom Noji from the National Oceanic and Atmospheric Administration (NOAA). The meeting was chaired by David Connor (UK) and attended by 22 delegates from seven countries.

Key points from meeting

Major national and international marine habitat mapping programmes are underway in many parts of the ICES area (e.g. BALANCE – Baltic Sea, MESH – north-west Europe, various – North Sea, GOMMI – north-east America), delivered variously through new high quality survey, broad-scale modelling and the collation of existing datasets. Whilst the level of such activity is a reflection of the increasing policy and management demands for such information, WGMHM identified the need for improved coordination of this effort to ensure the resultant maps are fully compatible. This requires further work to develop common or harmonised classification schemes and to interface web delivery systems.

Despite the range and volume of habitat mapping programmes being undertaken, there is only limited internationally-agreed guidance available on the techniques which should be used. WGMHM has reviewed available guidance; that being developed by the MESH project (which includes a set of Recommended Operating Guidelines and survey metadata standards) appears to be the most advanced and comprehensive; it will be published during 2007 (www.searchMESH.net). WGMHM needs to consider if further guidance is required to meet the needs of ICES.

The provision of accuracy and confidence assessments in habitat maps is an important new topic which WGMHM considered. The lack of such assessments to date needs to be redressed; various approaches were identified which need further development.

International programmes

Several major programmes have made substantial progress in mapping and modelling the distribution of seabed and water column habitats, for example BALANCE for the Baltic Sea; MESH for north-west Europe; OSPAR for selected habitats across the north-east Atlantic. The release of these maps represents significant progress compared with several years ago. In examining various maps available for the North Sea, WGMHM assessed the range of different data sets and methodological approaches used and identified the need for additional work to produce complete maps for the North Sea at a suitable level of detail.

National programmes

WGMHM has continued to review national programmes, providing a valuable forum for the exchange of information, techniques and strategies. WGMHM has collated much useful information in its National Status Reports (metadata on mapping programmes) during its past meetings. Bringing these reports together and making them more widely available via a web portal would greatly improve access to this work.

Mapping strategies and survey techniques

Limited attention was given to this theme during the 2007 meeting, although relevant issues were raised during other agenda items. The role of mapping and modelling in relation to pelagic habitats and fish communities was briefly examined.

Protocols and standards for habitat mapping

A review of a set of guidelines by the MESH project for deploying a range of survey techniques highlighted the need for good international guidance for habitat mapping and identified some gaps. Examination of the outcomes of a video analysis workshop indicated the importance of standards and intercalibration for the interpretation of video footage, as part of the mapping process. Calibration of video systems during surveys was discussed.

Uses of habitat mapping in a management context

Recognising the importance of habitat mapping to a wide range of marine management and policy contexts (as evidenced by the many programmes reviewed in the international and national reports above) WGMHM started to draw upon its experience to outline a paper on the role of habitat mapping in an ecosystem-based context. This will recognise the many areas of ICES activity for which marine habitat mapping has relevance, including ecosystem functioning, coastal zone management, fisheries, protected areas and spatial planning.

1 Opening of the meeting

The Working Group on Marine Habitat Mapping (WGMHM) was convened at the National Oceanic and Atmospheric Administration (NOAA).in Woods Hole, USA from 17–20 April 2007.

The meeting was chaired by David Connor (UK) and was hosted by Dr Tom Noji from NOAA. It was attended by 22 delegates from Canada, Denmark, Germany, Ireland, Sweden, the UK and the USA (Annex 1). Each participant provided a brief introduction about themselves. Apologies were received from the following WG members: Roger Coggan (UK), Fiona Fitzpatrick (Ireland), Anthony Grehan (Ireland), Brigitte Guillaumont (France), Kerstin Geitner (Denmark), Vladimir Kostylev (Canada), Alain Norro (Belgium), Anu Reijonen (Finland), Ricardo Santos (Portugal), Fernando Tempera (Portugal) and Els Verfaillie (Belgium).

1.1 Terms of Reference

The Terms of Reference for the meeting were reviewed and are given in Annex 2. The Agenda and this report were specifically structured to address each item on the ToR, within the set of theme topics established previously by WGMHM.

1.2 Appointment of Rapporteurs

The task of preparing the report of the meeting was shared amongst delegates as follows: Mike Robertson (ToR a), Brian Todd and David Limpenny (ToR b), Sara Ellis (ToR c), David Connor (ToR d), Matt Service (ToR e), Neil Golding (ToR f), Tommy Furey (ToR g), David Connor (ToR h), Chris Cogan (ToR i), and with additional contributions from individuals who made presentations.

2 Adoption of the agenda

A draft Agenda distributed before for the meeting was discussed, adding several additional national status reports and adjusting scheduling. The adopted Agenda is given in Annex 3.

3 International programmes

3.1 Progress in international mapping programmes

Review progress of international mapping programmes (including MESH, EEA, OSPAR, BALANCE and HERMES (ToR a)

3.1.1 The Interreg MESH programme for north-west Europe

David Connor (UK) described the Interreg-funded habitat mapping project MESH (Mapping European Seabed Habitats) which was initiated in 2004 to develop a framework for marine habitat mapping in Europe and to develop the first co-ordinated seabed habitat maps for the north-west Europe region. MESH is being undertaken by a consortium of twelve partners across Belgium, France, Ireland, the Netherlands and the UK. Its duration has recently been extended; it is now due to finish in early 2008. The main achievements of the project are:

a) Development of an on-line catalogue of habitat mapping studies, now containing over 1000 metadata entries (www.searchMESH.net/metadata).

b) Collation of available habitat maps for the five MESH countries, and their conversion into a common GIS format and to a common habitat classification scheme (the European Environment Agency's EUNIS scheme).

c) Development of Data Exchange Formats (DEFs) for habitat mapping and other associated types of data to facilitate rapid exchange of data across countries.

d) Development of an interactive guide to marine habitat mapping, including protocols and standards for mapping survey techniques and the interpretation of data, to promote future collection of data which are of high quality and inter-operable (allowing them to be combined with other mapping data). This includes a series of Recommended Operating Guidelines (ROGs) and survey metadata standards. This Guide is due to be published in summer 2007.

e) New surveys in over 60 study areas, which have added to the available knowledge on seabed habitats, tested and evaluated survey procedures and facilitated the transnational exchange of expertise. A final survey, in the deep-water canyons in the south-west approaches to the Celtic Sea, is being undertaken in summer 2007.

f) Development of a series of modelling techniques and studies, from very broad scale to very fine scale, which enable the production of predicted habitat maps. As the coverage of existing habitat maps in still very patchy, and mostly confined to coastal areas, such modelling techniques can fill large gaps in mapping coverage until such times as high quality habitat surveys can be undertaken. Examples of broad-scale outputs include a marine landscape map for UK waters (www.jncc.gov.uk/UKSeaMap) and a map to EUNIS levels 3 or 4 for Belgian, Dutch, French and UK waters (www.searchMESH.net/webGIS).

g) Case studies examining the use of habitat maps for a variety of management and industry needs.

h) Dissemination of the data, reports and maps emanating from the project via the MESH web site (www.searchMESH.net) including an interactive webGIS application.

i) Communication with stakeholders via newsletters, conferences and bespoke stakeholder workshops in each country, to help ensure the work undertaken meets end-user needs. A project conference held in Dublin in March 2007 was attended by over 200 delegates from 21 countries.

The habitat maps and modelled data outputs from MESH are now publicly available on the webGIS application.

3.1.2 The OSPAR habitat mapping programme

Neil Golding (UK) outlined the OSPAR programme and its progress to date. The OSPAR Commission adopted an initial list of threatened and/or declining species and habitats in 2003, extending the list in 2004. A total of fourteen habitats are currently on the list:

- Littoral chalk communities;
- Intertidal *Mytilus edulis* beds on mixed and sandy sediments;
- Intertidal mudflats;
- *Sabellaria spinulosa* reefs;
- *Modiolus modiolus* horse mussel beds;
- *Zostera* beds;
- *Ostrea edulis* beds;
- Maerl beds;
- Seapens and burrowing megafauna communities;
- *Lophelia pertusa* reefs;
- Carbonate mounds;
- Deep-sea sponge aggregations;
- Seamounts;
- Oceanic ridges with hydrothermal vents/fields.

As part of a wider programme to develop measures for the protection and conservation of the species and habitats on this list, OSPAR's Biodiversity Committee (BDC) agreed in 2003 on a programme to collate data on the distribution of the fourteen habitats on this list. Each Contracting Party compiles data for its own marine waters and submits these to the programme coordinator (the UK's Joint Nature Conservation Committee) for collation into composite maps on the distribution of each habitat across the whole OSPAR area. In addition, data for *Seamounts* and *Lophelia pertusa reefs* has been sought from other sources to particularly aid their mapping in high seas areas. To date, a total of 13 652 habitat records have been collated; the data are made available on the OSPAR mapping website[1] which was last refreshed in September 2006.

The OSPAR habitat mapping data are relevant to the following OSPAR work areas:

a) Species and Habitats on the OSPAR Initial List – the mapping data provide essential information about the known distribution (and extent) of the habitats, which will be of use in relation to the assessment of threats (from human activities) and in the development of appropriate management measures;

b) OSPAR Marine Protected Areas – OSPAR is working towards an ecologically coherent network of well-managed sites by 2010. It is expected that sites will need to be identified for habitats on the OSPAR List;

c) Ecological Quality Objectives (EcoQOs) – an EcoQO for threatened and declining species and habitats is under consideration. This is likely to need specific EcoQOs for particular species and habitats. The habitat maps will inform the feasibility of establishing suitable EcoQOs;

d) Assessments of human activities – consideration could be given in future assessments (by the Environmental Impacts of Human Activities Working Group) as to whether particular human activities are having an impact on any of the OSPAR List habitats, and whether there is a particularly strong relationship between the habitat and a specific activity;

e) Joint Assessment and Monitoring Programme (JAMP) – As part of the JAMP process, OSPAR requires an assessment of the status of the habitats on the OSPAR List in 2009, including a collation of information on the distribution, extent and quality of each habitat. The habitat mapping data provide a clear contribution to the first two of these attributes (distribution, extent);

f) Quality Status Report (QSR) – The 2010 QSR is expected to include an assessment of the habitats on the OSPAR List (based on the JAMP assessments).

In 2006, the Data Exchange Format (DEF) for submitting habitat data was reviewed and modified in the light of its practical use, ongoing developments on DEFs for habitat mapping data in the Interreg MESH programme and because there was a growing demand from Contracting Parties to submit data in GIS polygon format. A modified DEF for point sample data includes simplified data entry and strengthened quality assurance aspects, whilst there is a new DEF for GIS polygon data. All the point data submitted to date has now been transferred into the revised DEFs. It is expected that a further upload of data will be made in autumn 2007, following the next deadline for data submission (31 July 2007). The data are also being made available via the MESH webGIS (www.searchMESH.net/webGIS).

In the light of the ongoing need to continue the programme, particularly to support the JAMP assessments leading to the 2010 QSR, the UK has recently agreed to continue in its role as co-ordinator until BDC 2009.

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1 OSPAR mapping site web address: www.searchNBN.net/hosted/ospar/ospar.html) or www.ospar.org/eng/html/welcome.html and follow links 'Protection and conservation of Marine Biodiversity and Ecosystems' then 'Mapping of habitats on the Initial OSPAR List'.

3.1.3 The Interreg BALANCE programme for the Baltic Sea

Per Sand Kristensen (Denmark) provided an update on the BALANCE project, with a particular focus on the broadscale mapping element of the project.

The Lead Partner is the Danish Forest and Nature Agency and there are 26 institutions from nine countries around the Baltic Sea, including Norway, involved in the project. Activities are being undertaken in the Baltic Sea, Kattegat and Skagerrak. The project is co-financed by the EU INTERREG IIIB fund for the Baltic Sea Region (BSR) and has a total budget of €4.7 million. More information is available at www.balance-eu.org, http://maps.sgu.se/Portal or BALANCE@SNS.DK. Lead contact: Johnny Reker, Forest and Nature Agency, Copenhagen.

BALANCE aims to develop an informed management template for the Baltic Sea focused on marine spatial planning through cross-sectoral and transitional co-operation and activities include:

- Identification and collation of available Baltic Sea marine data (physical, biological, socio-economic), meta-database;
- Identification and mapping marine landscapes and habitats in the Baltic Sea;
- Assessment of the Baltic MPA network and development of a "blue corridors" concept;
- Development of Baltic marine zoning plans in 2 pilot areas;
- Development of a stakeholder communication strategy.

The BALANCE approach has been to:

- Collate and analyse available geophysical and hydrographical information for the entire Baltic Sea and Kattegat;
- Define and agree on a unified data format;
- Decide a common platform for data handling, processing and projection of marine landscape maps, for example, in WGS84, UTM;
- Define standards for classifying Baltic marine landscapes;
- A validation scheme to confirm whether the predicted landscapes appropriately describe the natural environment;
- Evaluate the existing Baltic network of MPAs, identifying Baltic marine diversity hotspots and a strategic tool for planning field work.

The presentation focused on the newly-developed landscape map for the Baltic Sea. This had been developed using a similar methodology to the UKSeaMap project (see Section 3.2) and was based on the following main data layers: topographic and bed-form features, sediment, bathymetry and salinity, with the following secondary data layers: oxygen, current velocity, ice cover, wave exposure, bed shear stress and temperature.

There will be a project end Conference in Copenhagen in October 2007.

3.1.4 Developments at the EC, EEA and OSPAR Commission

David Connor (UK) provided a brief overview of recent European policy developments which may influence the future use and direction of marine habitat mapping.

Firstly, OSPAR's Biodiversity Committee, at its meeting in March 2007, was briefed on progress in the development of habitat maps in the MESH, UKSeaMap and OSPAR habitat mapping programmes. These newly available datasets provided the opportunity for OSPAR to consider using such information for the first time in their forthcoming 2010 Quality Status Report for the north-east Atlantic.

Secondly, the European Commission has two new policy developments, the Maritime Green Paper and the proposed Marine Strategy Directive. The Maritime Green Paper is in a consultation phase until June 2007 and includes consideration of the need for an atlas of the oceans and mapping of the distribution of the fauna and flora in European marine waters. The draft Marine Strategy Directive will require periodic assessment of the state of European seas including the provision of information and maps on marine habitats. This will be further considered at a meeting of the European Marine Monitoring and Assessment (EMMA) working group in May 2007.

Lastly, the European Environment Agency (EEA) who are responsible for developing the pan-European EUNIS habitat classification (http://eunis.eea.eu.int/habitats.jsp) are considering what further development might be needed with regard to marine habitats. There is recognition that the marine section of the classification still requires further development, in two particular aspects: to add further detailed habitats for regions which are not well covered by the classification and to ensure the classification is better suited to use in a habitat mapping context, including clarification of the relationship with remote survey techniques (acoustic and satellite imaging techniques).

3.1.5 Reformation of the ICES Science Structure

Thomas Noji (Chair of the ICES Marine Habitat Committee) presented an overview of proposed changes to the structure of ICES.

ICES is reforming both its Science and Advisory Structures. This short report summarizes some of the most important points, as they affect the Expert Groups (EG), and recommends actions at the EG level. Much of the material is extracted from the ICES report on reformation of the Science Structure (ICES 2007).

Current weaknesses of Science Structure:

- A science strategy is currently missing to guide the work of the committees and co-ordinate this with the work of the ICES advisory process.
- Clear strategic goals, action plans and review procedures are needed to direct the work and generate more commitment.
- The work in the EGs and Committees is largely dependent upon the leadership of the respective chairs.
- National priorities are not always adequately reflected in ICES science priorities.
- The transatlantic science funding cooperation, for instance between the DG Research and National Science Foundation, is underexploited.
- Role of Committees is unclear to the outside world (and not often apparent even within ICES).
- A review process is missing for the EG reports

Potential solutions:

- Develop clear strategy and action plans to direct the activities at different levels.
- Better define the roles and responsibilities of the Consultative Committee (ConC), Science Programme and the EGs.
- Promote E-working including video conferencing to facilitate EG and Committee work to allow people to work more closely without increasing costs significantly.

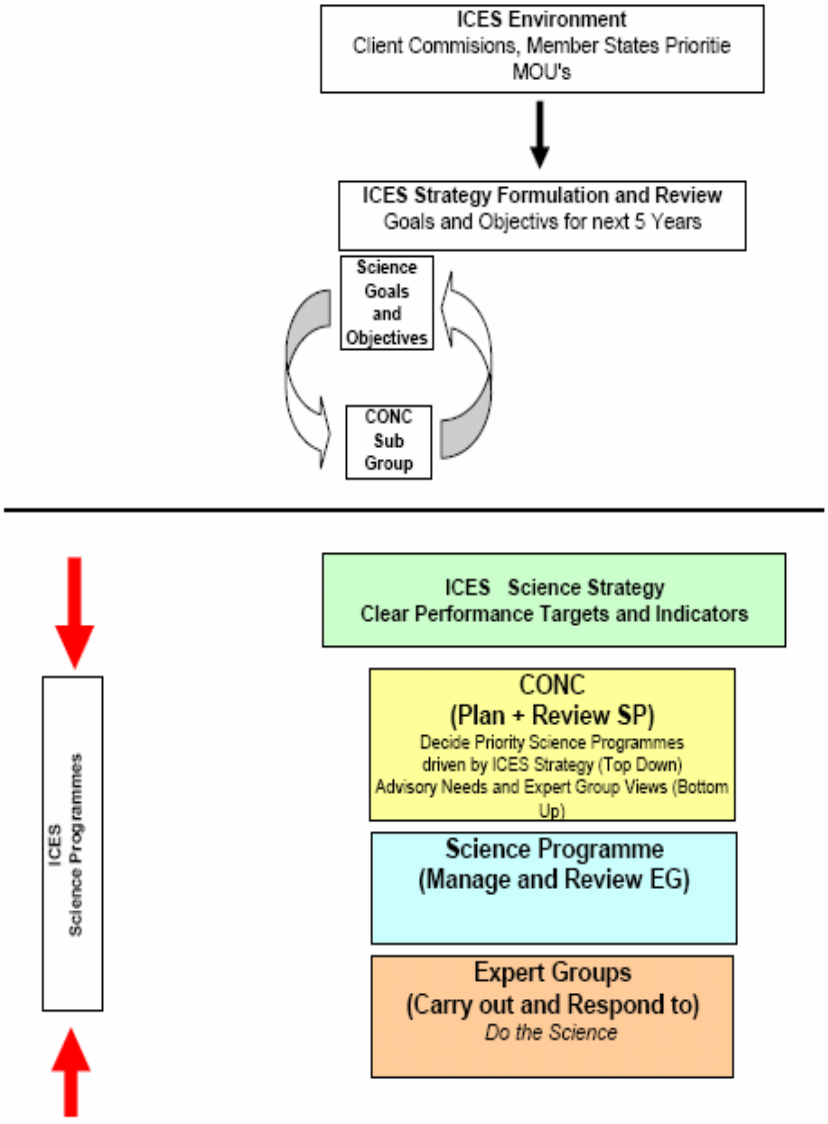
Actions to reform the ICES science structure:

- Recommendations for a strategy to reform the science structure will be developed by a subgroup of the ConC. This has already been completed (ICES 2007).

- A new ICES Science Strategy will be developed by the ConC to be endorsed by the Bureau at its meeting in June 2007.
- Once the Science Strategy has been endorsed, the ConC will derive and define Science Programmes to replace the current Science Committees.
- The new Programmes will develop Action Plans to implement the Strategy within the system of Expert Groups, through ToRs.

Development of a Science Strategy:

- The new ICES Science Strategy and Science Programmes will be developed through top-down interactions with ICES clients as well as bottom-up input from ICES experts.



New ICES Science Programmes:

The new Science Programmes will probably replace the current Science Committees. The Science Programmes will have a much larger role to play in a reformed ICES Science Structure. It is recommended that the Programmes have national representation. Further, representation of EG Chairs on the Programmes should ensure a more efficient and coordinated bottom-up communication of science. The new Science Structure will be

implemented using the current structure to a large extent. It may be expected that 2008 will be a year of transition to the new system, which will be fully operational by January 2009.

The Programmes will probably be expected to:

- coordinate the bottom-up science process
- align the implementation of the ICES Science Strategy with national priorities
- develop Action Plans in support of a Science Plan / ConC
- establish the EGs to implement the Action Plans
- discuss and bring to the attention of newly emerging mainstream science issues
- to update the Science Action Plan with mainstream science
- review the work of the EGs and ensure that they are 'fit for purpose' and that participation is appropriate
- provide feedback for updating the ICES Science Strategy

It is noted that for the last bullet point, the review of ToRs would be a genuine task of the Science Programmes while reviewing the scientific content of reports would require a separate procedure, preferably including external reviews.

Discussions within Science Committees and Expert Groups:

It is important for ICES experts, EGs and Science Committees to consider the impending changes to the Science (and Advisory) Structure and provide feedback on the proposal. Importantly, EGs and Science Committees need to consider how their respective activities will support a new ICES Science Structure. This will become easier to do once the actual Science Programmes have been identified by ConC. However, in most if not all cases, the supporting roles of the scientific EGs and Committees is clear and can be articulated already. The Habitat Committee chair encourages you to do this; these deliberations and recommendations should be communicated to the MHC chair directly or via the EG chairs. These deliberations will be an important part of considerations for reformation of the Science Structure when ConC meets in May and at the ICES Statutory Meeting in September.

Reference

ICES. 2007. Report on Reforming the ICES Science Structure, 17–19 January 2007. 16 pp.

3.2 Habitat maps of the North Sea

Review available habitat maps for the North Sea and their methodologies and make recommendations on how these maps may be further developed (ToR b)

This item was addressed by a sub-group comprising Brian Todd, Dave Limpenny, Neil Golding and Dieter Boedeker.

A number of habitat maps have been produced within the North Sea area in recent years. These maps are of varying coverage, resolution and quality. Within this ToR a systematic assessment was applied to each of the four maps made available to the WG, and comments were made on various aspects of their composition and on their relative utility to others. Where possible, those responsible for the production of the maps were consulted in order to better understand how the maps were constructed. A detailed comparison of the four maps is provided in Annex 4, according to the following factors:

- Map area;
- Datasets used;
- Analytical method;
- Resolution;

- Confidence;
- Limitations, and
- Lessons learned.

3.2.1 UKSeaMap

This map was produced in 2006 by the UK JNCC (with funding partners, including the EU Interreg IIIB programme) (Connor *et al*. 2006, www.jncc.gov.uk/UKSeaMap). The GIS data layers can be viewed on the web site. The map covers the western part of the North Sea and consequently has limited geographic coverage for the purposes of this ToR. The data are predominantly hydrodynamic and physical in nature. The hydrodynamic and physical data are very well documented with excellent metadata underlying each map layer. It is difficult to comment on the confidence levels that can be applied to this map as the underlying data points used are not presented in the report. The map is very easy to understand. The map has used a 'landscape' classification rather than the EUNIS system but this has been applied in a way that makes it easy to understand for experts and non-experts alike.

3.2.2 EEA/NIVA EUNIS map

This map was produced by Norwegian Institute for Water Research (NIVA) under an EEA-funded project completed in 2005 (Norderhaug and Moy 2005). This map has the advantage that it covers all of the North Sea. A list of datasets used to make the map has been provided, but it is not possible to view the data density of any of the layers; hence, it is difficult to assess the utility or contribution of each of the datasets. An example of the differing levels of data density is given, but this information is not available for the entire map. However, it is clear from the example that some areas are underpinned by far higher data density than others. There is very little information on how the map was constructed or how accurate interpolations were made between distant points. This makes it difficult to provide an assessment of confidence. The map is classified to EUNIS level 3. It is stated that some biological datasets have been used in the construction of the map but it is not clear how or where they have been used.

3.2.3 MarGIS

This map was produced under the MarGIS project in 2006 by the University of Vechta and the Alfred Wegner Institute (AWI) in Germany (Pesch *et al*. in press; www.awi-bremerhaven.de/GEO/Marine_GIS). GIS layers from MarGIS can be viewed on the above website. The map covers the German EEZ and consequently has limited geographic coverage for the purposes of this ToR. It has been produced on the basis of modelled data and uses a geostatistical decision-tree approach. Both physical and biological data have been used and the data points can be seen. The abiotic data do not include hydrodynamic energy layers and as such this map differs from others. The methodology for map construction has been clearly laid out. This map was not produced by biologists and does not use the EUNIS classification. A second map which uses the same datasets has been produced by Eike Rachor of AWI and shows a different distribution of benthic communities (provided at the meeting by D. Boedeker). Consequently, it is not clear which of these two approaches is most reliable. WGMHM considers the decision-tree mapping method to be robust and should be considered for application across the entire North Sea area if sufficient data exist. There would be value in comparing the resulting map with other North Sea habitat maps.

3.2.4 MESH EUNIS triplet model

This map was produced under the MESH project in 2007 (www.searchmesh.net/webGIS). The map covers the MESH part of the North Sea (UK, Dutch, Belgian and French waters) and consequently has limited geographic coverage for the purposes of this ToR. The abiotic

datasets used are similar to those used for other maps (particularly UKSeaMap) and are fairly comprehensive. These abiotic data have been modelled and classified to EUNIS levels 3 or 4. The metadata underlying each dataset is comprehensive. Biological and other environmental data (e.g. photographic images) are available to view. These data have been classified where possible to EUNIS but have not yet been compared to the EUNIS modelled map. Although the data layers are provided within a GIS format it would be helpful to have hard copies of certain layers, particularly those which show EUNIS habitats.

3.2.5 Conclusions

It was concluded that there was no complete North Sea seabed habitat map with adequate associated metadata. However, there are a growing number of broad-scale modelling projects that have produced habitat maps for parts of the North Sea.

There is a need:

- for more consistency in types of data used;
- to clearly document data used, sample intensity and methods of analyses and map construction, and
- to continue work towards harmonised classifications so that maps can be aggregated. However, it is recognised that there is merit in the application of several classification schemes for a single map (e.g. EUNIS, marine landscape) as they serve different purposes.

It is recommended that:

- further work is undertaken to achieve full coverage of the North Sea at a resolution similar to that achieved in the UKSeaMap and MESH projects and the inshore parts of the EEA project.
- further examination of the methods and data sets used is needed as there may be merits in using the MarGIS modelling approaches.
- metadata is made available for the EEA EUNIS North Sea habitat map.
- A multi-national approach could be adopted, similar to the BALANCE and MESH projects, to develop a habitat map for the entire North Sea area. Given the large area to be mapped, it is recognised that considerable effort would be needed to produce the necessary data layers (e.g. seabed substratum) in sufficient resolution prior to analysis and map production. This would require a coordinated effort amongst the North Sea countries.

References

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Norderhaug, K. M and Moy, F. 2005. Holistic mapping of potential EUNIS habitats in the North Sea. Report from NIVA, Norway (European Topic Centre on Water) to the European Environment Agency, Copenhagen. 11pp

Pesch, R., Pehlke, H., Jerosch, K., Schröder, W. and Schlüter, M. (in press). Using decision trees to predict benthic communities within and near the German Exclusive Economic Zone (EEZ) of the North Sea. 16 pp.

4 National programmes (National Status Reports)

Present National Status Report updates according to the standard reporting format by evaluating national habitat mapping activity during the preceding year (ToR c).

WGMHM discussed the National Status Reports based on presentations from national representatives in the Working Group. Annex 5 provides a compilation of the National Status Reports submitted to the meeting, according to a modified format developed for WGMHM 2007. Additionally more detailed information is available in further annexes as detailed below.

4.1 Canada

Brian Todd (Geological Survey of Canada, Natural Resources Canada) described the habitat mapping that is being undertaken in Canada's three oceans: the Pacific, the Arctic and the Atlantic.

Within Natural Resources Canada, the national Geoscience for Oceans Management (GOM) programme (http://ess.nrcan.gc.ca/2002_2006/gom/index_e.php) entered Phase 2 (2006–2009) in April 2006. Within GOM, the "top-down" project is a morphodynamic map of the Canadian continental shelves in the Atlantic, Pacific, and Arctic oceans. "Bottom-up" projects are tasked with habitat mapping in specific geographical regions to address ocean management priorities. Selection of areas to be mapped is based on the requirements of stakeholders including governments (federal, provincial and territorial), industry and other stakeholders. Individual projects are detailed in Annex 5.

GOM Phase 2 projects include the Northwest Passage through the Canadian Arctic Islands, Placentia Bay in Newfoundland, the St. Lawrence River estuary, and the Bay of Fundy. Maps at scales of 1:50,000 and 1:250,000 will be produced. A map series is nominally composed of four sheets: topography, backscatter strength, surficial geology and, where sufficient groundtruth data allow, benthic habitat.

The Department of Fisheries and Oceans Canada (DFO) has completed a project on Essential Fish Habitat mapping on the Scotian Shelf, with multibeam bathymetric mapping and analysis contributed by the Geological Survey of Canada (GSC). DFO is also involved with academia, the US Gulf of Maine Census of Marine Life Programme and the GSC in the multi-year Discovery Corridor project (http://marinebiodiversity.ca/en/corridor.html). The Discovery Corridor extends from the Fundy Isles Region of the lower Bay of Fundy across the northern Gulf of Maine, and has been situated with two objectives in mind: 1) maximize known information and 2) traverse a variety of habitats. The area encompasses coastal areas, offshore banks, submarine canyons, and seamounts. In conceptual terms the corridor extends from the land-sea margin to abyssal plain depths of 6000 m. See Annex 5 for project details.

4.2 Denmark

Per Sand Kristensen (Difres) discussed Denmark's mapping of exploited Danish bivalve stocks. Natural Danish bivalve stocks waters have been exploited throughout the last century with increasing annual landing volumes in the last fifty years, peaking in 1993 in a total landing of all species of approximately 137,000 tonnes. The most important species are mussels (*Mytilus edulis*), cockles (*Cerastoderma edule*), clams (*Spisula solida*) and European flat oysters (*Ostrea edulis*). Other bivalve and gastropod species are sporadically caught and landed in small amounts, e.g. queen scallops (*Chlamys opercularis*) and whelks (*Buccinum undatum*). The main fishing areas for mussel are Limfjorden, Kattegat, Little Belt and the Wadden Sea. Cockles are fished east of the islands in the Danish Wadden Sea as well as in coastal areas outside the Wadden Sea. Clams and cockles have been landed for almost 10 years from Horns Reef and Roede Klit Sand (two sandbanks in the North Sea) and cockles the

last couple of years as by-catch in the mussel fishery in Limfjorden. Oyster landings from Limfjorden have for the last three years been around 1,000 tonnes annually (a quota given for the fishery).

Since 1986 the Danish Institute for Fisheries Research (DIFRES) has monitored and assessed the different important stocks. Management and exploitation advice has been based on analysis of traditional biological parameters. Introduction of GIS has improved the analysis and made it possible to improve advice by mapping the stock abundance and biomass for smaller subdivisions of fishing areas for different bivalve stocks in order to limit the fishing effect to only the most productive beds.

Local stock variations, mortality rates and growth conditions can be mapped temporally and spatially to improve advice for authorities to ensure that the exploitation of the Danish bivalve stocks is maintained on a sustainable level in each area. Advantages of using the modern GIS tools in the management of exploited Danish bivalve stocks are presented and compared with the traditional biological tools used during the last twenty years. Further details are presented in Annex 6.

4.3 France

Brigitte Guillaumont (IFREMER) was unable to attend the meeting, but provided the following report:

Apart from REBENT and MESH projects operated by IFREMER, the Hydrographic Institute has several ongoing national projects:

- a national synthesis of available bathymetric data called the "Histolit project," with different grids products generated,
- a new project in collaboration with the National Geographic Institute to generate high resolution MNT around coastline "Litto 3D Project" using LIDAR and multibeam techniques,
- a national coast line generated in collaboration with the National Geographic Institute (1:25,000), and
- the "G map project," which will produce seabed sediment maps (1:50,000).

4.4 Germany

Dieter Boedeker (BfN[2]) gave a presentation on marine habitat mapping activities with special focus on the EEZ of the German North and Baltic Seas. The driving forces were the implementation of the European Union's Habitats and Birds Directives in the EEZ (NATURA 2000 network) as well as to contribute to the identification of "low conflict areas" for offshore wind farms.

Surveys to improve the knowledge on sediment distribution, seafloor topography and benthic fauna and flora are ongoing. Respective maps and GIS layers are constantly updated. The most important habitats for harbour porpoises and seabirds are also available as maps.

The EC Habitats Directive Annex I habitat types *sandbanks* and *reefs* have been identified and mapped using depth and sediment data as well as data on benthic invertebrates (in the Baltic Sea also benthic vegetation).

A new product in 2007 is a first (draft) GIS layer of EUNIS habitats down to level 4. Existing data on depth and sediment distribution were overlaid on the sediment classification used so far, and then transferred into the EUNIS classification system. A future task will be to overlay

2 German Federal Agency for Nature Conservation (**B**undesamt **f**ür **N**aturschutz).

the EUNIS level 4 information layer with benthic invertebrate data in order to produce a EUNIS level 5 map.

As a contribution to physical planning in the German EEZ, BfN has constructed maps on bird migration routes over the North Sea and the Baltic Sea including the NATURA 2000 sites and additional marine areas of particular ecological value and conservation interests that are not covered by NATURA 2000 sites. Additional data, images, maps, reports and important links are available online at www.habitatmarenatura2000.de and in Von Nordheim *at al*. 2006.

Reference

Von Nordheim, H, Boedeker, D., and Krause, J. C. 2006. Progress in marine conservation in Europe. NATURA 2000 sites in German offshore waters. Springer Verlag, Berlin-Heidelberg. 281 pp.

4.5 Ireland

Tommy Furey (Marine Institute) presented national seabed mapping report for Ireland. In 1999 the Irish Government allocated €32M to fund the Irish National Seabed Survey (INSS) project, which was designed to map Ireland's offshore area. The Geological Survey of Ireland (GSI), in partnership with the Marine Institute of Ireland (MI), managed the project mapping over 520,000km^2 of the Irish Extended EEZ prior to completion of the project in 2006.

In mid 2005 a proposal was submitted to government for a successor programme, which was accepted in April 2006 with the launch of INFOMAR (Integrated Mapping for the Sustainable Development of Ireland's Marine Resource), with an allocated budget of €4m per annum between 2006-2008. INFOMAR is currently planned as a 20-year programme, which aims to carry out integrated mapping over the entire shelf and coastal waters off Ireland. Through extensive stakeholder consultation 26 Priority Bays and 3 Priority Areas have been identified for mapping during the first phase of the project.

In 2006 the R.V. Celtic Explorer surveyed off south-west Ireland, working southward from adjoining 2005 survey coverage. Operations extend from the INSS data acquired to the west, inshore to the 50 m contour within Bantry and Dunmanus Bays. Data acquisition included multibeam, geophysical data, and more than 100 grab samples.

Marine LIDAR survey was carried out in Bantry, Dunmanus, and Galway Bays in October 2006. Penetration was severely hindered to the south-west due to suspended sediment content as a consequence of significant rainfall run off. No coverage was acquired in Dingle Bay which was originally included in the contract, again due to poor survey conditions. Galway Bay was incorporated at the survey planning stage, as a back up area in the event of poor conditions to the south-west. This proved very successful and permitted extensive survey coverage to be acquired in Galway during extended periods of low cloud coverage to south-west Ireland.

Preliminary results of seabed classification of this LIDAR data through GSI, Quester Tangent, and LADS cooperation look promising, and require further investigation following final LADS data processing, and ground-truthing.

4.6 Portugal

Fernando Tempera (University of the Azores) provided via email the contribution for Portugal given in Annex 5.

4.7 Spain

Ibon Galpasoro (AZTI Foundation) provided via email a report for Spain (Annex 7) which is summarized below.

Spain has been working to define and map marine habitats in the Basque coast and continental shelf (north-east of Spain, Bay of Biscay), including bathymetry (with the main physiographical characteristics of the bottom), and the identification of the structuring species associated to those habitats. To reach these goals, several objectives were defined: the European EUNIS habitat classification was used to classify the intertidal and subtidal habitats within the coast and continental shelf; new habitats were described and proposed in case they were not identified in the EUNIS classification and they were representative of the study area; finally, the main environmental factors (such as wave energy, etc.) that contribute to the habitat distribution were analysed.

Bathymetric information was acquired using a high resolution multibeam SeaBat 7125 system. Bathymetric data were acquired and processed using specific software PDS2000. A Digital Terrain Model (DTM) was produced and exported into ESRI grid format.

Underwater seafloor images were taken with digital cameras by divers and integrated into the GIS as a point shapefile with hyperlink to each image.

High resolution ortophotographs were used to identify and classify the supralittoral, intertidal and underwater habitats to 5 m depth. Habitat classifications were made using 0.25 m resolution airborne photographs taken in 2002 and 2004 by the Environment and Territory Management Department of the Basque Government. Habitat changes in this period were analysed to study the rate of artificialisation and natural shifts.

The distribution of wave energy along the continental shelf was calculated using hydrodynamic numerical modelling. Terrestrial DTM of 1 m resolution was extracted from airborne LIDAR data. Terrestrial DTM and seafloor DTM were integrated into the GIS as ancillary data for intertidal and marsh habitat mapping. Biological data was collected from other studies done in the study area. Information concerning species presence, species richness and biomass was used for analysis.

All the information described above was integrated into a corporate marine GIS called *ItsasGIS*, developed in 2005 to store a large portion of the marine information generated in the Basque continental shelf and the Bay of Biscay. The information is classified hierarchically into seven categories: biology and fisheries, bathymetry, geology and geomorphology, hydrography, land cartography, meteorology, and uses and management. Other products were generated to extract the features of seafloor morphology.

Taking into account that the Habitats Directive defines the natural habitats as terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, for each point with real data samples, abiotic parameters signature was calculated and habitat suitability maps were generated.

All the available intertidal and supralittoral habitats were analysed during the first two years of the project. About 7 715 ha have been interpreted and 18 habitat types have been identified, including four of which are of special interest in relation to the EC Habitats Directive.

The acquisition, processing and interpretation of bathymetric data are more time and effort consuming. To date, more than 60% of the coverage between 5 m and 50 m has been sampled. For underwater habitat mapping, only abiotic parameters have been taken into account to map to the 3rd level of EUNIS classification and Annex I habitat distribution mapping.

All the results of this project are being published on the web using Open GIS MapServer. The ability to generate maps, to manage information layers, ease of use, and accessibility makes it a very powerful tool.

4.8 Sweden

Ulf Bergström and Göran Sundblad (Swedish Board of Fisheries) provided a summary of mapping programmes for Swedish waters.

Within the EU Interreg IIIB project BALANCE (2005–2007), Sweden has been involved in both the landscape mapping at a Baltic Sea scale as well as habitat modelling in northern Skagerrak and in the northern Baltic Sea. The landscape mapping used data from the national marine geological survey programme of the Swedish Geological Survey on sediment composition. The national geological survey programme has a long-term goal of making high-resolution maps of the sediment composition within the Swedish EEZ, by using single beam echosounder, side-scan sonar, sub-bottom profiling, seismic reflection, cores, grabs, video and photography. In the BALANCE landscape mapping, Baltic-wide maps of salinity, photic depth, bed shear stress and slope have been collated in addition to the surface sediment maps.

The habitat modelling done by the Swedish partners within BALANCE in the archipelago region between Sweden and Finland includes identification of marine Annex 1 habitats of the EC Habitats Directive, as well as mapping of fish recruitment habitats. The essential fish habitat modelling, run by the Swedish Board of Fisheries, has produced validated high-resolution maps of habitats of a number of the most common fish species in the 40,000 km^2 international archipelago region. The fish habitat maps are being used by national and regional authorities in planning involving nature conservation and fisheries management. They will also be used in evaluating the connectivity and coherence of the Natura 2000 network in the Baltic Sea, which is a task within BALANCE.

Essential fish habitats are also modelled in the Kattegat by the Swedish Board of Fisheries and Aquabiota, as part of the national VINDVAL project (2006–2009), funded by the Swedish Energy Agency. In this area, habitat suitability maps for macroalgae and zoobenthos and a number of fish species are being produced. In the modelling, geological and biological data have been incorporated from the national survey of Swedish offshore banks (2003–2006), headed by the Swedish Environmental Protection Agency. The fish habitat models and maps will be used in spatial planning related to conservation, fisheries management and the establishment of offshore wind farms.

Within the EU Interreg projects Forum Skagerrak I and II (the latter project terminating in 2007), benthic habitat mapping using multibeam and backscatter has been undertaken in the Swedish parts of Skagerrak. This data has been used for mapping and modelling of Annex 1 habitats, cold water coral reefs, and important fish nursery grounds. These maps have been the basis for establishing trawl-free zones around the coral reefs and in coastal fish nursery areas.

A national project mapping the spatial distribution of all Swedish commercial fishery catches in 1999-2003 within the Swedish EEZ was carried out in 2005. The logbook data used for producing the species-wise interpolated maps is detailed (1 nm grid resolution). The maps have been used to designate "Areas of national importance for the Swedish commercial fishery", giving them particular status in national marine planning.

The Baltic Algae Watch System is a satellite-based surveillance system that has been running since 1997, the last years by the Swedish Meteorological and Hydrological Institute. Interpretations of daily satellite images are overlaid and used for producing maps of yearly averages of cyanobacterial blooms for the whole Baltic Sea, maps that may be used for characterisation of pelagic habitats.

4.9 UK

Recent UK mapping programmes undertaken within the MESH project are listed in Annex 5. Annex 8 provides further details on some of these and additional projects. These were

presented by Neil Golding (Joint Nature Conservation Committee), Matt Service (AFBI), Dave Limpenny (Cefas) and Mike Robertson (FRS) and covered the following:

- Reefs in the mid Irish Sea;
- SEA 7 (Strategic Environmental Assessment) ;
- HabMap (Moray Firth) ;
- Northern Ireland ;
- Eastern English Channel;
- Mapping Annex I habitats (primarily *Sabellaria spinulosa* reefs) ;
- Offshore SAC mapping ;
- Inshore SAC mapping.

4.10 USA

Overview of NOAA Activities

Vince Guida of the Northeast Fisheries Science Center gave an overview of mapping activities within the National Oceanic and Atmospheric Administration (NOAA). NOAA's Office of Ocean Exploration facilitates an intra-agency activity called the Integrated Ocean Mapping (IOM). The IOM is designed to enhance progress on mapping the world's oceans with initial emphasis on the U.S. EEZ and other areas that are suspected to support unique living and non-living resources. NOAA efforts are divided among a number of offices and regional science centers, occurring in a wide range of locations and purposes. Drivers for most of the work include navigational safety, coral reef and deep-sea coral conservation. While efforts toward habitat mapping have been conducted independently by the regional Fisheries Science Centers for several years, there have been no uniform protocols or standards for data gathering or product generation until 2006, when standards and specifications for nationwide data collection were first considered. Mapping efforts by other agencies and non-governmental entities are not represented in this document. The succeeding presentations provide details on a few projects underway in the north-eastern U.S.

Stellwagen Bank

Page Valentine of the U.S. Geological Survey's Coastal and Marine Geology Programme reported on seabed geological and habitat mapping on the Stellwagen Bank National Marine Sanctuary. Stellwagen Bank is located in the Gulf of Maine, off Boston, Massachusetts. It covers approximately 1,660 sq mi and includes a variety of features, most notably steep basins and shallow banks. The presentation focused on a small portion of Stellwagen known as Quadrangle 6, which includes diverse substrata and habitats.

A series of maps were shown, including backscatter, topography, ruggedness, coarse-grained versus fine-grained substrate, mobile versus immobile substrate, and level of disturbance, to illustrate various features of the bank. Habitats are closely aligned with substrate types. Mobility of substrate also affects the types of species that can inhabit an area, *i.e.*, some species that cannot survive in mobile sand can survive where sand is immobile. It is not realistic to think that one geological or habitat map will satisfy all purposes. Different maps can provide managers or fisheries biologists with a framework, depending on management needs.

The Gulf of Maine Mapping Initiative

Sara Ellis, Coordinator for the Gulf of Maine Mapping Initiative (GOMMI), described the goals, activities, and challenges of GOMMI.

The Gulf of Maine is one of the world's most productive ocean systems. It is home to many industries including fisheries, communications, energy production and mining, and it is used extensively for marine transportation. Meeting these demands is a great challenge. Despite the proven value of seafloor maps for research and management, only about 24% of the Gulf of Maine has been mapped using modern survey technologies.

The Gulf of Maine Mapping Initiative (GOMMI) is a partnership of organizations in the US and Canada whose goal is to map the entire Gulf of Maine basin for better management of its uses. GOMMI is a subcommittee of the Gulf of Maine Council on the Marine Environment, and is led by an 11-member volunteer Steering Committee representing state and federal government and academia. GOMMI's strategy is to facilitate communication and collaboration within the mapping community, build logistical and financial support for new projects in priority areas, and make maps and data widely available to users and stakeholders.

Although GOMMI is a bi-national programme, its current focus is on the US side of the Gulf of Maine, since seafloor mapping is progressing well in Canadian waters. In Canada, seafloor mapping is a national priority under the 2005 Oceans Action Plan, and is a line item in the federal budget; Natural Resources Canada has a national mandate to map priority areas. In stark contrast, no single US entity is mandated to map US seafloor, and there are no dedicated federal funds. However seafloor mapping is occurring in the US, but it is not a national priority and is not yet well-coordinated or funded. GOMMI is attempting to remedy this situation, at least on a regional scale, through outreach and education. It is currently working on a legislative strategy to help raise national awareness and financial support of seafloor mapping.

GOMMI aims to establish a Gulf of Maine seafloor mapping programme at the Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC) at the University of New Hampshire (UNH). CCOM/JHC has a national reach, but is still a logical place to host a regional Gulf of Maine mapping programme. It is located in the Gulf of Maine; specializes in coastal and ocean mapping and hydrographic sciences; employs and collaborates with many mapping experts; has an excellent student training programme; and has already gathered and processed a large amount of mapping data in the western Gulf of Maine on GOMMI's behalf. The Center also has a long-term Cooperative Agreement with the U.S. Geological Survey's Coastal and Marine Geology Programme, which has been mapping significant portions of the Gulf of Maine since 1994. A more formal association with UNH's Center for Coastal and Ocean Mapping would provide GOMMI with sound infrastructure including technical expertise, administrative support, and strategically located headquarters.

GOMMI is helping coordinate two field projects in 2007. The first project, led by the Gulf of Maine Research Institute, will focus on mapping cod habitat on Cashes Ledge, in collaboration with University of Ulster (UU). A graduate student from UU will develop acoustic facies maps using backscatter data collected in 2005, then use video to test the predictions and create preliminary habitat maps. The second project is designed primarily to map new shipping routes in Cape Cod Bay, which have been located to minimize likelihood of ship strikes on endangered northern of right whales, for safety of navigation. Plans are underway to add a benthic habitat mapping component. This project will include collaboration between multiple agencies including NOAA's Office of Coast Survey, Northeast Fisheries Science Center, and Office of Protected Resources, as well as US Geological Survey, CCOM/JHC, Massachusetts Office of Coastal Zone Management, and Massachusetts Department of Marine Fisheries.

Hudson Canyon Benthic Habitats: Lessons from the mid-Atlantic Continental Margin

Vincent Guida described work that was undertaken as an exercise in understanding habitat associations, rather than as an attempt to map habitat. However, it contains all the data

elements needed for creation of a habitat map, which may be developed in the future. Sampling since 2001 has included use of the USGS Sea Bottom Observation and Sampling System (SeaBOSS) drift vehicle with Page Valentine, grabs for benthic infauna and grain size distribution, CTDs, near bottom water sampling, and biological sampling using both 11-m otter trawl with roller gear and 2-m beam trawl. The diversity of bottom types and the complex and dynamic hydrological regime appears to maintain that biological diversity and contribute to high local productivity. Conclusions regarding benthic habitat mapping in the context of Ecosystem Based Management should ideally include:

- High quality acoustic mapping,
- High quality visual ground-truthing,
- A multi-method, integrated programme of hydrological, geological, chemical and biological sampling to confirm, explain and/or refine acoustic and visual patterns, and
- A willingness to revisit and if necessary, re-collect data resulting from previous efforts.

HabCam

WGMHM members were invited by Richard Taylor to the Woods Hole Oceanographic Institution for a demonstration of the HabCam project (http://habcam.whoi.edu) by Scott Gallager.

HabCam is a high-resolution continuous benthic imaging system has been developed by the Woods Hole Oceanographic Institution with funding from NOAA and the US scallop industry. The system is designed to assist in scallop assessment in small areas, produce high volume ground-truthing for acoustic data during simultaneous surveys, and is currently towed by a commercial scallop vessel. Typical deployment parameters include flying 2 meters off bottom at 4–5 knots while collecting continuous overlapping 1 meter-width still images suitable for producing mosaics, automated target extraction, and species counts. A 100 nm (~175 km) track-line is flown each 24 hour day producing about 300 000 images covering approximately 175 000 m^2. Currently over 60 taxa in over 100,000 images from many areas and substrate types have been identified to serve as test sets for validation of the multiple automated target extraction approaches. Currently funded projects include simultaneous side-by-side comparison with NOAA scallop survey dredge tows, the addition of stereo cameras to improve measurement capabilities, and integration of both high frequency (>1200 kHz) sidescan and EM3002 multibeam instruments during imaging transects.

4.11 Conclusions

The Working Group acknowledged that there had been considerable effort both at national and international level in marine habitat mapping studies.

Mapping has been undertaken for a variety of purposes including specific fisheries and industry needs, international pressure for the identification and management of marine protected areas, and the fulfilment of national programmes. This is with the aim of using the information for a wide range of planning and regulatory purposes.

Many countries e.g. Canada, Ireland, France, now have coordinated national mapping programmes which are systematically surveying their waters using the latest state of the art technologies to produce high quality maps of multiple application.

Some countries, e.g. UK, have undertaken comprehensive inventories of available data, but have yet to develop nationally coordinated programmes for ongoing surveys.

Recommendation: WGMHM recognises that many countries have multiple government agencies, academic institutes and industries undertaking new mapping programmes for a

variety of sectoral and research needs. Given the high degree of commonality to these studies, the high cost of survey and the potential to make much greater use of the resulting information and maps across multiple interest groups, wherever possible, seabed mapping effort should be coordinated through national and international programmes and the data and maps should be made publicly available to ensure their wide use.

Recommendation: WGMHM recognises the benefits of consistent interpretation of mapping data so that data from different areas and sources can be readily compared and aggregated. To this end there is a need to harmonise classification systems and to work towards fully operational international habitat classification schemes. Additionally WGMHM recognises that individual schemes do not always meet the needs of all end users and that there is merit in having several schemes or being able to arrange particular schemes in different ways to suit different end needs. WGMHM recommends directing further effort towards establishing suitable international classification schemes, based on approaches available in North America (Green *et al*., 1999, Valentine *et al*., 2005) and Europe (EUNIS 2004; BALANCE and UKSeaMap Connor *et al*. 2006). Furthermore, national, regional and local mapping programmes should be encouraged to use and test the available classification schemes to help ensure they are 'fit for purpose'.

Recommendation: In recognition of the growing volume of information (metadata) being produced from mapping programmes, including that collated by WGMHM in its National Status Reports, better use of these metadata (i.e. the NSR spreadsheets) is required by collating the annual reports and making these more widely available via a web portal.

5 Mapping strategies and survey techniques

5.1 Multibeam backscatter interpretation

Assess recent advances with acoustic techniques for marine habitat mapping, with particular reference to techniques used in combination to develop maps and frameworks used for ecosystem-based management (ToR d).

This ToR was one of the theme topics which WGMHM 2006 considered useful to address. Due to limitations of time and expertise, the WG was not able to fully address the topic during the meeting. However relevant information was made available to the meeting in a report of a workshop held at the University of Ulster, Northern Ireland in March 2006. The report is given at Annex 9.

5.2 Habitat modelling for identification of essential fish habitats

Ulf Bergström (Sweden) presented a study on how essential fish habitats may be mapped using statistical GIS modelling, in which fish habitats are identified using environmental variables. The study is part of the BSR Interreg IIIB project BALANCE.

The mapping has been performed in the northern Baltic Sea, in a 40,000 km^2 archipelago region spanning between the coasts of Sweden and Finland. Essential recruitment habitats have been identified for four of the most abundant and commercially important species in the region. The study has been directed towards early life stages, since these are generally much more dependent on specific habitats than their adult conspecifics, making them more vulnerable to habitat degradation.

The occurrence of young fish is related to wave exposure, water clarity and water depth. These variables were available at a sufficiently high resolution (25 m pixel size) for capturing the small-scale environmental complexity which is characteristic for the archipelago region. Water depth was interpolated from nautical charts, and wave exposure was GIS-derived using the method described by Isæus (2004). Water clarity was GIS-derived by the Swedish Board

of Fisheries and calibrated against field data from across the region. The statistical relationship between fish and their environment was described using Generalised Additive Models. These models are data driven and highly flexible, and thus suitable for describing non-linear relationships.

The resulting habitat suitability maps for the different species and life stages were fairly accurate (ROC values 0.7–0.9), especially considering the high resolution of the maps in relation to the large extent. Habitat suitability maps such as these are in high demand from nature conservation and fisheries managers, as they provide an efficient tool in spatial planning and the basis for ecosystem-based management.

Reference

Isæus, M. 2004. Factors structuring Fucus communities at open and complex coastlines in the Baltic Sea. PhD thesis, Department of Botany, Stockholm University, Sweden.

5.3 Mapping strategies for Annex I habitats in UK offshore waters

Neil Golding [UK] gave an overview of the strategies and tools being used to assist the mapping of Annex I habitats of the EC Habitats Directive in the UK offshore waters.

The Joint Nature Conservation Committee (JNCC) is responsible for the identification of SACs (Special Areas of Conservation) to protect marine Annex I habitats in UK offshore waters. Sites where these habitat types are found are assessed against a set of site selection criteria; if they pass this assessment, there is then a public consultation before the sites are formally notified to the European Commission.

The British Geological Survey (BGS) produced maps based on existing data to show the location of potential Annex I reef habitat. These maps enabled JNCC to focus survey effort in particular locations in the UK offshore (12-200 nm) zone, to fully assess the distribution, extent and ecological character of these Annex I habitats.

A survey is planned for June 2007 looking at a deep-water canyon system in the south-west approaches of UK waters. This survey is being undertaken as part of the MESH project and directly involves three MESH partners; JNCC, Marine Institute and BGS.

The survey will test the application of the MESH Guide to Marine Habitat Mapping, from planning through to inception. A number of the MESH planning tools have already been trialled, including the interactive MESH scoping tool.

An appraisal of the MESH Guide to Marine Habitat Mapping and the results of the survey will be presented at WGMHM in 2008.

6 Protocols and standards for habitat mapping

6.1 Guidelines for habitat mapping

Review and critique guidelines for habitat mapping, including protocols and standards for habitat mapping developed under relevant initiatives (e.g. MESH, HERMES) (ToR e)

6.1.1 Protocols for deploying survey gear

WGMHM discussion regarding this ToR considered whether the topic was dealing with data gathering or data processing and concluded that the WG should focus initially on protocols that related to data acquisition. A set of Recommended Operational Guidelines (ROGs) from the MESH project were made available for review; several other examples of guidelines were provided by Vincent Guida (USA) during the meeting. The WG considered that the MESH ROGs are at present the most comprehensive set of protocols available. However, it was

recognised that there were techniques not at present covered by MESH and that other possible sources of guidelines may be available. WGMHM reviewed the following MESH ROGs (which were noted as still in draft form) and provide specific comments (at Annex 10):

- Swathe bathymetry (multi-beam echo sounder, interferometric sonar);
- Side-scan sonar;
- Single beam echo sounder;
- Acoustic Ground Discrimination Systems (e.g. RoxAnn);
- 3D seismic imagery;
- Sub-bottom profiling;
- Sediment Profile Imagery;
- Trawls and dredges;
- Underwater video and imaging techniques;
- Satellite imagery;
- Airborne digital imagery (inc. CASI);
- LIDAR;
- Aerial photography.

There was some concern that the ROGs were not consistent in their level of detail and that some were more reviews than operating guidelines. Additionally techniques not explicitly covered in the MESH set of ROGs but which WGMHM considered should be developed are:

- Photographic landers – Landers with camera systems (video and/or stills with appropriate lighting) mounted atop a frame with lights and cameras pointed downward. The lander is lowered to the bottom on a conducting cable controlled by winch, signalled to take still or brief video footage within the base of the frame while the cable is slack, followed by lifting and repositioning for replicate samples before being hauled back aboard the vessel for transport to subsequent stations. Operating procedures are similar to those for drop cameras employed in point survey mode. While dynamic positioning is not required in water less than 40 m depth, a calm sea state is essential. There is a MESH ROG for the Sediment Profile Imagery instrument, which could be adapted as a generic lander ROG.
- Data visualization - The format of the final mapping product and the visualization techniques used are important considerations for achieving the best presentation of the data. The choice of format and technique will depend upon several factors, including purpose, audience, data density, data quality and data type. It is recommended that guidelines for data visualization be developed.
- Pelagic information in support of habitat mapping - It is recommended that guidance on the types of pelagic data useful for benthos habitat mapping be developed, preferably with an ecological explanation for the significance of these data types. Further, it is recommended that the developing guidelines focus on ecological linkages between the pelagic and the benthic habitats. In addition to chlorophyll and temperature, useful data types may include, but are not limited to, depth of upper mixed layer, primary productivity and export production. It was noted that development of pelagic habitat classification systems has been a topic at previous ICES and OSPAR workshops (e.g. Southampton 2001[3]), and pelagic habitat classification schemes have been developed. These previous efforts might be a useful start for development of guidelines for pelagic habitat mapping.

  It is noted that marine mapping exercises typically neglect the pelagic habitat. Conceivably, ROGs and guidance could also be specified for pelagic mapping

[3] OSPAR Commission. 2000. Second OSPAR/ICES/EEA workshop on marine habitat classification (Southampton, 18-22 September 2000): Summary Record. OSPAR Commission, London (Biodiversity Committee paper BDC 00/6/Info.1).

efforts. ROGs for pelagic sampling are much more common than for benthic sampling, and the WG felt that it was not necessary to address the absence of pelagic ROGs. However, as indicated above, there is a need to provide more guidance on the pelagic data in support of benthic mapping.

- Shipboard logging of survey gear deployment - Peter Lawton (Canada) observed a marked difference in the degree to which recommendations for electronic shipboard data logging appear in the draft MESH ROGs compared to current practice and ongoing software development for benthic survey protocols within Fisheries and Oceans Canada (DFO). The MESH ROGs do cover the required information to be recorded on deployment of different survey gears and examples of paper logs in some ROGs indicate that additional comments are frequently recorded on aspects the survey process while gear is deployed (e.g. observations of specific benthic habitat features or species). Electronic field logbooks bring a substantial degree of standardisation, efficiency, and quality control to benthic survey operations. A comprehensive logbook system (CAROL) was developed by David McKeown (DFO, Bedford Institute of Oceanography (BIO), Canada) to handle survey operations for a variety of optical and acoustic survey systems. Originally designed to support shelf benthic surveys using sampling tools (CAMPOD, VIDEOGRAB, TOWCAM) developed at BIO (Gordon *et al*. in press), its structure is modular so that additional devices with customized logging windows can easily be added. This software includes a utility that will clean up and transfer the logged data file to an ACCESS or equivalent structured database. In addition to tracking gear deployment and associated video and still image metadata, subcomponents of this software allow for real-time georeferenced annotation of species and habitat features (an example of this type of application can be found in Strong and Lawton (2004); see Section 6.3).

Reference

Gordon D.C. Jr, McKeown D.L.,Steeves G.,Vass P.,Bentham, K. & Chin-Yee M. In press. Canadian imaging and sampling technology for studying benthic habitat and biological communities. GEOHAB book on Marine Habitat Mapping.

6.1.2 Standards for video analysis

The UK National Marine Biological Analytical Quality Control scheme (NMBAQC) (www.NMBAQCS.org) recently convened a workshop (Belfast, April 2007) that reviewed the processing of video data. The principle topics covered were:

- Variation due to quality of video;
- Operator variability;
- Taxonomic and biotope identification;
- Analytical procedures.

Many of the presentations at the workshop illustrated issues concerning comparability between operators and the principle conclusions were:

- Video quality has less influence on the ability to adequately define habitat than in its scope to adequately identify particular taxa. This led to the probability that rare or important species may be missed;
- There were disturbing differences between different operators in their ability to identify habitats and enumerate species. More problematic was the apparent discrepancy in their ability to describe and quantify sediment type;
- Statistical techniques for analysing both video and stills imagery were discussed. It was recognised that for certain end uses quantitative data may be required.

Recommendations from the workshop centre on the development of:

- Training tools to assist with identification;

- User guides to assist the determination of species abundance;
- Techniques to assess the quality of video material;
- Guides to aid recognition of the composition of substrata.

The workshop charged the NMBAQC coordinating committee with the role of developing a video 'ring test' to circulate around laboratories conducting video analyses, with a view to defining acceptable standards. Basic content of the ring test would be:

- Circulation of 10 video clips;
- 3 times per year;
- 60 seconds per transect?
- A range of both camera (quality) and habitat variability;
- Ranges of types of camera;
- Range of types of habitat.

The aim will be to test taxonomic identification skills, habitat recognition, species enumeration and substratum identification.

The WGMHM members were invited to participate in the Ring Test when available. The NMBAQC will circulate the full report on the Workshop when it becomes available.

6.2 Accuracy and confidence in habitat maps

Develop approaches for the assessment of accuracy and confidence in habitat maps, and validation requirements (ToR f)

This ToR was addressed by a sub-group comprising Chris Cogan, Tommy Furey, Neil Golding, Vincent Guida, Peter Lawton, Göran Sundblad, Megan Tyrrell and Page Valentine.

The current use of confidence and accuracy assessment processes in habitat mapping was discussed. It was concluded that some current practices completed during the production of habitat maps could be considered as contributing towards a confidence assessment. However, these steps are often hidden and it is not obvious to the map user that a process of confidence assessment has been undertaken.

The MESH project developed a confidence assessment process in 2006 that provides a transparent way of presenting these often 'hidden' steps, and leads to an assessment of the reliability of a map. The assessment process was demonstrated (Annex 11). The WG noted that this was, according to their knowledge, the first time such a systematic methodology had been developed.

The WG commented on the MESH confidence assessment process and explored future considerations in marine habitat map accuracy and confidence assessment.

6.2.1 Comments on the MESH confidence assessment process

The WG welcomed the contribution of a confidence assessment process developed by the MESH project for use by the marine habitat mapping community. This was considered to be the first multi-criteria, systematic, confidence assessment methodology of its kind to be produced for marine habitat mapping.

As discussed in Annex 11, the confidence assessment process that has been developed is split into three sections, namely remote-sensing, ground-truthing and data interpretation. There are benefits to this strategy. For example, a habitat map may have been assessed as having good ground-truthing and interpretation but the remote-sensing may have been judged as poor (e.g. if it was a widely-spaced AGDS survey). As the scoring system is transparent, and the aspects

which reduce the overall confidence can be identified, it would be possible to increase the confidence of the final map by adding a new remote-sensing dataset (for example a 100% coverage multibeam/sidescan dataset). The WG saw this as a great benefit to the confidence assessment process, as it can highlight the weak areas of particular habitat maps and give the opportunity for these to be addressed. It was also seen as a useful tool for assigning confidence in historical habitat maps.

The WG commented that even though the scoring methodology was developed by a broad range of specialists within the MESH partnership, there may still be some areas in the scoring criteria where commonly used techniques are accorded higher scores than some less common ones. An example was given from the physical ground-truthing section. A recent paper compared sediment grab samples to bottom photographs, and showed that photographs capture/sample the coarsest gravel component (>2 mm), which are technically difficult sediments to sample in the field, and subsequently sub-sample in the laboratory (Orpin & Kostylev 2006). In the existing MESH scoring system, image-based sediment analyses are attributed a lower score, and hence confidence.

The WG examined the MESH confidence assessment flash tool, and concluded that this was a useful and interactive tool which could assist in survey planning by giving an insight into what the final confidence assessment would be, depending on how the survey was ultimately completed.

It was noted that the MESH confidence assessment methodology was developed to be completed by persons other than those who initially produced the mapped products. If the assessment is to be undertaken by persons who have produced the maps themselves, then the wording of some of fields may need some adjustment.

6.2.2 Future requirements in the confidence assessment process

The WG recommended that for future habitat mapping studies, a structured confidence assessment should be completed by the person who produced the habitat map, rather than a third party who was external to the map development process, as the map producer is more likely to have an in-depth knowledge of how the map was compiled, and its limitations.

A narrative should be provided with the map explaining authorship and the purpose of the map. This narrative may be provided in the map metadata, but a small text box should also be present on the map itself, so that map users are aware of the reasons the map was made, and the resulting limitations it may have.

The WG recommended the addition of an authority diagram model on the final map; this could take the form of a label on the map that states who/which organisation contributed to what sections of the map, e.g. one research group did the remote sensing while a separate group did the ground truthing.

It was agreed that a measure of variance would be useful to add to the confidence assessment; e.g. to include standard deviation as a measure of spread of the scoring. For example, you may have a map where one section such as the remote sensing was good, but the other two sections on ground-truthing and interpretation were poor. As the final score is formulated by taking a average of these three sections, this methodology could mask a high score in a particular section.

It was recognised that thematic scale had important implications for map confidence. For example, when mapping at a coarse scale such as separating land from sea, you can have a great deal of confidence in each class. However, when mapping at much finer thematic scales, such as different habitats on the seabed, confidence can diminish somewhat. An important conclusion is to map at the coarsest scale which will satisfy the objectives of the project, i.e.

do not map at the finest scale made possible by the mapping instruments, as the burden on the amount of ground-truthing required to achieve a satisfactory level of confidence will be significant.

An intimate link is required between the metadata recorded when the data were collected and the confidence assessment. Using a structured confidence assessment process allows the consistent interpretation of metadata. The link between metadata and confidence could be strengthened by indicating the relationship between confidence assessment fields and the corresponding metadata fields, such as in the proposed MESH survey metadata standards (see Section 6.4).

The WG considered that an independent evaluation of the MESH confidence assessment process in its current iteration would be very useful. It was recognized that GOMMI (the Gulf of Maine Mapping Initiative) was at a point in its programme development where issues of accuracy and confidence assessment in historical maps and approaches to conduct new surveys are currently under review. Representatives from GOMMI within the WG agreed to take forward a proposal to trial the MESH confidence assessment process over the coming year and to report back to WGMHM 2008 on their findings.

The confidence assessment process developed by MESH has shown that there are processes in place for assessing confidence for the overall habitat map, but there are no processes in place for assessing confidence and accuracy at a polygon level. There are a number of factors which could be recorded at the polygon level:

- A measure of polygon delineation accuracy (spatial accuracy of boundaries): Different boundaries could be depicted depending on the type of data which were used to make the map. For example, dashed boundaries could be used where inferred boundaries are made (e.g. using AGDS). Solid boundaries could be used when mapping certain boundaries e.g. when delineating a boundary between rock reef and sand plain using 100% sidescan sonar/multibeam data. A matrix of map classes could be developed, which highlights the potential for particular boundary conditions to have a greater or lesser transition gradient. For example sand to mud, or rock to sand.
- A measure of confidence in our knowledge of the contents of each polygon: Where a polygon is classified as sand for example, this could be labelled as the primary habitat type. However, secondary and tertiary habitat types could also be recorded for polygons or some indication given for the polygon as to the likelihood of it being the habitat class mapped.

The WG acknowledged that assessing the confidence and accuracy at the polygon level is a potentially major undertaking. As a start, a small proportion (say 15%) of polygons could be assessed, or the assessment could be done at the habitat class level. A proportion of polygons could be selected through stratified sampling; for example stratified by sensitivity or area.

Further information could be obtained on polygon accuracy and confidence by incorporating sensitivity analysis approaches into the confidence assessment. Randomized spatial shifts or slight thematic reclassifications could illustrate and quantify how such “map error” would or would not alter the utility of the map for particular queries. This approach would be helpful to establish guidelines for appropriate and inappropriate use of the map data.

Reference

Orpin, A. R., and Kostylev V. E. 2006. Towards a statistically valid method of textural sea floor characterization of benthic habitats. Marine Geology, 225(1-4): 209–222.

6.3 Calibrating survey systems

Review standards for calibrating survey systems (single beam echo sounder, AGDS, underwater video (ToR g)

The MESH Recommended Operating Guidelines (ROGs) for Single Beam Echo Sounder, Underwater Video and Imaging Techniques, and Acoustic Ground Discrimination System were available for review in the context of survey systems calibration.

Video calibration

Although very useful information had been compiled in the MESH Video ROG, it was agreed that the issue of system calibration in a controlled environment is worthy of some further investigation. In particular it would be useful to develop a process which would enable determination of the maximum resolution and optimal configuration of a video or imaging system, and possibly allow a qualifier or rating to be assigned to it.

The potential of developing a standard system performance assessment procedure, the results of which would be processed or analysed by an assessment laboratory, would enable maintenance of a database of performance upon which developments and system improvements could be tracked.

This could, for example, take the form of a tank test, under varied background light intensity / turbidity, and could incorporate a target definition and colour calibration check, and or varied light array configurations. Technically assessed results may provide useful information on the optimal lighting configuration and or camera to target distance. Performance variation due to cable changes would also be more easily identifiable.

Alternatively, on a more simplistic scale, simple deployment of an imaging system at the start and end of a survey or on a daily basis, with a colour calibration card, could provide useful system calibration information.

Recommendations in summary:

- Use of Colour Card to calibrate system e.g. amphibico colour card;
- Capture quality of a video system;
- Review light filter adjustment literature to optimise camera setup.

Based on recent experience using a variety of benthic video systems in coastal and offshore survey contexts Peter Lawton (Canada) recommended that in addition to calibration for optimal video system performance that a system of operational (realized) video quality criteria be developed. This can be as simple as recording a video quality rating based on the minimum resolvable features observable in the video footage as it is acquired during the survey. As with recommendations under Section 6.1.1, the use of electronic field logbooks can enable a much more comprehensive set of video survey data attributes to be recorded in real time (although paper logs should also be maintained on primary survey data (start, stop, maximum depth, etc). Current approaches within DFO use georeferenced event logging software to record both continuous (class) and discrete (event) observations which are time and position stamped at each GPS system update (e.g. Strong & Lawton 2004). With field electronic logbook recording, fairly straightforward and automated loading processes can be developed against relational databases. Use of a searchable video and still imagery database or catalogue will improve interpretation repeatability, and assist with system calibration.

Reference:

Strong, M. B., and Lawton P. 2004. URCHIN - Manually-deployed geo-referenced video system for underwater reconnaissance and coastal habitat inventory. Can. Tech. Rep. Fish. Aquat. Sci., 2553: iv +28 p.

AGDS calibration

The MESH AGDS ROG is well compiled and provides a good overview of installation and general operating guidelines for an AGDS system. Hyperlinks need to be validated however.

Section 2.5.3 could be expanded slightly to provide more information on testing and verification protocols, or more specifically system calibration for a particular survey site. System calibration is admittedly specific to the manufacturer; however given the limited number of systems available, perhaps consideration could be given to appending the guidelines for calibrating individual systems. Consideration could also be given to the merit of recommending as standard a start and end of survey calibration line configuration. Alternatively for permanent fit systems, the implementation of an annual system calibration plan proximal to the vessel home base should be considered. This would enable demonstration of system repeatability on similar grounds, meeting some level of calibration confidence.

Under section 2.5.4 it would be helpful to elaborate on how one could identify if the ship's echo sounder is interfering with the AGDS.

Under section 2.5.9 it is advised that some reference be made to electrical safety requirements for deployment of generators on small vessel temporary fit systems, as per the Natura 2000 Marine Monitoring Handbook reference (www.jncc.gov.uk/page-2430).

Single Beam Echo Sounder calibration

The MESH SBES ROG is an interesting review of single beam echo sounder functionality with a view to assessing the presence of kelp; however the document needs to be elaborated to incorporate specific calibration requirements for single beam echo sounders. Input from the ICES Fisheries Acoustic Working Group would perhaps provide vital information on optimisation of single beam echo sounder use in a habitat mapping context.

6.4 Discovery and survey/method metadata standards

Review progress in the development of 'discovery' and 'survey/method' metadata standards for marine habitat mapping, illustrated with worked examples (e.g. from MESH) (ToR h)

WGMHM 2005 examined initial ideas on the development of metadata standards for specific survey techniques used in habitat mapping studies. It considered that data arising from each technique should be accompanied by good quality metadata, so that those using the data knew of its provenance and quality. To date, the absence of agreed standards for such metadata (at the survey technique level) meant that data were often poorly documented leading to subsequent limitations on its use. Since WGMHM 2005 the MESH project had undertaken further development of the task, making a draft metadata spreadsheet available to WGMHM for comment in 2006.

Since WGMHM 2006, MESH had substantially developed this area of work to develop a fully integrated approach to metadata standards which would:

- Accommodate all types of habitat mapping survey metadata in a generic survey data model;
- Provide a logging system which interrelates data from different techniques collected during a survey;
- Allow logging of metadata through the lifespan of the data, from planning stages through to collection, processing, interpretation and archiving stages;
- Relate detailed metadata requirements to those needed for 'discovery' metadata catalogues;
- Include the metadata needed to help evaluate accuracy and confidence in habitat maps;

- Ensure the metadata fields were fully compatible with other relevant data systems.

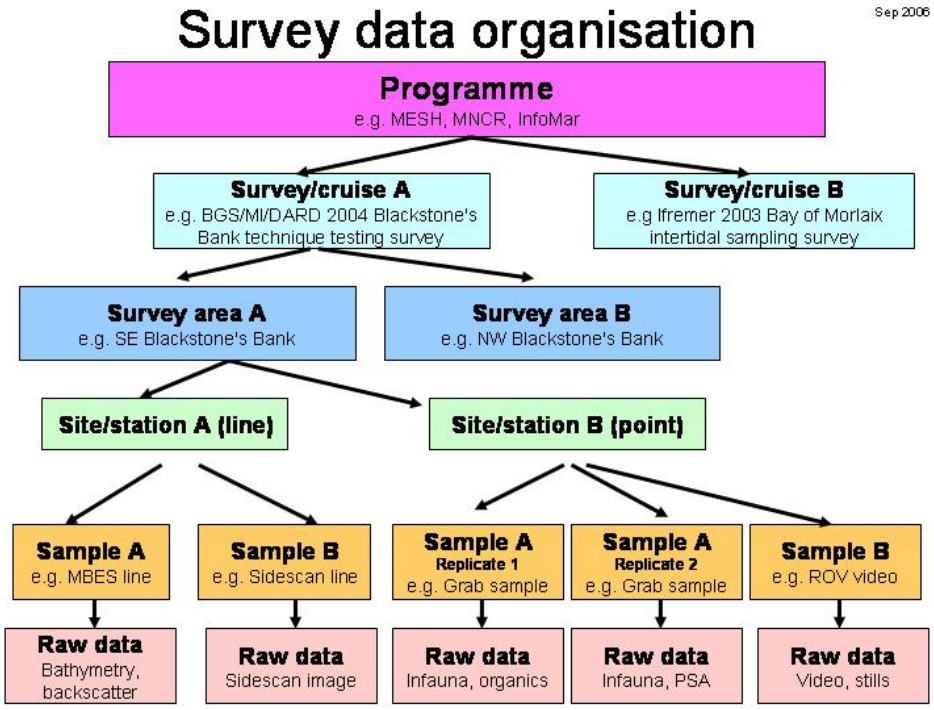

Figure 6.4.1. Proposed model structure for organising data in marine habitat mapping surveys (from MESH Guide to Marine Habitat Mapping).

A generic model for structuring data collection during surveys is given in Figure 6.4.1, and this is followed through into the main phases of metadata entry requirements in Figure 6.4.2.

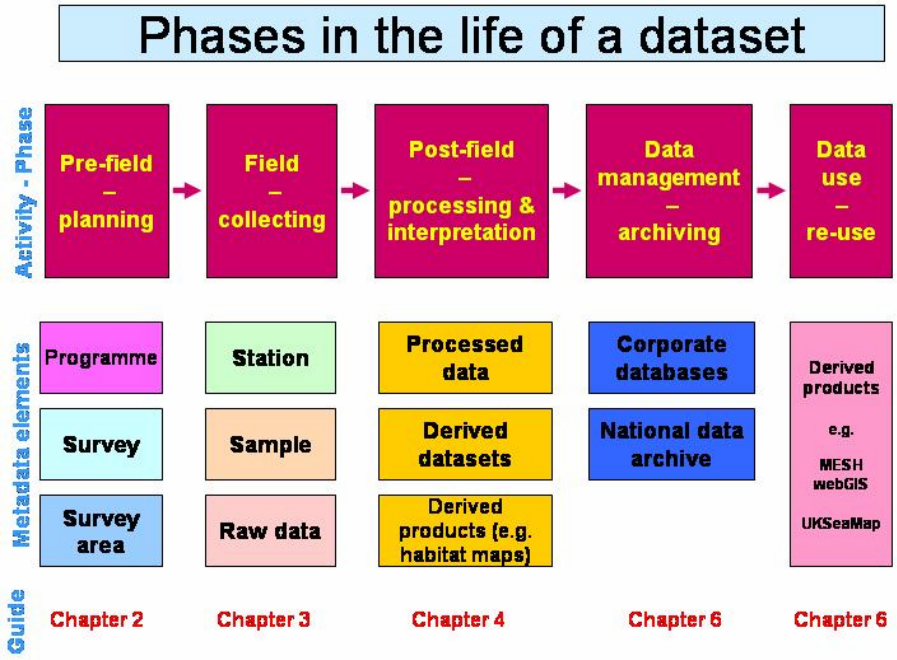

Figure 6.4.2. Phases in the life of data and their relationship to metadata recording (from MESH Guide to Marine Habitat Mapping).

Following finalisation of metadata fields, the MESH project plans to design an Access database to facilitate capture of metadata during new surveys.

The WG examined the revised metadata fields and the overall scheme, noting the following:

- The approach developed by MESH was welcomed as it would allow a more comprehensive and integrated approach to data logging during surveys, and subsequently. Ensuring greater consistency in the types of and level of detail in metadata recorded was considered very important.
- Fields were needed to record the type of quality assurance mechanism used at both the field collection phase and the data interpretation phase. Recognising that established QA systems are at present very limited for many elements of the marine habitat mapping process, a set of generic terms was devised to provide an initial way to capture this information.
- The fields for the following techniques were checked and, where appropriate, modified: SBES, echo-sounder, video, grabs, trawls, cores, dredges, video, camera.
- The scheme should be compatible with other major metadata schemes to ensure future interoperability with such schemes. Important schemes identified were the ICES Integrated Environmental Reporting Format and the EDIOS (European Directory of the Initial Ocean Observing System) scheme.
- There may be benefit in examining existing data logging systems to learn from how they operate or to adopt their functionality. Refer to Sections 6.1.1 and 6.3 for details about Canadian systems.

The revised metadata fields are presented at Annex 12.

7 Uses of habitat mapping in a management context

Review the application of and needs for habitat maps in an ecosystem-based management context (ToR i)

This ToR was addressed by a sub-group comprising: Dieter Boedeker, Ulf Bergström, Christopher Cogan, Sara Ellis, Peter Lawton, David Limpenny, Thomas Noji, Göran Sundblad, Richard Taylor, Brian Todd and Page Valentine.

Overview

The group met to discuss and outline the preparation of a peer-review paper with the working title: The Role of Marine Habitat Mapping in Ecosystem-Based Management. This paper will focus on two related issues:

- Placing marine habitat mapping (MHM) practices in context with biodiversity models and ecosystem-based management (EBM);
- Showing how habitat mapping contributes to critical marine science issues – including current and future ICES terms of reference.

Summary of progress to date

1) A working outline for the paper has been prepared as a starting point for discussions.

2) Key topics related to the paper were discussed and considered for potential inclusion:

   a) LME – Large Marine Ecosystems;

   b) CZM – Coastal Zone Management;

   c) EFH – Essential Fish Habitat;

   d) MPA – Marine Protected Areas;

   e) Marine Spatial Planning – as promoted by the European Commission Maritime Green Paper (2006).

3) Marine habitat mapping is ongoing now. Ecosystem-based management is less advanced but some examples do exist, e.g. Tri-lateral Wadden Sea Management Plan. The group considered how this lag-time for ecosystem-based management will influence its approach.

4) Examples to link key elements of ecosystem-based management to mapping will need to be looked at from both the ecosystem perspective and the mapping perspective. The group agreed to incorporate these alternative perspectives into the paper.

5) A starting point list of case studies was discussed, emphasizing the need for broad geographic and international representation.

The paper will be further developed over the coming year, led by Chris Cogan, with a view to finalising it for publication in 2008.

Reference

European Commission. 2006. Towards a future Maritime Policy for the Union: A European vision for the oceans and seas. Luxembourg: Office for Official Publications of the European Communities.

8 Recommendations and Actions

Location for 2008 meeting

Offers had been received from Kirsten Geitner (DIFRES) to host the meeting in Copenhagen, Denmark, from Sergei Olenin (University of Klaipeda) to host the meeting in Klaipeda, Lithuania and from Ricardo Santos (University of the Azores) to host the meeting in Horta, Azores, Portugal.

The Working Group gratefully acknowledged all offers. It was appreciated that moving the location between the European and North American continents had benefits in allowing a wider variety of experts to attend from each side of the Atlantic. After consideration of the offers to host the meeting, it was recommended that the offers be taken up as follows (subject to the offers still being able in subsequent years):

- 2008: Azores;
- 2009: Copenhagen;
- 2010: USA/Canada;
- 2011: Klaipeda.

Following the meeting, Peter Lawton extended an invitation to host the meeting in Canada in 2010.

A draft set of Terms of Reference for next year's meeting were developed are given in Annex 13, whilst Recommendations and Actions from the meeting are given in Annex 14.

9 Adoption of the Report

The draft report and list of annexes was discussed by the Working Group before the close of the meeting. It was circulated to the participants for comment before finalising.

10 Close of Meeting

The Chair, David Connor, thanked Tom Noji and NOAA for providing excellent facilities and hospitality for the Working Group meeting. In addition he thanked the Rapporteurs and participants for their considerable contributions which had made for a productive, interesting and enjoyable meeting.

Annex 1: List of participants

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Annex 2: WGMHM 2007 Terms of Reference

2006/2MHC07 The **Working Group on Marine Habitat Mapping** [WGMHM] (Chair: D. Connor, UK) will meet in Woods Hole, USA from 17–20 April 2007 to:

International programmes

f) Review progress of international mapping programmes (including MESH, EEA, OSPAR, BALANCE and HERMES).

g) Review available habitat maps for the North Sea and their methodologies and make recommendations on how these maps may be further developed.

National programmes (National Status Reports)

h) Present and review national habitat mapping activity during the preceding year, providing National Status Report updates according to the standard reporting format, an overview map, and focusing on particular issues of relevance to the rest of the meeting.

(presentations strictly limited to 10 minutes per country; posters welcomed; NSR entries to be circulated BEFORE meeting; outline map of study areas in shape-file GIS format)

Mapping strategies and survey techniques

i) Assess recent advances with acoustic techniques for marine habitat mapping, with particular reference to techniques used in combination to develop maps and frameworks used for ecosystem-based management.

Protocols and standards for habitat mapping

j) Review and critique guidelines for habitat mapping, including protocols and standards for habitat mapping developed under relevant initiatives (e.g. MESH, HERMES).

k) Develop approaches for the assessment of accuracy and confidence in habitat maps, and validation requirements.

l) Review standards for calibrating survey systems (single beam echo sounder, AGDS, underwater video).

m) Review progress in the development of 'discovery' and 'survey/method' metadata standards for marine habitat mapping, illustrated with worked examples (e.g. from MESH).

Uses of habitat mapping in a management context (human activities; implementation of Directives and Conventions) and its relevance in understanding ecosystems

n) Review the application of and needs for habitat maps in an ecosystem-based management context.

WGMHM will report by 3 May 2007 for the attention of the Marine Habitat and the Fisheries Technology Committees, as well as ACE.

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 AND RELATION TO ACTION PLAN	Action Plan nos.: 1.4.1, 1.4.2, 1.4, 1.4.3. **a)** The WG provides an important forum to present and discuss the progress of multinational programmes, in particular those of NIVA for the EEA, within the Interreg MESH project for North West Europe, the OSPAR-wide programme, the BALANCE project for the Baltic Sea and the HERMES FP6 project. The strategies, standards and issues addressed by each programme need to be assessed to facilitate sharing of best practice, sharing of difficulties and to work towards integration of resultant maps if feasible. **b)** WGMHM has considered the production of habitat maps for the North Sea for several years. Several mapping projects covering all or part of the North Sea (e.g. the EEA's EUNIS map, the UKSeaMap project and ongoing MESH modelling work) will become available during 2006. Each of the studies uses different approaches and datasets, leading to differing maps; WGMHM should consider their relative merits, particularly in the light of ongoing ICES needs for North Sea maps (e.g. by REGNS), and comment as appropriate. **c)** The compilation of National Status Reports is required to keep abreast of current activities and bring attention to new initiatives, developing techniques and data availability. **d)** In recent years there have been considerable advances in the use of remote acoustic techniques for marine exploration. Many of these new technologies provide excellent tools, which can be easily adapted to marine habitat mapping. The WGMHM provides and excellent forum in which new techniques can be shared and the relative merits discussed, transferring technology and experience. **e)** Review of standards for habitat mapping is of key importance to promoting best practice in mapping studies and in the interoperability of the data. The MESH project will have made significant progress on this topic during 2006 and WGMHM should provide peer review of the work on the basis of its wider expertise, and assess any requirement for further development. **f)** Assessment and presentation of issues about accuracy and confidence is marine habitat mapping, to better inform end-users of potential limitations in the maps, is at an early stage in development. This is a significant new area in which WGMHM members can contribute to developing new approaches. **g)** As part of the development of standards, an assessment of the needs for calibrating survey systems is required, again to promote best practice in use of this equipment. Calibration for these three techniques would compliment the paper completed in 2006 on multibeam systems. **h)** Sound data management is important in the archiving and distribution of data sets. There is a need to clarify the relationship between data types, including through illustrated examples, and to learn from data management approaches adopted in other sectors. **i)** The relevance of habitat mapping to other aspects of ecosystem structure and function needs to be examined, to reveal strengths and potential weaknesses and to highlight the relevance of habitat mapping to other sectors of research and environmental management, e.g. fisheries management.
RESOURCE REQUIREMENTS	None.
PARTICIPANTS	Representatives from Member Countries with experience in habitat mapping and classification. Participation of the Baltic countries and from USA and Canada is particularly sought. The participation of members of BEWG, WGEXT, WGECO, WGDEC, WGFAST would be helpful in developing appropriate linkages to other areas of ICES work.

LINKAGE TO ADVISORY COMMITTEE	ACE
LINKAGES TO OTHER COMMITTEES OR GROUPS	BEWG and SGNSBP, WGEXT, WGECO, WGDEC, WGFAST and SGASC, SGEH (Baltic Committee)
LINKAGES TO OTHER ORGANIZATIONS	OSPAR, HELCOM, EEA

Annex 3: Agenda for the WGMHM 2007 meeting

ICES Working Group on Marine Habitat Mapping, Woods Hole, USA, 17–20 April 2007

Tuesday
17 April
10h00

Opening of the meeting
Terms of Reference
Appointment of Rapporteurs
Adoption of the Agenda
International programmes
ToR a: Review progress of international mapping programmes (including MESH, EEA, OSPAR, BALANCE and HERMES).

- Overview of the north-west Europe MESH project and its main achievements (David Connor, UK)
- Progress in mapping habitats on the OSPAR List (Neil Golding, UK)
- Progress with the Baltic Sea BALANCE project, including pelagic habitat models for the Bornholm Basin (Per Sand Kristiensen, Denmark)
- Briefing on EU and EEA mapping and habitat classification perspectives (David Connor, UK)
- Report on restructuring of ICES scientific groups (Tim Noji, USA)

Protocols and standards for habitat mapping

pm (sub-group) **ToR e**: Review and critique guidelines for habitat mapping, including protocols and standards for habitat mapping developed under relevant initiatives (e.g. MESH, HERMES).

- Based upon MESH Review of protocols and standards for habitat mapping (www.searchmesh.net/Default.aspx?page=1442), MESH Recommended Operating Guidelines, and other input by WG.
- Based upon report from HERMES (if available)

pm (sub-group) **ToR f:** Develop approaches for the assessment of accuracy and confidence in habitat maps, and validation requirements.

- Based upon report on accuracy and confidence (Bob Foster-Smith, Envision, UK) and other input by WG.
- MESH procedure for assessment of confidence in habitat maps (Neil Golding, UK)

Wednesday
18 April
09h00

National programmes (National Status Reports)
ToR c: Present and review national habitat mapping activity during the preceding year, providing National Status Report updates according to the standard reporting format, an overview map, and focusing on particular issues of relevance to the rest of the meeting (presentations strictly limited to 10 minutes per country; posters welcomed; NSR entries to be circulated BEFORE meeting; outline map of study areas in shape-file GIS format).

- Canada (Brian Todd, Bedford Institute)
- Denmark (Per Sand Kristensen, DTU/Difres)
- France (report from Brigitte Guillaumont, Ifremer)
- Germany (Dieter Boedeker, Bfn)
- Ireland (Tommy Furey, Marine Institute)
- Portugal (report from Fernando Tempera, University of the Azores)
- Sweden (Ulf Bergström, Swedish Board of Fisheries)
- Spain (report from Ibon Galpasaro, AZTI)
- UK (Dave Limpenny, Cefas; Mike Roberston, FRS, Matt Service, AFBI & Neil Golding, JNCC)
- USA (Vincent Guida, NOAA; Page Valentine, USGS & Sara Ellis, GOMMI)

International programmes (cont.)

pm (sub-group) **ToR b**: Review available habitat maps for the North Sea and their methodologies and make recommendations on how these maps may be further developed.

- Based upon a review of the EEA North Sea EUNIS project, UKSeaMap, the MESH EUNIS modelling and the German MarGIS project (led by Dave Limpenny, UK & Brian Todd, Canada)

Protocols and standards for habitat mapping (cont.)

pm (sub-group) **ToR h:** Review progress in the development of 'discovery' and 'survey/method' metadata standards for marine habitat mapping, illustrated with worked examples (e.g. from MESH).

- MESH survey metadata standards (David Connor, UK)

Thursday 19 April

09h00 **Mapping strategies and survey techniques**

- High resolution modelling of recruitment habitats for fish species in the northern Baltic Sea (Ulf Berström & Göran Sundblad, National Board of Fisheries, Sweden)
- Strategies for mapping the distribution of Habitats Directive Annex I habitats in UK offshore waters (Neil Golding, UK)

ToR d: Assess recent advances with acoustic techniques for marine habitat mapping, with particular reference to techniques used in combination to develop maps and frameworks used for ecosystem-based management.

- Based upon a report from a multibeam workshop in 2006 (Craig Brown, University of Ulster) and other input by WG

Uses of habitat mapping in a management context (human activities; implementation of Directives and Conventions) and its relevance in understanding ecosystems

ToR i: Review the application of and needs for habitat maps in an ecosystem-based management context.

- Based on paper by Chris Coggan (AWI, Germany)

Protocols and standards for habitat mapping (cont.)

ToR g: Review standards for calibrating survey systems (single beam echo sounder, AGDS, underwater video).

- Report on NMBAQC video workshop, April 2007 (Matt Service, AFBI, UK)
- MESH Recommended Operating Guidelines for SBES

pm Complete any sub-group work and report back

Friday 20 April

09h00 **Recommendations and Actions**
Adoption of the Report

13h00 **Close of Meeting**

Annex 4: Review of habitat maps for the North Sea

The following table provides a review of the four maps/projects assessed as part of ToR b, and accompanies the report provided in Section 3.2.

	MarGIS	EEA / NIVA	MESH EUNIS	UKSeaMap
Map Area	German EEZ	North Sea	Mesh Project Area	UK waters
Comment:	It is evident that this does not cover the whole North Sea	Appropriate coverage.	Not entire North Sea. UK, Dutch, French and Belgian areas.	The drawback is that only half North Sea covered
Datasets	Abiotic - 235,000 observations including sediment grain size, ammonium, nitrate, phosphate, silicate, salinity, temperature, bathymetry Biotic - 182 sites with 8 benthic communities statistically derived	Abiotic - water depth, secchi depth, light attenuation (light intensity is ≥ 1%), wave exposure, tidal currents, substrate Note: the document states that chemical, physical, geological and biological data were collected	1. Seabed sediments from France, Belgium, the Netherlands, UK; classified according to Folk scheme 2. Bathymetry - GEBCO 1minute / 2 km resolution 3. Light attenuation - SeaWIFS ocean colour observations at 9 km resolution; areas where light intensity is ≥ 1% 4. Maximum wave-base depth - distinguish disturbed/undisturbed seabed, i.e. areas where seabed is shallower than maximum wave-base 5. Maximum near-bed stress - bed stress is shearing force per unit area and is used as a surrogate for 'energy' levels used within EUNIS	1. Available geological, physical and hydrographical data: a) substrate, light attenuation, water depth, bottom temperature, wave-base, near-bed stress b) four seasons of salinity, surface to seabed temperature differences, frontal probability 2. Ecological data a) distribution data for 6 plankton taxa (for water column) and biological sample data (for seabed)
Comment:	Biological information used. Abiotic information different from other maps.	Biological data unclear.		
Analytical Method	1. Geostatistically-estimated (kriging) abiotic raster data (indicator variable) and bathymetry were intersected with 182 benthic community data sites (target variable) 2. Calculate decision tree (CART) to statistically describe habitat classes with respect to abiotic conditions	1. Text, numbers, points, lines, polygons collected 2. data were imported to ArcView 8.3 and were transformed to the same format, i.e. shape files to raster, point files interpolated into raster 3. Rasters combined to identify EUNIS habitats 4. Inverse Distance Weighted interpolation method applied	1. Vector grid cell size of 1 nautical mile; west of UK, cell size of 25 nm 2. 'Triplet classes' of three numbers; first is a combination of bathymetry, wave-base, light attenuation, second is sediment type, third is maximum bed stress 3. 75 combinations that equate to EUNIS habitats are used to produced modelled EUNIS level 3 and 4 habitat types	1. Define series of environmental data layers needed to characterize seabed and water column 2. Source data sets covering UK seas 3. Process into GIS format 4. Derive classes and create vector grids 5. Supervised classification analysis 6. Validate with groundtruth data 7. Abiotic and biological characterization 8. Deliver underlying data in web GIS 9. Asses map confidence level
Comment:		Interpolation method unclear. Item 3 is not described.		Excellent description, metadata
Resolution	Insufficient information to comment.	500 m	2 km grid	0.02 decimal degrees (1 nautical mile); 25 nm in NW approaches
Confidence	Quality of decision tree to predict 8 benthic communities misclassification rate, or risk estimate, of 16%	Limited explanation of how the map was produced. Also no information on data density across the map area.	Rocky habitats under-represented; areas smaller than 2 km grid size missed	

	MarGIS	EEA / NIVA	MESH EUNIS	UKSeaMap
Comment:		The report indicates areas of low data density and areas of high data density. The report lacks a map of data density which makes it difficult to assess confidence across the area.		Not yet understood
Limitations	Geographically limited. Not classified according to EUNIS so hard to compare with other maps.	Needs more documentary evidence of how the map was produced.Not classified according to EUNIS so hard to compare with other maps.	Geographically limited.	1. Coarseness of grid limits suitability to fine-scale management use 2. Fine-scale topographic and bed-form features not identified 3. Areas of insufficient data 4. Under-representation of rock substrate in coastal region 5. Uncertain biological validation in some areas 6. Lack of biological validation data for offshore and deep-water regions
Comment:	An alternative and conflicting map exists based on the same data sets using biological statistical methods. These two maps need to be compared.	Report does not provide enough description to enable fair assessment of method. Not all data sources were acknowledged	The biological data are in the database. The ground truth data have not yet been tested against the map therefore, the confidence level is not yet established.	
Lesson Learned	Differing classification systems make it difficult to compare maps.	Important to present appropriate metadata.		1. Challenge of mapping through large scale (local) to small scale (regional) in terms of data volume, technical expertise, available time 2. Challenge of acquiring suitable data sets over the scale range 3. Challenge of processing available data to compatible GIS format 4. Physical data single-sourced; biological data multiple-sourced 5. Managing stakeholder expectation concerning the detail level
Comment:				
Summary:		It would be useful to contact the EEA and access the full report that is associated with this map.		Comprehensively reported. Well represented however, only half North Sea represented. Project specific classification system.

Annex 5: National Status Reports – summary table

ORGANISATION NAME OF CONTACT PERSON*	GEOGRAPHICAL COVERAGE (COUNTRY, REGION)*	PROJECT TITLE	DATE OF WORK, EXPECTED YEAR OF REPORTING *	TECHNIQUES USED (E.G. ACOUSTICS, GROUND-TRUTHING)*	DATASETS GENERATED (E.G. BATHYMETRY, PHYSICAL HABITAT, BIOLOGICAL, PHOTOGRAPHIC)*	BRIEF DESCRIPTION OF WORK (INCLUDING DEPTH RANGE)	OUTPUTS: REPORTS, PUBLICATIONS, MAPS, REFERENCE LISTS	CLASSIFICATION USED; LOCAL (WITHIN PROJECT), NATIONAL (STATE), EUNIS	TARGETED END-USERS
Belgium									
Vera Van Lancker, University of Gent	Southern North Sea	Vlakte van de Raan	June 2006	*In situ*		ground-truthing of previously acquired acoustic data Area north of the Vlakte van de Raan 02-06-05			
Vera Van Lancker, University of Gent	Southern North Sea		2006	*In situ*		Survey carried out by the deartment of Sea Fisheries. Samples were taken on behalf of Ghent University to complete overall sediment grid on the Belgian shelf Fairy bank 02-06-01			
Vera Van Lancker, University of Gent	Southern North Sea		Jan. 2006 - Feb. 2006	Acoustic		large-scale multibeam survey covering the swale north of the Sierra Ventana region Sierra Ventana region 02-06-02			
Vera Van Lancker, University of Gent	Southern North Sea	ST0602	Jan. 2006 - Feb. 2007	Acoustic ; *In situ*		Filling the gaps regarding sediment distribution and occurrence of macrobenthos in the upper northern part of the Belgian shelf Area in the northern part of the BCS 02-06-03			
Vera Van Lancker, University of Gent	Southern North Sea	Vlakte van Raan	2006	*In situ*		identifying bioherms from sonar data Area north of the Vlakte van de Raan 02-06-04			
Canada									
Dr. Vladimir E. Kostylev and Mr. Steve Blasco, Geological Survey of Canada (Atlantic)	Canada, Beaufort Sea	Benthic Habitat and Offshore hydrocarbon development in the Beaufort Sea.	4/1/2002-3/1/2007	Multibeam bathymetric surveys, sidescan surveys, photo and video sampling, box cores, grabs.	GIS maps of bathymetry, backscatter, grain size, iceberg scouring rates, benthic biomass and diversity.	0–200 m, as ice conditions permit.	Digital maps published by the Geological Survey of Canada, scientific publications in peer-reviewed journals.	Habitat template based on disturbance and scope for growth as developed and applied to Scotian shelf	Governments (federal, provincial and state), NGOs, fishing industry, oil and gas industry, cable and pipeline industries

ORGANISATION NAME OF CONTACT PERSON*	GEOGRAPHICAL COVERAGE (COUNTRY, REGION)*	PROJECT TITLE	DATE OF WORK, EXPECTED YEAR OF REPORTING *	TECHNIQUES USED (E.G. ACOUSTICS, GROUND-TRUTHING)*	DATASETS GENERATED (E.G. BATHYMETRY, PHYSICAL HABITAT, BIOLOGICAL, PHOTOGRAPHIC)*	BRIEF DESCRIPTION OF WORK (INCLUDING DEPTH RANGE)	OUTPUTS: REPORTS, PUBLICATIONS, MAPS, REFERENCE LISTS	CLASSIFICATION USED; LOCAL (WITHIN PROJECT), NATIONAL (STATE), EUNIS	TARGETED END-USERS
Dr. Vladimir E. Kostylev and Dr. John Shaw, Geological Survey of Canada Atlantic	Canada, continental shelves of the Atlantic, Pacific and Arctic Oceans	A practical morpho-dynamic framework for mapping seafloor environment for seabed management in the Canadian EEZ	4/1/2006-3/31/2010	There are no field surveys planned. The project uses a compilation of existing geological, biological and oceanographic data, and employs physical modeling techniques for creating spatial factor fields.	Bathymetry, grain size, sediment type, geomorphology, Temperature, Salinity, Temperature variability (seasonal and interannual), oxygen saturation, dissolved nutrients, seasonal ice cover, maximum extent of seasonal ice, ice scouring rates, primary productivity, stratification of water column, biodiversity hotspots, sediment mobility, generalized disturbance, scope for growth.	In recent years some of the largest advances in science have taken place at the intersection between formerly separate disciplines. Habitat mapping - at the intersection between marine ecology, marine geology and physical oceanography - has come to prominence as a necessary tool for ocean management. Habitat mapping recognizes that the physical nature of the sea floor, i.e., surficial geology, is critical to understanding the distribution of marine biological resources that economically sustain coastal communities in Canada. In 2006 Natural Resources Canada commenced a 4-year project to address these questions, with an emphasis on establishing a national perspective of the geo-environment and habitats on Canadian continental shelves. The goal of the project is to describe broadscale patterns in seabed habitat structure and processes in Canadian waters, their impacts on seabed life, and relevance to major issues under Ocean Action Plan. The emphasis is on understanding how geological controls on benthic habitat vary through time, and on the assessment of the relative importance of physical factors at different spatial scales. The unifying idea of the project is to interpret and map emergent, rather than apparent, properties of Canadian seabed habitats based on the integration of knowledge of geologic, oceanographic and ecological patterns and processes on different spatial and temporal scales. The project accommodates a variety of interdisciplinary issues important for Ocean Management, crucial for achieving balance between resource exploitation and preservation of unique seabed habitats. 0–1 000m.	Digital maps published by the Geological Survey of Canada, scientific publications in peer-reviewed journals	Kostylev *et al*., 2005	Department of Fisheries and Oceans, Oceans Sector, Natural Resources Canada, various stakeholders.

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Mr. Kim Conway and Dr. J. Vaughn Barrie, Geological Survey of Canada (Pacific)	Canada, Queen Charlotte Basin; Georgia Basin	Queen Charlotte Basin ocean management : Benthic habitat mapping, sponge reefs, deep-sea coral reefs. Georgia Basin ocean management ; Transboundary area USA/Canada - San Juan and Gulf Islands.	3/31/2006-4/1/2009	Multibeam, sidescan, ROV, sampling.	Provide assessment of potential coral reef distribution as determined from multibeam data sets as they are acquired. Refine models of controls on sponge reef development. Provide geoscience basis to groundfish and rockfish habitat related studies.	150–800 m shelf and upper slope of British Columbia.	Conway, K. W., Barrie, J. V. and Krautter, M. 2005. Geomorphology of unique reefs on the western Canadian shelf: sponge reefs mapped by multibeam bathymetry. - Geo-Marine Letters, 25/2; Berlin. Whitney, F., Conway, K. W., Thomson, R., Barrie, J. V., Krautter, M., and Mungov, G. 2005. Oceanographic Habitat of Sponge Reefs on the Western Canadian Continental Shelf. Continental Shelf Research, 25: 211–226, 10 figs., 2 tab.; Amsterdam. Conway, K. W., Krautter, M., Barrie, J. V., Whitney, F., Thomson, R. E., Reiswig, H., Lehnert, H., Mungov, G., and Bertram, M. 2005. Sponge reefs in the Queen Charlotte Basin, Canada: controls on distribution, growth and development. Ed by A. Freiwald and J. M. Roberts. *In* Cold-water Corals and Ecosystems, 601–617, 9 figs.; Springer (Berlin Heidelberg). Conway, K. W., Barrie, J. V., Hill, P. R., Austin, W. C., Picard, K. 2007. Mapping sensitive benthic habitats in the Strait of Georgia: deep-water sponge and coral reefs. Geological Survey of Canada, Current Research 2007-A2, 6 p.	Greene mapping scheme to be applied in Trans Boundary area of Georgia Basin.	Department of Fisheries and Oceans, Oceans Sector, Natural Resources Canada, various stakeholders.

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Mr. Russell Parrott and Dr. Brian J. Todd, Geological Survey of Canada (Atlantic)	Canada, Bay of Fundy	Benthic habitat mapping of the Bay of Fundy	4/1/2006-31/04/2009	Multibeam sonar, seismic reflection profiling, sidescan sonar, sediment coring and grab sampling, video and still photography	ESRI ArcGIS coverage including bathymetry, backscatter, sediment grain size, videography and photography, surficial geology and benthic habitat maps	Bay of Fundy is 290 km long with an entrance 100 km wide; water depths are up to 215 m; tidal rage increases up the bay from 6 m to 16 m; regional multibeam sonar surveys are followed by groundtruth surveys to obtain both regional samples and samples of particular interest	Digital maps published by the Geological Survey of Canada, scientific publications in peer-reviewed journals	Local classification scheme (I.e. northeastern US and eastern Canadian waters) has been developed by tailoring EUNIS and other schemes	Governments (federal, provincial and state), NGOs, tidal power industry, fishing industry, hydrocarbon industry, cable and pipeline industries
Dr. Peter Lawton and Ms. Maria Buzeta, Fisheries and Oceans Canada, Biological Station, Saint Andrews, NB	Canada, Lower Bay of Fundy; New Brunswick coastal areas	Coastal research by principal contacts and other collaborators (e.g. Geological Survey of Canada (Atlantic); Department of Biology and Ocean Mapping Group, University of New Brunswick; Acadia University)	Different timelines and reporting mechanisms. Work by Buzeta in support of graduate thesis (completion expected 2007). End date for reporting 2010.	Both investigators are using diver and remotely-operated video to document benthic community composition in relation to habitat complexity in coastal habitats (0 - 40 m). Buzeta's work has included synthesis of historical biodiversity studies in the lower Bay of Fundy in relation to environmental context. Much of Lawton's prior coastal habitat work has focused on evaluation of habitat suitability for commercial invertebrates (e.g. lobster).	Principal contributions by contacts is development of quantitative approaches to benthic diversity inventory in coastal habitats. Remote video system developed by Lawton and coworker Mike Strong has a comprehensive relational database architecture for storage of habitat class, and biota event records derived from video analysis. Maria Buzeta is conducting multivariate analysis of biological, structural and environmental factors to develop a framework for predicting species assemblages and species richness in coastal habitats.	Diver-based quadrat and transect video are acquired in depths ranging from 0 to 20 m. Initial remote video system used low-light B/W cameras on transects ranging from 200 m to > 1km in extent in water depths to 40 m (path width 0.7 to 1.5 m, speed over bottom < 1kt). A new survey system incorporating a color pan and tilt camera will be operational in 2007 with enhanced survey capability to 60m depth)	Strong, M. B., and Lawton, P. 2004. URCHIN – Manually-deployed geo-referenced video system for Underwater Reconnaissance and Coastal Habitat Inventory. Can. Tech. Rep. Fish. Aquat. Sci. 2553: iv + 28 p. Buzeta, M-I, R. Singh and S. Young-Lai. 2003. Identification of significant marine and coastal areas in the Bay of Fundy. Rep. Fish. Aquat. Sci. 2635. 177 p + 69 figs. Singh, R, and M-I Buzeta. 2005. Musquash Ecosystem Framework development; progress to date. Can. Manuscr. Rep. Fish. Aqua. Sci. 2727.	2005 project led by Lawton, investigating effects of ocean dredge spoil disposal on habitat suitability for lobsters, applied the northeastern US and eastern Canadian waters habitat classification scheme developed by Valentine, Todd and Kostylev. Selection of this scheme was due to the incorporation of human usage and habitat disturbance classes in the schema. Coastal habitat framework developed by Maria Buzeta will be compared against other classification schemes. See also entry under Discovery Corridor	Area management & planning (coastal Marine Protected Area (Musquash) multibeamed during designation process, and work is underway to define biological monitoring requirements to evaluate its effectiveness) Environmental quality assessment (monitoring) Nature conservation Navigation (including dredging) Research (development of coastal diving and remote video approaches to groundtruthing) Coastal development (Preliminary coastal habitat classification used in GIS-based decision support tool for coastal zone management, to be revised as new regional-scale seabed mapping projects are completed). Fisheries

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Dr. Brian J. Todd, Geological Survey of Canada (Atlantic)	Canada, Gulf of Maine	Benthic habitat mapping of the Gulf of Maine	4/1/2003-3/31/2008	Multibeam sonar, seismic reflection profiling, sidescan sonar, sediment coring and grab sampling, video and still photography	ESRI ArcGIS coverage including bathymetry, backscatter, sediment grain size, videography and photography, surficial geology and benthic habitat maps	Banks range from 30 to 100 m, troughs and basins reach 300 m; regional multibeam sonar surveys are followed by groundtruth surveys to obtain both regional samples and samples of particular interest	Todd, B. J. and Shaw, J. 2006. Sun-illuminated seafloor topography, Browns Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2086A, scale 1:100 000. Todd, B. J., Shaw, J. and Courtney, R. C., 2006. Backscatter strength and sun-illuminated seafloor topography, Browns Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2085A, scale 1:100 000. Todd, B. J., Fader, G. B. J. and Shaw, J. 2006. Surficial geology and sun-illuminated seafloor topography, Browns Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2093A, scale 1:100 000. Todd, B. J., Kostylev, V. E. and Shaw, J. 2006. Benthic habitat and sun-illuminated seafloor topography, Browns Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2092A, scale 1:100 000. Todd, B. J., 2007. Sun-illuminated seafloor topography, German Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2107A, scale 1:50 000. Todd, B. J., 2007. Backscatter strength and sun-illuminated seafloor topography, German Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2106A, scale 1:50 000. Todd, B. J., Valentine, P. C., Longva, O., and Shaw, J. 2007. Glacial landforms on German Bank, Scotian Shelf: evidence for Late Wisconsinan ice sheet dynamics. Boreas, 36(2): 148–169.	Local classification scheme (I.e. northeastern US and eastern Canadian waters) has been developed by tailoring EUNIS and other schemes	Governments (federal, provincial and state), NGOs, fishing industry, hydrocarbon industry, cable and pipeline industries

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Dr. Donald Gordon and Dr. John T. Anderson, Fisheries and Oceans Canada	Canada, Six 10 x 10 km boxes on the Scotian Shelf (Emerald, Western and Sable Island Banks)	Spatial utilization of benthic habitat by demersal fish	2001–2005	Sidescan sonar, single beam seabed classification, DT Biosonics fish assessment, towed (Towcam) and tethered (Campod) video, still photography (both Towcam and Campod), grab sampling and experimental fishing with otter trawl.	Bathymetry Physical habitat (i.e. sidescan, single beam acoustic metrics, video, photos and grabs) Benthic communities (i.e. video, photos and grabs) Fish communities (i.e. Biosonics, video, photos and trawl) Stomach contents of fish	Large team effort including scientists from DFO at both the Bedford Institute (BIO) and the Northwest Atlantic Fisheries Centre; also scientists from the Natural Resources Canada at BIO. Conducting surveys at the six 10 x 10 km study sites. Depth range 40–70 m. Sites selected after analysis of historical groundfish data (32 years). Three sites have the highest probability of encountering juvenile haddock (hot spots) while three sites have the lowest probability of encountering juvenile haddock (cold spots). Selected paired hot and cold spots on each of the three banks. Data are gathered on annual cruises run in September/October after juvenile haddock have settled to the bottom. Different data sets are being compared. Also attempts at data synthesis and extrapolation. Full field program completed in 2005, including high-resolution (0.1 m) multibeam coverage at three of six sites. 40–70m.	Multiple outputs are expected including maps, reports at scientific meetings, and publications. Gave some preliminary results at the 2004 GEOHAB meeting in Galway.	No decision yet. Most likely local but done with knowledge of other classification systems. Habitat is being assessed by different tools (i.e. acoustic, imagery, and sampling) and by different team members.	Scientific community, resource managers, offshore industry (e.g. oil and gas, fishing), NGOs, etc.
Dr. Ellen Kenchington and Dr. Peter Lawton, Fisheries and Oceans Canada Dr. Anna Metaxas, Dalhousie University Dr. Paul Snelgrove, Memorial University of Newfoundland	Gulf of Maine Biodiversity Discovery Corridor in the northern Gulf of Maine (http://www.marinebiodiversity.ca)	Census of Biodiversity Resources in Canada's Discovery Corridor	Two week research cruise (July 2006) co-funded by the Dept of Fisheries and Oceans and Canada's Natural Science and Engineering Research Council revisited sites initially sampled in 2005 as extended deepwater sampling within the corridor to 2500m.. Results will be released when available. End date Mar 07.	Deepwater ROV (www.ropos.com) investigated hard and soft-bottom habitats to 2500m. New species records, size and bathymetric records obtained for corals in the NE Channel / Georges Bank area. Additional sampling tools included a multicorer for soft-sediments. Deepwater ROV tracks (1500, 2000 and 2500m) taken over prior seismic survey lines in western channel of NE Fan (24h groundtruthing video resource for marine geology research community in addition to marine biodiversity)	Benthic diversity from video and still imagery and in situ collection (e.g. suction sampling), correlated with habitat type/complexity measures derived from seabed acoustic coverage where available, or interpretation of imagery. Evaluation of coral communities inside and outside of coral conservation area, as well as in relation to bathymetry. Voucher specimens for species previously recorded from 2005 survey, but not identified to species. Additional studies on coral and brittle star community genetic diversity.	This was the second offshore cruise to be conducted in the Gulf of Maine Biodiversity Discovery Corridor, a large swath of ocean space extending from intertidal to abyssal plain depths across the northern Gulf of Maine. The biodiversity-related inventory and research to be conducted within the corridor will represent a component of Canada's contributions to the International Census of Marine Life. 200m to 2 500m	Multiple outputs expected including graduate theses, reports at scientific meetings, and publications. A significant element of the corridor program is education and outreach, and thus results will be interpreted through various media. New taxonomic reports will become available online through regional (http://gmbis.marinebiodiversity.ca) and international (http://www.iobis.org) bioinformatics nodes.	Lawton's team has recently adopted elements of Valentine *et al*. (2005) regional benthic habitat classification scheme to analyze ROPOS video imagery, including development of relational database structure and modification of georeferenced habitat class/biota event video analysis software (Benjamin, DFO)	Scientific community, resource managers, offshore industry (e.g. oil and gas, fishing), NGOs, etc. The specific focus in the current research on the deepwater coral communities in the NE Channel is expected to provide context for ongoing management of coral conservation areas.

Organisation name of contact person*	Geographical coverage (country, region)*	Project title	Date of work, expected year of reporting*	Techniques used (e.g. acoustics, ground-truthing)*	Datasets generated (e.g. bathymetry, physical habitat, biological, photographic)*	Brief description of work (including depth range)	Outputs: Reports, publications, maps, reference lists	Classification used; local (within project), national (state), EUNIS	Targeted end-users
Denmark									
Per Sand Kristensen DIFRES Department of Marine Fisheries psk@difres.dk	Specific areas for mussels in Denmark (Wadden Sea, Limfjord, Little Belt)	National monitoring of mussels	ongoing, annual status reports	Aerial photography, ground truthing	Distribution maps for different mussels	Depth range 0–15 meters. Annual surveys of mussel beds based on interpretation of aerial photography. Quality control based on field surveys.	DIFRES report, available on webpage. http:/www.difres.dk	None	DK Gov't Dept's
Peter Munk DIFRES Department of Marine Ecology and Aquaculture Kavalergården 6 DK-2920 Charlottenlund pm@difres.dk	North Sea	Oceanographic influence on herring recruitment	period 2005–2006, reported ultimo 2006	Databases of hydrography and herring larval distribution	Physical habitats compared to distributions	Depths from 10–150 m, analysis of bottom and/or surface temperature, salinity and density	Journal article	none	Scientific community
Henrik Jensen DIFRES Department of Marine Fisheries Charlottenlund Slot DK-2920 Charlottenlund hj@difres.dk	Sandeel fishing areas in the North Sea and Skagerrak	AHA.DOT	2007	GPS data on fishing locations	GIS maps on fishing locations	Fishing grounds are mapped using fishermens navigation data and detailed information about the fishery		None	DK Gov't Dept's
Jørn Bo Jensen, GEUS Øster Voldgade 10 DK-1350 Copenhagen K	The Danish Territorial Waters	Mapping of marine Annex 1 habitats in Denmark (Natura 2000 code 1110, 1140 and 1170)	1980–2000, review produced in 2000	Review based on existing datasets acoustics, ground truthing, models and literature	Digital maps of the distribution of marine Annex 1 habitats (1110, 1140 and 1170)	Mapping of marine Annex 1 habitats in Denmark (Natura 2000 code 1110, 1140 and 1170) using eksisting data on bathymetry, marine aggregates and seismic data.	Jensen, J.B. 2000. Kortlægning af marine naturtyper i Danmark i forbindelse med EF-Habitatdirektivet.GEUS Rapport no. 2000/106	None	DK Gov't Dept's, Industry
Jørgen O. Leth GEUS Øster Voldgade 10 DK-1350 Copenhagen K E-mail: jol@geus.dk	Eastern North Sea, west coast of Jutland, Denmark	Geological mapping off the Danish west coast	1991–2001	Acoustics (sidescan sonar, boomer, pinger, chirp sonar, watergun, sparker), ground truthing (sediment coring and grab sampling)	Bathymetry, sediment grain size, geology maps	Survey of the geological composition of the seafloor and sediment transport analysis along the coast of Jutland. Depth range 0–50 m	GEOLOGI - nyt fra GEUS nr. 3. Leth, J.O. 2003. Nordsøen efter istiden - udforskningen af Jyske Rev. GEOLOGI - nyt fra GEUS nr. 4 Larsen, B. 2003. Blåvands Huk - Horns Rev området - et nyt Skagen?	None	DK Gov't Dept's, Industry

ORGANISATION NAME OF CONTACT PERSON*	GEOGRAPHICAL COVERAGE (COUNTRY, REGION)*	PROJECT TITLE	DATE OF WORK, EXPECTED YEAR OF REPORTING *	TECHNIQUES USED (E.G. ACOUSTICS, GROUND-TRUTHING)*	DATASETS GENERATED (E.G. BATHYMETRY, PHYSICAL HABITAT, BIOLOGICAL, PHOTOGRAPHIC)*	BRIEF DESCRIPTION OF WORK (INCLUDING DEPTH RANGE)	OUTPUTS: REPORTS, PUBLICATIONS, MAPS, REFERENCE LISTS	CLASSIFICATION USED; LOCAL (WITHIN PROJECT), NATIONAL (STATE), EUNIS	TARGETED END-USERS
Zyad Alhamdani GEUS Øster Voldgade 10 DK-1350 Copenhagen K E-mail: azk@geus.dk	The Great Belt, Inner Danish Waters.	Seabed classification and habitat mapping of stone reefs in Denmark	2003	Multibeam and ground truthing (grap sampling, under water video and still photography) and Quester Tangent software	Bathymetry, sediment grain size, geology maps	Seabed mapping and classification of sediment as well as biomass contents of stone reefs. Depth range 3–20m	Poster: Alhamdani, Z. K., Lundsteen S., Jensen, J. B. Sea-bed classification and habitat mapping of stone reefs in Denmark. A multibeam and ground truthing pilot study. Available at azk@geus.dk	None	DK Gov't Dept's
Jonas Teilmann NERI Frederiksborgvej 399 DK-4000 Roskilde E-mail: jte@dmu.dk	Inner Danish Water, western Baltic, North Sea (DK) and area around the Shetland Isle (UK)	Satellite tracking of Harbour Porpoise (Phocoena phocoena) in Danish waters and surrounding seas.	1997–2002, date of reporting 2004	Satellite tracking, biological sampling	Biological, homerange area maps	From 1997 to 2002 Harbour Porpoises were marked with satellite transmitters and a number of areas important for Harbour Porpoises were identified.	Teilmann, J., Dietz, R., Larsen, F., Desportes, G., Geertsen, B. M., Andersen, L. W., Aastrup, P., Hansen, J. R. and Buholzer, L. 2004: Satellitsporing af marsvin i danske og tilstødende farvande. Danmarks Miljøundersøgelser 86 s. NERI Technical Report no. 484	None	DK Gov't Dept's
Bo Riemann NERI Dept. of Marine Ecology Frederiksborgvej 399 PO Box 358 DK-4000 Roskilde	The Baltic Sea	Characterisation of the Baltic Sea Ecosystem: Dynamics and Functions of Coastal Types (CHARM).	2002–2004, date of reporting 2005	Wide range of physical, hydrochemical and biological data generated from national monitoring programmes.	Predictive models of hydrochemical compounds with maps. Distribution maps for infauna and macrophytes and predictive models. Draft typology.	Development of a typology for the Baltic ecoregion on the basis of hydrographic and biological variables. Evaluate and modify the typology with respect to the biological indicators of the Water Framework Directive.	Second annual report covering the period 1 December 2001 to 30 November 2003. Characterisation of the Baltic Sea Ecosystem (CHARM), In press.	Local ?	Gov't Dept's in Denmark, Poland, Sweden, Finland, Latvia, Lithuania Estonia, Germany and Italy
Jesper Andersen NERI Dept. of Marine Ecology Frederiksborgvej 399 PO Box 358 DK-4000 Roskilde	Denmark (aquatic and terrestic environment)	NOVANA (national monitoring programme)	2004–2009 (continued from previous monitoring programmes since 1987). Reports produced every year.	Wide range methods to collect physical, hydrochemical and biological data.	Among the outputs is distribution maps for macrophytes and predictive models. Marine habitat mapping is not a priority	NOVANA integrates environmental monitoring of aquatic and terrestical ecosystems and ensures a coherent approach at a national level.	NOVANA 2003. Programbeskrivelse del 1-3. Several technical guidelines and status reports (most in Danish). Published on \www.dmu.dk	None	National and regional authorities in Denmark

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Kerstin Geitner DIFRES Department of IT-T Charlottenlund Slot DK-2920 Charlottenlund kjg@dfu.min.dk	Bornholm Bassin	BALANCE	2007	3d modelling of biological and hydrographic data	3d films showing the reproductive volume of cod and spat as well as distribution maps for adult cod and sprat	The hydrographical conditions suitable for egg and fish are used to make an delimination of the suitable areas at different times of the year, especially during the spawning period.	BALANCE final report	None	EU
Claus R. Sparrevohn DIFRES Department of Marine Ecology and Aquaculture Kavalergården 6 DK-2920 Charlottenlund crs@difres.dk	Kattegat	BALANCE	2007	Surveys, modelling	Areas suitable for juvenile flatfish	Biological and fysical parameters that charcterize areas suitable for juvenile flatfish are identified and a predictiv model is developed that can generate predictive maps of potential areas suitable for juveniles.	BALANCE final report	None	EU
Per Dolmer DIFRES Department of Marine Ecology and Aquaculture Kavalergården 6 DK-2920 Charlottenlund pdo@difres.dk	Limfjord	Pacific Oyster mapping	2007	Field work, involvement of the public	Areas where there is occurrence of pacific oyster	Interviews with people with local knowledge, reporting through the Internet and ground truthing	Report	None	National authorities in Denmark
France									
Steven Piel/Jacques Populus, Ifremer	Western Channel	REBENT (Abers)	May 2006 - June 2006	Remote		This survey is intended to cover a part of the more inshore shallow area of the Trégor site, an area where larger ships such as Thalia cannot explore. The survey contour has been worked out so as to overlap seaward with sidescan sonar and inshore side wit			
Axel Ehrhold, Ifremer		REBENT: Trégor	2006	Acoustic ; *In situ* ; Acoustic		A baseline survey on one site (Tregor) among twenty sites retained in Brittany pilot study for Rebent project, Rebent network was implemented to meet increasing demand in terms of description and monitoring of the benthic habitats and of their biodiversity			

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Dominique Hamon, Ifremer		REBENT: Trégor	2006	VideoImage ; *In situ*		Second part of the baseline survey on the site of Tregor retained in 2006 for the Rebent project (Sea mesh_survey_Rebent sub1). The purpose is to characterise faunal communities of the major acoustic facies recognized during the April survey, 110 km^2 03-			
Germany									
Federal Agency for Nature Conservation (BfN), Dieter Boedeker, Isle of Vilm, D-18581 Putbus	German EEZ for North- and Baltic Seas (partly also Territorial Sea)	HABITAT MARE NATURA 2000	2002–present	Grabs (sediments and biota), acoustic sediment mapping, video profiles, SCUBA diving, ship based and aerial bird and mammal investigations, stationary PODs to detect harbour porpise movements, satellite tracking of seals	Maps of sediment distribution, bathymetry and habitat maps on Natura 2000 habitats (OSPAR in prep.) as well as for birds and harbour porpoise in the German North- and Baltic Seas (Maps 1:375.000, depth 100m grid); first draft of a map containing EUNIS level 3-4 habitats for the German North Sea	Commissioning projects to marine research institutions, collecting and assessing relevant data at BfN (GIS)	Scientific reports, publications, maps, reference lists and links www.habitatmarenatura2000.de	NATURA 2000, OSPAR	Basic expert material for the assessing EIAs and contribute to spatial planning process
Ireland									
Thomas Furey (Marine Institute)	W & SW Irish Coastal Waters	INFOMAR	August - November '06	Acoustic, LIDAR, *In situ*	Multibeam & LIDAR Bathymetry, Geophysical, Multibeam & LIDAR seabed classification	National Mapping Programme 2006 - 2008. Hydrographic, Geophysical, Groundtruthing, Oceanographic data acquisition in support of the national mapping strategy, from 0 - 200m water depth. Target areas incorporate a prioritised selection of the 26 priority bays and 3 priority areas identified during INFOMAR stakeholder consultation process	Survey reports, hydrographic and geophysical data , groundtruthing analysis reports, digital map products to be defined June 2007		
Oisin Naughton (Marine Institute)	Irish Coastal Waters, Clew Bay	AquaReg Pilot Survey	May 2006	Acoustic	Interferometric bathymetry data, and GIS Geodatabase	Integrated coastal zone mapping pilot survey for determination of optimal location of fin fish aquaculture sites, and in support of regional planning and management requirements. Survey coverage achieved east of Clare Island in depths of 30–50m .			

Organisation name of contact person*	Geographical coverage (country, region)*	Project title	Date of work, expected year of reporting *	Techniques used (e.g. acoustics, ground-truthing)*	Datasets generated (e.g. bathymetry, physical habitat, biological, photographic)*	Brief description of work (including depth range)	Outputs: Reports, publications, maps, reference lists	Classification used; local (within project), national (state), EUNIS	Targeted end-users
Emer O'Keeve (BIM)	SE Irish Coastal Waters	ADFish Survey	May and July 2006	Acoustic; *In situ*; VideoImage	Multibeam bathymetry, GIS map defining gravel, sand, rock	Multibeam data acquisition in Scallop Grounds off S. Ireland, to investigate the correlation between scallp catch rates and groundtype as characterised from the backscatter amplitude values.			
Colm Lordan (Marine Institute)	Irish Coastal Waters: Aran Grounds, Celtic Sea, Irish Sea	Nephrops	June and July 2006	Acoustic: *In situ*; VideoImage	Multibeam bathymetry, video tows, sub bottom profile data, GIS linking sediment distribution to burrow density.	Multibeam bathymetry acquired along and between video tow lines within known Nephrops grounds. Grab samples taken to ground truth sediment distribution interpretation, and burrow density mapped and interpolated between tracklines. Water depths range from 30–50 m			
Jonathan White and Fiona Fitzpatrick (Marine Institute)	Minches and West Scotland	CV 06-03	August 2006	Acoustic ; *In situ* ; VideoImage		Ground truthing video tows and grab sampling of areas surveyed with multibeam in 2005 off the north coast of Ireland/west coast of Scoltland. Additional multibeam acquired, and interferometric system trialled in some sites.			
Netherlands									
Sytze van Heteren, TNO (KW & NITG)		Survey Thornton Bank	Oct 2006	Acoustic ; *In situ*		Cores taken in search of previous levels and periods of enhanced biological activity 06-06-09			
Jan van Dalfsen, TNO (KW & NITG)	Southern North Sea	Monitoring B13	September 2006	*In situ* ; Acoustic		The objective of the survey was to perform a habitat mapping survey in the B13-section of the Dutch Continental shelf, in order to identify the presence shallow gas and of indicators of the Marine Habitat 1180. Indicators are active seepage of gas and flu			
Sytze van Heteren/ Norbert Dankers, TNO (KW & NITG)	Southern North Sea		Oct 2006	Acoustic		Uittesten van verschillende typen side scan sonar en kwantificeren van bedekking 06-06-08			
Sytze van Heteren, TNO (KW & NITG)	Northern North Sea	Raan3_06	Jan. 2006						
Sytze van Heteren, TNO (KW & NITG)	Western Channel	oosterschelde	Feb. 2006	Acoustic ; Remote					
Jan van Dalfsen, TNO (KW & NITG)	Southern North Sea	Monitoring verdiepte baggerstortlocatie	August 2006	*In situ*		determine benthic recruitment in dumpsite 06-06-11			

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Jan van Dalfsen, TNO (KW & NITG)	Southern North Sea	MWTL NorthSea benthos	Mar. 2006 - Apr. 2006	*In situ* ; Acoustic ; *In situ*		Yearly monitoring of benthos on the Dutch continental shelf, part of monitoring programme of the Netherlands on behalf of the Min of RWS >>>>> 06-06-05			
Sytze van Heteren, TNO (KW & NITG)		Oosterschelde	Apr. 2006			06-06-03			
Jan van Dalfsen, TNO (KW & NITG)	Southern North Sea	Hoek van Holland 2006	Apr. 2006 - June 2006	*In situ*		baseline description of potential sandextraction and reference area 06-06-06			
Jan van Dalfsen, TNO (KW & NITG)	Southern North Sea	Doggerbank 2006	Apr. 2006	VideoImage ; *In situ*		Environmental description with special focus on seasonal variation. Data can be compared with earlier surveys from 1999, 2000, 2001 and 2003 approx. 3 km² 06-06-04			
Sytze van Heteren/ Norbert Dankers, TNO (KW & NITG)	Southern North Sea		May 2006	Acoustic		in kaart brengen van litorale en sublitorale gebieden in de waddenzee 06-06-07			
Portugal									
Ministry of National Defence	Portuguese EEZ and area to be potentially claimed	Task Group for the Extension of the Continental Shelf	2005–2009	Hydrographic surveying (multibeam, magnetometer), biological water sampling and exploratory seismics; grabs	Maps of physical habitat, bathymetry, biomass spatial quantification and geological characterization	Study of geomorphology and geological nature of deep sea structures (50–2000; >2000m)	Reports, maps and publications	Standards of the International Hydrographic Organization; Scientific and Technical Guidelines of the CLCS	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	MARMAC	2003–2006	scuba surveys	biotope survey data	Implementation of monitoring schemes in marine SAC (0–40m)	ongoing	data will possibly be processed to integrate a EUNIS-tailored classification	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	MAREFISH (fish habitat use)	2003–2006	passive and active fish telemetry, in situ behavioural observations by scuba	biological descriptions of habitat usage/preferences	Analysis of movements and habitat selection for a selection of coastal fish species with the aim of testing the theorectical benefits of marine protected areas with field experiments (0–150m)	reports, thesis, papers	habitats preferences of coastal fish species will possibly be related to EUNIS-compatible habitat types	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	MAREFISH (fish larval settlement task)	2002–2006	otolith microchemistry	larvae and post larvae habitat prefences for a selection of coastal fish species	coastal and shallow seamount tops (0–40m)	reports, probably papers	None	

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Dept. of Oceanography & Fisheries - Univ. of the Azores	North Atlantic	Telemetry of loggerhead turtles in the North Atlantic	ongoing	telemetry of loggerhead turtles	descriptions of pelagic phase loggerhead turtles' movement patterns in the North Atlantic	Epipelagic environment	reports, probably papers	None	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	Classification and Mapping of Benthic Sublittoral Biotopes in Faial Island and Neighbouring Channel	2003–2007	multibeam, bathymetric sidescan, AGDS, scuba-diving and ROV surveys, desktop models	bathymetry, backscatter, bottom type, wave exposure model, current model,	Mapping and classification of sublittoral biotopes in Faial island and neighbouring Channel to Pico Island (0-200m)	report, probably papers	EUNIS tailored biotope classification scheme	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	Satellite Imagery (ocean colour and temperature)	ongoing	satellite remote sensing, ctd	mesoscale maps of temperature and ocean colour for Azores region, satellite remote sensing validation	Epipelagic environment	reports, papers, maps	None	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	CETAMARH	2003–2006	visual census of cetaceans and data from fisheries observers programme associated with GIS modelling	cetaceans habitats (Tursiops truncatus and others)	Ecology and population structure of bottlenose dolphins and sperm whales in the Azores: assessing the relationship with habitat features (epipelagic)	reports, thesis, posters http://www.horta.uac.pt/projectos/Cetamarh/Artigos/pub_projecto/magalhaes_etal_ecs05.pdf; http://www.horta.uac.pt/projectos/Cetamarh/Artigos/pub_projecto/seabra_etal_ecs05.pdf	none	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	GOLFINICHO	2005–2007	Viisual transects	species occurences; photographic images	Ecological niche partitioning between two species of dolphins around the Azores and Madeira. Main aim: to investigate spatial and trophic niche partitioning between two dolphin species, the common dolphin (Delphinus delphis) and the Atlantic spotted dolphin (Stenella frontalis), around the Azores and Madeira. (epipelagic)	reports, papers	not relevant	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	EXOCET/D Extreme ecosystem studies in the deep ocean: technological developments (STREP)	2004–2006	acoustics, ROVs, imagery, sensors	bathymetry, physical properties, photography	Development of technologies and methodologies to map deep sea assemblages environments such as hydrothermal vent fields (deep sea: 700–2300m))	reports, probably papers	None	

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Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	Seamounts (Azores)	ongoing	spatial desktop analysis of bathymetry datasets	seamount inventory for the Azores	Seamount inventory within the Azores EEZ sub-area (max ca. 5000m deep)	papers, map, thesis; http://www.horta.uac.pt/ppl/tmorato/publ.html	EUNIS habitat	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	Defending Our Oceans Expedition (Greenpeace & Univ of the Azores)	2006	Diver surveyor; Video (drop-down)	habitat record; biological records	Seamount exploration by scuba diving and drop-down camera (20-500m)	poster, probably papers	Other	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	BANCOMAC	2004–2006	diver surveyors; long-line	biological samples; geo-referenced deep water coral and sponges occurences	Database of Marine Organisms of Macaronesia. Main aim: to build up an inventory of historical and present georreferenced occurences of deep-sea corals and sponges; build up and maintenance of a reference collection of specimens by-caught by demersal fishermen and scientific cruises; supply material for genetic and taxonomic analyses; build taxonomic expertise (0–1500m)	database, reference collection	OSPAR priority habitats	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Faial Island, Azores)	Study of the structure, distribution and dynamics of Codium elisabethae populations (Faial, Açores) through the use of cartographical techniques of marine habitats aided by underwater robotics	2002–2007	diver-held video and still imagery, image processing, light, temperature and adcp dataloggers, algorithms for automated detection and measurement of *Codium elisabethae* (Chlorophycota)	video and still photo mosaics, description of physical habitat, mapping of potential habitat	Study of the structure, distribution and dynamics of Codium elisabethae assemblages (shallow sublittoral to 30m deep)	poster, reports, probably papers	EUNIS habitat	
Dept. of Oceanography & Fisheries - Univ. of the Azores	Portugal (Azores)	Mapping of island slopes and shelves in Azores Central Group	2003-present	multibeam	bathymetry, backscatter	Analysis of slope geomorphology and identification of potential hazardous areas (50 to 1300m)	reports, papers	none	

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Dept. of Biology - Univ. of the Azores	Portugal (Azores)	BIOTOPE	2003–2006	diver-held imagery, quadrat sampling	biotope description and classification	Littoral and Infrallitoral (<0m (intertidal); 0–30m)	reports, papers?	EUNIS-tailored? biotope classification scheme	
Dept. of Biology - Univ. of the Azores	Portugal (Santa Maria island, Azores)	PARQMAR	2002–2006	diver-held imagery, quadrat sampling	Includes classification and distribution of biotopes in Santa Maria Island	Littoral and Infrallitoral (<0m (intertidal); 0–30m)	reports, papers	EUNIS-tailored? biotope classification scheme	
Dept. of Biology - Univ. of the Azores	Portugal (Graciosa Island, Azores)	PADEL/Graciosa	2006–2007	diver surveyors, intertidal surveyors	biotope description; biodiversity lists	Natural Heritage and Sustainable Development in the Azorean Coastal Zone: Graciosa island as a case study ((<0m (intertidal); 0–30m)	reports, papers?	EUNIS-tailored? biotope classification scheme	
CIMA - Univ. of the Algarve	Portugal (Azores)	Marche 2006	2006–2009	Multibeam	bathymetry; backscatter	Multibeam survey of area between Mid Atlantic Ridge and Graciosa/Faial islands (400–3000m)	reports; papers	not relevant	
Dept of Biology, University of Aveiro and Portuguese Hydrographic Institute	Nazaré and Lisbon-Setúbal canyons (off Portuguese mainland coast)	HERMES	2005–2009	multibeam, arrays of dataloggers, grabs	biological communities assessments, physical, geological and chemical parameters	Description of benthic assemblages in canyons off mainland Portugal; characterization of physical, geological and chemical processes (200–4000m)	reports and possible papers	unknown	
Portuguese Hydrographic Institute	shelf of mainland Portugal	SEPLAT Programme	ongoing	acoustics, grab groundtruthing	SED 1 Sheet [Minho river mouth to Espinho] published in 2006	Programme for shelf sedimentary cartography (0–200m)	maps	sediment classification	
Portuguese Hydrographic Institute	western Portuguese margin	DEEPCO	2005	seismics; grabs	geophysical data	Deep sedimentary conduits of the west-Iberian margin. Deep submarine valleys, in particular canyons, are peculiar features that enhance oceanic physiography. In the west Iberian margin they are inserted in different geographic setting with different distances from the shoreline. Despite their (still) discussed origin, the Porto, Aveiro and Nazaré canyons location, shape and evolution are due to the complexity of geological processes (both tectonic and sedimentologic) that affected the outer shelf and slope of the west Iberian margin. Although the unquestionable scientific interest, studies in canyons and slope environments are still very scarce because of the difficulty in data acquisition. Contributing to fill this gap, this project address to the study of the origin, evolution and the role	reports, papers	unknown	

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						of submarine canyons, gullies and valleys in the present day environment. It is known that oceanic processes are intensified near the shelfbreak and in submarine valleys and canyons. This intensification is responsible for particle transport (in suspension or near bottom) through submarine conduits. This is one of the major mass transfer mechanisms between the coastal area and deep ocean (e.g. major catastrophic mass transfer can be triggered by neotectonic activity and the presence of submarine depressions in bottom morphology will guide those dense currents towards abyssal plains). We propose an interdisciplinary approach to this purpose based in previous experiences. In order to have a complete data set, geophysical surveys will be combined with bottom sediments sampling. Also suspended particles will be sampled and complemented with physical measurements. At the end of the project a more accurate conceptual dynamic model regarding submarine canyon sedimentary dynamics will be drawn. It is expected that results obtained during this project will improve the knowledge of the sedimentary processes that occur in the west Iberian Margin in order to predict future evolution and minimize negative humane impacts in natural systems. (100–3000m)			
SPEA	Portuguese EEZ	IBAS marinhas	2004	Satellite Imagery; Telemetry	distribution of seabird species	Application of the Birds Directive in the marine environment through an invetory of the marine areas more important to seabirds (IBAs) in Annex I which occur in Portugal. The final aim is to use the list of identified IBAs to designate SPAs in coastal and pelagic areas. (epipelagic)	reports, papers?; http://www.spea.pt/MIBA/index.php?op=documentos	Not relevant	
CIIMAR - Univ. of Oporto	mainland Portugal	LIMITS	2005	intertidal surveyors; diving surveyors	geographical distributions of species	Population dynamics, geographical distribution and genetic diversity of macroalgal species at their southern distributional limits - The overall objective of this project is to determine the vulnerability and conservation value of some brown algae and the communities they dominate at their distribution limit. (<0m; 0–50m)	reports, papers	unknown	
CCMAR - Univ. of the Algarve	mainland Portugal	FLORA	2003	intertidal surveyors; diving surveyors	geographical distributions of species	Global related changes in the Portuguese marine flora over a long time scale (<0m; 0–50m)	reports, papers	unknown	

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CCMAR - Univ. of the Algarve	Atlantic coasts of the Iberian Peninsula	MAERLPICON	2006	grabs; diving surveyors	maerl distribution data and status assessment	Conservation status of maërl beds in the Atlantic coast of the Iberian Peninsula. Main aim: to describe the long-term changes in the benthic marine flora of the continental coast of Portugal by comparing the actual situation with the only available description of the Portuguese marine flora, which was done in the 1960´s by Ardré (1970, 1971). (0–20m)	reports, papers	EUNIS habitat	
CCMAR - Univ. Algarve	southern Portuguese coast (Ria Formosa)	TELEMETRIA	2004	Telemetry	fish habitat maps and description of preferences	Sea bream spatio-temporal dynamics and habitat use in the Ria Formosa lagoon. The main objective of this project is to study habitat use within the Ria Formosa lagoon. We will be using tagging studies (telemetry and external T-tags) to obtain information on sea bream movements within the lagoon. We will be able to answer questions such as: how important are the sea grass beds for sea breams? do sea breams use the small creeks and the areas that are flooded at high tide? are there daily migratory patterns? (0-20m)	reports, papers	local	
CCMAR - Univ. Algarve	southern Portuguese coast	Cartography and characterization of the marine communities off the National Underwater Ecological Reserve between Galé and Ancão	2005	diving surveyors; beam trawl; video	biotope maps; biodiversity lists; biological samples	The entire portuguese coast, as far as 30 meters deep, is classified as National Underwater Ecological Reserve. However, its characterization is only beginning. The biological characterization is being made at a 1:50000 scale and includes density maps and calculation of several biodiversity, vulnerability and ecological sensibility indexes. The sampling procedure includes underwater visual census for ichthyofauna and macrofauna on rocky bottoms; quadrats for algae; beam trawl and video transects for sandy bottoms. All the information is being integrated in Geographic Information Systems for a complete analyses of all the different maps.	reports, papers	unknown	
Universidade Lusófona de Humanidades e Tecnologias	Portugal (Gorringe Seamount)	LusoExpedição 2006	2006	diver surveyor	species occurences; photographic images; biological samples	Seamount top exploration by scuba diving (20-50m)	reports	Unknown	
Instituto de Oceanografia, Faculdade de Ciências da Universidade de Lisboa	Portugal	PORTCOAST	2005	Satellite imagery; databases	Maps of water collumn physical characteristics	Aims: a) to characterize the Portuguese coastal climate variability during the XXth Century with special emphasis on the physical effects on the ocean environment that are most relevant for the climate change vulnerability of biological communities. These include changes in sea-surface temperature, wind stress, upwelling, wave climate, storminess, salinity, stratification, and circulation	reports, papers	Unknown	

ORGANISATION NAME OF CONTACT PERSON*	GEOGRAPHICAL COVERAGE (COUNTRY, REGION)*	PROJECT TITLE	DATE OF WORK, EXPECTED YEAR OF REPORTING *	TECHNIQUES USED (E.G. ACOUSTICS, GROUND-TRUTHING)*	DATASETS GENERATED (E.G. BATHYMETRY, PHYSICAL HABITAT, BIOLOGICAL, PHOTOGRAPHIC)*	BRIEF DESCRIPTION OF WORK (INCLUDING DEPTH RANGE)	OUTPUTS: REPORTS, PUBLICATIONS, MAPS, REFERENCE LISTS	CLASSIFICATION USED; LOCAL (WITHIN PROJECT), NATIONAL (STATE), EUNIS	TARGETED END-USERS
						patterns. b) study the vulnerability of selected coastal biological communities to climate change effects. Particular attention will be given to sea-surface temperature, wind stress, upwelling, and column stratification. The sensitivity of seabirds in selected coastal regions of Continental Portugal and of Açores to climate-ocean changes and their migration strategies in a changing climate will also be studied. These vulnerability and sensitivity studies constitute the essential framework for an assessment of the impacts of climate change on the Portuguese coastal ecosystems. The climate change scenarios for the coastal regions will be obtained from downscaled General Circulation Models (GCMs) results and validated through the modelling of the observed coastal climate variability. Projected shifts in the geographic distribution of marine biota and changes in biodiversity will be studied, for dynoflagellate cysts, coastal fish assemblages, and migratory birds. First order damage or beneficial effects on fish harvest levels from climate change and its implications on the Portuguese fishing industry will also be assessed, taking into account the compounding effects of the overcapacity of fishing fleets, overfishing and deterioration of aquatic habitats.(0–30m)			
Paulo Fonseca (pfonseca@ipimar.pt) Instituto de Investigação das Pescas e do Mar (IPIMAR) & Instituto de Telecomunicaçõ es (IT)	southern Portuguese coast	Nephrops automated counting	2006	Video	crustacean counts	Development of a method of automated detection and counting of *Nephrops norvegicus* in underwater imagery collected over crustacean fishing grounds. 500m.	reports, papers	Unknown	scientists, fisheries managers
Instituto de Oceanografia, Faculdade de Ciências da Universidade de Lisboa	mainland Portugal	NURSERIES	2005	water properties measurements; grabs; fishery techniques	fish habitat maps and description of preferences; biological samples	Importância das Áreas de Viveiro Estuarinas e Costeiras para a Manutenção dos Stocks de Espécies de Peixes com Interesse Comercial da Costa Portuguesa. Habitat mapping related aims include: Identification of the nursery areas for selected commercial species in the main Portuguese estuarine systems and ajoining coastal waters; Determination the habitat features essential for the maintenance of the nursery function for the selected species; Study the juvenile fish ecology in each nursery. (0-30m)	reports, papers	Unknown	

Organisation name of contact person*	Geographical coverage (country, region)*	Project title	Date of work, expected year of reporting *	Techniques used (e.g. acoustics, ground-truthing)*	Datasets generated (e.g. bathymetry, physical habitat, biological, photographic)*	Brief description of work (including depth range)	Outputs: Reports, publications, maps, reference lists	Classification used; local (within project), national (state), EUNIS	Targeted end-users
Spain									
Secretaría general de pesca	Spanish continental shelf	ESPACE	1994–2014	Multibeam echosounder, high resolution seismic, grab sampling, underwater video	Bathymetry, reflectivity, digital terrain model, slope, seabed classification	10–170m	Three map series: Serie A: Bathymetry and seabed characteristics; Serie B: Environmental management; Serie C: Digital terrain model and geomorphology	National	
AZTI-Tecnalia. Ibon Galparsoro	Basque continental shelf	Seafloor cartography and marine habitat delimitation of the Basque continental shelf	2005–2007	Multibeam, sidescan sonar, grab sampling, underwater video. Existing datasets	Bathymetry, seabed classification, habitat maps	5–100m	Annual reports to the Basque Government	EUNIS	Public information
Sweden									
Geological Survey of Sweden, Dr. Johan Nyberg	Swedish Territorial waters and EEZ	Geological mapping of the Swedish Territorial Waters and EEZ	Ongoing	Single beam echosounder, side-scan sonar, sub-bottom profiling, seismic reflection, cores, grabs, video (drop-down), photography (stills)	Digital geological maps, themes and cross-sections (ESRI ArcGIS), bathymetry, photographic images, data on various elements and organic micropollutants in soft-bottom sediments	A systematically survey of the geological composition of the seafloor within the Swedish marine territory and Exclusive Economic Zone (EEZ). Depth range, from the coast to the deepest basins (0-400 m)	Digital maps and reports published by the Geological Survey of Sweden (at www.sgu.se)	EUNIS	Various stakeholders (e.g. national and regional authorities)
Ulf Bergström, Swedish Board of Fisheries	Northern Baltic Sea: Stockholm-Uppland archipelagos in Sweden, Åland archipelago and Archipelago Sea in Finland	Fish recruitment habitat modelling (part of the BALANCE EU Interreg IIIB project)	2005–2007	Diver surveyor, satellite imagery	Predictive models and fish recruitment habitat maps, macrophyte distribution maps, turbidity maps	Mapping of recruitment habitats of coastal fishes in the Baltic Sea. Field data on fish occurrence is coupled with environmental characteristics predictions are made using statistical GIS modelling.	www.balance-eu.org	Local (species/life stage level)	Research, area management, nature conservation. National and regional fisheries and environmental managers

Organisation name of contact person*	Geographical coverage (country, region)*	Project title	Date of work, expected year of reporting *	Techniques used (e.g. acoustics, ground-truthing)*	Datasets generated (e.g. bathymetry, physical habitat, biological, photographic)*	Brief description of work (including depth range)	Outputs: Reports, publications, maps, reference lists	Classification used; local (within project), national (state), EUNIS	Targeted end-users
Ulf Bergström, Swedish Board of Fisheries	Fladen and Lilla Middelgrund in Kattegatt	Fish habitat modelling (part of the Swedish Energy Agency project VINDVAL)	2006–2007	Trapnet fishery in combination with data from Swedish national survey of offshore banks	Predictive models and habitat maps of important fishes, vegetation and zoobenthos	Mapping of essential fish habitats at offshore grounds in Kattegatt. Field data on fish occurrence is coupled with environmental characteristics predictions are made using statistical GIS modelling.	www.naturvardsverket.se/Vindval	Local (species/life stage level)	Research, area management, nature conservation. National and regional fisheries and environmental managers, windpower industry
Ulf Bergström, Swedish Board of Fisheries	Swedish EEZ	Identification of Areas of special importance for the Swedish commercial fishery	1999–2003	Fishery logbook data (1 nm resolution)	GIS maps on fish catches by species within Swedish EEZ	Mapping of fishing areas for commercially important species, using fishermens logbook data (0–400m)	Thörnqvist 2006. Områden av riksintresse för yrkesfisket. Finfo 2006:1. ISSN 1404-8590 (at www.fiskeriverket.se)	Local (species/life stage level)	Area management and planning, fisheries. National and regional planning agencies
Swedish Environmental Protection Agency	Swedish waters in Skagerrak, Kattegatt, the Baltic Proper and the Gulf of Bothnia	National survey of Swedish offshore banks	2003–2005	Single beam echosounder, side-scan sonar, sub-bottom profiling, seismic reflection, grab sampling, diver surveyors, video and photography techniques(drop-down), photography (stills)	Maps on EUNIS and Natura 2000 habitats, species distributions, sediment composition, hydrography	Mapping of geological, hydrographic, and biological characteristics of Swedish offshore grounds, for spatial planning purposes (especially the large scale establishment of offshore windfarms) (0–20m)	Inventering av marina naturtyper på utsjöbankar. Naturvårdsverkets rapport 5567. ISBN 91-620-5576-3 (at www.naturvardsverket.se)	EUNIS, Natura 2000	Area management, nature conservation. National and regional environmental managers, wind farming industry
Swedish Environmental Protection Agency	Swedish territorial waters	National Swedish marine biological monitoring programme	Ongoing	Diver surveyors, grab sampling, video techniques, SPI, gillnets, plankton nets	Distribution maps and time series of marine species	Environmental monitoring programme of plankton, vegetation, benthos, fish (0–400m)		Natura 2000	Environmental quality assessment. National and regional authorities
Swedish Environmental Protection Agency	Designated Natura 2000 habitats in Swedish territorial waters	National biological survey of marine Natura 2000 areas	2005–2007	Diver surveyors, grab sampling, video techniques	Distribution maps of priority species	Mapping of biota of designated marine Annex 1 habitats in Sweden (0–30m)	www.naturvardsverket.se	Natura 2000	Area management, nature conservation. National and regional environmental managers

Organisation name of contact person*	Geographical coverage (country, region)*	Project title	Date of work, expected year of reporting*	Techniques used (e.g. acoustics, ground-truthing)*	Datasets generated (e.g. bathymetry, physical habitat, biological, photographic)*	Brief description of work (including depth range)	Outputs: Reports, publications, maps, reference lists	Classification used; local (within project), national (state), EUNIS	Targeted end-users
Martin Isaeus, Aquabiota	Several smaller coastal areas in Swedish territorial waters	Habitat modelling projects	2005–2007	Diver surveyors, grab sampling, video techniques	Predictive models and maps of dominant species	Modelling of vegetation and benthos using field survey data (0–50m)		Local (species/life stage level)	Area management, nature conservation. National and regional environmental managers
Cecilia Lindblad, Naturvårdsverket	Swedish EEZ	Morphometric identification of potential Natura 2000 areas	2003	GIS analyses of morpometric data	Maps of potential distribution of 1130 estuaries, 1150 Lagoons, 1160 Large shallow inlets and bays, 1650 Narrow bays in the Baltic, 1620 Skerries and small islands in the Baltic.	Morphometric modelling of the distribution on a national scale of six Annex I habitats of the Habitat Directive: 1130 estuaries, 1150 Lagoons, 1160 Large shallow inlets and bays, 1650 Narrow bays in the Baltic, 1620 Skerries and small islands in the Baltic. (0–30m)	www.naturvardsverket.se	N2000	Identification of certain Annex 1 habitats by morphometric analyses
Sandra Wennberg, Metria	Northern Baltic Sea: Stockholm-Uppland archipelagos i Sweden	Swedish Natura 2000 habitat modelling (part of the BALANCE EU Interreg IIIB project)	2006–2007	Existing datasets on bathymetry, geology, wave exposure	Models and maps of potential Annex 1 habitats	Physiographic modelling of Annex 1 habitats using data on bathymetry, geology, wave exposure etc. (0–30m)	www.balance-eu.org	Natura 2000	Area management, nature conservation. National and regional environmental managers
Mattias Sköld, Swedish Board of Fisheries	Northern parts of Swedish territorial waters in Skagerrak	Benthic habitat mapping in Swedish parts of Skagerrak	1999–2002	Multibeam, backscatter and biological ROV surveys	Bathymetric maps with hardness classification, biological distribution maps (coldwater corals etc)	Bathymetric and biological surveys in Skagerrak, for nature conservation and fisheries management purposes (0–300m)	Bathymetric and biological maps, reports	Natura 2000	Nature conservation, fisheries management, research. National and regional environmental managers
Mattias Sköld, Swedish Board of Fisheries	Gullmarsfjorden, a fjord in Skagerrak	Benthic habitat mapping and modelling in Gullmarsfjorden, Skagerrak	2003–2004	Multibeam, backscatter and biological surveys	Bathymetric maps with hardness classification, biological distribution maps, predictive modelling of Annex 1 habitats	Bathymetric and biological surveys in Skagerrak, for research, nature conservation and fisheries management purposes (0–120m)	Bathymetric and biological maps, reports	Natura 2000	Nature conservation, fisheries management, research. National and regional environmental managers
Mattias Sköld, Swedish Board of Fisheries	Bratten, an offshore area in Skagerrak	Benthic habitat mapping in Bratten, Skagerrak	2003–2004	Multibeam, backscatter and biological surveys	Bathymetric maps with hardness classification, biological distribution maps	Bathymetric and biological surveys in Skagerrak, for research, nature conservation and fisheries management purposes (130–440m)	Bathymetric and biological maps, report at http://www.forumskagerrak.com/download/744/x/WP6%20pop%20web.pdf		Nature conservation, fisheries management, research. National and regional environmental managers

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Martin Hansson, Swedish Meteorological and Hydrological Institute	Baltic Sea, incl. Kattegatt	Baltic Algae Watch System	1997–present	Satellite imagery (NOAA-AVHRR)	Daily maps of accumulations of phytoplankton	Satellite imagery for monitoring of algal blooms in the Baltic Sea	Daily reports on algal blooms	Local	Environmental monitoring
UK									
Bob Foster-Smith, Envision Mapping Ltd	Eastern Channel	Sussex Sea Fisheries: development of sonar techniques for biogenic identificatio n	May 2006	Acoustic ; *In situ* ; VideoImage		Developing new techniques for the fine scale mapping of reef like structures - new protocols for the detection and identification of biogenic reef structures using scanning sonar deployed on the sea bed - extended testing of methodologies on *Sabellaria* sp			
Dave Long, NERC (BGS)	Minches and West Scotland	CD180 cruise. BGS 06/02	June 2006	Acoustic		seismic profile across areas of multibeam backscatter stanton bank 4 12-06-01			
Matt Services, QUB/DARD	Irish Sea	MESH North Western Shelf Consortium ground-truth survey	June 2006	Acoustic ; VideoImage ; Acoustic		Ground-truth SurveyAnticipating to go to:Stanton Banks ComplexNorth Maidens North ChannelLaconia Bank Shamrock Pinnacle Irish Sea, Minches & West Scotland 08-06-01			
Roger Coggan, CEFAS	Eastern Channel	Eastern English Channel large-scale seabed habitat map	July 2006	VideoImage ; *In situ* ; VideoImage		To conduct directed ground-truth survey of new acoustic 'corridors' (each approx 300 m wide)' in the Eastern English Channel. These are additional corridors to those that were ground-truthed in Survey Code 07-05-02 (making a finer grid of corridors)			
Bob Foster-Smith, Envision Mapping Ltd	Southern North Sea	Eastern Sea Fisheries: development of sonar techniques for biogenic identification	September 2006			Developing new techniques for the fine scale mapping of reef like structures - new protocols for the detection and identification of biogenic reef structures using scanning sonar deployed on the sea bed - extended testing of methodologies on *Sabellaria* sp			

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Bob Foster-Smith, Envision Mapping Ltd	Irish Sea	Strangford Lough: development of sonar techniques for biogenic identification, on rocky substrata	Oct 2006			To test alternative applications of new techniques. Equipment and techniques developed for ENV/CEFAS work for the detection and identification of biogenic reef structures using scanning sonar deployed on sediment dominated sea bed, previously tested on on *Sabellaria* sp			
USA									
Walter Barnhardt, USGS, Page Valentine, USGS, and Tony Wilbur, Massachusetts Office of Coastal Zone management	Gulf of Maine	High-Resolution Geologic Mapping of the Sea Floor Offshore of Massachusetts	1994–present, reporting is ongoing	multibeam, video and photographic imagery and sediment samples	bathymetry, geological, biological, photographic	The U.S. Geological Survey, in cooperation with the Massachusetts Office of Coastal Zone Management (CZM), the National Oceanic and Atmospheric Administration (NOAA), the University of New Brunswick, the University of New Hampshire, and the Canadian Hydrographic Service is conducting geologic mapping of the sea floor to characterize the surface and subsurface geologic framework offshore of Massachusetts. The long-term goal of this mapping effort is to produce high-resolution geologic maps and a Geographic Information System (GIS) that will serve the needs of research, management and the public. Geologic mapping has been completed in the Stellwagen Bank National Marine Sanctuary and Western Massachusetts Bay. Mapping is presently focused in nearshore areas, largely inside the 3-mile limit of State waters, and includes the acquisition of new data as well as reprocessing of existing data.	open file reports, maps, fact sheets, sonar images, and bottom photographs available at http://woodshole.er.usgs.gov/project-pages/coastal_mass/		research, management and the public.
Sara Ellis, Gulf of Maine Mapping Initiative	Gulf of Maine	Mapping cod habitat on Cashes Ledge	2005–2008	multibeam, video and photographic imagery	bathymetry, video, biological, photographic, habitat	In 2005, NOAA conducted acoustic surveys of several important features in the western Gulf of Maine, incldluing Cashes Ledge, Platts Bank and northen Jefferys Ledge. Mutlibeam and backscatter data were processed by the Center for Coastal and Ocean Mapping at the University of New Hampshire. Based on the the resulting maps of Cashes Ledge, Jonathan Grabowski of the Gulf of Maine Research Insitute (GMRI) planned a sampling strategy for cod habitat on Cashes Ledge in 2006 and 2007. Chris McGonigle, a graduate student from the University of Ulster will work on this project in 2007, to run Quester Tangent Multiview on the backscatter data to develop acoustic facies map. He will use video collected on Cashes Ledge in 2006 and 2007 to test the predictions and create preliminary habitat maps. This project is being coordinated by GOMMI.	reports, habitat maps	to be determined	fisheries biologists, managers, public

Annex 6: National Status Report – Denmark

ICES Working Group Meeting (WGMHM) in Woods Hole April 2007.

Mapping of exploited Danish bivalve stocks

By

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Abstract

Natural Danish bivalve stocks in different Danish waters have been exploited throughout the last century with increasing annual landing volumes in the last fifty years, peaking in 1993 in a total landing of all species of approximately 137 000 tonnes. The most important species are mussels (*Mytilus edulis*), cockles (*Cerastoderma edule*), clams (*Spisula solida*) and European flat oysters (*Ostrea edulis*). Other bivalves and gastropods of different species are sporadically caught and landed in small amounts, e.g. queen scallops (*Chlamys opercularis*) and whelks (*Buccinum undatum*). The main fishing areas for mussel are Limfjorden, Kattegat, Little Belt and the Wadden Sea. Cockles are fished east of the islands in the Danish Wadden Sea as well as in coastal areas outside the Wadden Sea. Clams and cockles have for almost 10 years been landed from Horns Reef and Roede Klit Sand (two sandbanks in the North Sea) and cockles the last couple of years as by-catch in the mussel fishery in Limfjorden. Oyster landings from Limfjorden have for the last three years been around 1 000 tonnes annually (a quota given for the fishery), an ancient fishery previously as a Royal prerogative. Since 1986 the Danish Institute for Fisheries Research (DIFRES) has monitored and assessed the different important stocks. Management and exploitation advice has been based on analysis of traditional biological parameters. Introduction of GIS has improved the analysis and made it possible to improve advice by mapping the stock abundance and biomass for smaller subdivisions of fishing areas for different bivalve stocks in order to limit the fishing effect to only the most productive beds. Local stock variations, mortality rates and growth conditions can be mapped temporally and spatially to improve advice for authorities to ensure that the exploitation of the Danish bivalve stocks is kept and maintained on a sustainable level in each area. Advantages of using the modern GIS tools in the management of exploited Danish bivalve stocks are presented and compared with the traditional biological tools used during the last twenty years.

Keywords: Bivalves, sampling techniques, traditional biological tools, GIS, stock analysis, management, advice.

Introduction

Danish bivalve stocks have been exploited throughout the last century with increasing annual landing volumes in the last fifty years, peaking in 1993 with a landing of approximately 137 000 tonnes. Over the last decade the Danish landings of bivalves have decreased to only approximately 70 000 tonnes, which is slightly lower than the average annual landings of around 80 000 tonnes in the four preceding decades. Exploited Danish bivalve species are mussels (*Mytilus edulis*), cockles (*Cerastoderma edule*), clams (*Spisula solida*) and the

European flat oysters (*Ostrea edulis*). Occasionally, other bivalve and gastropod species are caught and landed by Danish fishermen, e.g. queen scallop (*Chlamys opercularis*) and whelks (*Buccinum undatum*). The main fishing area is Limfjorden with annual landings of around 80 000 tonnes of mussels (Kristensen, 1997a; Kristensen and Lassen, 1997, Dolmer *et al*, 1999, 2001; Hoffmann and Kristensen, 1997; Kristensen and Hoffmann, 1999, 2004) and around 1 000 tonnes of European flat oysters (Kristensen, 1997a; Kristensen and Hoffmann, 2006). Landings of mussels from the Belt area (Little Belt and the southwestern part of Kattegat) rank second with annual landings of around 30 000 tonnes (Kristensen, 1995a, 1996b, 1997a, 2001, 2002, 2003, 2004). Mussels and cockles are landed from the Danish Wadden Sea according to quotas annually set for the fishery (Kristensen, 1995b, 1996a, 1997a, and 1997b; Pihl and Kristensen, 1998; Kristensen and Pihl 1999, 2001, 2003 and 2006; Munch-Petersen and Kristensen, 2001; Kristensen and Borgstrøm, 2005). Annual landings of mussels during the last 13 years have in average been around 3 500 tonnes. The annual cockle landings have in the same period been around 1 500 tonnes (Kristensen, 1997a, 1997c, 1998, 2000; Kristensen *et al*, 2002 and Kristensen and Pihl, 2004). Clams have been caught for a ten year period on Horns Reef and Roede Klit Sand and landings have annually in average amounted to around 2 000 tonnes (Kristensen, 1996c, 1997a; Jensen *et al*., 2003).

Since 1986, DIFRES has regularly monitored and assessed the exploited Danish bivalve stocks in all areas mentioned, to establish valid advice for the authorities and to set advice for sustainable quotas and exploitation levels for the fishery.

Before 2002, traditional biological methods were utilized to present biomasses, abundances and size distributions of bivalves in each subarea of Danish bivalve fishing areas. The amount of bivalves in the stock suitable for fishing was estimated as well. Different GIS tools were introduced and applied in 2002 to improve the visualisation of the distribution and abundance patterns of mussels in the stock in the different fishing zones, thereby strengthening both the assessment and the scientific advice made for the authorities.

GIS mapping is employed in many relations, e.g. to describe and visualise sediment structures, benthic communities, usage of marine areas, selection of Marine Protected Areas (MPAs), etc. (Anon., 2006; PROTECT, 2005). This paper presents the application of GIS tools for describing and visualising exploited Danish bivalve stocks in coastal areas. Very few fisheries have been analysed and visualized by use of GIS mapping so far. However, a longline tuna fishery around the Samoa Islands in the Pacific has been illustrated through the use of GIS mapping (Riola; 2006).

DIFRES has mapped different fish and shellfish species as well as environmental factors with GIS (Munch-Petersen, 2005; Jensen, 2003; Jensen and Rolev, 2004; Sandbeck *et al*., 2005; Christensen, *et al*., 2007; Nielsen *et al*., 2006), e.g. mapping of sand eel in the North Sea (TEMAS and BALANCE). Use of GIS in the description of Danish fish and shellfish stocks is a relatively new evaluation and illustration method, helping to visualise stock distribution and exploitation possibilities (Jensen *et al*., 2003). In Greenland waters, data were transferred to GIS maps to visualise the relations between bottom substrate and recruitment of young halibut (Boje and Simonsen, 2005). GIS maps were used in the Pilot project "Læsø National Park" to illustrate the best positions and time of year for data sampling of the marine life around the island of Læsø (Pedersen, 2005). The Working Group of *Crangon* Fisheries and Life History has in the 2005 report applied GIS tools to describe the landings and the distributions of LPUE's (Landing Per Unit Effort) for *C. crangon* per ICES square in the North Sea (Anon., 2005).

Application of GIS tools makes it easy to map the location and the monitoring of specific sensitive ecological elements within any of the subdivisions. Introduction of GIS helps the administrator to develop a proper management plan for the exploitation of the bivalve and to protect and even exclude dredging in vulnerable parts of the ecosystem (Dolmer *et al*., 2001).

In 2004, administrative GIS maps were produced for the Limfjorden area to assist in regulating mussel culture (long lines) activities. The aim was to organise geographical data relevant for management of culture of mussels on long line systems. GIS data was organised in separate layers. A layer representing the result of the analysis shows the areas in the fjord divided into different categories. One category represents areas unsuitable for mussel production for various reasons, while other categories show areas with a number (from 1 to 9) of reservations. Other layers describe the bivalve and finfish fisheries in Limfjorden, activities that conflict with long line culture systems. Unsuitable areas for mussel production concerning restrictions due to pollution around harbours, areas where pipes and cables are located, as well as the other layers used for the analysis, are all shown in separate layers (Dolmer and Geitner, 2004; Geitner *et al*., 2006).

The Danish Institute for Fisheries Research plan within a couple of years to initiate a regular annual survey (onboard leased commercial vessels) along the coast of Jutland and the Danish Wadden Sea in the eastern part of the North Sea with the purpose of monitoring brown shrimp (*Crangon crangon*) and the juveniles of different important commercial fish species. To monitor the Danish and international fishery for brown shrimp, visiting researchers will regularly be onboard a selected group of commercial vessels from 2008. Mapping of the distribution and biomasses of the shrimps and demersal juvenile fish stocks through the application of GIS tools will be one of the important tasks in visualising the distribution of the different fish and shellfish stocks in the Danish coastal waters in the North Sea.

This paper will primarily focus on GIS used for mapping of the different Danish exploited bivalve stocks, and how the tools has been helpful in visualising and generating an improved overview of the bivalve stock and their exploitation.

Materials and methods

Since 1986, the monitoring of Danish bivalve stocks has been carried out using well documented traditional biological methods. Different sampling techniques have been applied during these twenty years of monitoring. Dredges were specifically constructed for sampling of subtidal epibenthic bivalve species. In sampling stations at water depth > 4 m, grabs were applied for sampling infauna bivalve species. Grabs and frames were applied on intertidal and at low water stations (< 4 m) for both sampling of epibenthic and infauna bivalve species.

Sampling techniques

Sampling grids. In 1992, all Danish fishing areas for bivalves were uniformly divided into a number of subareas (Figure A6.1) for selection of water and bivalve samples for algae toxin analysis. After 1994, all landing statistics have been allocated to these subareas. The subareas were divided into sampling grids of a size of either 1 km² or 1 nm² squares, depending on the distribution pattern of the individual species in the different fishing areas. Position and direction of dredges were randomly selected.

Systematic monitoring and sampling of the different Danish bivalve stocks over many years have made it possible to introduce and apply GIS tools to produce distribution maps of the different bivalve stocks. The monitoring programme is defined within Danish waters and allocated to the subarea units (Figure A6.1).

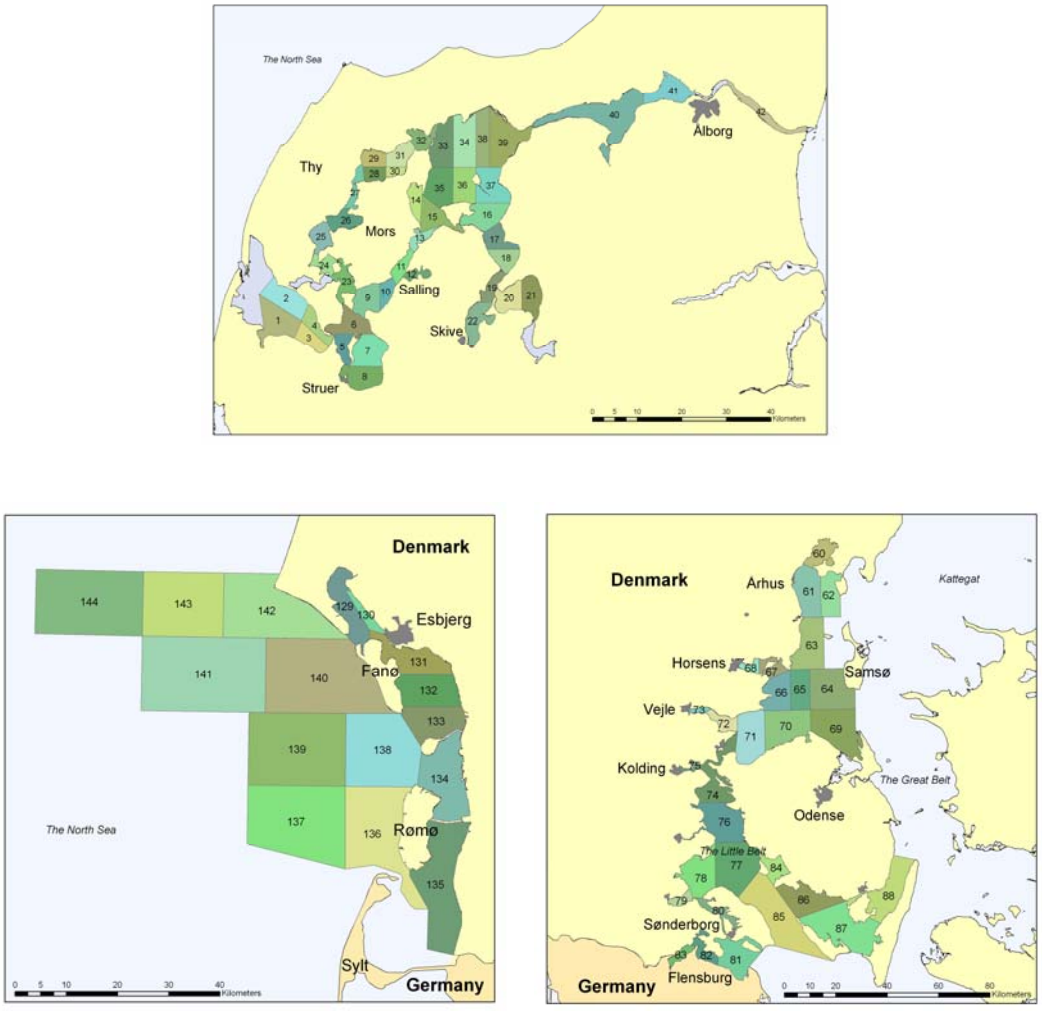


Figure A6.1. Classification of Danish waters in bivalve fishing zones to safeguard that landed mussels are free of algal toxins from Limfjorden, the Wadden Sea, the Little Belt and Kattegat.

Sampling vessels. Sampling was conducted from different vessels and boats, i.e. both DIFRES survey vessels and commercial vessels. A 20 tonne, ordinary Danish fishing vessel with a 120 kW engine was used in the surveys. During sampling the speed was kept between 2.1 and 4.2 knots and the duration of hauls was kept between ½ to 4 minutes representing the swept area. A small boat of 19 feet was employed for collection of the grab and frame samples of mussels and cockles were collected from the intertidal beds and at the low water sampling stations. Different commercial vessels have been leased for dredging and grab sampling in the Wadden Sea area. Sampling positions were notified using a DGPS navigation system (DGPS, Shipmate 5300 and Koden KGP 98D or DGPS Furuno GP50/MBX).

Dredge sampling. Sampling with the survey vessel in Limfjorden, a smaller version (1:2) of the dredge used in the traditional mussel fishery was applied. The catch efficiency for the dredge was defined in 1996 (Dolmer *et al*., 1999), and the catch efficiency formula to be used for this dredge is:

$$Eff_{\%} = 37 * b^{0.71}$$

This catch efficiency is only applicable when the HAVFISKEN is operating the dredge.

Setting the dredge was done at a specific position and the hauling time depended on the abundance of mussels in the different beds. Swept area estimates were used to estimate abundance and biomass of mussels pr. square meter of mussel bed (Dolmer *et al*, 1999; Hoffmann and Kristensen.1997).

Sampling of mussels on subtidal beds in the Wadden Sea was carried out with help from local fishermen applying their traditional mussel dredge. Operating a dredge from a commercial vessel, the catch efficiency for the ordinary dredge was set to 100% (water depth < 5 m) (Munch-Petersen and Kristensen, 2001; Kristensen and Borgstrøm, 2005).

For sampling of oysters, an old type oyster dredge was applied of less than 15 kg in total weight and with an iron mat to prevent deterioration of the catch net. The catch net was of nylon with a mesh size of 60 mm (whole mesh size). The width of the dredge was 0.85 m. The catch efficiency of the dredge was around 33% estimated using a smaller boat. It is assumed that this efficiency also is valid when the dredge is used from a larger 20 BRT vessel at normal wind speeds (< 8 m/s) and moderate waves. The maximum catches were 25 kg. The dredge was emptied like a cod end in a common trawl. The swept area was determined by use of a DGPS navigation system.

Grab sampling. At waters depths below 4 meters, grab samples (van Veen grab; 0.1 m^2) were taken on transects perpendicular to the coastline with a distance of one kilometre between transects. Sampling stations were located applying a DGPS satellite navigation system (Furuno model GP50). The boat was anchored at the sampling position and the real sampling position was noted after the sampling.

Mussel sampling. Data consists of dredge, frame and grab samples from a number of positions in all the Danish bivalve fishing areas (2,729 in all) (Table A6.1 and Figure A6.2). Not all stations have been sampled every year (Table A6.1). Dredging was standardized with a definite wire length connected to the water depth (25 fathoms < 10 m of water depth; 35 fathoms between 15 m and 10 m depth; 50 fathoms 20 m to 15 m etc.). The angle between the sea bottom and the wire was kept around 10º to ensure homogeneous catch efficiency. Since 1993, dredge sampling has been carried out in different Danish waters where mussels are fished and is now a routine procedure in the monitoring programme for mussels.

Table A6.1. Number of dredge samples taken each monitoring year. * Both dredged and van Veen grab samples. ** Samples applying frames. ***All 2 729 stations have at least been sampled once between 1986 and 2005.***

Year	Numbers of dredged stations in Limfjorden *Mussels*	Numbers of dredged stations in Limfjorden *Oysters*	Numbers* of sampling stations in the Wadden Sea *Mussels*	Numbers** of sampling stations in the Wadden Sea *Cockles*	Numbers* of sampling stations on Horns Reef and Roede Klit Sand *clams*	Numbers* of sampling stations in ICES area 22 A (Kattegat and the Belt Sea *Mussels*
1986 - 1992	-	-	70	-	108	-
1993	388	-	20		-	-
1994	337	-	-		-	402
1995	72	-	60		-	191
1996	149	-	69		-	480
1997	179	-	40	99	-	623
1998		-	95		-	-
1999	184	-	-		-	-
2000	-	-	131	117	-	-
2001	172	-	-		-	-
2002	-	106	115	133	-	291
2003	205	-	-		-	-
2004	113	206	75	82	-	84
2005	-	206	20		-	-
Mean	200	173	69	108	108 (sum)	2071 (sum)

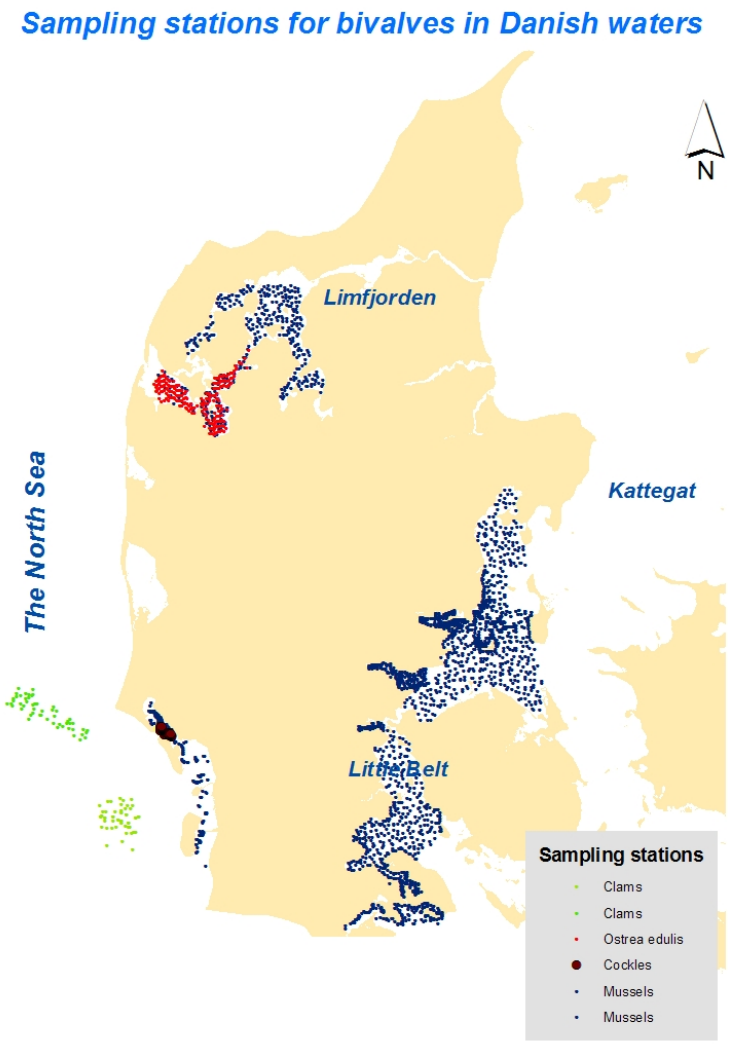


Figure A6.2. The positions of all 2,729 sampling stations for bivalve in the fishing areas in Danish waters.

Cockle sampling. To sample and estimate the fishing potential of cockles in the Danish Wadden Sea, a number of permanent stations have been evenly laid out with a distance between stations of 100 and 300 metres (Table A6.1). At each station a circle with a diameter of 5 meters was drawn and 5 duplicate samples were taken randomly within the circle. Cockles are collected within a randomized total area of 0.2 m². An average of 108 (Table A6.1) stations has been selected in Grey Deep, the channel to Esbjerg in the intertidal fishing area for cockles. Sampling was carried out in April of every second year (2000, 2002 and 2004, etc.).

All five samples taken at each station were pooled and placed in a plastic bag and frozen for later analyses in the laboratory. All live cockles were measured in width and length with a calliper and weighted on an electronic weight.

Before 2004, cockle cover and distribution in fishing areas was measured applying a planiometre. After 2004 GIS tools have been applied to analyse digitised aerial photos. The total area of the cockle beds in m² is multiplied with the estimated mean biomass of cockles pr. m² to estimate the total biomass of cockles in the stock. Also a VPA (Virtual Population Analysis) was carried out.

Clam sampling. A randomised sampling grid was distributed over the potential clam fishing area at Horns reef and Roede Klit Sand, two coarse sand localities in the North Sea close to the Danish Wadden Sea (Table A6.1). Two samples were collected with a van Veen grab of 0.2 m² at each of the 109 stations. The samples for each separate station were pooled and frozen for later analysis in the laboratory.

Oyster sampling. Area divisions similar to the procedure applied in the mussel sampling (Table A6.1 and Figure A6.1) were applied to estimate the biomass of oysters in Limfjorden (Kristensen and Hoffmann, 2006). Limfjorden is around 1 575 km² and oysters are fished in an area of approx. 246 km² (zones 1–10). In 2004, 206 stations for oyster sampling were evenly distributed on a map in squares of 0.5 * 0.5 km². A dredge station was set in the centre of each of the squares. A random dredge direction was chosen.

Sample analysis. All samples were sorted in the different species, i.e. mussels, cockles, clams or oysters, starfish and other benthic species as well as different abiotic materials (shells, sediments, pebbles, etc.). The gross catch was weighted on an electronic scale (model: Morel M60, weighing limit max. 60 kg). A representatively sorted subsample (on 0-, 1- or 2-level) of the different bivalve species and single sorted fractions of abiotic materials were weighed on an electronic scale (model: Morel M60, weighing limit max. 6 kg). The shell length of each individual bivalve was measured in semi centimetres on a special semi centimetre board (stainless steel).

Monitoring blue mussels in the Danish Wadden Sea by use of digital aerial photographs.

Estimation of bed sizes is based on aerial photographs, which have been improved throughout the whole period since its introduction in 1986. In the early days, black/white aerial photos were used, which to a certain point made it possible to distinguish blue mussels from other organisms in the beds (Munch-Petersen and Kristensen 1987, 1989). From 1993 and onwards, colour photos have been used to estimate the sizes of mussel beds. Recognized and defined mussel beds were previously drawn on transparent plastic foil and weighed to determine bed sizes (Kristensen, 1994).

In 2002 GIS was introduced at DIFRES, making it possible to estimate the areas with mussels by performing digital image analysis on ortho photos (aerial photos corrected for terrain distortions, etc.) (Kristensen and Borgstrøm, 2005). Provided that the quality of the ortho photos and the physical parameters such as the tidal situation (low tide), clouds etc. are optimal, it is possible to semi-automatically detect and estimate the sizes of mussel beds.

This was done by a process of digital image processing, where a supervised classification technique (called Maximum Likelihood) was used to classify the pixels of the aerial photography into values based on the abundance of the blue mussels. The classification process was based on the possibility to identify ‘training areas’, which act as areas that with certainty (based primarily on the competence and knowledge of the interpreter) were defined as mussel areas. On the basis of the training areas the classification process was run and results in a classification of pixels as mussels or not mussels. See an example of the results in Figure A6.3.

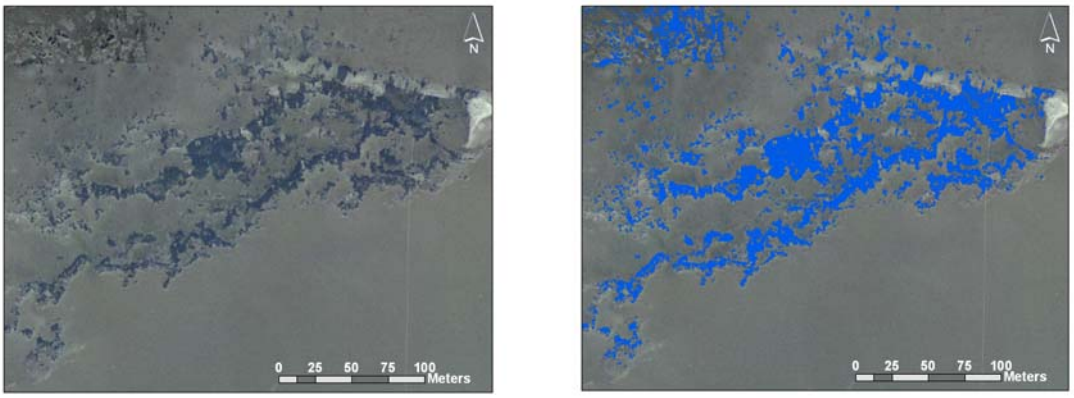


Figure A6.3. Digital ortho photo of a small mussel bed in the Danish Wadden Sea (aerial photos from 2002). The blue areas on the right correspond to pixels classified as mussels. (Note: *each pixel in blue is 0.16 m²*). (From Kristensen and Borgstrøm, 2005).

However, it is important to stress that the most reliable results are obtained when using digitised aerial photos on intertidal beds. Measuring bed sizes in the subtidal beds by using the same technique depends on the tidal situation (low tide only), the position of the sun (the angle created with the Earth's surface), refection from the sea surface, cloud conditions etc. Fortunately, the Danish Wadden Sea is relatively shallow with a maximum water depth < 5 meters at low tide in the main parts, which makes it possible to interpret the sizes of the subtidal mussel beds in large parts of the Danish Wadden Sea using aerial photos.

Production of interpolated maps

ESRI ArcGIS version 9.0 was used to produce the maps and the grids. Data for mapping was first archived in Excel spreadsheets with positions in latitudes and longitudes. Using ArcGIS, a map layer was made from each spreadsheet file. The geographical coordinates of the map layers were then converted to UTM zone 32 coordinates.

Interpolation of data was performed by the Spatial Analyst extension for ArcGIS. It was assumed that mussel density decreases in influence with distance from its sample location. Hence Inverse Distance Weighted (IDW) was chosen as the interpolation method (Table A6.2). This interpolation method assumes that the surface is driven by local variation and it preserves the maximum and minimum values at sample points.

In the case of interpolation of data in fjords, an interpolation mask was prepared, hence only areas of the fjord where a number of samples were taken were included in the interpolated surface. Since the data in the Wadden Sea was sparse with low point densities, the data from this area was interpolated with a fixed search radius, and the results were discontinuous grids (large areas with no data). IDW interpolation method requires a power value, i.e. the higher the power, the shorter the distance of the points that have influence on the prediction. A power of 0 indicates that there is no decrease of influence with distance. During interpolation the most commonly applied value of 2 was used. An analysis of the data that was performed later with ArcGIS Geostatistical Analyst showed that a power of 1 gave the optimum results, but the difference in the output surface was minimal, so the inverse distance squared weighted interpolation was kept. There was no directional influence on the weighting of the data.

Table A6.2. Details for interpolation methods used in the different areas.

	Limfjorden	The east Jutland fjords, the Little Belt and Kattegat areas	The Wadden Sea
Grid cell size	100 m	100 m	100 m
Interpolation mask	yes	yes	none
Interpolation method	Inverse distance weighted (IDW)	Inverse distance weighted (IDW)	Inverse distance weighted (IDW)
IDW power	2	2	2
IDW search radius type	variable	variable	fixed
IDW number of search points	12	5	
IDW search distance			300 m
IDW minimum points			1

Results

The annual landings of mussels from the different exploited Danish bivalve stocks in the most important fishing areas are shown in Table A6.3.

Table A6.3. Danish landings of mussels from the most important Danish stocks.

Year	Limfjorden	Kattegat Little Belt	Isefjorden	The Wadden Sea	Denmark
1990	84.964	5.731	-	1.759	92.454
1991	108.845	11.034	-	5.539	125.418
1992	111.792	19.399	-	5.041	136.232
1993	111.063	22.098	-	3.490	136.652
1994	94.876	26.232	-	4.397	125.505
1995	74.396	24.048	-	8.931	107.375
1996	112.197	26.401	-	2.212	140.810
1997	64.566	25.977	-	263	90.805
1998	74.339	30.211	-	3.775	108.325
1999	59.595	31.841	90	4.015	95.541
2000	82.719	25.143	1.022	2.718	111.602
2001	81.915	33.076	2.590	4.907	122.488
2002	76.436	29.457	2.501	2.445	110.839
2003	72.782	18.416	995	263	92.456
2004	70.336	28.009	1.073	38	99.456
2005	45.043	21.149	2.952	-	69.144
2006	29.520	22.579	2.576	-	54.675
Mean	79.728	23.577	1.725	2.929	107.046

Monitoring of the mussel biomasses in **Limfjorden** has been carried out for more than ten years, making it possible to describe and compare the biomass changes between years (Figure A6.4). There has been a decrease in the mussel biomass in Limfjorden from around 700 000 tonnes in 1993 to only around 400 000 tonnes in 2003. However an increase is observed to around 500 000 tonnes between 2003 and 2004. In 2006 the biomass dropped again to only around 150 000 tonnes (Figure A6.4). The decrease in the mussel biomass in Limfjorden is clearly visualized on the GIS maps in Figure A6.5. The ten years average and maximum biomasses are shown in Figure A6.6.

In the last couple of years, the reappearance of the European flat oysters (*Ostrea edulis*) in Limfjorden after thirty years of absence of fishable specimens has been mapped applying GIS tools. Results are shown in Figure A6.7. The biomass has increased from around 2 600 tonnes in June 2004 to around 3 600 tonnes in 2005. In 2006 the biomass decreased to around 3 200 tonnes. As can be seen on the maps, the increase is equally distributed in most of the subareas save subareas 1 to 4 (the most western parts of the fishing areas), where the increase has been around 100% (see Figure A6.7).

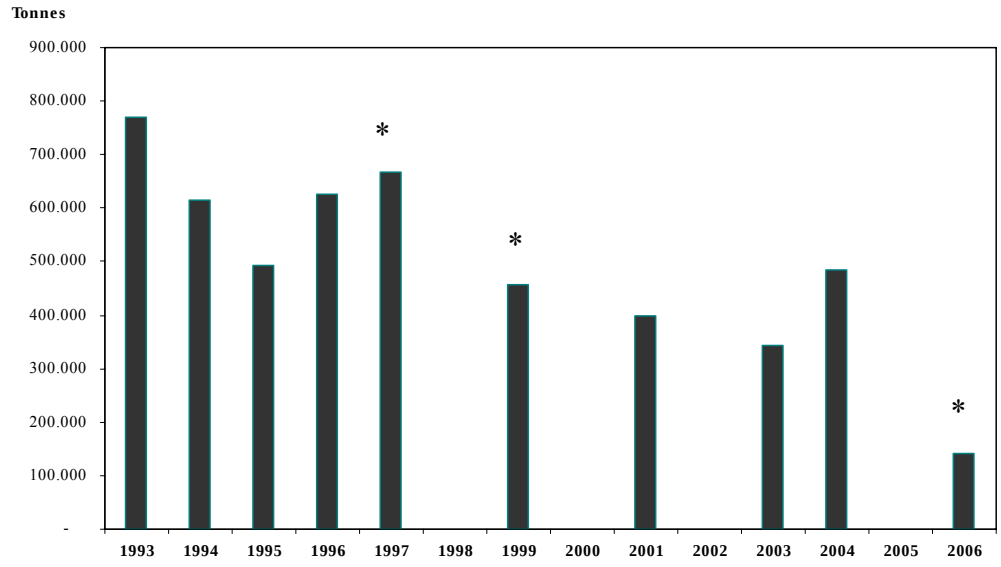


Figure A6.4. The development in the mussel stock in Limfjorden. * High mortalities in the stock due to oxygen deficiencies and H_2S effluent from the bottom sediment.

The sampling stations and distribution of mussel biomass in the **Kattegat and Little Belt** (ICES subarea 22A) area are shown on Figure A6.2 and Figure A6.13. The maps of the mussel biomass in Kattegat and Little Belt are based on a monitoring programme carried out between 1994 and 1997. The latest monitoring programme for the northernmost subareas was carried out in 2002 and for the central Belt Sea in 2004. The low water stations were only investigated in the fjords and in southern Little Belt. The average biomass of mussels based on the traditional biological analysis is approx. 750 000 tonnes and the distribution pattern is illustrated on the maps in Figure A6.8a. With an annual landing of around 23 000 tonnes, the exploitation level is only around 3% and thus far below the exploitation level for many common fish stocks.

To map the overlap between mussel beds and eelgrass meadows and to assess the possible areas of conflict between mussel fishery and preservation of eelgrass meadows, samples of eelgrass (*Zostera marina*) were collected at low water stations (< 4 m) in 1994, 1995 and 1996 in the coastal zone and the fjords of eastern Jutland. Overlap between mussel beds and eelgrass is shown in Figure A6.8b and appears most often at water depths below 4 m. The most substantial overlap was in the fjord systems along the east coast of Jutland. Today it is prohibited to harvest bivalves in the most vulnerable and important eelgrass areas within all known Danish bivalve fishing areas.

Mapping of mussels, cockles, clams and oysters in the **Wadden Sea** region using GIS is shown on Figure A6.9, A6.10, A6.11 and A6.12.

During the whole monitoring programme in the Danish Wadden Sea, the largest biomass of mussels is concentrated in the northern part in the Ho Bight. Distributions of mussel beds are shown on the maps in Figure A6.9.

Dredging for cockles is only permitted in a very limited area of the Danish Wadden Sea, namely in the Grey Deep tidal area (the sailing channel to Esbjerg). The stock and fishing potential (TAC allocation (Total Allowable Catch)) is monitored and assessed every second year in order to advice authorities and the fishery. The biomass and distribution are shown on the maps in Figure A6.10.

In the 1980s the Pacific oyster (*Crassotrea gigas*) was introduced in the southern part of the Wadden Sea (the Netherlands) and has since spread further and further north. The first observation of Pacific oysters in the Danish Wadden Sea was in 1996 (Dietrich, 1996) in intertidal mussel beds north of Esbjerg. Over the last couple of years, the distribution and the biomass have increased substantially and have in 2006 reached an estimated biomass of around 3 500 tonnes (Kristensen and Pihl, 2006). The Pacific oyster distribution and biomass in the Danish Wadden Sea are shown on maps in Figure A6.11.

The distribution of the clam biomass at Horns Reef and Røde Klit Sand monitored and assessed in 1992 is shown in Figure A6.12. After ten years of intense fishery, the biomass had in 2002 decreased considerably (Jensen *et al*., 2002).

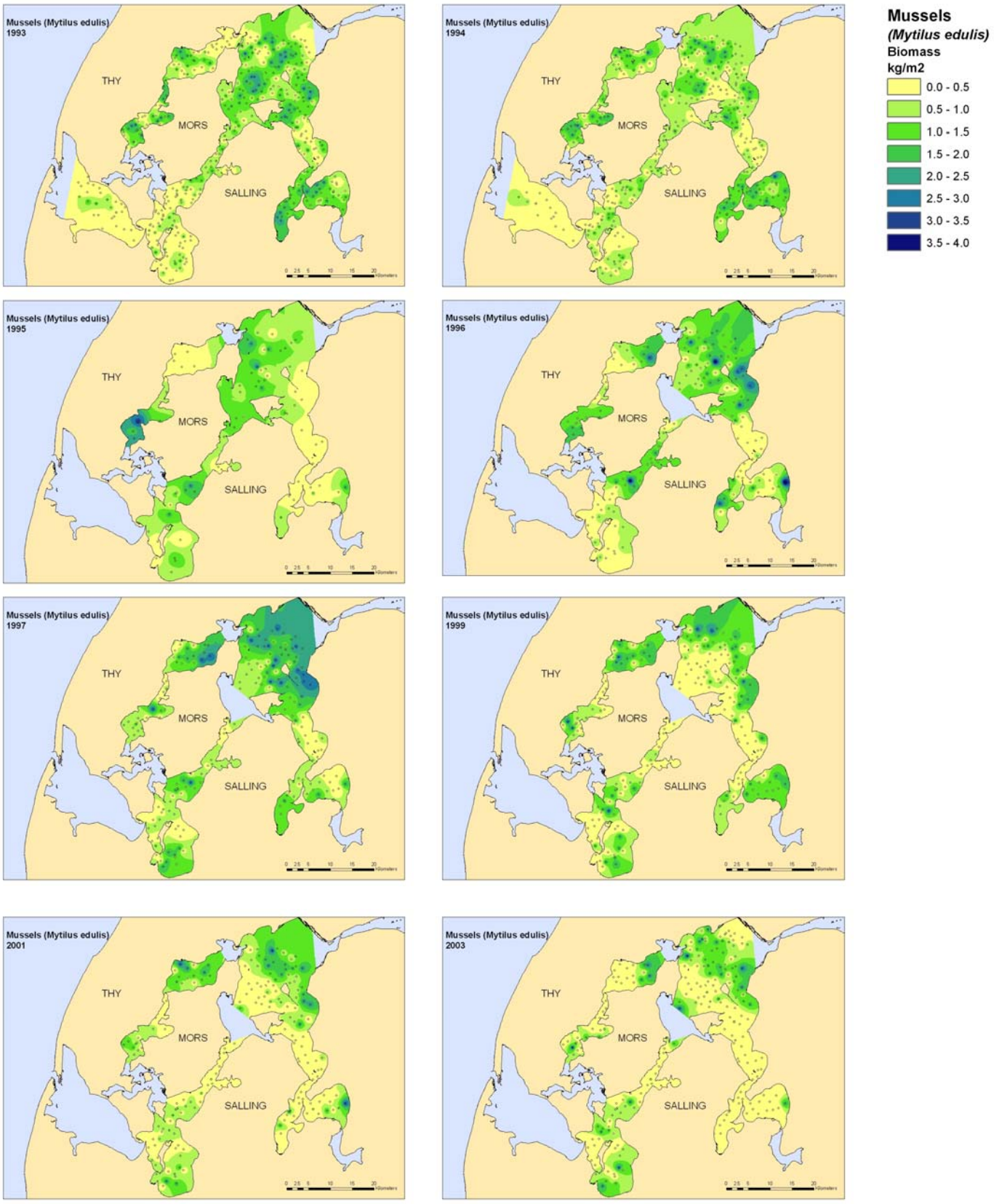


Figure A6.5. Annual changes of the biomass and distribution of mussels (*Mytilus edulis*) in Limfjorden 1993–2003 illustrated with GIS.

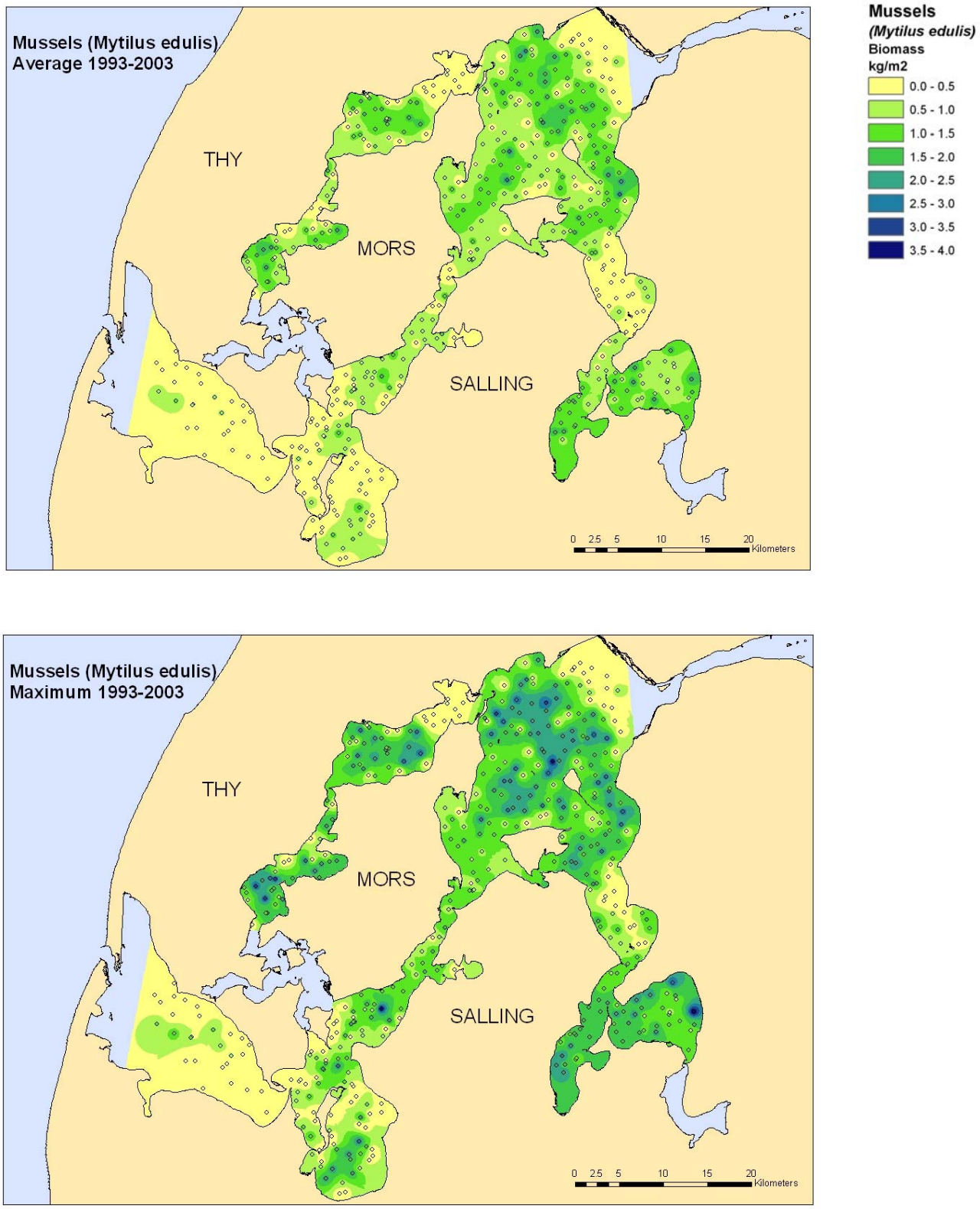


Figure A6.6. A GIS map showing the average and maximum biomass (kg/m²) of mussels (*Mytilus edulis*) over 10 years in Limfjorden. *The legends cover all graphs in Figure A6.5 and A6.6.*

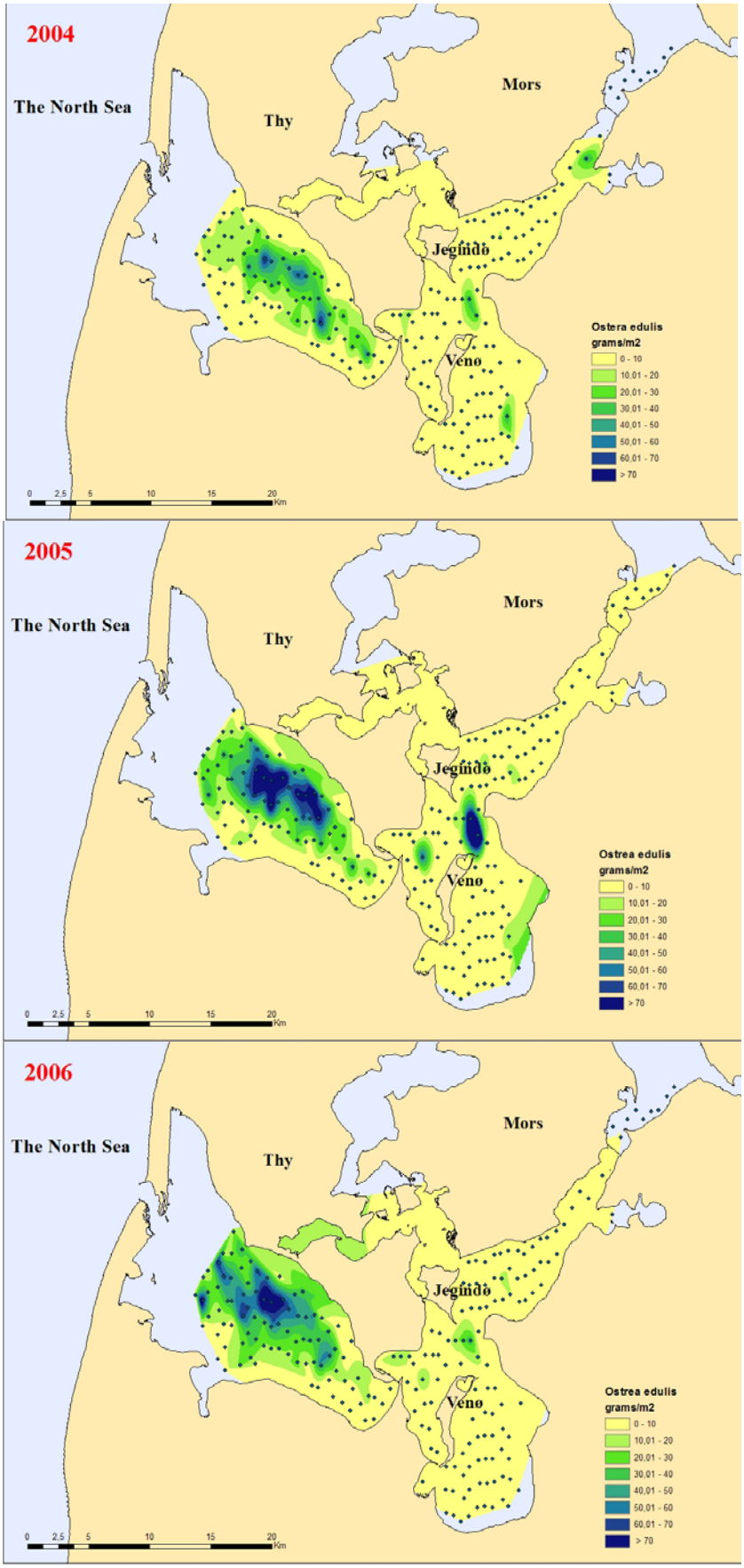
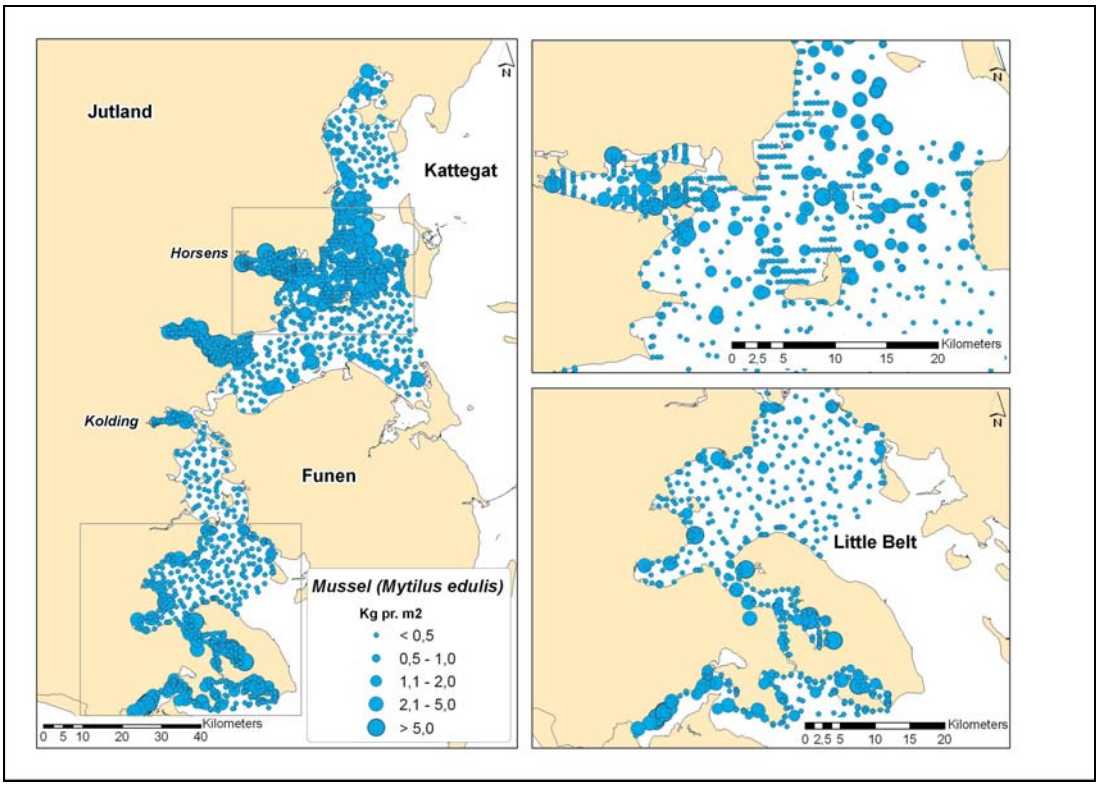


Figure A6.7. GIS-maps showing the biomass (grams/m²) and distribution of oysters (*Ostrea edulis*) in Limfjorden in 2004, 2005 and 2006. *Dots are sampling stations*.

a.



b.

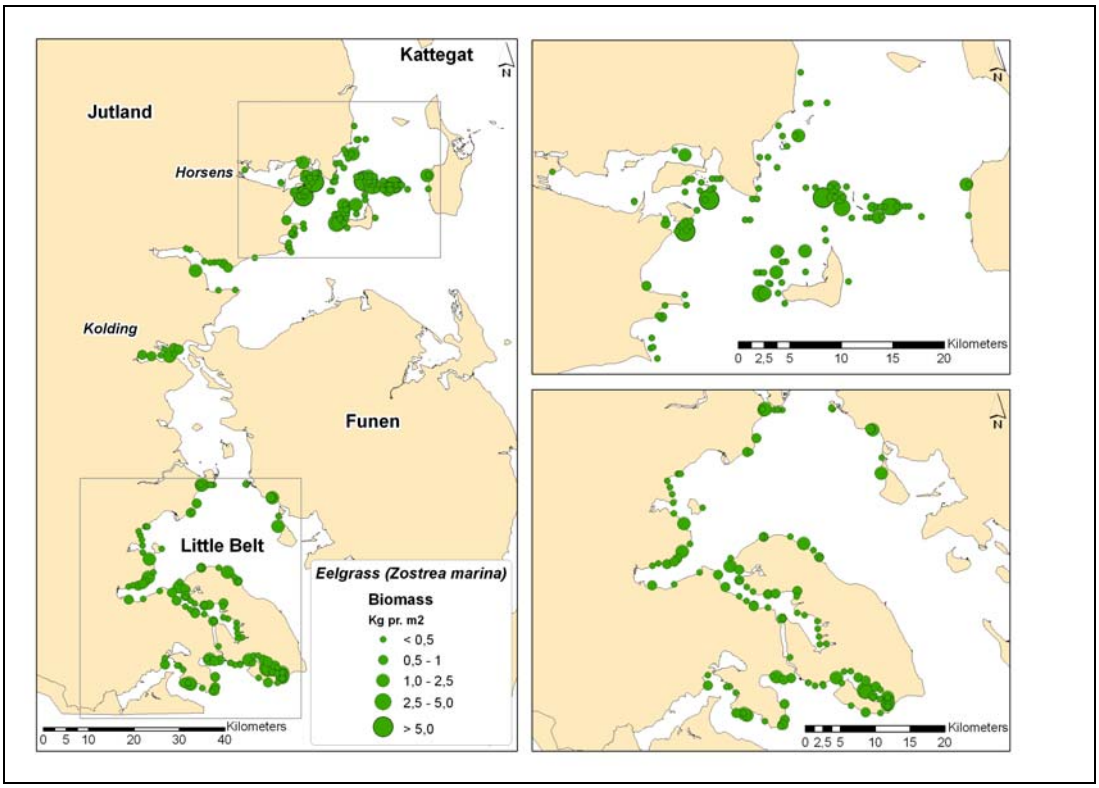


Figure A6.8. a: Mussels (*Mytilus edulis*) and b: eelgrass (*Zostera marina*) biomasses in Little Belt and Kattegat (ICES subarea 22A).

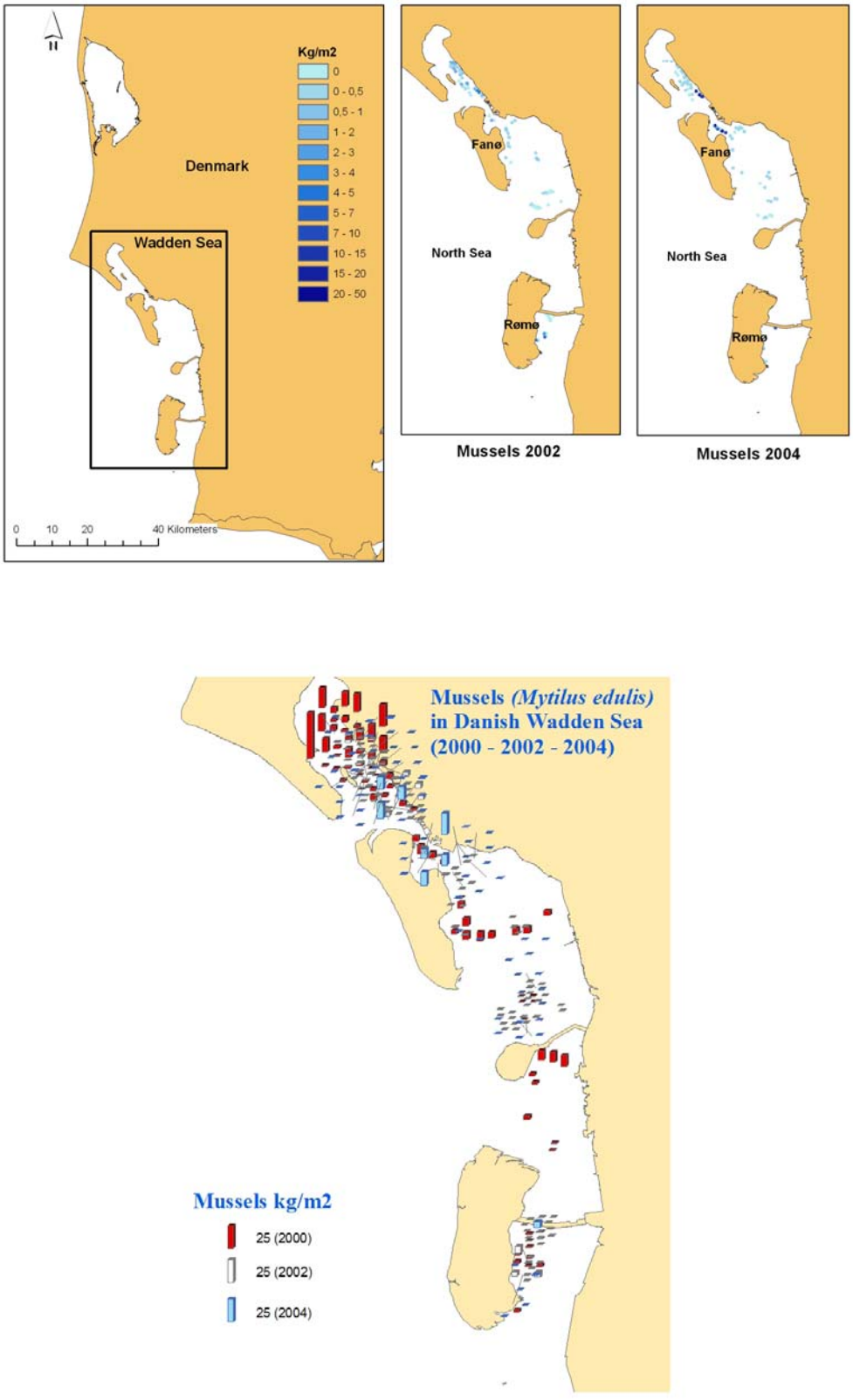


Figure A6.9. Mussel (*Mytilus edulis*) biomasses and distribution pattern in the Danish Wadden Sea in 2000, 2002 and 2004.

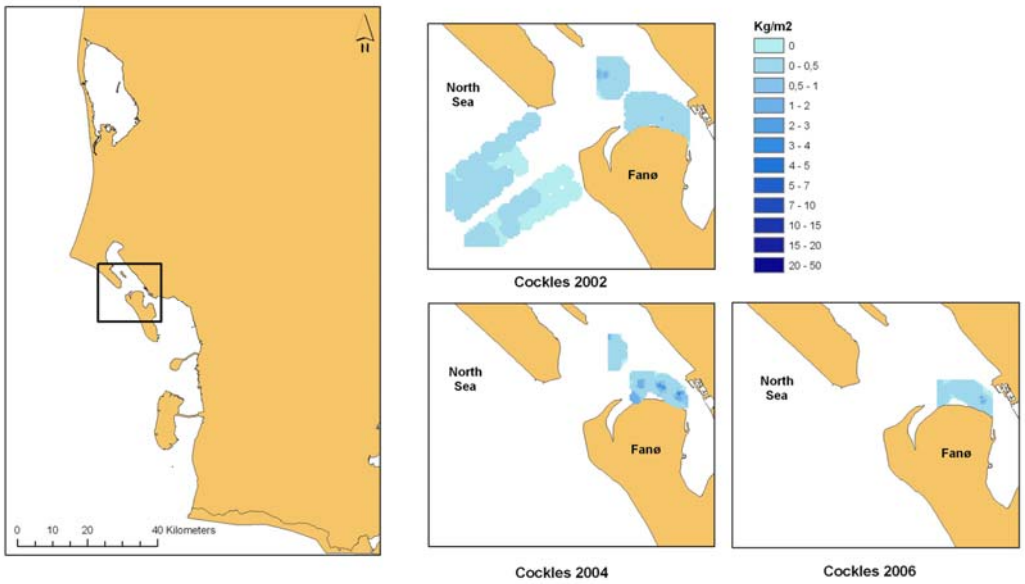


Figure A6.10. Biomass and distribution of cockles (*Cerastoderma edule*) in the Danish Wadden Sea (2002–2006).

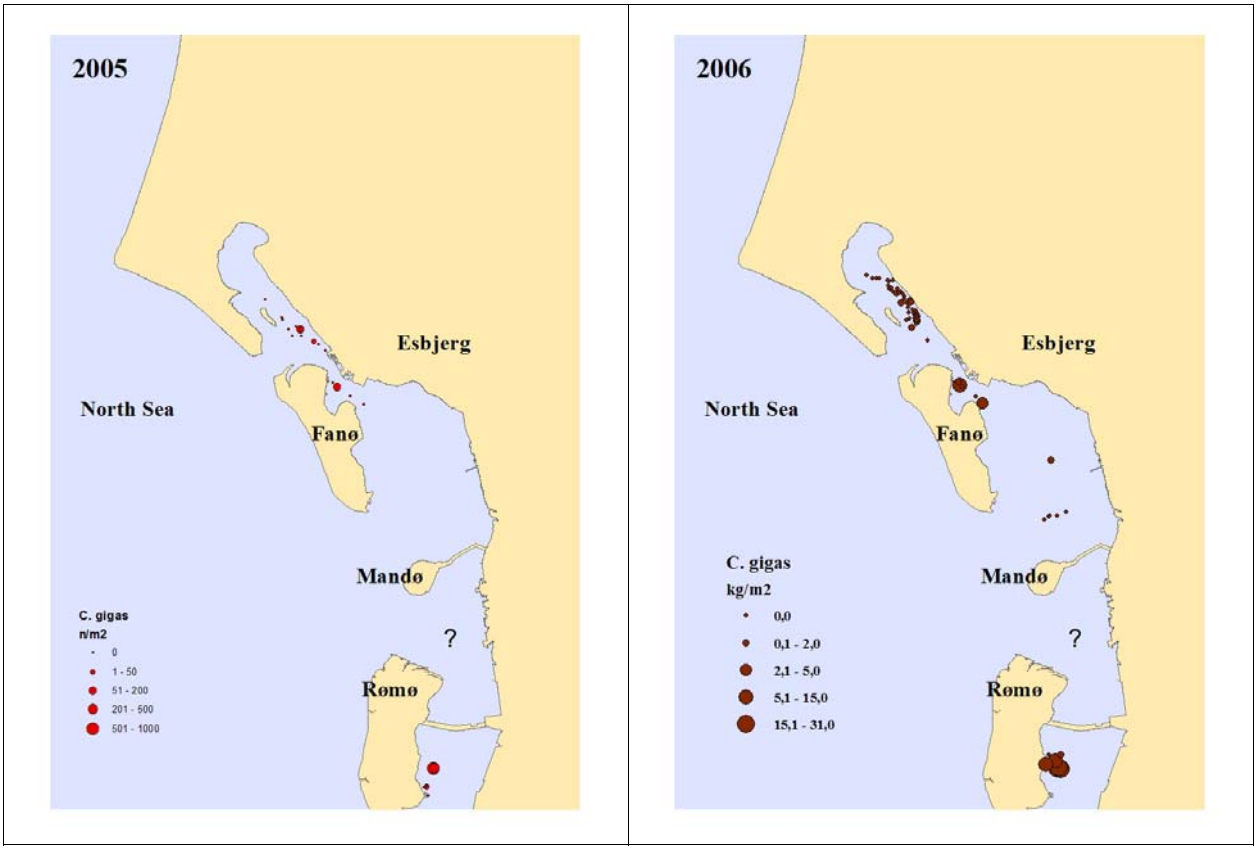
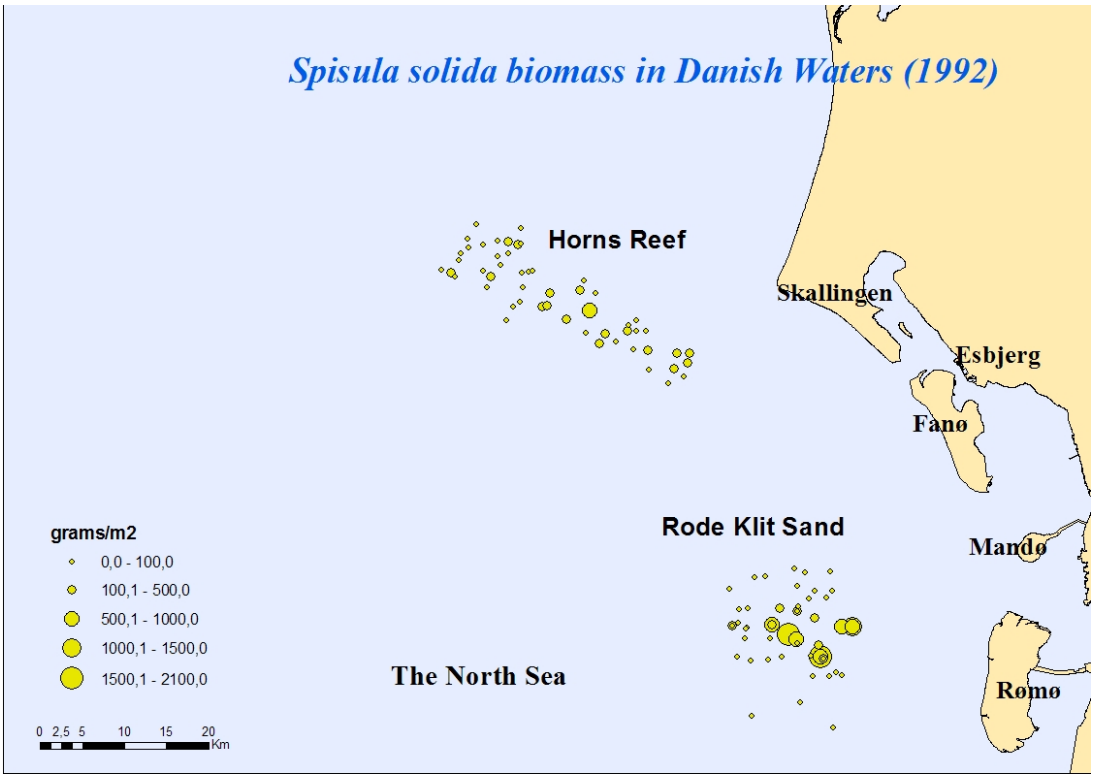


Figure A6.11. Abundance (n/m²) and biomass (kg/m²) of Pacific oysters (*Crassostrea gigas*) in the Danish Wadden Sea in 2005 and 2006. (Note: ?) *Means Not an investigated area, even though oyster beds have been observed (area protected from mussel fishery).*



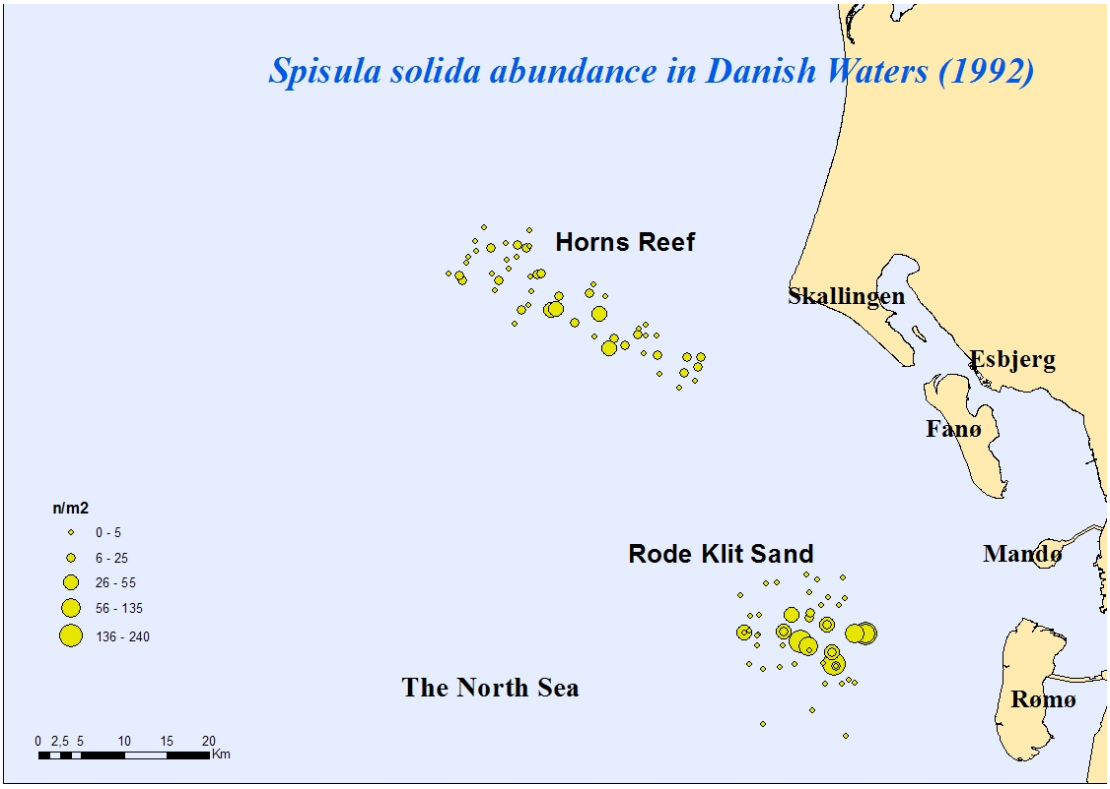


Figure A6.12. Biomass (kg/m²) and abundance (n/m²) of clams (*Spisula solida*) in Horns Reef and Roede Klit Sand (*Data from 1992*).

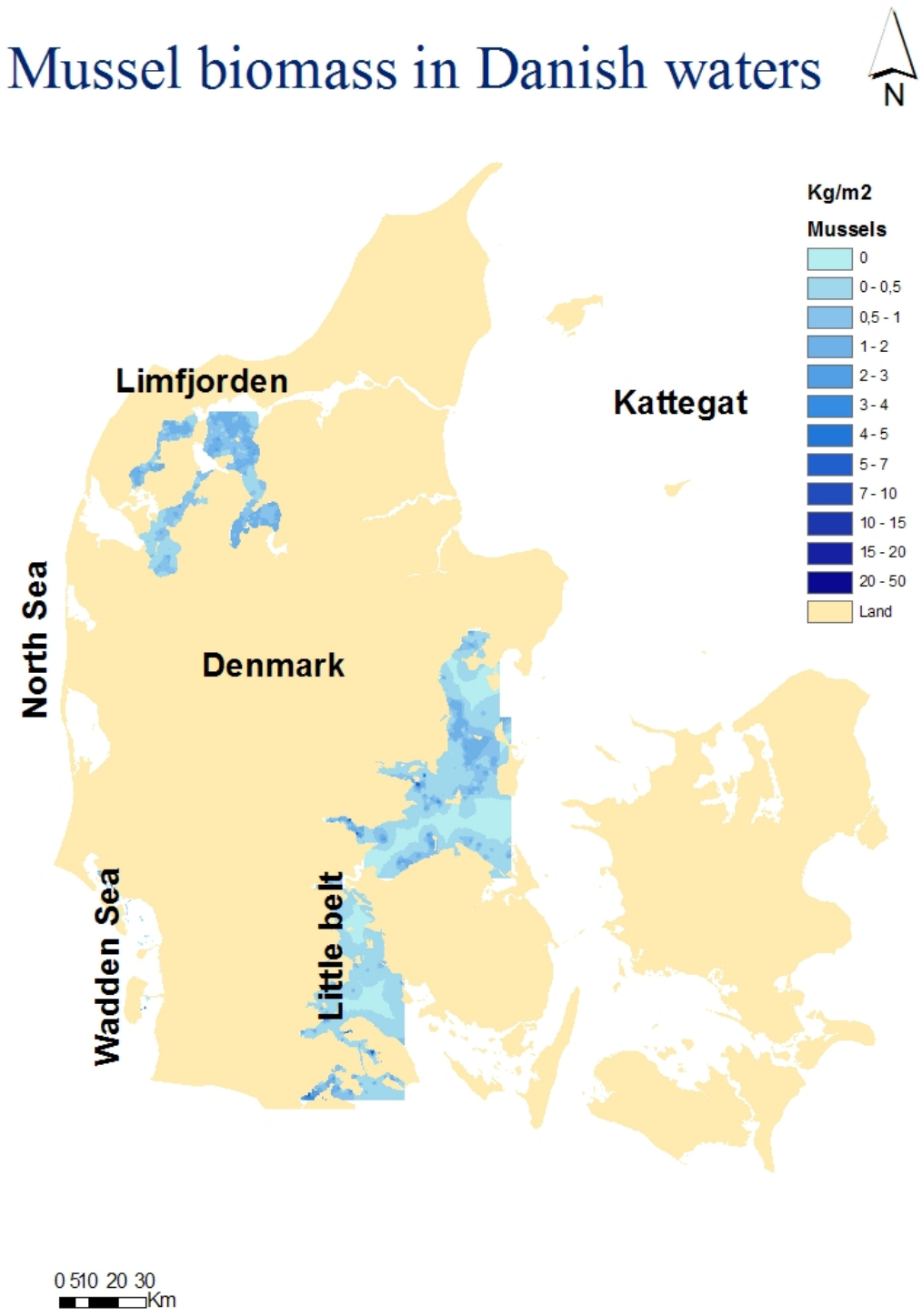


Figure A6.13. The biomass (kg/m²) and distribution of mussels in the Little Belt, Kattegat and the neighbouring fjords (ICES subarea 22A), Limfjorden and the Wadden Sea. (Note: *The mussel biomasses in Little Belt has been estimated for separate years; 1995, 1996, 1997, 2002 and 2004*).

Discussion and conclusions

Previously bivalve data was traditionally presented using graphs (histograms) showing the development in the stock regarding biomass, abundances and size distribution for each investigated fishing area. The spatial distribution over time was only insufficiently presented in these graphical presentations. The visualization of spatial distribution patterns of the exploited Danish bivalve stocks has improved by use of GIS mapping or "imaging" showing many more temporal and spatial (geographical) details. The introduction of GIS does improve visualisation of the abundances and biomass of the different bivalve species exploited in Danish fisheries, and makes it more clear for managers and fishermen, which fishing area or parts of a fishing area is or is not suitable for fishing. The GIS illustrations presented in this paper clearly show the advantage of basing the scientific advice on this new geographical and illustrative information technique. You can easily follow the development in the bivalve stock of interest in each fishing area and during seasons.

The data collection to monitor the development in the mussel stock in Limfjorden has been followed annually over 13 years. The GIS maps (Figure A6.5) clearly demonstrate the spatial and temporal changes in the stock of mussels in the different fishing areas between 1993 and 2005. It is evident that it has become much easier to develop and propose advice regarding areas most applicable for fishing and exploitation. In applying GIS, one has an instrument to concurrently safeguard nature preservation and achieve an overview of the vulnerable habitat types, which have to be protected from fishing activities.

The illustrative information you gain by applying GIS mapping of changes in the distribution and biomass of the different bivalve species in Danish waters clearly strengthen our knowledge and capability to describe the stock developments over time in the various areas. In the future such information will be essential for advice and decision making regarding bivalve fisheries in all Danish fishing areas, i.e. when dealing with issues pertaining to sustainable exploitation levels of the different Danish bivalve stocks and protection of vulnerable environments.

Mapping of the biomass of the European flat oysters in Limfjorden is used in the advice of the authorities on the general exploitation level and to which extent some stocks may be fished stronger compared to others in the different subareas. In 2004 and again in 2005 the fishery was e.g. allocated an annual quota of 1 000 tonnes equal to around 10 000 000 oysters. The harvest could be, according to the distribution pattern presented on GIS maps, more comprehensive in subareas 1–4 compared to the other subareas in Limfjorden. The estimates document that the exploitation level of the stock biomass over the last three years has been less 25%. The exploitation level below 25% is assumed to be sustainable for most of the oyster stocks in Limfjorden.

Applying GIS tools for mapping of the distribution of mussels and eelgrass in the coastal areas in ICES subarea 22A has improved the understanding and knowledge on the overlap between mussel beds and eelgrass meadows. It elucidates where a potential conflict may occur between nature conservation and fishery. The investigations in the Belt area and southwestern parts of Kattegat in the years 1996 to 2002 resulted in substantial changes of the management and exploitation pattern of the mussel stocks in the east Jutland's fjords (*Horsens, Vejle and Kolding fjords*). The inner parts of the fjords were permanently closed for mussel dredging. Along the coastline, protection zones between 200 and 400 meters were issued and were permanently closed for mussel fishing. The permanent closure of these areas has not at all resulted in a decrease in the mussel landings from ICES subarea 22A. So far, no limitations of the mussel fishery have been introduced in other areas in ICES subarea 22A, where a potential conflict between mussel fishery and preservation of eelgrass may occur anytime.

The monitoring programme for Danish bivalve stocks was already initiated in the Wadden Sea in 1986. Aerial photograph in black and white (1983 edition; in Munch-Petersen and

Kristensen, 1987) was applied in the beginning to map out tidal areas with mussel beds. Sizes of mussel beds were estimated applying these photos. The mussel biomass was determined by field samples of mussels in the beds. Since 1992 aerial photographs in colour have been applied to improve the reading and interpretation of the distribution pattern of mussels in the beds. The results have been a more precise estimation of the sizes of mussel beds, taking into account the cover and the delimitations between different beds. Field sampling programme has not changed since 1986 and is still carried according to the same procedure as previous years (Kristensen and Borgstrøm, 2005).

The monitoring programme for mapping and assessing the mussel stock in the Wadden Sea was initiated due to great concern about a strong competition between fishery and the preservation of sufficient food for the mussel eating bird species that regularly migrate between their nesting and wintering areas. The mussel fishery has since been regulated very strongly. Only a minor part of the annual production that the standing stock is able to produce within one production period has been allocated to the fishery as an annual quota. This is done to make sure that birds have sufficient food available during resting in the Wadden Sea (Munch-Petersen and Kristensen, 2001 and Kristensen and Borgstrøm, 2005). The knowledge concerning the biomass and distribution of mussels in the Wadden Sea is essential if one wants to safeguard sufficient food for mussel eating birds and, accordingly, also wants to set and recommend a sustainable quota for the fishery.

Areas allocated for cockle fishery in the Danish Wadden Sea are limited to minimize the potential conflict between fishery and the preservation of sufficient amounts of cockle as food for birds (e.g. oyster catchers). The exploitation level of cockles in the restricted fishing areas in the Grey Deep is based on a careful plan to monitor and assess the cockle stock to set a sustainable quota for a restricted season which again takes into account the food supply for and undisturbedness of the birds. A prognosis is given for the stock development (including estimations of mortality rates at 50 % and 80% levels and growth rates, respectively) for the following years after monitoring. Application of GIS mapping establishes the spatial distribution of the cockles, making it possible to limit the fishing effort to only those parts of the bed that are most densely populated, and by doing so reducing the negative impact of fishery on the environment.

Occurrences in the Wadden Sea of the invasive Pacific oyster (*C. gigas*), which evidently competes with mussels in the intertidal beds, have made it essential to observe and to control its spreading. Aerial photography or satellite imaging, combined with GIS mapping, would be very helpful tools to follow and visualise the spreading of the species. Information of this type may help the authorities in deciding how and when to control the spreading of the oyster in the Danish Wadden Sea. The information in this report clearly shows that the spread of the Pacific oysters visualised using electronic media and GIS mapping can be very helpful for decision makers in order to decide on how to cope with the invasive species.

The clam (*Spisula solida*) stocks in Horns Reef and in Røde Klit Sand have only been monitored in 1992 and again on a limited scale in 2002 within the wind turbine area erected on Horns Reef in 2002. A dramatic decrease in the biomass with a factor of approximately 100 had taken place between 1993 and 2002. The GIS maps visualising the biomass and distribution of clams monitored in 1992 illustrates clearly where the biomass and abundance were high and low respectively within the sampling grid (Figure A6.12). The stock has been fished from 1992 until 2004 by use of hydraulic suction dredges with no fishing in the years 1996–1999 due to limited pipe length, which had to be adjusted to fish in deeper waters. The total landings have over the twelve years of fishing been around 20 000 tonnes. Half of the landings were taken by Danish fishermen and the other half by fishermen from other EU-countries.

In 2004, administrative GIS maps were produced for the Limfjorden area to assist in regulating mussel culture (long lines) activities. The aim was to organise geographical data relevant for management of culturing mussels on long line systems (Dolmer and Geitner, 2004; Geitner *et al*., 2006).

Why apply GIS mapping in shellfish and fish biology and management of the stocks? GIS mapping can be applied in many contexts to create visual information and to give a better and more comprehensive overview to stakeholders, authorities and decision makers. An overview that makes it easier for all parties to make decisions regarding exploitation levels for the different commercial fish and shellfish stocks as well as to decide in which areas one has to be more careful and protective in preserving the environment, i.e. to conserve important nature types. Thus GIS was introduced and applied in management of the different commercial Danish bivalve stocks a few years ago. The purpose was to illustrate locations of conflicts between different bivalve fisheries and the need to protect and preserve important environmental areas in Danish marine waters. In addition, once data are in a GIS format, many types of analyses become more feasible, e.g. calculation of area, measuring of distance and many others, which often results in new insights.

At the DIFRES homepage http://www.difres.dk/dk/GIS-lab.asp you can find GIS maps over the exploited Danish bivalve stocks (presently only in Danish).

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Annex 7: National Status Report – Spain

MARINE HABITAT MAPPING IN THE BASQUE COUNTRY (BAY OF BISCAY)

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INTRODUCTION

This contribution presents the progress status of the definition and mapping of the marine habitats present in the Basque coast and continental shelf (NE of Spain, Bay of Biscay), including bathymetry (with the main physiographical characteristics of the bottom), and the identification of the structuring species associated to those habitats. To reach these goals, several objectives were defined: the European Environmental EUNIS habitat classification was used to classify the intertidal, subtidal and circalittoral habitats, within the coast and continental shelf; new habitats were described and proposed in case they were not identified in EUNIS classification and they were representative of the study area; finally, the main environmental factors (such as wave energy, etc.) that contribute to the habitat distribution were analysed.

INFORMATION DATA SETS

Bathymetric information was acquired using a high resolution multibeam SeaBat 7125 system. Its operation frequency is 400 kHz and the equipment produces 256 beams in 130º angle swath and up to 50 swaths per second. Bathymetric data were acquired and processed using specific software PDS2000. Tide correction was applied and 1 m resolution seafloor Digital Terrain Model (DTM) was produced. Finally, the DTM was exported into ESRI grid format.

Underwater seafloor images were taken with digital cameras by divers. Geographic position, depth, date and hour was recorded for each photograph. All this information and the interpretation of the image were integrated into the GIS as point shapefile with hyperlink to each image.

High resolution ortophotographs were used to identify and classify the supralittoral, intertidal and first 5 meters of underwater habitats. Habitat classifications were made using 0.25 m resolution airborne photographs taken in 2002 and 2004 by the Environment and Territory Management Department of the Basque Government. Habitat changes in this period were analysed to study the rate of artificialisation and natural shifts.

The distribution of wave energy along the continental shelf was calculated using hydrodynamic numerical modelling. The wave analysis was done in undefined depth (out from the platform), the most representative cases were simulated and waves were propagated up to the coast. Results were processed in order to get the medium wave flux along the coast per meter of width of the front. After that, the medium flux of the wave energy per meter of width in the first meter from the seafloor was calculated to get the influence on the waves over the seafloor. The grid of energy distribution was exported at 400 m resolution.

Terrestrial DTM of 1 m resolution of the Diputación Foral of Gipuzkoa (2005) was extracted from airborne LIDAR data. Terrestrial DTM and seafloor DTM were integrated into the GIS as ancillary data for intertidal and marsh habitat mapping.

Biologic data was collected from other studies done in the study area. Information concerning species presence, species richness and biomass was used for alter analysis.

DATA INTEGRATION AND PROCESSING

All the information previously described was integrated into a Corporative Marine GIS, called ItsasGIS. This system has been developed since 2005 and it stores a large portion of the marine information generated in the Basque continental shelf and the Bay of Biscay. The information is classified hierarchically into seven categories: biology and fisheries, bathymetry, geology and geomorphology, hydrography, land cartography, meteorology, and uses and management. The bathymetry information generated was integrated into ArcGis environment and ArcGis 3D analyst was used to process the seafloor DTM. Other products were generated to extract the features of seafloor morphology: slope, topographic Position Index and hillshade surfaces were generated with the azimuth and altitude values that could highlight the geomorphologic features of the seabed. The aspect was generated to calculate different degrees of seafloor exposition to wave fetch. Taking into account that the Habitats Directive defines the natural habitats as terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural, for each point with real data samples, abiotic parameters signature was calculated and habitat suitability maps were generated.

CONCLUSIONS

Up to now, all the intertidal and supratidal habitats have been analysed due to the availability of required information during the first two years of the project. About 7 715 ha have been interpreted and 18 habitat types have been identified, where 4 of them are of special interest for the European Community.

The acquisition, processing and interpretation of bathymetric data are more time and effort consuming. Up to now, more than 60% of the coverage between 5 m and 50 m has been already sampled. For underwater habitat mapping, only abiotic parameters have been taken into account to reach up to the 3rd level of EUNIS classification and Annex I interesting habitat distribution mapping.

All the results produced during the project are being published into the web using Open GIS MapServer. The aim of this web map service is to distribute and make accessible environmental information. The possibility to generate maps, to manage information layers, ease to use, and accessibility makes it a very powerful tool. As the habitat mapping approach requires a multidisciplinary analysis and data interpretation, GIS tools are essential. The availability of habitat maps is becoming an essential tool for coastal management and decision makers. In this sense, high quality bathymetric DTM is necessary to characterise and describe the morphology of the seafloor in order to improve the management of different uses of the coast, specially in those areas where human activities are specially intensive.

KEYWORDS

Marine Habitat Mapping, GIS, Habitat Directive, EUNIS, Natura 2000

Annex 8: National Status Report - UK

Mid-Irish Sea reefs

JNCC ran a research contract to survey an area of the Irish Sea identified as potentially containing Annex I reef habitat according to the Habitats Directive. The potential Annex I reef area for this area was roughly delineated using British Geological Survey (BGS) 1:250,000 Seabed Sediment data (Graham *et al*, 2001[1]). Funding for this work was provided by Defra (Department of Environment, Food and Rural Affairs) Natural Environment Group Science Division (Contract No CRO 365).

To investigate and characterise the habitats and biotopes of an area of potential reef in the mid Irish Sea, new acoustic survey and biological survey was undertaken. The extent and distribution of the habitats and communities were mapped, and assessment was made as to whether any of the habitats found fit the interpretation of Annex I reef according to the Habitats Directive.

Survey cruises were undertaken in November 2006 and January 2007 onboard the University Marine Biological Station, Millport (UMBSM) Research Vessel Aora. The survey area was split into three sections covering the northern, central and southern patches of potential reef identified by BGS.

In spite of bad winter weather and technical issues with camera equipment, the survey successfully collected acoustic data from target areas within the central Irish Sea and sufficient ground-truthing data to enable the classification and mapping of seabed habitats for the northern part of the survey area. Further acoustic data will be required to map the central survey area, and further ground-truthing data will be required to map both the southern and central areas.

The surveyed depth ranged from approximately 60 to 155 m. The shallowest depths were located on the western side of the southern survey area deepening gradually to the east and north. The deepest area was found in the south-eastern corner of the northern survey area where a trough, approximately 2 km wide, deepened from a surrounding seabed of 90 m to approximately 155 m in its centre. There was a trend across the whole survey area of increasing depth from west to east, towards the deepest part of the Saint George's Channel.

SEA 7 (Strategic Environmental Assessment)

The JNCC participated in the SEA 7 cruise off the north-west coast of Scotland in the offshore zone (outside 12nm). A multibeam survey was completed for specific areas previously identified as potential Annex I reef. This multibeam dataset was then ground-truthed using drop-down video/stills. The biological data is currently being analysed in order to develop habitat maps of the survey areas.

HABMAP

Fisheries Research Services, Aberdeen are undertaking a two year HABMAP project. This work builds directly on the fieldwork undertaken and results obtained during the EC funded MAFCONS project. Samples and information gathered during MAFCONS will provide benthic and fish community data from sites surveyed acoustically thus allowing investigations into the link between habitat heterogeneity and species diversity. Identification of structural

1 Graham C, Campbell E, Cavill J, Gillespie E & Williams R (2001) JNCC Marine Habitats Version 3: its structure and content. British Geological Survey Commissioned Report, CR/01/238, 45 pp.

features that provide essential habitat for a variety of vertebrate and invertebrate species is essential to furthering the ecosystem approach to fisheries management.

HABMAP started in April 2006 and all data gathering was completed by March 2007. Over this time, three cruises were completed (one in the North Sea in August 2006 and two off the Scottish west coast in November 2006 and March 2007 respectively). During each cruise, acoustic data were logged from a series of intensively surveyed 3NM by 3NM boxes which were drawn up around the immediate area surrounding and including the track of a trawl haul undertaken for the International Bottom Trawl Survey (IBTS). Further to this, data were also gathered from the survey vessel's cruise track when approaching and leaving each trawl position. These data will determine how representative the habitat type and variability observed in the small boxes and the vessel track are of the larger ICES rectangles in which they are contained and will also allow assessment of the extent to which the single trawl samples in particular ICES rectangles provide representative samples of the fish assemblage occupying each rectangle.

Although no formal habitat maps have yet been produced, acoustic data, ground truthing and infaunal grab samples have been collected from 20 ICES rectangles in the North Sea and from 12 ICES rectangles on the west coast of Scotland.

During the final year of HABMAP, it is planned to complete all cleaning and database preparation for the data collected from the intensive survey boxes and from the IBTS tracks during the three cruises completed in 2006 and 2007. Also to report the results of all analyses undertaken and to interpret habitat types and habitat distributions in relation to the biological data collected in MAFCONS.

Northern Ireland

Agri- Food Biosciences Agency (AFBI) mapping activity is undertaken under an umbrella project: "The Sensitivity of Benthic Habitats in NW Irish and Malin Shelf" which includes AFBI contribution to MESH.

In 2007 the major activities were:

Mapping burrow *Nephrops* burrow density in the NW Irish Sea "mud patch" is undertaken as part of ongoing fisheries stock assessment. The specific aim of this project was to examine environmental variables which may be important in determining burrow density throughout the Western Irish Sea, with a view to building a predictive habitat suitability model for this species. The Irish Sea has been surveyed and studied extensively and therefore a number of datasets are available relating to a range of abiotic factors. The linear regression modeling approach has shown that of the abiotic factors investigated the following have some impact upon burrow densities in the Western Irish Sea:

- u component (east-west) minimum current speed: higher current speeds = lower densities
- sediment sorting: more poorly sorted = higher densities
- silt/clay sediment fraction: higher silt/clay fraction = higher densities
- sediment median phi: higher median phi (finer sediment) = higher densities
- stratification probability density function in Spring: higher stratification probability = higher densities

Alternative modelling approaches are being investigated, such as the use of non-linear regression modelling, neural networks and genetic algorithms, to see if these can yield better results with the same input datasets and variables.

In addition, the potential energy anomaly (Φ), which is generally used as a measurement of stratification as it represents the amount of energy needed to mix the water column, is being calculated from actual (rather than modelled) data to see how well it supports the modelled stratification data.

By-catch data and infaunal data from grab samples are being used to derive general biological community distributions across the Western Irish Sea which may also have notable differences in their *Nephrops* burrow densities. Finally, at two finer-scale sites within the Western Irish Sea multibeam echosounder data will be examined to see if backscatter data may be related to burrow densities.

Maerl beds off the north-east coast of Northern Ireland which currently support a scallop fishery are liable to form part of a future Special Area of Conservation. A number of swathe surveys have been completed in 2006: multibeam sonar (Reson SeaBat 8101) at Garron Point South (June 2006), and GeoSwath Plus bathymetric sonar over the Red Bay and Ballygally sites (September 2006). These provided additional high resolution bathymetric and backscatter data at 2m resolution, building upon existing multibeam sonar data at 5m resolution to cover the main beds off the East Antrim coastline. Diving surveys carried out in October 2006 will be used to form a detailed study of the bathymetric limits of maerl in this area, based upon existing and new ground-truthing data, and also an interpretation of backscatter data with respect to maerl cover and available sediment data. The morphology of maerl thalli collected during the 2006 grab samples and diver-operated cores is also being studied with respect to indicating the prevailing hydrodynamic regime, in order to help build a habitat suitability model for maerl on this coastline.

Areas of potential rocky reef lying between Northern Ireland and Scotland were surveyed in June 2006 using MBES with biological ground truth studies undertaken in February 2007. The multi-beam data was used to test the development of tools for allocating ground truth samples based acoustic variation. Biological samples are currently been processed.

Under MESH Action 3 "testing protocols and standards " an joint cruise between AFBI, BGS, JNCC and MI targeted specific habitats for testing both ground truth strategies and assessing technologies for analysing acoustic data analysis. Primary focus was on the Stanton Banks an area of rocky reef off the North West of Scotland. Tools applied included drop camera, ROV, box corer and grab. Data gathered is been used to assess the effectiveness of a range of multi-beam backscatter analysis techniques.

Cefas – Eastern English Channel habitat map (MEPF 04/01)

Cefas, in conjunction with BGS, JNCC and MES Ltd have undertaken a 3 yr project funded by the Aggregate Levy Sustainability Fund (www.alsf-mepf.org.uk) to produce habitat maps of the Eastern English Channel. This part of the English Channel will soon be subject to impacts from aggregate extraction. The aggregate industry has conducted a large volume of work in the vicinity of the extraction sites but the potential influence of the activity over the wider region is not well understood. Consequently this study has conducted geophysical, biological and photographic survey work at a regional scale in order that the potential impacts of aggregate extraction on seabed habitats can be put into a wider context. This work will be reported in May 2007 and will be available via the ALSF website.

Cefas – Mapping of Annex 1 (primarily *Sabellaria spinulosa* reefs) habitats (MA008)

This was a project that pulled together experts from Cefas, JNCC and Envision Mapping Ltd. The primary purpose of the project was to provide guidance on the most appropriate ways to detect, map and evaluate biogenic and cobbley reefs. This included not only remote sensing techniques but also methods for observation and sampling the habitats to assess the degree to

which Annex I reef habitats characteristics are expressed (in particular *Sabellaria spinulosa* reefs).

Although there are many reports of the detection of hitherto unreported *Sabellaria* reefs through the inspection of side scan images (and possibly multibeam images) and the identification of unusual textures thought to be caused by the reefs, the discovery of reefs in this way has been largely serendipitous and no previous study has adopted a structured and methodical approach to testing the success of side scan for this purpose.

Of the ground truthing techniques, those based on video and stills camera are considered most suitable for seeing reef structures, but grab samples may also needed to confirm the presence of characterising reef species, such as *Sabellaria*, and sampling small tube structures that might escape detection by the former method.

The survey work attempted to trial the above techniques in a structured way to test their ability for detection and assessment. The sites used for testing was an aggregate extraction site 107 and Saturn reef off the Lincolnshire coast and another aggregate extraction site near Hastings all of which were reported to have (or have had) well developed *Sabellaria* reef.

Offshore SAC mapping (ME1102)

This work is being conducted for the JNCC in the central part of the English Channel outside the 12mile limit. Under the EU habitats directive, JNCC have an obligation to identify and submit proposed sites for SAC status. In order to do this, they need to have reliable information on the habitats present in the proposed areas. To this end, Cefas have been conducting survey work in the central Channel during 2006 using sidescan sonar, multibeam bathymetry, underwater video and stills, grabs and trawls (Figure A8.1). This work will provide the necessary information to allow JNCC to carry out their responsibilities. The final report will be produced prior to SAC designation in 2008.

Inshore SAC mapping

Cefas, in conjunction with BGS and UKHO, will be conducting survey work in the western English Channel during 2007 in support of Natural England's responsibilities to recommend SACs within the U.K.12 mile limit. This work will be concentrated on the Lizard and Lands End/Cape Bank areas (Figure A8.2) and will particularly focus on rocky reef habitats. We will be using a suite of survey tools which will include sidescan sonar, multibeam bathymetry, grabs, trawls and underwater photography. Additional surveys will be carried out by other contractors in 5 other regions around the U.K. coast in 2007.

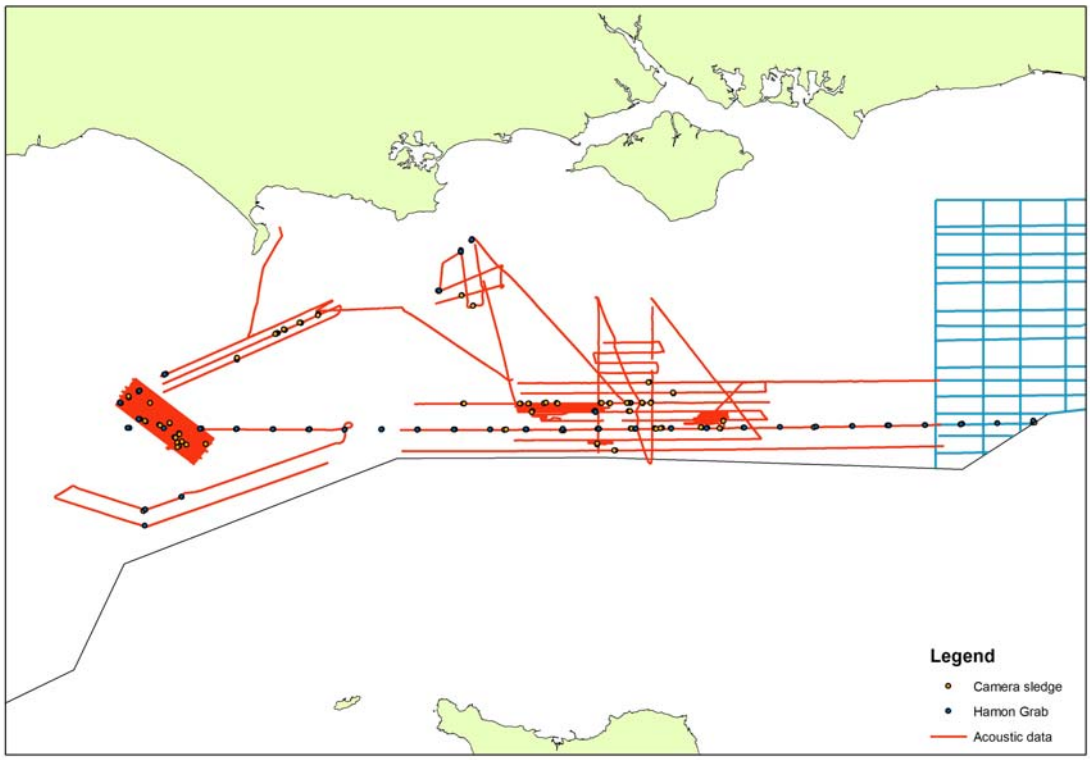


Figure A8.1. Red lines and black dots show the scope of work presently conducted under this project.

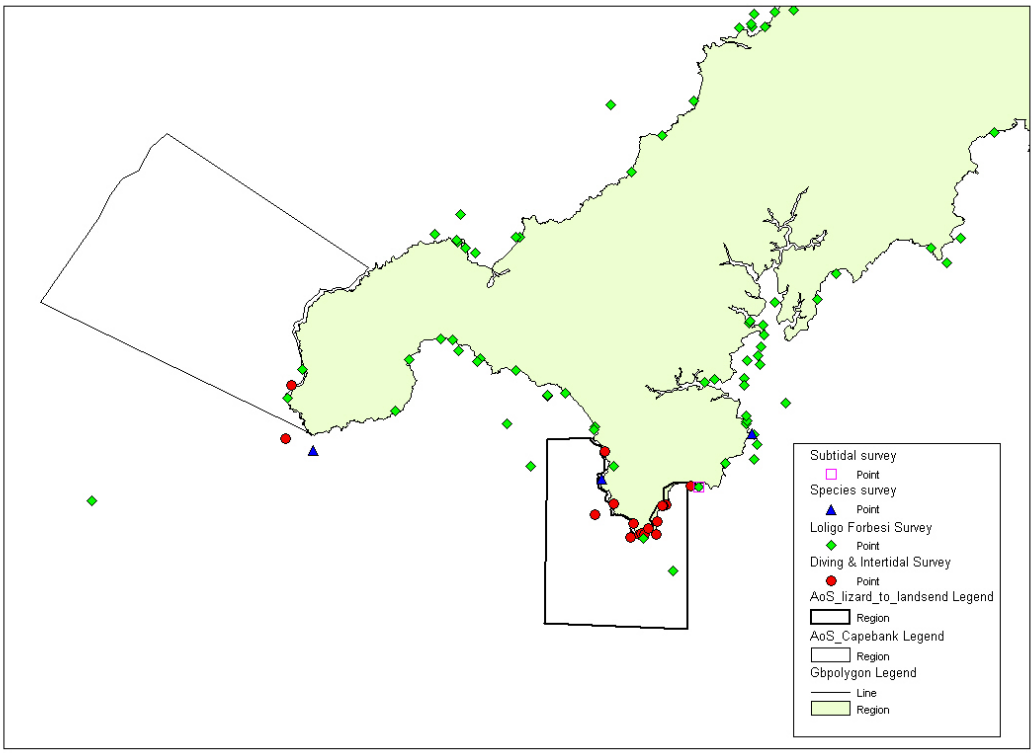


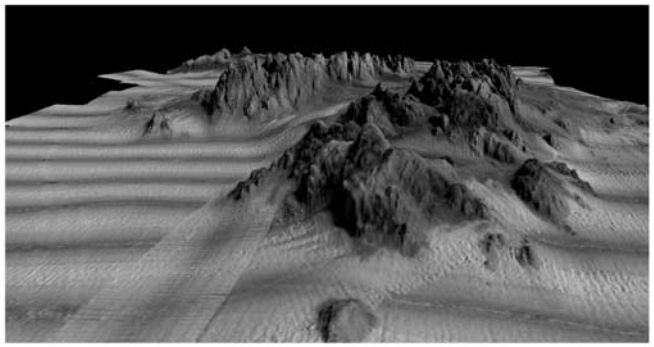
Figure A8.2. The two polygons show the intended areas of work for 2007. Coloured dots show some of the data already available for these areas.

Annex 9: Report of the multibeam backscatter workshop in March 2006

WORKSHOP SUMMARY REPORT

Seabed habitat mapping: assessing the utility of multibeam backscatter data for habitat discrimination

Acoustic backscatter processing and interpretation workshop
30 and 31 March 2006



Prepared by: Dr. Craig Brown: Centre for Coastal and Marine Research, School of Environmental Sciences, University of Ulster, Cromore Road, Coleraine, Co. Londonderry, BT52 1SA

MESH Backscatter Workshop – Ulster University, Coleraine 30th & 31st March, 2005

MEETING NOTES			
Name	MESH survey consortium Tele-conference	**Meeting Date**	30 – 31 March/2006
Meeting Location	Respective offices	**Meeting Time**	
Meeting Called by	All	**Meeting Duration**	
Meeting Notes Prepared by	Jonathan White and Craig Brown	**Meeting Notes – Date**	30-31/3/2006
Purpose of Meeting	Review survey data, analysis and survey plans for 2006		

Programme & Attendees	Summary
Workshop Programme: Backscatter workshop programme Attendees list: Attendance list.xls	This workshop aimed to assess the understanding among geo-physicists, geologists and biologists of the information content of multibeam echo sounder backscatter and it's use in delineating areas of the seafloor based upon the acoustic signal and inferred geological and biological facies and habitats. Discussions provided evidence of successful and uncertain classifications and while several different automated classification approaches were presented, the key to useful classification still appears to rely on ground truthing, empirical knowledge of the area being survey and user intervention in classifying areas.

Meeting Agenda

Item No	Item	Duration Minutes
1.	Introductions	
2.	**Jon Davies, JNCC, UK – "Introduction to MESH"** Jon Davies provided an overview of the aims and achievements of MESH to date. Details were provided regarding the MESH website and mapping website. The Map-Server (open source web GIS) is delivered through CMS. Data can be pulled straight into a desktop GIS. Maps will be available to all, at no cost. The (MESH) definition for "***habitat***" was stated as: The physical and biological environment that support a particular biological community. This is described as the physical and biological characteristics of an area Further information regarding MESH is contained in the attached ppt presentation: "Davies ppt.pdf".	"Davies ppt.pdf"
3.	**Craig Brown, University of Ulster, UK – "Setting the scene"** An overview of seabed mapping techniques and the problems associated with mapping sublittoral benthic habitats was given by Craig Brown (see attached ppt presentation "Brown ppt.pdf"). The presentation focused on how habitats are mapped and flagged up the main problems associated with linking in-situ ground-truthing to broad-scale acoustic data sets, in particular backscatter data from sidescan sonar and MBES. Case studies were presented of surveys in Loch Linnhe, Scotland, which have explored the relationship between sidescan sonar backscatter and seabed geological and biological characteristics, and of MBES surveys in the Minch, Scotland which have looked at mapping biogenic reefs. Finally, a number of questions were presented to the participants for consideration during the workshop:	Brown ppt v2.pdf

	• Advances in backscatter – where's the technology heading? • Interpretation of backscatter – what are we measuring? Can MBES backscatter be used as the primary guide for habitat delineation or surficial geology/sediment delineation? • Habitat delineation – automated routines…can these help us? Objective classification is clearly desirable • Can we further improve backscatter imagery? • How do we bridge the gap between in-situ data and remote sensed data?	
4.	***Backscatter Data Collection*** ***Tim Le Bas, NOC, UK*** - Chair Keynote: **Bill Danforth, USGS, Woodshole, MA, USA - "MBES Data Acquisition Issues, Methods and Strategies"** Bill Danforth provided an overview of issues relating, primarily, to MBES data collection, although examples of sidescan sonar and interferometric sonar backscatter data were also included. Topics covered included transmit properties of systems and beam footprints, system compensations for power, gains, spherical spreading and attenuation. A range of different and commonly seen MBES acquisition problems and artefacts were presented. Issues relating to how these affect backscatter were covered and case studies illustrated how the backscatter imagery can be affected depending on acquisition parameters and post processing methods/techniques. Interpretation of backscatter imagery can be significantly influenced by the way the data is acquired and processed. Keynote: **Véronique Lutes-Jégat, Marine Institute, Ireland – "The Irish National Seabed Survey"** Véronique Lutes-Jégat provided an overview of the Irish National Seabed Survey (INSS). Information was provided on the survey strategy for this seabed-mapping programme. Details on data acquisition strategies and protocols were provided. MBES surveys on the Celtic Voyager and Celtic Explorer have used a Simrad EM1002 system. Bathymetry and backscatter are recorded. Examples from surveys where acquisition issues have resulted in different backscatter signatures were presented. The strategy adopted for processing MBES backscatter as part of the INSS was also covered in detail (see "Lutes-Jégat ppt.pdf").	 "Danforth ppt.pdf"  "Lutes-Jégat ppt.pdf"
5.	**Backscatter Data Collection – Discussion:** Following the keynote presentation a discussion session was chaired by Tim La Bas on issues relating to MBES backscatter data collection. The discussion covered topics including QA/QC of backscatter data, acquisition problems and data storage. The following are the main points, and recommendation arising from this session: • When combining data sets from two different surveys, a ± 2 to 5 dB difference in BS between surveys would constitute a good join between surveys • When collecting MBES backscatter (and sidescan sonar data) it is important to record the raw data values, which enables reprocessing from source. Recorded values depend upon the systems and the approach of visualisation used. Similarly, good metadata records facilitate post-processing (and re-processing of data). • When collecting MBES backscatter (and sidescan sonar data) it is important to try to maintain acquisition parameters throughout any one survey. If settings are changed during a survey it is very important to ENSURE they are recorded. • Recommendation – record all settings; ensure that any changes are known of, avoid blackbox processes that change acquisition settings.	

	• Different IHO standards were discussed: For habitat mapping do we need 100% coverage? This was discussed at length. The conclusions were that it really depends on the purpose of the survey. Special order standard is required for high accuracy bathymetry. This may not provide optimal backscatter data. If habitat mapping is the primary focus of the survey (when accurate bathymetry may not be so important) then line spacing can be increased to cover more ground. If backscatter is the primary out put of the survey, the power needs to be kept low, to ensure non-linearity is not introduced. However, this will result in a need to keep the survey lines closer together, and hence increase the survey time. Costs can be kept down if a compromise between hydrographic survey and backscatter quality can be reached, rather than conducting two separate surveys for two different purposes. • Water depth is a critical factor when deciding on what system to use. In near shore regions MBES are slow and costly owing to smaller swath widths (10 – 15m water) while Interferometrics give a wider swath and therefore greater survey area to time and cost ratio. • Data formats: Most formats are readable and readers can be written / acquired. XTF format - not a good format for recording data. Manufacturers are getting better at getting all data recorded with acquisition files. (XTF is an export function, used quite commonly). SEGY – corrupted data format from the 1975's, and many different types/ variations of SEGY now exist as the standard has "evolved".	
6.	**Backscatter processing and automated classification** ***Colin Brown, NUI Galway*** - Chair Keynote: **Tim Le Bas, NOC, UK - "Comparison of MBES BS & SSS for environmental mapping"** Tim Le Bas presented a comparison of backscatter processing between MBES backscatter data and sidescan sonar backscatter processing. The presentation introduced and covered the physics of sonar, acquisition characteristics, processing of sonar data and concluded with a number of examples showing how post processing techniques can significantly improve the resolution of backscatter data which greatly increases the ability to delineate seabed features (and potentially habitats). See the attached "Le Bas ppt.pdf" for more details. Keynote: **Jon Preston – Quester Tangent Corporation, Canada – "Principles and practice of Automated Classification"** Jon Preston provided a Tutorial book covering this topic. The presentation provided an overview of the science of automated seabed classification, and ways that acoustic segmentation (i.e. delineation of the seafloor into areas with similar acoustic characteristics) can be achieved. **Definition of Acoustic Seabed Classification:** The organisation of the seabed into discrete units based on characteristics of its acoustic response. An overview was provided on how Quester Tangent's Multiview software classifies MBES backscatter data. Keynote: **Luciano Fonseca, CCOM/JHC, University of New Hampshire, USA – "Remote Estimation of Surficial Sediment acoustic Properties through the application of AVO Analysis to Multibeam Sonar Data"** Luciano Fonseca presented a method which uses AVO analysis (Amplitude Versus Offset) for the classification of backscatter data (see "Fonseca ppt.pdf"). AVO analysis of multibeam data is a promising technique for acoustic seafloor characterization - (Inverse Problem). Better observations, i. e., radiometrically and geometrically corrected backscatter is a very important step towards remote acoustic seafloor characterization. The definition of better high frequency acoustic backscatter models is essential for understanding the acoustic signature of seafloor sediments.	Le Bas ppt v2.pdf "Fonseca ppt.pdf"

7.	**Backscatter processing and automated classification – Discussion:** Following the keynote presentation a discussion session was chaired by Colin Brown on issues relating to MBES backscatter processing and automated classification. The discussion covered topics including data cleaning, image enhancement and automated classification routines. The following are the main points, and recommendation arising from this session: • Backscatter mosaics – flattening the angular response can both introduce and remove seafloor characteristics. • To perform classification on SSS data you really need bathymetry to drape it over. To correct / extract an angular response the grazing angle must be known to get the true BS value out and not just the response from the slope of the seafloor. • Full access to the data is really necessary (Bathymetry and backscatter), to classify/ demark areas, not just a backscatter mosaic. • It was suggested by several workshop participants that extraction of quantitative values from the MBES backscatter (e.g. backscatter intensity or measures of patterns in the backscatter) may provide a means of assisting in delineation of habitats and seabed features • Understanding what the backscatter can tell us about the seabed environment is a crucial stage in the production if geological and habitat maps. Differences in MBES backscatter signatures over an area of seabed are likely due to a complex interaction of geological and biological characteristic. Backscatter relates to grain size, roughness and volume (subsurface qualities), as well as the biological components of the seafloor. • It is important to realize that benthic habitats are 3 dimensional. Incorporation of other water column parameters (e.g. currents, temperature etc.), when used alongside acoustic measurements of the seafloor, will likely provide a more robust way of delineating benthic habitats.	
	Day 2 Friday March 31st	
8.	**Automated classification – common data set analysis** ***Craig Brown, University of Ulster*** - Chair As part of the MESH project, MBES surveys have been conducted by the MESH North Western Shelf Consortium (Marine Institute, DARD/QUB, BGS, University of Ulster). One of these data sets, Stanton Banks 4, was selected for use for a common data set exercise. Research teams were invited to process the backscatter data from this area using their own classification/processing protocols. The results from this exercise were presented by each of the research groups/teams who participated in the exercise. A brief summary of the approaches each team adopted, along with a copy of their classification (as pdf files) is presented below: **Tim Le Bas – NOC, UK.** • Results from a basic analysis and classification using PRISM – The Processing of Remotely-sensed Imagery for Seafloor Mapping – were presented. This approach creates join lines through overlap between two adjoining swaths. Four acoustic classes were identified using unsupervised classification. A basic classification achieved which still shows many facets of the survey. For details see "Le Bas ppt" above. **Ivor Marsh - NUI-Galway, Ireland** • Results from unsupervised classification of the multibeam backscatter mosaics using artificial networks were presented. A Kohonen competitive neural network was used to classify the data. Results were compared with IsoData classifications. Intensity and texture features of the backscatter were used in the	 "Common data set introduction.pdf"  "Marsh ppt.pdf"

classification. For details see "Marsh ppt.pdf".

Olga Gómez Sichi – University of Bath, UK.

- Results from a classification carried out using an approach developed at Bath University (TexAn – textural Analysis) were presented by Olga Gómez Sichi (working with Philippe Blondel, Bath University). Texan is usually used for the classification of sidescan sonar data, and this was the first time it has been used to classify MBES backscatter data. Texan uses Grey level Co-occurrence Matrices to classify the data, and details of the classification approach are provided in the "Gómez Sichi ppt.pdf". The preliminary results from the classification were presented and a large number of acoustic classes were identified (~40 classes). It should be noted that many of these classes would likely be grouped together upon further investigation of the data, and early results indicate that Texan is bringing out the main features and boundaries within the data set. The classification would likely be improved through a supervised approach once ground-truthing data is available.

"Gómez Sichi ppt.pdf"

Ben Radford - Uni. Western Australia (presented by Jonathan White, Marine Institute)
Paul Kennedy - FUGRO – Australia (presented by Jonathan White, Marine Institute)

- Two presentations were given by Jonathan White covering work underway in Australia. See the attached files ("Radford ppt.pdf" and "Kennedy ppt.pdf") for details.

"Radford ppt.pdf"

"Kennedy ppt.pdf"

Luciano Fonseca - CCOM/JHC, University of New Hampshire, USA

- Luciano Fonseca presented the results of the classification of the common data set using the AVO analysis approach described during his keynote presentation. The importance of removing acquisition features from the data prior to classification was stressed, and "cleaned mosaics" were resented. The AVO approach was applied and Inverted Properties – Impedance, Roughness (cm) and Grain size – were mapped using this approach. These are presented in "Fonseca ppt.pdf" above.

Jon Preston – Quester Tangent Corporation, Canada.

- Results from classifying the backscatter from the common data set using QTC Multiview were presented. This approach segments the data based on acoustic characteristics (mean, standard deviation and higher-order moments, histogram and quantile, power spectra, grey-level co-occurrence matrices and fractal dimension). Results revealed an optimum of 12 acoustic classes (see "Preston ppt.pdf").

"Preston ppt.pdf"

DISCUSSION:

Craig Brown, University of Ulster - Chair.

- The exercise revealed some very interesting results.
- The common data set will be ground-truthed as part of the MESH work in June 2006.
- It was proposed that the segmented acoustic classes from each classification approach described above be used to design forthcoming ground truthing sampling (MESH cruise - *RV Cryosets* 13 – 23 June 2006).
- A range of ground-truthing techniques will be available during this cruise (ROV and drop camera, video trawls, Box corers, Hammon grabs etc). In addition, "blind" random sites will be taken to establish – and indeed TEST how the classifications fit.
- Ground truthing data should be made available to the 6 groups to see how this changes the classifications.
- There was wide agreement amongst the workshop participants that publication of the exercise through a spatial issue of a journal would be very beneficial. Craig Brown/Philippe Blondel will look into this in the coming months. Various

	journals were discussed but a decision will be made in due course and those involved will be approached. The structure of the special issue would be an opening paper introducing the common data set and providing a synopsis of the workshop, followed by individual papers on each of the classification approaches, concluding with a paper including the ground-validation data.	
9.	**Data interpretation and map production** ***Craig Brown, University of Ulster*** - Chair Keynote: **Jane Denny, USGS, Woodshole, MA, USA – "Strategies for production of seabed geological and habitat maps in the USA".** Jane Denny provided an overview of the Habitat Geoscience & Geologic Framework used by the USGS in their Coastal & Marine Geology Program. The approach is designed to classify and address geology, biology and oceanographic attributes and Natural and anthropogenic processes affecting habitat. Sub surface geology is also considered and has proved to be important in classifying habitat owing to ability to define glacial muds breaking though younger depositional silts. A number of different mapping strategies were described along with case studies. Different strategies incorporating suites of equipment depending on the environmental parameters (e.g. water depth) were covered. Further details can be found in "Denny ppt.pdf". Keynote: **Roger Coggan, CEFAS, UK - "Data Interpretation and Map Production."** Roger Coggan presented finding from a number of seabed mapping studies undertaken by CEFAS, primarily using sidescan sonar. Case studies from the English Channel were presented which have used a range of techniques to map seabed sediments and habitats. Facies delineated by acoustic surveys were found to be an accurate representation of the study site. Directed ground-truthing sampling adequately described biological & physical characteristics of the area and the acoustic facies were found to be ecologically significant units. Further details can be found in "Coggan ppt.pdf".	 Denny ppt v2.pdf  "Coggan ppt.pdf"
10.	**Data Interpretation Group Exercise – and discussion on data interpretation.** ***Craig Brown, University of Ulster*** - Chair A short exercise was run to compare how an identical data set can be classified using geophysical, geological and biological attributes (see "Group exercise ppt.pdf"). A subset of a data set was provided by the Geological Survey of Canada consisting of seabed photographs (with accompanying information) from 15 ground-truthing stations on Browns Bank. The workshop participants were divided into 3 specialist sub-groups - geophysicists, geologists and biologists – and each sub-group was asked to group the ground-truthing stations based on (assumed) geophysical characteristics, geological characteristics or habitat (biological) characteristics respectively. The consensus between the groups was that this exercise was quite difficult and highlights the importance of a robust classification approach. There was disagreement between the three sub-groups as to how the samples would be classified based on their acoustic, geological and biological characteristics: • The Geophysicists proposed that the stations would be divided into four classes based on their acoustic characteristics. • The Geologists also suggested that the sites could be broken into four characteristics based on their geological characteristics, however, the 15 stations were not divided into the same four classes as those derived by the geophysicists. • The Biologist identified 7 broad classes based on biological/habitat characteristics evident in the seabed photos. This exercise highlighted the many problems when trying to link geophysical, geological and biological data sets to make seabed surficial geology and habitat maps. This issue arose many times during the discussion, and illustrates that there are no clear recommendations as to how habitat maps should be produced at this moment in time. There was wide agreement that a multi-	 "Group exercise ppt.pdf"

	technique approach often assists in the production of seabed habitat maps. Further research is required to establish the most robust approach to mapping habitats. Discussions provided evidence of successful and uncertain classifications and while several different automated classification approaches were presented, the key to useful classification still appears to rely on ground truthing, empirical knowledge of the area being survey and user intervention in classifying areas.	
11.	**Acknowledgments:** This workshop would not have been possible without the financial support of the MESH project and INI Networking funding. Thanks are due to: the keynote speakers; the research teams who presented the finding of the common data set exercise; Tim Le Bas and Colin Brown for chairing sessions during the workshop; Rory Quinn and Bernie Lafferty for support in running the event; Linda Allen for organizational assistance; Jonathan White for acting as rapporteur during the workshop; Larry Mayer, Philippe Blondel and Rory Quinn for constructive suggestion on the format of the workshop; The Geological Survey of Canada for providing the Brown's Bank ground-truthing data for use in the workshop; Quester Tangent for providing Acoustic Classification tutorial books for the participants; and finally – all the workshop participants for their valuable contributions to the event.	

MESH Backscatter Workshop – University of Ulster.
Thursday & Friday 30th & 31st March, 2006

Name	Organization	email address	Attending	EXPERT GROUPS	
Craig Brown	UU	c.brown2@ulster.ac.uk	1	1	1= Biology
Rory Quinn	UU	RJ.Quinn@ulster.ac.uk	1	3	2 = Geology
Bernie Lafferty	UU	b.lafferty1@ulster.ac.uk	1	3	3 = Geophysics
Matt Service	DARD	Matt.Service@dardni.gov.uk	1	1	
Annika Mitchell	QUB	a.j.mitchell@Queens-Belfast.AC.UK	1	1	
Fernando Tempera	St Andrews University	fnct@st-andrews.ac.uk	1	1	
Tim LaBas	NOC	tlb@noc.soton.ac.uk	1	3	
Veerle Huvenne	NOC	vaih@noc.soton.ac.uk	1	3	
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Ivor Marsh	NUI Galway	imarsh@indigo.ie	1	3	
Klaus Leurer	NUI Galway		1	3	
Kerry Howell	Plymouth University	kerry.howell@plymouth.ac.uk	1	1	
Luciano Fonseca	UNH	luciano@ccom.unh.edu	1	3	
Bill Danforth	USGS	bdanforth@usgs.gov	1	3	or 2
Jane Denny	USGS	jdenny@usgs.gov	1	2	or 3
Jon Preston	Quester Tangent	jpreston@questertangent.com	1	3	
		TOTAL ATTENDING	**44**		

Annex 10: Comments on the draft MESH Recommended Operating Guidelines (ROGs)

MESH AGDS ROG 2.2.4

This ROG is somewhat cursory in comparison to other MESH ROGs. For example, data analysis is handled by reference to other documents, which were not directly available. To be more useful, it is recommended that this ROG be developed to provide more detail and perhaps an example of application and data analysis.

MESH 2.3.3 Trawls and dredges

Introduction: paragraph 4

Duration of trawl and dredge tows may be dictated by the size of habitat patch or polygon size; they can be as short as 5 minutes or as long as 30, although tows longer than 15 minutes run the risk of filling beyond the capacity of nets to maintain high catch efficiency.

Mobilisation

Vessel Requirements

Is there enough cable for the water depth to be worked, allowing for sufficient wire scope (e.g. 2X depth or 3X depth) for towing at those depths.

Is the cable diameter suitable for towing the trawl or dredge; too light a cable may break, too heavy a cable can weigh down the front of the device, causing it to dig into the bottom or fish badly.

Operational Guidelines

Processing the Sample

For species that cannot be identified with certainty onboard, photographs of fresh specimens can be helpful for later identification. For this purpose, prepare a waterproof paper label with cruise, station and tentative identity on it and take a digital photomacrograph (with the "macro" lens or setting on the camera) of one or more representative individuals with a ruler for scale in the photo. Do this prior to preservation. Record the label information on a photographic logsheet that also contains the sequential photo number. This provides a natural colour photo of the specimen to aid in laboratory identification with links back to the identity recorded on the catch log and the preserved specimen(s). Photos thus obtained can also be assembled into an onboard pictorial identification guide for subsequent cruises. For organisms that are severely contracted, they can be relaxed and photographed in seawater if desired. Then preserve them with the label.

Processing the Sample and Subsampling Procedure

If adequate motion compensated balances are available, gross sample and subsample weights can be substituted for volumes in estimating total sample bulk and for making subsample calculations with greater precision. Balances must be tared with empty containers before determining bulk weights for this purpose.

MESH 2.5 Underwater video and imaging techniques

Reference to the SACFOR scale, as guidance for analysis of data does not detail how the scale is to be applied. It is recommended that more guidance on data analysis be provided. Guidance and metrics may be provided for the amount of video to be analyzed (per habitat type) in terms of e.g. new species observed per distance covered or other indicators.

2.5.3. Test and verification protocols:

Calibrating' the field of view of the camera, paragraph 1:

To assist with interpretation and analysis it is important that the scale of the image can be determined. For habitat mapping, this does not have to be precise for purposes of object measurement, as there is rarely a need to take exact measurements of objects, but the calibration should allow the observer to appreciate the true scale of the objects viewed in the image. However, precise measurement of the size of the field of view itself is essential if images are to be utilized to determine the density of objects on the bottom. Calibration' for either purpose can be achieved in several ways.

MESH Satellite Imagery ROG 2.6.3

The technologies covered are explicitly for subsurface hard-substrate in-shore habitats. As habitat mapping takes on the broader meaning to include pelagic habitats, as well as benthic, many more types of satellite imagery become relevant. In fact, pelagic properties such as chlorophyll and temperature contribute significantly to characterizing the benthic habitat particularly in shallow waters. This information is also part of EUNIS and other classification systems. It is recommended that in future iterations of such an ROG, pelagic satellite imagery be considered.

Annex 11: Outline of the MESH confidence assessment procedure

Neil Golding (UK) outlined the MESH confidence assessment process to the group. As part of the MESH project, a methodology for assessing the confidence of marine habitat maps has been developed. MESH has defined confidence as "an assessment of the reliability of a map given its purpose". The methodology was developed through an accuracy and confidence sub-group; they developed a systematic, multi-criteria process, which has advantages over an informed but unstructured assessment in that:

- The steps involved in the assessment are transparent;
- The assessments of many maps can be compared so that, if a choice exists, the better quality map can take precedence, and finally;
- The criteria can be published so that people preparing a habitat map in future can ensure that relevant data are included and they can anticipate the confidence assessment.

The evaluation of a habitat map can be split into three parts, largely reflected by the way the majority of habitat maps have been collated and/or produced through the MESH project. Most of the maps collated within the MESH project were developed by combining remote-sensing data with ground-truthing data, and then interpreting this to produce a habitat map (see figure A11.1).

Figure A11.1: showing the generalised method by which habitat maps collated/produced by the MESH project were produced.

The confidence assessment can be completed either through an MS Excel spreadsheet or through a FlashTM program. The spreadsheet format is useful if there are a large number of maps, or if a meta-database of mapping studies already exists (such as the MESH meta-database). The FlashTM program is more interactive. Its particular application is for people wishing to assess a single map. It also allows a survey planner to 'tweak' the scores to see how different methods will affect the confidence in the final map.

Map details	How good is the remote sensing?					How good is the ground-truthing?						How good is the interpretation?					Summary			
GUI	RemoteTechnique	RemoteCoverage	RemotePositioning	RemoteStdsApplied	RemoteVintage	BGTTechnique	PGTTechnique	GTPositioning	GTDensity	GTStdsApplied	GTVintage	GTInterpretation	RemoteInterpretation	DetailLevel	MapAccuracy	Overall % score	Overall score	GT score	Remote score	Interpretation score
WASH001	2	1	3	2	3	1	1	2	2	1	1	2	2	1	2	58	0.58	0.43	0.73	0.58
NORTH005	3	3	3	2	2	3	2	3	3	2	2	3	3	3	3	91	0.91	0.87	0.87	1.00

Figure A11.2. The spreadsheet format of the MESH confidence assessment showing the fields used to assess confidence in habitat maps.

The fields used to assess confidence in habitat maps can be seen in figure 2. It is important to note that you can alter the weighting of each of these fields. Within the MESH confidence assessments, a standard set of 'MESH weightings' was used across all the maps being assessed. Further details of the MESH confidence assessment can be found on the MESH project website www.searchMESH.net and will be available in the MESH Guide to Habitat Mapping, available by summer 2007.

The confidence assessment scores can be seen on the MESH webGIS (www.searchMESH.net/webGIS). A colour scheme has been developed consisting of a ramp with six grades of increasing intensity: confidence not assessed (green hatch) then pale green for very low confidence, through to dark green for very high confidence. The confidence layer within the webGIS can be queried to view the confidence assessment, ensuring that the assessment is kept as transparent as possible.

The system is a compromise between being comprehensive and being easy to understand and use. The key goal was to produce a simple yet robust assessment. Whilst the exact score for any one field could be debated, the overall score is little affected by tweaking the individual scores for the fields. The system was biased towards the assessment of habitat maps by persons not involved in the production of the map; partly due to the fact that the MESH project collated many historic marine habitat maps. Therefore, the system had to be designed to allow the maps to be assessed as objectively as possible.

It is worth noting that even though a map may not score highly when assessed, it may still prove useful, and may correlate well with other independent datasets. If it matches with local knowledge, and proves useful (despite a low confidence score), it will be the end-user who ultimately determines the reputation of the map.

Annex 12: Survey metadata fields

Attached is the set of metadata fields developed in the MESH project and as modified by WGMHM; the example data entries for each field, together with the detail for each survey technique have been removed, to simplify presentation here. Users wishing to adopt these standards are advised to contact MESH (info@searchMESH.net) or check the MESH website (www.searchMESH.net) for the latest version.

Order	Stage	Level	Field	Purpose	Format	Mandatory
0	**Pre-field**	**1 Programme**	**Programme**	**- Composed of a series of surveys undertaken with a common purpose**		
1	Pre-field	1 Programme	Programme reference	An alpha-numeric reference code.	Text	Mandatory
2	Pre-field	1 Programme	Programme name	Provides the name/title of the programme.	Text	Optional
3	Pre-field	1 Programme	Programme date - start	Indicates the year in which the programme started.	Date (YYYY)	Optional
4	Pre-field	1 Programme	Programme date - end	Indicates the year in which the programme ended (if finished at time of record).	Date (YYYY)	Optional
5	Pre-field	1 Programme	Periodicity of sampling	Indicates if the programme involves one-off studies or repeat (monitoring) studies	Term list	Optional
6	Pre-field	1 Programme	Programme synopsis	Provides a summary of the main purpose of the programme and how it was undertaken.	Text	Optional
7	Pre-field	1 Programme	Language	Defines the language used for entered data	Term list	Mandatory
0	**Pre-field**	**2 Survey**	**Survey (cruise, campaign)**	**- Implemented within a programme or as a one-off. Undertaken by a set of surveyors over a defined (usually continuous) period in a single general location and for a single overall purpose**		
1	Pre-field	2 Survey	Survey reference	An alpha-numeric reference code.	Text	Mandatory
2	Pre-field	2 Survey	Survey name	Provides the name/title of the survey.	Text	Mandatory
	Pre-field	2 Survey	Alternative name			
3	Pre-field	2 Survey	Survey date - start	Indicates the start date for the survey.	Date (DDMMYYYY)	Mandatory
4	Pre-field	2 Survey	Survey date - end	Indicates the end date for the survey.	Date (DDMMYYYY)	Mandatory
5	Pre-field	2 Survey	Time zone	Indicates the time zone in which the survey was undertaken, including whether in daylight saving period.	Term list	Optional
6	Pre-field	2 Survey	Survey run by	Lists the organisation(s) who conducted the survey.	Name (person & organisation) - from dictionary table	Mandatory
7	Pre-field	2 Survey	Survey run for	Lists the organisation(s) who commissioned the survey (and who thus may own the data).	Name (person & organisation) - from dictionary table	Optional
8	Pre-field	2 Survey	Surveyors	Lists the surveyors on the survey (used subsequently as a pick list at Site and Sample levels)	Name (person & organisation) - from dictionary table	Optional

Order	Stage	Level	Field	Purpose	Format	Mandatory
9	Pre-field	2 Survey	Survey boundary (Northern-most Latitude)	Provides a bounding box for the geographical extent of the survey; allows database to check subsequent site and sample positions are within stated box.	Co-ordinate (DD:MM:MMMM)	Mandatory
10	Pre-field	2 Survey	Survey boundary (Southern-most Latitude)		Co-ordinate (DD:MM:MMMM)	Mandatory
11	Pre-field	2 Survey	Survey boundary (Eastern-most Longitude)		Co-ordinate (DD:MM:MMMM)	Mandatory
12	Pre-field	2 Survey	Survey boundary (Western-most Longitude)		Co-ordinate (DD:MM:MMMM)	Mandatory
13	Pre-field	2 Survey	Survey platform - type	Indicates type of platform used for the survey.	Term list	Optional
14	Pre-field	2 Survey	Survey platform - name	Indicates name of survey platform.	Text	Optional
15	Pre-field	2 Survey	Survey platform - date of last vessel survey	Indicates date survey vessel was last inspected for ???????????	Date (DDMMYYYY)	Optional
16	Pre-field	2 Survey	Survey platform - heave compensation type	Indicates the heave compensation type (make, model) of the survey vessel	Text	Optional
17	Pre-field	2 Survey	Positions - coordinate system	Provides to coordinate system used throughout the survey.	Term list	Mandatory
18	Pre-field	2 Survey	Positions - derived from	Indicates what type of instrument (or map) was used to derive site positions.	Term list	Optional
19	Pre-field	2 Survey	Positions - ellipsoid	Indicates the ellipsoid adopted for the survey.	Term list	Optional
20	Pre-field	2 Survey	Positions - spheroid	Indicates the spheroid adopted for the survey.	Term list	Optional
21	Pre-field	2 Survey	Positions - datum	Indicates the datum adopted for the survey.	Term list	Optional
22	Pre-field	2 Survey	Position fixing - Survey (vessel) datum	Indicates the datum point on the vessel used to reference positions to.	Term list	Optional
23	Pre-field	2 Survey	Position fixing - primary navigation	Provides the type of instrument (make, model, signals) used as the primary means of navigation.	Text	Optional
24	Pre-field	2 Survey	Position fixing - primary navigation - dGPS beacon used	Indicates the dGPS beacon used for the primary navigation system.	Term list	Optional
25	Pre-field	2 Survey	Position fixing - accuracy (primary or only navigation)	Provides the level of accuracy of the geopositioning data from the primary navigation system.	Number/term list	Optional
26	Pre-field	2 Survey	Position fixing - secondary navigation	Provides the type of instrument (make, model, signals) used as the secondary means of navigation.	Text	Optional
27	Pre-field	2 Survey	Position fixing - secondary navigation - dGPS beacon used	Indicates the dGPS beacon used for the secondary navigation system.	Term list	Optional
28	Pre-field	2 Survey	Position fixing - accuracy (secondary navigation)	Provides the level of accuracy of the geopositioning data from the secondary navigation system.	Number/term list	Optional

Order	Stage	Level	Field	Purpose	Format	Mandatory
29	Pre-field	2 Survey	Position fixing - Ship track logging software	Indicates which software was used to capture geopositioning data.	Text	Optional
30	Pre-field	2 Survey	Orientation - Gyro	Provides the type of Gyro (make, model) system used.	Text	Optional
31	Pre-field	2 Survey	Orientation - Gyro QA calibration date	Indicates the date the gyro system was last calibrated.	Date (DDMMYYYY)	Optional
32	Pre-field	2 Survey	Orientation - Gyro QA offset deviation from True North	Indicates the amount of deviation from True North in the gyro data.	Number (degrees; 0-360)	Optional
33	Pre-field	2 Survey	Survey purpose	Indicates the main purpose of the survey.	Term list	Optional
34	Pre-field	2 Survey	Survey description (purpose, strategy etc)	Provides a summary of the main purpose of the survey and how it was undertaken.	Text	Optional
35	Pre-field	2 Survey	Survey quality - QA processes used	Indicates the overall level of quality of the survey.	Term list	Optional
36	Pre-field	2 Survey	Techniques used (generic)	Lists the generic types of techniques used during the survey (could be derived from the specific techniques listed).	Derived term list	Mandatory
37	Pre-field	2 Survey	Techniques (gear) used (specific)	Lists the specific types of techniques used during the survey.	Term list	Mandatory
38	Pre-field	2 Survey	Techniques used (instrument details & operating parameters)		**See next section**	Optional
0	**Pre-field**	**2 Survey**	**Survey**	**- continued (define techniques used, system details & operational settings)**		
1	Pre-field	2 Survey	Techniques used (specific)		Term list	Conditional
2	Pre-field	2 Survey	Technique method reference (e.g. SOP, MESH ROG)		Reference list	Optional
3	Pre-field	2 Survey	Technique QA procedure		Term list	Optional
4	Pre-field	2 Survey	Instrument 1 make & model		Text	Conditional
5	Pre-field	2 Survey	Instrument 1 software application & version		Text	Conditional
6	Pre-field	2 Survey	Instrument 1 parameter		Text	Conditional
7	Pre-field	2 Survey	Instrument 1 parameter		Text	Conditional
8	Pre-field	2 Survey	Instrument 1 parameter		Text	Conditional
9	Pre-field	2 Survey	Instrument 1 parameter		Text	Conditional
10	Pre-field	2 Survey	Instrument 1 parameter		Text	Conditional
11	Pre-field	2 Survey	Instrument 2 make & model		Text	Conditional
12	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
13	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
14	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
15	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
16	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
17	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional

Order	Stage	Level	Field	Purpose	Format	Mandatory
18	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
19	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
20	Pre-field	2 Survey	Instrument 2 parameter		Text	Conditional
21	Pre-field	2 Survey	Instrument 3 make & model		Text	Conditional
22	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
23	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
24	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
25	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
26	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
27	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
28	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
29	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
30	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
31	Pre-field	2 Survey	Instrument 3 parameter		Text	Conditional
32	Pre-field	2 Survey	Instrument 4 make & model		Text	Conditional
33	Pre-field	2 Survey	Instrument 4 parameter		Text	Conditional
34	Field	2 Survey	Operating parameter - field of view		Number (degrees; 0-360)	Conditional
35	Field	2 Survey	Operating parameter - average post spacing		Number (m)	Conditional
36	Field	2 Survey	Operating parameter - swathe width (twice range)		Number (m)	Conditional
37	Field	2 Survey	Operating parameter - % overlap between adjacent swaths		Number (%)	Conditional
38	Field	2 Survey	Operating parameter - no. of pulses per second		Number	Conditional
39	Field	2 Survey	Operating parameter - no. of bands		Number	Conditional
40	Field	2 Survey	Operating parameter - film type		Term list	Conditional
41	Field	2 Survey	Operating parameter - instantaneous field of view		?	Conditional
42	Field	2 Survey	Operating parameter - view angle		Number (degrees; 0-360)	Conditional
43	Field	2 Survey	Operating parameter - horizontal beam width		Number (m)	Conditional
44	Field	2 Survey	Operating parameter - across track resolution		Number (m)	Conditional
45	Field	2 Survey	Operating parameter - beam depression angle		Number (degrees; 0-360)	Conditional

Order	Stage	Level	Field	Purpose	Format	Mandatory
46	Field	2 Survey	Operating parameter - operating frequency (or specify dual freq)		Number (KHz)	Conditional
47	Field	2 Survey	Operating parameter - (power) range setting		Number (m)	Conditional
48	Field	2 Survey	Operating parameter - dynamic range of system		Number (m)	Conditional
49	Field	2 Survey	Operating parameter - beam angle port/starboard		Number (degrees; 0-360)	Conditional
50	Field	2 Survey	Operating parameter - samples per sweep		Number	Conditional
51	Field	2 Survey	Operating parameter - backscatter		Term list	Conditional
52	Field	2 Survey	Operating parameter - SSS points per sweep		Number	Conditional
53	Field	2 Survey	Operating parameter - sound velocity correction mode		Text	Conditional
54	Field	2 Survey	Operating parameter - point save frequency		Time (ss)	Conditional
55	Field	2 Survey	Operating parameter - Beam angle		Number (degrees; 0-360)	Conditional
0	**Pre-field**	**3 Area**	**Area**	**- Geographically-defined place/location visited during the survey in which a set of stations are sampled**	**Areas table**	
1	Pre-field	3 Area	Area reference	An alpha-numeric reference code.	Text	Optional
2	Pre-field	3 Area	Area name	A suitable place name for each area surveyed.	Text	Optional
3	Pre-field	3 Area	Region	Indicates which region (e.g. Regional sea/MNCR Sector/ICES rectangle), according to standard schemes, the area falls into (allows for easy searching in metadatabase catalogues).	Term list	Optional
4	Pre-field	3 Area	Area boundary (Northern-most Latitude)	Provides a bounding box for the geographical extent of the Survey area.	Co-ordinate (DD:MM:MMMM)	Optional
5	Pre-field	3 Area	Area boundary (Southern-most Latitude)		Co-ordinate (DD:MM:MMMM)	Optional
6	Pre-field	3 Area	Area boundary (Eastern-most Longitude)		Co-ordinate (DD:MM:MMMM)	Optional
7	Pre-field	3 Area	Area boundary (Western-most Longitude)		Co-ordinate (DD:MM:MMMM)	Optional
8	Pre-field	3 Area	Salinity regime	Indicates the main salinity category of the area (part of broad characterisation of the area).	Term list	Optional

Order	Stage	Level	Field	Purpose	Format	Mandatory
9	Pre-field	3 Area	Temperature regime	Indicates the main temperature regime (biogeographical zone) of the area (part of broad characterisation of the area).	Term list	Optional
10	Pre-field	3 Area	Tidal current regime(s)	Indicates the main tidal current category of the area (part of broad characterisation of the area).	Term list	Optional
11	Pre-field	3 Area	Wave exposure regime(s)	Indicates the main wave exposure category of the area (part of broad characterisation of the area) (coastal areas only).	Term list	Optional
12	Pre-field	3 Area	Depth band(s)	Indicates the main depth band category of the area (part of broad characterisation of the area).	Term list	Optional
13	Pre-field	3 Area	Zone(s)	Indicates the main biological zone categories of the area (part of broad characterisation of the area).	Term list	Optional
14	Pre-field	3 Area	Main substrata	Indicates the main substrata categories of the area (part of broad characterisation of the area).	Term list	Optional
15	Pre-field	3 Area	Marine landscape type(s)	Indicates the main marine landscape categories of the area (part of broad characterisation of the area).	Term list	Optional
16	Pre-field	3 Area	Geology	Indicates the main geological categories of the area (part of broad characterisation of the area).	Text	Optional
17	Pre-field	3 Area	Area description	Provides a summary text description of the Survey area, to encompass its main characteristics.	Text	Optional
0	**Pre-field/Field**	**4 Station**	**Station (site)**	**- Place visited within a survey area at which one or more samples (single or multiple techniques) are taken**		
1	Pre-field/Field	4 Station	Station reference	An alpha-numeric reference code.	Text	Mandatory
2	Pre-field/Field	4 Station	Station name	Provides a place name for the station, if required.	Text	Optional
3	Pre-field/Field	4 Station	Station date - start	Indicates the date the station was surveyed	Date (DDMMYYYY)	Mandatory
4	Pre-field/Field	4 Station	Station date - end	Indicates the date survey at the station was completed (if extended over more than one day).	Date (DDMMYYYY)	Optional
5	Pre-field/Field	4 Station	Planned position - at start	Indicates the planned starting position for the station.	Co-ordinate (DD:MM:MMMM)	Optional
6	Pre-field/Field	4 Station	Planned position - at end	Indicates the planned end position for the station.	Co-ordinate (DD:MM:MMMM)	Optional
7	Pre-field/Field	4 Station	Planned orientation of survey line (from-to)	Indicates the planned orientation of the survey line.	Number (degrees; 0-360)	Optional
8	Field	4 Station	Station description	Provides a text description of the characteristics of the station.	Text	Optional

Order	Stage	Level	Field	Purpose	Format	Mandatory
9	Field	4 Station	Weather - time	Notes the time weather records were taken. Allow for multiple weather reports (e.g. at start of each sample/every two hours)	Time (hhmm)	Conditional
10	Field	4 Station	Weather - cloud cover	Indicates the cloud cover	Percentage or fraction (8ths)	Optional
11	Field	4 Station	Weather - sun glint	Indicates the degree of sun glint (for aerial/satellite techniques).	?	Optional
12	Field	4 Station	Weather - wind direction	Indicates the wind direction.	Term list	Optional
13	Field	4 Station	Weather - wind strength (Beaufort)	Indicates the wind strength.	Number (0-12)	Optional
14	Field	4 Station	Weather - sea state (swell)	Indicates the sea state.	Number (m)	Optional
0	**Field**	**5 Sample**	**Sample**	**- Data collected using a single technique at a specific place or habitat within the site/station**		
1	Field	5 Sample	Sample reference	An alpha-numeric reference number.	Text	Mandatory
2	Field	5 Sample	Technique used	Indicates technique deployed for the sample (links back to list specified at survey level).	Term list	Conditional
3	Field	5 Sample	Technique used - comment			
4	Field	5 Sample	Sample type(s)	Indicates the type of sample(s) derived from the technique	Term list	Mandatory
5	Field	5 Sample	Sample replicates - number taken	Indicates how many replicate samples were taken (default for most techniques is 1)	Number (default=1)	Mandatory
6	Field	5 Sample	Samples aggregated to make replicate	Indicates if samples were aggregated to provide a larger sample volume	Term list	Optional
7	Field	5 Sample	Surveyors	Surveyors who took the sample (subset from list at Survey level).	Name (person or organisation) dictionary	Optional
8	Field	5 Sample	Surveying (instrument) height/depth (above/below sea level)	Indicates the height or depth of the surveying instrument at the time of sampling.	Number (m)	Conditional
9	Field	5 Sample	Surveying speed	Indicates the speed of the survey vessel during the sampling.	Number (knots or km/h)	Conditional
10	Field	5 Sample	Sample time - start	Indicates the time at the start of the sample	Time (hhmmss)	Mandatory
11	Field	5 Sample	Sample time - end	Indicates the time the sample was completed	Time (hhmmss)	Mandatory
12	Field	5 Sample	Position - type	Indicates whether the sample position is a point, line or area.	Term list	Mandatory
13	Field	5 Sample	Position (CRP) - at start	Indicates the position (the the vessel) at the start of sampling	Co-ordinate (DD:MM:MMMM)	Optional
14	Field	5 Sample	Position (CRP) - at end	Indicates the position (of the vessel) when sampling was completed.	Co-ordinate (DD:MM:MMMM)	Optional
15	Field	5 Sample	Position - correction method (e.g. to towfish)	Indicates the method used to correct the vessel position to the sample position,	Term list	Optional

Order	Stage	Level	Field	Purpose	Format	Mandatory
16	Field	5 Sample	Position - dGPS offset from transducer mount (+/- ref to datum point)	Provides the distance the dGPS is offset from the transducer.	Number (m)	Optional
17	Field	5 Sample	Position (corrected) - at start	Provides the corrected position (i.e. the vessel position corrected for layback etc) at the start of the sample.	Co-ordinate (DD:MM:MMMM)	Mandatory
18	Field	5 Sample	Position (corrected) - at end	Provides the corrected position (i.e. the vessel position corrected for layback etc) at the end of the sample.	Co-ordinate (DD:MM:MMMM)	Optional
19	Field	5 Sample	Orientation of survey line (bearing/heading)	Provides the actual orientation of the survey line (cf the planned orientation)	Number (degrees; 0-360)	Optional
20	Field	5 Sample	Sample height/depth - upper (uncorrected)	Provides the upper (highest) point surveyed (not corrected for tide)	Number (m)	Mandatory
21	Field	5 Sample	Sample height/depth - lower (uncorrected)	Provides the lower (deepest) point surveyed (not corrected for tide)	Number (m)	Mandatory
22	Field	5 Sample	Sample height/depth - average (uncorrected)	Allows an average depth of survey to be recorded if required.	Number (m)	Optional
23	Field	5 Sample	Sample length (tow or line length)	Indicates the distance covered by the sample (length of tow or survey line)	Number (m)	Conditional
24	Field	5 Sample	Sample area	Indicates the area of seabed sampled.	Number (m^2)	Mandatory
25	Field	5 Sample	Operating parameter - UBSL/trisponder on device	Indicates if the sampling device (e.g. grab) had a UBSL/trisponder mounted on it.	Term list	Conditional
26	Field	5 Sample	Operating parameter - Camera on device	Indicates if the sampling device (e.g. grab) had a camera mounted on it.	Term list	Conditional
27	Field	5 Sample	Operating parameter - Power/frequency	Indicates the power/frequency used for the sample (for ??? Technique)	Number (KHz)	Conditional
28	Field	5 Sample	Operating parameter - Nominal frequency	Indicates the nominal frequency used for the sample (for ??? Technique)	Number (KHz)	Conditional
29	Field	5 Sample	Operating parameter - No. of digibuoys	Indicates the number of digibuoys used for the sample (for ??? Technique)	Number	Conditional
30	Field	5 Sample	Operating parameter - wire angle	Indicates angle of sampling device???	Number (degrees; 0-90)	Conditional
31	Field	5 Sample	Sediment penetration depth	Indicates the depth to which the sediment sampling device penetrated the sediment	Number (cm)	Conditional
32	Field	5 Sample	Sediment sample volume	Indicates the volume of sediment collected by the sampling device	Number (litre)	Conditional
33	Field	5 Sample	Operating parameter - Sieve mesh size	Indicates the mesh size used to sieve the sediment sample.	Number (mm)	Conditional
34	Field	5 Sample	Operating parameter - Sample fixative	Indicates the fixative used for the biological sample.	Term list	Conditional
35	Field	5 Sample	Sample quality	Indicates the overall quality of the sample.	Term list	Optional

Order	Stage	Level	Field	Purpose	Format	Mandatory
36	Field	5 Sample	Sample description	Provides a text description of the sample, such as details of the habitat characteristics.	Text	Optional
0	**Field**	**6 Replicate**	**Replicates**	**- Repeat sample using same technique & parameters at the same place**		
1	Field	6 Replicate	Replicate reference	An alpha-numeric reference number.	Text	Conditional
0	**Post field**	**7 Processing**	**Processing**			
1	Post field	7 Processing	Data type		Term list	Conditional
2.1	Post field	7 Processing	Processing date		Date (DDMMYYYY)	Mandatory
2.2	Post field	7 Processing	Processed by (person/organisation)		Name (person or organisation) dictionary	Mandatory
3.1	Post field	7 Processing	Position: Data corrected for speed of vessel over ground		Term list	Optional
3.2	Post field	7 Processing	Position: data geo-referenced		Term list	Optional
3.3	Post field	7 Processing	Position: corrections QA'd		Term list	Optional
3.4	Post field	7 Processing	Horizontal accuracy (?derive from Survey level)		Number (m)	Mandatory
3.5	Post field	7 Processing	Horizontal resolution		Number (m)	Optional
4	Post field	7 Processing	Tide		Text	Optional
4.1	Post field	7 Processing	Vertical Datum		Term list	Mandatory
4.2	Post field	7 Processing	Tidal height - nearest port used		Text	Optional
4.3	Post field	7 Processing	Tidal height - time and date of each data point available		Term list	Optional
4.4	Post field	7 Processing	Tidal hieght - time interval for depth correction		Time (mm)	Optional
4.5	Post field	7 Processing	Tidal height - corrected to Chart Datum		Term list	Optional
4.6	Post field	7 Processing	Tidal height - corrections QA'd		Term list	Optional
4.7	Post field	7 Processing	Sample height/depth - upper to lower (corrected to CD)		Number (m)	Mandatory
4.8	Post field	7 Processing	Vertical accuracy		Number (m)	Optional
5	Post field	7 Processing	Method		Text	Conditional
5.1	Post field	7 Processing	Method QA		Term list	Optional
5.2	Post field	7 Processing	Method: Sample pretreatment to remove organic matter or biogenic carbonate, or to break up aggregates formed as a result of sample processing		Text	Conditional
5.3	Post field	7 Processing	Method: software used		Text	Conditional
5.4	Post field	7 Processing	Method: model used to generate value		Text	Conditional
6.1	Post field	7 Processing	Accuracy of land cover map		Number (%)	Conditional

Order	Stage	Level	Field	Purpose	Format	Mandatory
6.2	Post field	7 Processing	Land cover map classification method		Text	Conditional
6.3	Post field	7 Processing	RMSE error		Text	Conditional
6.4	Post field	7 Processing	Wavebands used		Text	Conditional
7.1	Post field	8 Processing	Operating parameter - Georeferencing band widths		?	Conditional
7.2	Post field	7 Processing	Band measurement mode ID's		Text	Conditional
7.3	Post field	7 Processing	Bits per pixel		Number	Conditional
7.4	Post field	7 Processing	Cell value type		Term list	Conditional
7.5	Post field	7 Processing	Interleaving		Text	Conditional
7.6	Post field	7 Processing	Thematic layer identification		Text	Conditional
8.1	Post field	7 Processing	Slant range corrected		Term list	Conditional
8.2	Post field	7 Processing	Gain correction (auto/can true backscatter be removed?)		Term list	Conditional
8.3	Post field	7 Processing	Navigation file name		Text	Conditional
9.1	Post field	7 Processing	Classes		??	Conditional
9.2	Post field	7 Processing	Thresholds		??	Conditional
10.1	Post field	7 Processing	System		Text	Conditional
10.2	Post field	7 Processing	No. of data points marked as dubious/removed		Number	Conditional
10.3	Post field	7 Processing	E1-E2 standardised		Term list, Number (%)	Conditional
10.4	Post field	7 Processing	Grid format		Text	Conditional
10.5	Post field	7 Processing	Grid spacing		Number (m)	Conditional
10.6	Post field	7 Processing	Interpolation algorithm		Text	Conditional
10.7	Post field	7 Processing	Search radius (distance over which interpolation is done)		Number (m)	Conditional
10.8	Post field	7 Processing	Type of search		Term list	Conditional
10.9	Post field	7 Processing	Max points used		Number	Conditional
10.10	Post field	7 Processing	Smoothing factor		Number	Conditional
11	Post field	7 Processing	Data type/classification		Term list	Conditional
12	Post field	7 Processing	Record quality		Term list	Conditional
13	Post field	7 Processing	Biotope - classification used & version		Term list	Conditional
0	**Data management**	**8 Data**	**Storage**			
1	Data management	8 Data	Data type generated (general)		Term list	Mandatory
2	Data management	8 Data	Data type generated (detailed)		Term list	Mandatory

Order	Stage	Level	Field	Purpose	Format	Mandatory
3	Data management	8 Data	Dataset - reference no.		Text	Mandatory
4	Data management	8 Data	Dataset - total size		Number	Optional
5	Data management	8 Data	Dataset - no. of separate track files		Number	Optional
6	Data management	8 Data	Dataset - separate track files amalgamated		Number	Optional
7	Data management	8 Data	Data format		Term list	Mandatory
8	Data management	8 Data	Storage media		Term list	Mandatory
9	Data management	8 Data	Dataset version		Date (DDMMYYYY)	Mandatory
10	Data management	8 Data	Data owner (copyright)		Name ([person or] organisation) dictionary	Mandatory
11	Data management	8 Data	Data held by (archive centre)		Name ([person or] organisation) dictionary	Mandatory
12	Data management	8 Data	Contact person (data manager)		Name (person [or organisation]) dictionary	Optional
13	Data management	8 Data	Data accessibility		Term list	Mandatory
14	Data management	8 Data	Country		Term list	Mandatory
15	Data management	8 Data	Output - Reference(s)		Reference	Optional

Annex 13: Draft Terms of Reference for WGMHM 2008

The **Working Group on Marine Habitat Mapping** [WGMHM] (Chair: D. Connor, UK) will meet in Horta, the Azores, Portugal from 31 March 2008 to 4 April 2008 [TBC] to:

International programmes

6) review progress in international mapping programmes (including MESH, EEA, OSPAR, BALANCE, HERMES, CHARM).

7) review the range of metadata and data portals available for marine habitat mapping, and assess how these systems could be integrated or enhanced to provide more coherent international access to mapping metadata and international maps.

National programmes (National Status Reports)

8) present and review national habitat mapping activity during the preceding year, providing National Status Report updates according to the standard reporting format, an overview map, and focusing on particular issues of relevance to the rest of the meeting.

(presentations strictly limited to a **10 minute** overview per country; posters are encouraged for supplementary information; NSR entries to be circulated BEFORE meeting; outline map of study areas in shape-file GIS format)

Mapping strategies and survey techniques

9) review and assess recent advances with marine mapping techniques for habitat mapping (for example, developments in multibeam backscatter analysis, and in LIDAR).

Protocols and standards for habitat mapping

10) review and critique guidelines for habitat mapping, including the *MESH Guide to Habitat Mapping* and those developed under other relevant initiatives. Identify critical gaps in the guidance available.

11) further develop approaches for the assessment of accuracy and confidence in habitat maps, through the assessment of selected habitat maps and their associated reports/metadata, considering both the final maps and the survey design.

12) review progress in the development of 'discovery' and 'survey/method' metadata standards for marine habitat mapping, illustrated with worked examples (e.g. from MESH) and assess whether these are suitable for wider application.

Uses of habitat mapping in management and ecosystems contexts

13) review a draft document which addresses the application of and needs for habitat maps in an ecosystem-based management context.

14) assess the role of the Working Group and its relationship to the needs of ICES science and advisory programmes.

WGMHM will report by 25 April 2007 for the attention of the Marine Habitat and the Fisheries Technology Committees, as well as ACE.

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 and relation to Action Plan	Action Plan nos.: 1.4.1, 1.4.2, 1.4, 1.4.3. The WG provides an important forum to present and discuss the progress of multinational programmes, in particular, within the Interreg MESH project for North West Europe, the OSPAR-wide programme, the BALANCE project for the Baltic Sea and the HERMES FP6 project. The strategies, standards and issues addressed by each programme need to be assessed to facilitate sharing of best practice, sharing of difficulties and to work towards integration of resultant maps if feasible. The compilation of National Status Reports is required to keep abreast of current activities and bring attention to new initiatives, developing techniques and data availability. In recent years there have been considerable advances in the use of remote acoustic techniques for marine exploration. Many of these new technologies provide excellent tools, which can be easily adapted to marine habitat mapping. The WGMHM provides an excellent forum in which new techniques can be shared and the relative merits discussed, transferring technology and experience. Review of standards for habitat mapping is of key importance to promoting best practice in mapping studies and in the interoperability of the data. The MESH project will have made significant progress on this topic in its publication of a Guide in 2007 and WGMHM should provide peer review of the work on the basis of its wider expertise, to assess whether any critical gaps exist in the available guidance. Assessment and presentation of issues about accuracy and confidence is marine habitat mapping, to better inform end users of potential limitations in the maps, is at an early stage in development. This is a significant new area in which WGMHM members can contribute to developing new approaches. Sound data management is important in the archiving and distribution of data sets and in interpreting the data to make maps and assess their confidence. There is a need to assess whether available standards are suitable for wider adoption (within ICES). The relevance of habitat mapping to other aspects of ecosystem structure and function needs to be examined, to reveal strengths and potential weaknesses and to highlight the relevance of habitat mapping to other sectors of research and environmental management, e.g. fisheries management. The importance of marine habitat mapping in ICES is growing and it is timely to assess whether the WG can improve its work in relation to the science and advisory needs of ICES (linked to proposals for restructuuring ICES Science and Advisory Structures).
Resource requirements	–
Participants	Representatives from Member Countries with experience in habitat mapping and classification. Participation of the Baltic countries and from USA and Canada is particularly sought. The participation of members of BEWG, WGEXT, WGECO, WGDEC, WGFAST would be helpful in developing appropriate linkages to other areas of ICES work.
Secretariat facilities	–
Financial:	–
Linkage to Advisory Committee	ACE
Linkages to other Committees or groups	BEWG and SGNSBP, WGEXT, WGECO, WGDEC, WGFAST and SGASC, SGEH (Baltic Committee)
Linkages to other organizations	OSPAR, HELCOM, EEA

Annex 14: Recommendations and actions

RECOMMENDATION OR ACTION	ACTION
1. Seek access to the data used in the preparation of the North Sea EUNIS map by NIVA/EEA	David Connor by 31 May 2007
2. Review maps available for the OSPAR habitat mapping programme (www.searchnbn.net/hosted/ospar/ospar.html), and advise of any data gaps, supplying additional data where possible	All WGMHM members by 31 July 2007
3. Advise WGMHM when the *MESH Guide to Marine Habitat Mapping*, including its protocols and standards, becomes available	David Connor by summer 2007
4. Review the *MESH Guide to Marine Habitat Mapping* and provide comments	WGMHM by 31 December 2007
5. Develop paper on the role of marine habitat mapping in ecosystem-based management	Chris Cogan and other WG members by 31 January 2008
6. North Sea - It is recommended that further work is undertaken to achieve full coverage of the North Sea at a resolution similar to that achieved in the UKSeaMap and MESH projects and the inshore parts of the EEA project. A multi-national approach could be adopted, similar to the BALANCE and MESH projects, to develop a habitat map for the entire North Sea area. Given the large area to be mapped, it is recognised that considerable effort would be needed to produce the necessary data layers (e.g. seabed substratum) in sufficient resolution prior to analysis and map production. This would require a coordinated effort amongst the North Sea countries.	North Sea countries
7. National programme coordination - WGMHM recognises that many countries have multiple government agencies, academic institutes and industries undertaking new mapping programmes for a variety of sectoral and research needs. Given the high degree of commonality to these studies, the high cost of survey and the potential to make much greater use of the resulting information and maps across multiple interest groups, wherever possible, seabed mapping effort should be coordinated through national and international programmes and the data and maps should be made publicly available to ensure their wide use.	National authorities
8. International classification schemes - WGMHM recognises the benefits of consistent interpretation of mapping data so that data from different areas and sources can be readily compared and aggregated. To this end there is a need to harmonise classification systems and to work towards fully operational international habitat classification schemes. Additionally WGMHM recognises that individual schemes do not always meet the needs of all end users and that there is merit in having several schemes or being able to arrange particular schemes in different ways to suit different end needs. WGMHM recommends directing further effort towards establishing suitable international classification schemes, based on approaches available in North America (Green *et al*., 1999, Valentine *et al*., 2005) and Europe (EUNIS 2004; BALANCE and UKSeaMap Connor *et al*. 2006). Furthermore, national, regional and local mapping programmes should be encouraged to use and test the available classification schemes to help ensure they are 'fit for purpose'.	European Environment Agency, ICES and other relevant international authorites
9. Metadata on mapping programmes: In recognition of the growing volume of information (metadata) being produced from mapping programmes, including that collated by WGMHM in its National Status Reports, better use of these metadata (i.e. the NSR spreadsheets) is required by collating the annual reports and making these more widely available via a web portal.	WGMHM

10. WGMHM recommends that for future habitat mapping studies, a structured confidence assessment should be completed by the person who produced the habitat map (see Section 6.2.2 for details):	Map producers