ICES WGMHM REPORT 2016

SCICOM STEERING GROUP ON ECOSYSTEM PRESSURES AND IMPACTS

ICES CM 2016/SSGEPI:19

REF. ACOM, SCICOM

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

9–11 May 2016

Winchester, UK

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Recommended format for purposes of citation:

ICES. 2016. Interim Report of the Working Group on Marine Habitat Mapping (WGMHM), 9–11 May 2016, Winchester, UK. ICES CM 2016/SSGEPI:19. 71 pp.

https://doi.org/10.17895/ices.pub.8543

Contents

Executive summary

The meeting was held at the Natural England Office, Winchester, UK, 9–11 May 2016. The meeting was planned to coincide with the end of the GeoHab conference that was also held in Winchester the previous week. The meeting was attended by 11 members from 6 countries. The first day of the meeting dealt with ToR A (International Mapping Programmes) and ToR B (National Mapping Programmes). Based on recommendations from the 2015 meeting, the reporting of national mapping progress is now undertaken using a templated form. The objective for this approach is to (i) standardize the reporting of mapping progress, (ii) allow country representatives not attending the meeting to still contribute to the working group and (iii) encourage the submission of information to the GeoNetwork.

Most of the meeting was dedicated to ToR C (Habitat mapping techniques and modelling), which generated much interest and discussion within the group. The Working Group also specifically focused on differing types of data segmentation and analysis as well as briefly reviewing some of the common habitat classification schemes used in seabed mapping. ToR D examined the ecological (e.g. landscape ecology) and managerial uses (e.g. assessments of environmental status) of habitat maps. The group was updated on the work being undertaken for WKFBI (ICES request work package to provide guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats). Issues associate with the WKFBI approach were highlighted and collated for reporting at the WKFBI workshop. Finally, based on discussions within the 2016 working group, there was collective agreement on several intercessional work packages.

1 Administrative details

Working Group name

Working Group on Marine Habitat Mapping (WGMHM)

Year of Appointment

2015

Reporting year within current cycle (1, 2 or 3)

2

Chair(s)

James Asa Strong, UK

Meeting venue

Winchester, UK

Meeting dates

9–11 May 2016

2 Terms of Reference and Summary of Work plan

ToR	Description
A	**International programmes** Report on progress in international mapping programmes (including OSPAR and HELCOM Conventions, Emodnet, EC and EEA initiatives, CHARM, Mesh-Atlantic and other projects)
B	**National programmes (National Status Reports)** Present and review important results from national habitat mapping during the preceding year, as well as new on-going and planned projects focusing on particular issues of relevance to the rest of the meeting. Provide National Status Report updates in geographic display in the ICES webGIS
C	**Habitat mapping techniques and modelling** Evaluate recent advances in marine habitat mapping and modelling techniques, including field work methodology, and data analysis and interpretation
D	**Review practise about the use of habitat maps** Review practise about the use of habitat maps, for example Mapping for the MSFD, marine spatial planning, and management of MPAs; and assess the ability to use habitat maps for monitoring of the environment
E	**2015/4 Support for the development of common and candidate OSPAR biodiversity indicators for benthic habitats: Benthic habitats** ICES is requested to support on-going OSPAR indicators work on benthic habitats, in support of the requirements under the MSFD

	a) Using mobile bottom contacting gear data, produce fishing abrasion pressure maps (2009-2014) using the BH3 approach as a follow-up of the OSPAR request to ICES (Request 5/2014). Fishing abrasion pressure maps should be analysed by gear distribution, and type, in the OSPAR maritime area and be based on the methodology propose on the physical damage indicator (BH3); b) Evaluate the applicability of a reduced list of habitats in support the development of Typical Species indicator (BH1). This work should consider those habitats that have previously been identified by the COBAM Benthic experts group. Evaluation should consider data availability, and suggest possible prioritisation of habitats already included in the OSPAR list of threatened and declining habitats. c) Evaluate monitoring and assessment requirements for multimetric indicator (BH2)[2] and/or typical species (BH1)
F	**Guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats (WKFBI)** a) Using input from WGDEC and BEWG, incorporate and evaluate information on sensitivity of the benthic community of the various seafloor habitats, and provide habitat maps for sensitivity of at least one demonstration area of NW European waters (MSFD region/subregion). b) Provide input based on ToR 1) to WGSFD

Summary of Work plan

Year 1	Working on all ToRs, but with special focus on ToR D, and identifying points of collaboration with othe WGs. Election of new chair.
Year 2	Working on all ToRs, but with special focus on ToR C. Election of new chair.
Year 3	Working on all ToRs, but with renewed focus on ToR A.

3 Progress report on ToRs

3.1 ToR A: International mapping programmes

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

EMODnet Seabed Habitats

Helen Lillis – JNCC (UK)

This is one of seven thematic projects under the European Marine Observation and Data Network (EMODnet; www.emodnet.eu). It is running from September 2013 to September 2016 and being undertaken by nine international partners (www.emodnet-seabedhabitats.eu/partners). It has two main aims (see www.emodnet-seabedhabitats.eu/about):

- Produce a broad-scale physical habitat map for all EU waters
- Provide access to European habitat maps through an online interactive map (www.emodnet-seabedhabitats.eu/webgis).

In the last 12 months the project has:

- Produced a draft interim broad-scale physical habitat map for all EU waters, plus some of Norway at a resolution of roughly 250 m.
- Uploaded several more habitat maps from surveys to the online interactive map. Note that the interactive map links directly with the ICES metadata catalogue used by this working group.

Conducted a review of the uses of broad-scale habitat maps in European seas (see ToR D).

By September 2016 the project will produce:

- An updated European broad-scale physical habitat map – the final update before the end of the project. This will be classified to:
  - EUNIS – where appropriate
  - A Bespoke scheme consistent with EUNIS – where EUNIS is less appropriate, e.g. Black Sea
  - MSFD predominant habitats
- A set of qualitative confidence maps to accompany the habitat maps.
- Reports describing the methods used in the broad-scale mapping.
- An updated online interactive map containing all the products of the project, including a compilation of habitat data products produced in other projects, e.g. EUNIS habitat maps from surveys, Habitats Directive Annex I habitat maps, OSPAR threatened and/or declining habitat maps, and single habitat distribution models.

ProAtlantic (EMODnet Atlantic Checkpoint)

Eimear O'Keeffe – Marine Institute (RoI)

As well as the thematic lots delivering work under EMODnet, the programme also funds six sea basin checkpoints: Arctic, Atlantic, Baltic, Black Sea, Med Sea and North Sea. The Atlantic Checkpoint (www.emodnet-atlantic.eu) is a basin-scale assessment of the various data sets used to monitor the marine environment by different sectors. The project is funded through DG-Mare. Eleven thematic challenges have been selected for evaluation; they cover:

- the energetic and food security sector (renewable energy, fisheries & aquaculture management);
- marine environment variability and change (climate change, eutrophication, river inputs, bathymetry, alien species);
- emergency management (oil spills, fishery impacts, coastal impacts);
- preservation of natural resources and biodiversity (connectivity of Marine Protected Areas and red list species).

The organisations participating in the challenges are: IFREMER, AZTI Tecnalia, CLS Group - France (Collecte Localisation Satellites), Marine Institute, ACRI group - France (ACRI Hocer Environment), HR Wallingford - United Kingdom, IPMA, CEFAS and Eurogoos-International (European Global Ocean Observing System).

The work plan for each challenge involves a literature review, collation of relevant datasets and an assessment of how these datasets have been used to date. The collated data will be used to complete the tasks outlined for each challenge highlighting performance and gaps within the data and assessing the fitness for purpose of these data within present monitoring systems.

3.2 ToR B: National habitat mapping programmes (National Status reports)

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

Introduction

The working group wishes to reduce the time dedicated to the reporting of National and International mapping programmes as this is often a lengthy process and often fails to distil the important or interesting values or topics. Furthermore, the previous reporting of national progress was typically limited to the country representatives attending the working group meeting. The reporting of progress was also undertaken in wordy, qualitative terms. As such, the group have adopted the use of a new 'National Progress Reporting' template. The objective for the template-based reporting is to (i) reduce the time dedicated to ToRs A and B during the meeting of the working group, (ii) encourage members to upload the metadata to the ICES GeoNetwork (support data for the EMODnet project), (ii) quantitatively define progress, (iii) encourage members of the working group that do not attend the meeting to submit progress reports and (iv) highlight new infrastructure. Members are still able to report important survey approaches, analysis techniques and map uses within ToR C. Two noteworthy international programmes were detailed by members of the working group, namely EMODnet (Seabed Habitats) and the Atlantic Checkpoint. Both project are described below.

Table 1 lists the countries that returned national progress reports for 2016. The reports detailing the progress of each country are accessible via the hyperlinks within table 1. Two presentations were also provided on mapping progress in Scotland (Marion Harrald – Marine Scotland Science) and the Republic of Ireland (Eimear O'Keeffe – Marine Institute).

Table 1. Index of 2016 National Progress Reports (NPR) that detail the progress and status of seabed mapping status within ICES member countries.

Country	Location of report	Comment
Belgium	Appendix 2.1	Complete
Canada	-	Not provided
Denmark	Appendix 2.2	Complete
Estonia		Not provided
Finland	-	Not provided
France	-	In progress
Germany	Appendix 2.3	Complete
Iceland	Appendix 2.4	Complete
Latvia	-	Not provided
Lithuania	-	Not provided
Netherlands	-	Not provided
Poland	-	Not provided
Portugal	Appendix 2.5	Complete
Republic of Ireland	Appendix 2.6	Complete
Russian Federation	-	Not provided
Spain	-	Not provided
United Kingdom	Appendix 2.7	Complete
United States of America	Appendix 2.8	Complete

National Mapping Progress – Overview

Significant investments have been made in habitat mapping apparatus during 2015-2016 period. Large investments include the new ocean-going research vessel 'Mar Portugal' (Portugal), a new inshore survey vessel (RoI) and a new suite of MBES on both RVs Celtic Explorer and Celtic Voyager (RoI). Many countries have also upgraded their ground-truthing equipment with numerous purchases of HD cameras, ROVs and SPI samplers (e.g. Belgium, UK, Iceland, and Portugal).

Noteworthy mapping projects include the SEACOP project (collaborative mapping of Belgian waters as part of a national mapping programme), near completion of the Iceland Seabed Map (from ISOR – Iceland Geosurvey) and the production of large number of habitat maps in the UK within the Data and Evidence Coordination Programme (MB0129) funded by Department of Environment, Food and Rural Affairs and coordinated by Cefas. Furthermore, Norwegian, Irish and British mapping scientists have formed the MIM group (MAREANO, INFOMAR and MAREMAP) to collaborate on the optimal sampling designs for ground-truthing – this will hopefully lead to greater standardisation and the development of best practice documents.

3.3 ToR C: Habitat mapping techniques and modelling

ToR c) Evaluate recent advances in marine habitat mapping and modelling techniques, including field work methodology, and data analysis and interpretation.

Introduction

Firstly, two presentations were provided on workshops that have addressed multiple aspects of habitat mapping. The first talk by Helen Lillis describes efforts in the UK to identify and reduce sources of uncertainty within the entirety of the mapping process. A subsequent presentation by Dieter Boedeker and Roland Pesch describes a recent workshop held on the Island of Vilm and organised by the German Federal Agency for Nature Conservation. The goal of the workshop was to summarize and discuss the status quo of marine biotope mapping in the Baltic and North Sea including issues related to the delineation and modelling of marine biotopes at different spatial scales. The remaining talks within ToR c) relate to specific methodological elements, examples of best practice or investigations of common problems.

Priorities for standards and guidelines in habitat mapping

Helen Lillis – JNCC (UK)

Many standards and guidelines exist for various stages of habitat map production, from survey design and equipment operation (e.g. Henriques *et al.*, 2013) to data management (e.g. Seeley *et al.*, 2014) and evaluating the quality of the overall approach (e.g. MESH, 2008). However, further gaps were identified by Strong (2015) that could be filled to lead to a more standard approach to habitat mapping in future. The benefit of this would be that habitat maps become of more use for monitoring and assessment of habitat status over time.

Strong (2015) made recommendations on best-practice for the reduction of uncertainty in habitat mapping methods, identifying 39 'uncertainty reduction solutions' (also summarised in Section 5.3.2 of ICES (2015)). Following this report, JNCC arranged a workshop to discuss and further prioritise the uncertainty reduction solutions. The workshop was held in Peterborough, UK, in November 2015 and attended by representatives from 17 organisations involved in seabed habitat mapping in the UK. The workshop outcomes are summarised in a report that is currently awaiting publication (Lillis *et al.* 2016).

By the end of the workshop the participants had identified three problems that should be prioritised in order to improve consistency in habitat mapping:

1. **Problem**: Different classification analysis methods can lead to different resultant habitat maps. There is no universal analysis method for all possible situations and it is not possible to know beforehand which method will be most appropriate.
   Proposed actions and products:
   a. Conduct a literature review examining classification analysis methods for various purposes.
   b. Arrange a workshop with experts to help formulate a decision tree to aid habitat mappers decide what methods to use.
   c. Write and publish a guidance document for classification analysis.

2. **Problem**: Inadequate distribution of ground-truthing samples between classes, between class units and/or within class units influences the training of models and prediction performance.

   Proposed actions and products:

   a. Make improvements to the existing Clements *et al.* (2010) Optimum Allocation Analysis tool.
   b. Write and publish a guidance document to cover aspects not covered by the improved tool.

3. **Problem**: Multi-beam backscatter data is extremely useful for producing seabed habitat maps; however various factors influence data quality and comparability of results, include survey hardware, environmental issues (e.g. depth) and the use of gain changes during data collection. International guidance has recently been produced (Lurton and Larmarche, 2015), but some organisations already have specifications that they follow. In addition a gap was identified in the communication of requirements from end users.

   Proposed actions and products:

   a. A review and comparison of existing standards and specifications for backscatter data collection in the UK.
   b. Workshop to develop and agree consistent guidance.
   c. Guidance for the collection of multi-beam backscatter data, including links to end user requirements.

These solutions are each presented in Section 4.2 of Lillis *et al.* (2016) as a simple project outline, including (i) objectives, (ii) benefits, (iii) products, (iv) exclusions, (v) dependencies and (vi) potential resources. The hope is that the identification of these top priorities for standardising habitat mapping will stimulate further work in these areas. The issues described here are common in many countries and would benefit from international collaboration, just as the MESH and MESH Atlantic projects did with their series of Recommended Operating Guidelines. The ICES WGMHM is one important conduit for potentially building collaborations to address some of these recommendations.

Summary on BfN Workshop on Marine Biotope Mapping

Dieter Boedeker and Roland Pesch – Federal Agency for Nature Conservation and University of Vechta/Bioconsult (Germany)

Dieter Boedeker and Roland Pesch reported on a workshop on marine biotope mapping with special focus on nature conservation issues held at the Federal Agency for Nature Conservation on the island of Vilm (Germany) from 30 Nov to 2 Dec 2015. The goal of the workshop was to summarize and discuss the status quo of marine biotope mapping in the Baltic and North Sea including issues related to the delineation and modelling of marine biotopes at different spatial scales. Common problems were to be identified and possible solutions to be dis-cussed. Overall, 41 participants attended the conference from different European countries. Next to introductory presentations and a final plenary discussion the main part of the workshop consisted of two working group session dealing with (1) mapping of hard substrates (including reefs) by combining geological and biological methods and (2) full coverage soft sediment biotope modelling with special emphasis on high resolution mapping.

In working group (1) adequate definitions and delineation aspects of hard substrate biotopes as well as mapping experiences and strategies within the areas of interest were discussed. Special focus was thereby laid on minimum mapping sizes of different hard sediment biotopes as interpreted from backscatter images. As a result four separate tables were developed for the northern and southern Baltic Sea and North Sea areas. Until now, the tables were filled out by attendee coming from Germany, Lithuania, Denmark, Norway and Sweden. It is planned by BfN to finish the table to serve as mapping recommendations for the European countries by 2017.

Working group (2) focused on soft sediment biotope mapping by data on benthos, backscatter information and other abiotic data that are seen relevant to predict benthic communities and species within a given region. Next to the applicability of given biotope classification systems like EUNIS and HUB, delineation and mapping aspects were discussed with special emphasis on the use of high resolution backscatter information. Further issues were the integration of biological information on benthic species and communities in the mapping process via different modelling procedures. More information on this workshop can be found in appendix section 3.1.

Summary on Pilot study Sylter Outer Reef

Roland Pesch – University of Vechta/Bioconsult (Germany)

Roland Pesch presented a study to investigate the association between the occurrence of infauna species and sediment composition from the southwestern part of the Sylter Outer Reef. The investigation was based on a sediment map which was derived from sidescan sonar images made available from the Alfred Wegener Institute (Sylt). The map differentiated ten sediment types reaching from clayey /silty sand to gravel. As a goal, 180 sites were to be sampled from a section of the corresponding area where the water depth gradient was no higher than eight meters but where still eight of the ten sediment classes could be found. The 180 sites were to be distributed over the area in terms of a stratified random sampling approach. At first the areal proportion of each sediment polygon to the entire area was calculated in a GIS. Next, the benthos sites were allocated to each polygon so that the percentage of benthos stations matches the areal proportion of the corresponding sediment polygon. Furthermore, each of the sediment classes were to contain at minimum ten benthos sites and monitoring stations from previous surveys were to be accounted for. At each site one infauna and one sediment grab were to be taken. The number of video transects within the area was restricted to two transects for each of the eight sediment classes.

The survey in the Sylter Outer Reef was carried out in July/ August 2015. 176 of the planned 180 sites could be sampled with regard to the infauna and all of the planned 16 video transects could be investigated. As a first conclusion, the sediment samples correspond well to the sediment types derived from the side scan sonar image. Currently, the infauna samples are investigated in the laboratory. Once finished, the resulting data will be used to compare the spatial heterogeneity of infauna species and communities to the spatial structure of sediment types. Furthermore, predictive modelling techniques will be applied to map species and communities for the entire area under study.

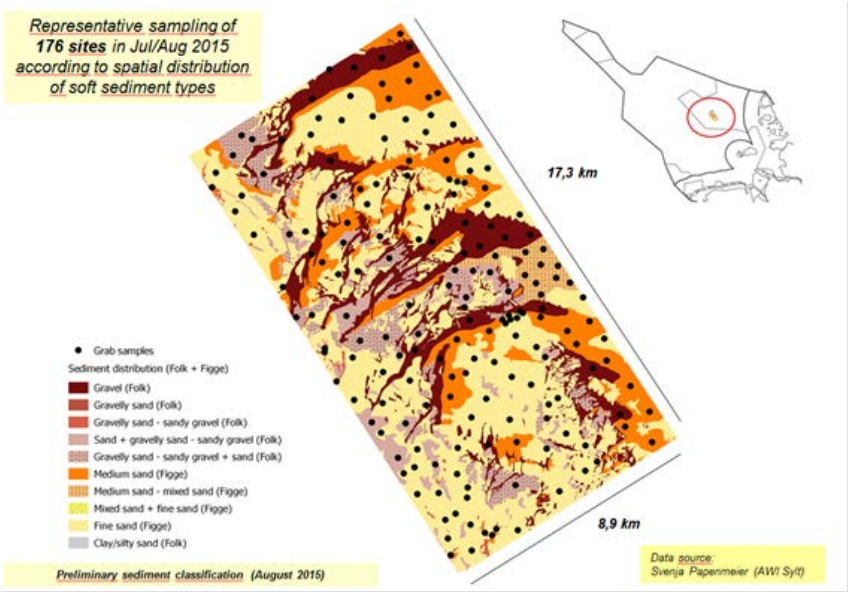

Figure 1. Sampling scheme for infauna investigations in the Sylter Outer Reef.

Seabed sediment mapping in the German Exclusive Economic Zone (EEZ): an approach for a standardized data interpretation

Claudia Propp – Federal Maritime and Hydrographic Agency (Germany)

The Federal Maritime and Hydrographic Agency (BSH) of Germany has started a sediment mapping program in cooperation with the Federal Agency for Nature Conservation (BfN) based on side scan sonar and ground truthing using grab sampler and underwater video. To establish a standardized mapping procedure, BSH and its project partners AWI, CAU, IOW and SaM have developed a specific technical guideline that includes requirements for the collection, processing and interpretation of backscatter data. Focus was put on the latter since the interpretation of backscatter data for the purpose of creating consistent sediment maps has not been defined or standardized by now. Concepts and rules for classification and discrimination were defined for different seafloor sediment types including the type of transition between them, the size of structures (minimum size = 100 m) and small-scaled combinations of different sediment types. Different levels of classification have been introduced for the sediment types, primarily based on the FOLK scheme (Folk, 1954). For the German North Sea, sand is classified according to the national classification scheme (Figge, 1981) to meet the requirements for biotope modelling on the sandy shelf of the German North Sea sector. According to the information available in the particulate area these data are combined in a standardized attribute table (GIS) together with additional information about the genesis of sediment types, ground truthing methods and other relevant information. In addition to these considerations, the technical guideline comprises a national catalogue of characteristic backscatter images of sediment types which occur in German territorial waters.

The guideline has been discussed with experts from state agencies for nature conservation and environmental protection or commented by consultancies in civil and environ-

mental engineering. At present, it is tailored to support German governmental marine mapping tasks in the EEZ but will soon be extended for mapping specifications applied in coastal zones. An alignment with similar efforts of the EU countries is planned in a further step in order to promote the effort of producing standardized maps that can easily be connected across the borders of the European coastal countries.

High resolution aerial imagery from a remotely piloted aircraft and object-based image analysis to map intertidal seagrass

Anna Downie – Cefas (UK)

Seagrass was mapped with a fixed-wing remotely piloted aircraft (RPA). The RPA flown over an intertidal seagrass meadow at Two Tree Island (Essex, UK) to acquire high resolution (3 cm) aerial imagery. Imagery was collected with a twin camera system that acquired blue, green, red (RGB) and near infra-red (NIR) spectral bands. Mosaics of the RGB and three-band NIR imagery were combined into one multiband image. A digital surface model (DSM), derived using the Structure from Motion technique, and was used to calculate terrain variables, including a terrain position index with a 100 m radius as well as slope.

Object based image analysis (OBIA) was used to identify real-world objects of different habitats in the RPA imagery. The multi-band image was segmented in eCognition software, using the multi-resolution segmentation algorithm on RGB bands. The segmentation procedure produces image objects containing consistent spectral characteristics. Image objects representing water, mud, saltmarsh, 100% seagrass cover and seagrass (all seagrass <100%) were selected visually, by expert judgement, from the image to act as training samples for classification. Summary statistics and textural attributes of input layers were calculated for objects. A Random Forest classification tree model was used to quantify the spectral, textural and topographic qualities of each land cover class and to generalise the classification to the whole image by predicting to unclassified objects. The model was validated using a bootstrap cross-validation procedure on ten random subsets of 70/30% selected as training and testing data, respectively, with random selection stratified across classes.

Cross-validation scores for class sensitivity, specificity and balanced accuracy all showed almost perfect prediction success. Water was found to be distinct from all other classes with very low NIR1/red ratio values. The same ratio for all vegetation was very high. Mud and 100% seagrass cover were separated by their high and low values of the red/green ratio, respectively. Out of all the land cover classes, saltmarsh and < 100% seagrass cover were most similar in their spectral attributes, differing mainly in elevation and texture, where saltmarsh objects had much lower entropy in the NIR1/red ratio layer. Textural attributes of the objects were found important in separating habitat classes.

The link between image spectral attributes and percent coverage of seagrass was investigated using ten quadrate based coverage estimates (collected concurrently with the acquisition of the RPA imagery), together with ten zero and ten 100% coverage objects selected from the image. Percent coverage showed a good curvilinear fit to the NIR2/green ratio. A generalised additive model was used to predict values to the seagrass objects to create a map of percentage cover. RPA imagery was found to be a

promising tool for acquiring low cost, high resolution aerial imagery, with the potential for high accuracy mapping of intertidal vegetation.

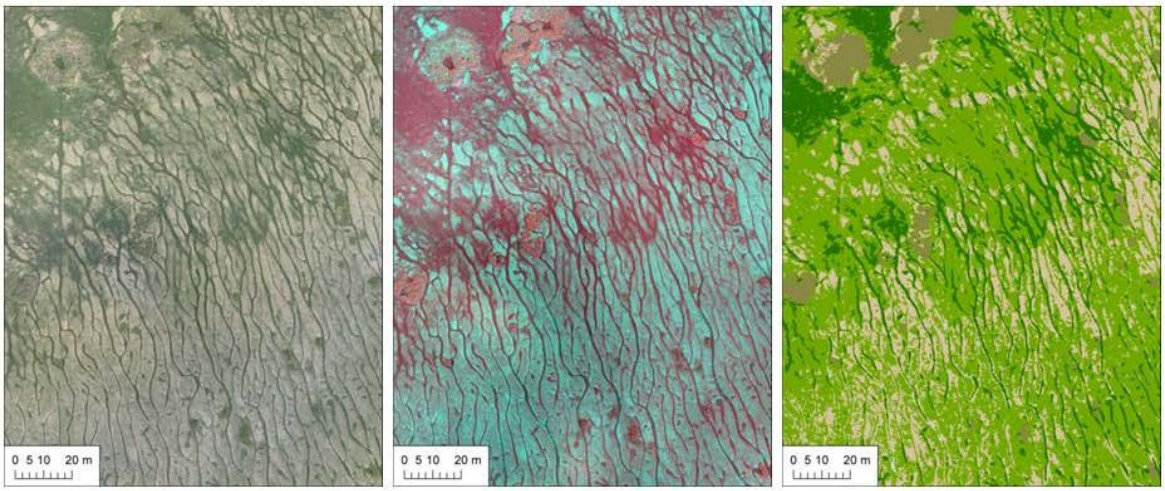

Figure 2. A close up from the study area illustrating the RGB image, false colour NIR image and the result of the classification in eCognition. Saltmarsh is shown in grey-green, mud in light brown, 100% seagrass cover in dark green and seagrass <100% cover in light green.

The effects of fishing activity as an explanatory term in predictive modelling of Vulnerable Marine Ecosystem (VME) indicator species biomass distribution

Anna Downie – Cefas (UK)

The predictive modelling of Vulnerable Marine Ecosystem (VME) indicator species biomass was done using data from the NEREIDA programme, a co-operative initiative between Canada and the EU around the Flemish Cap and the tail of the Grand Banks of Newfoundland (NAFO Regulatory Area). The study aimed to address the question of how potential noise in biological data, introduced by the impact of bottom fisheries, affects the ability of predictive models to accurately represent the natural distribution of species. Normally HSM do not account for the effects of human disturbance. Hence, input data can indicate absences or low biomass in areas that would otherwise be suitable physical habitat, adding noise to the models. The study presented took a novel approach to the problem, by including fishing effort into the habitat suitability modelling process. Data from Vessel Monitoring System (VMS) records was used to determine the level of bottom fishing effort in the area. The VMS data in conjunction with high resolution bathymetric data and other available environmental layers, was used to construct random forest regression models for the biomass of sponges (Porifera), large gorgonian corals (Octocorallia) and sea pens (Pennatulacea). Predictions were made both for current fishing level and a 'no fishing'-scenario. The latter predictions represent the expected distribution of biomass in prevailing environmental conditions, with fishing intensity set to zero. Hence areas that are currently heavily fished, but have the appropriate environmental conditions, would be expected to show higher biomass than is currently observed.

All of the models predicted biomasses with a RMSE within approximately 10% of the range observed for the taxa. Models for sponges and sea pens achieved mean R2 values of 0.53 and 0.38, respectively. The model for large gorgonians, however, only had an R2 value of 0.04, indicating very low correlation between predicted and observed values and hence a poor model. Model performance was compared for models including and excluding the fishing pressure predictor. The inclusion of fishing pressure as a predictive term in the model showed no difference in the large gorgonian model performance and only a marginal improvement in the performance of the sea pen model. For the sponge model, however, the improvement in model performance was highly significant. The gorgonian biomass prediction was largely driven by terrain features and depth. Fishing intensity was not found to be important. Sea pen biomass was best approximated by minimum bottom temperatures above 3.5 °C, sediment with a high clay content and low bottom fishing intensity. Sponge biomass was found to be most sensitive to the fishing pressure. Fishing intensity was the most important factor in the sponge model, with high biomass found only at very low fishing intensity. Otherwise, high sponge biomass was predicted in coarser sediments with low silt and clay content, high bottom current speeds and low temperature variability. Whilst highest biomasses are predicted outside the fished areas under both scenarios, predictions to the 'no fishing' scenario identified two areas adjacent to the Grand Banks that currently support very low biomass of sponges where environmental conditions would potentially support higher biomass under unfished conditions.

Review of seabed habitat classification schemes

Helen Lillis, James Strong, Anita Clements and Roland Pesch

Based on the overriding importance of classification schemes on the presentation and interpretation of habitat maps during the 2015 WGMHM meeting, it was agreed that the group would review the available habitat schemes for seabed habitat mapping and summarise their strengths and weaknesses. As part of this process, four classification schemes (Table 2) were presented during the 2016 meeting. It is hoped that the WGMHM will complete this review by the end of 2016.

Table 2. Habitat classification schemes presented with the 2016 WHMHM meeting. Additional schemes are being included in the review being prepared by the group intersessionally.

Classification scheme	Speaker	Comment
HELCOM Underwater Biotopes (HUB)	Roland Pesch	See additional material in Appendix 4.
European Nature Information System (EUNIS) marine habitat classification	Helen Lillis	
Potential Habitat classification (Greene *et al.* 2005, 2007)	James Strong	
Australian National Intertidal/Subtidal Benthic (NISB) Habitat Classification Scheme	Annika Clements	

3.4 ToR D: Use of broad-scale seabed habitat maps in Europe

ToR d) Review practise about the use of habitat maps, for example Mapping for the MSFD, marine spatial planning, and management of MPAs; and assess the ability to use habitat maps for monitoring of the environment.

Use of EMODnet seabed habitat maps

Helen Lillis, JNCC

The EMODnet Seabed Habitats project has conducted a review of the use of broad-scale seabed habitat maps in Europe, with particular focus on their use with regard to environmental status assessments (under the Marine Strategy Framework Directive (MSFD)) and Marine Protected Area (MPA) designation and network coherence assessments.

For this purpose a 'broad-scale seabed habitat map' was defined as: "a map that shows the distribution of (primarily) physically-defined seabed habitat types over a larger area than could typically be achieved through direct survey. The result is often associated with a lower spatial resolution."

The analyses are anchored in maps developed by a series of interlinked European projects (e.g. UKSeaMap, BALANCE, MESH, MeshAtlantic, EUSeaMap, and EUSeaMap 2). The review was conducted through:

a. Analysis of the download history from the EMODnet Seabed Habitats portal
b. An online questionnaire
c. Literature review

Initial results show that:

- Downloads of broad-scale habitat maps from the EMODnet Seabed Habitats have increased greatly during EMODnet phase 2 (2013–2016), with nearly half of downloads coming from the UK.
- More than half of all downloads are reported by the users as being for research and/or education.
- Most EU Member States have used broad-scale habitat maps in the production of MSFD Initial Assessments and the usage of broad-scale habitat maps is likely to increase in the second MSFD assessment, which is understandable due to the recent increased coverage of EUSeaMap.
- Broad-scale habitat maps are widely used for assessments of various indicators of ecological coherence of MPA networks.
- The maps are increasingly being used in conjunction with habitat sensitivity information and data on the extent of human activities in order to assess potential cumulative pressures on seabed habitats.

As MPA designation turns into monitoring and as subsequent MSFD assessments required comparison with regional baseline information, there seem to be a growing need for more accurate and frequently updated broad-scale habitat maps, nationally, regionally and on a pan-European scale.

3.5 ToR E: Support for the development of common and candidate OSPAR biodiversity indicators for benthic habitats: Benthic habitats

Completed in 2014/2015.

3.6 ToR F: Progress on the ICES WKFBI

ToR f) Using input from WGDEC and BEWG, incorporate and evaluate information on sensitivity of the benthic community of the various seafloor habitats, and provide habitat maps for sensitivity of at least one demonstration area of NW European waters (MSFD region/subregion).

Objective of WKFBI

Combine fishing-induced abrasion pressure maps with benthic habitat maps, attributed with sensitivity to abrasion, to evaluate the impact (and related indicators) of this activity throughout the MSFD assessment area. Mandatory elements include:

- The coverage should align with the MSFD assessment area (i.e. spatial coverage of greater important than thematic resolution).
- Fishing pressures are restricted to surface and sub-surface abrasion only (i.e. other pressures such as re-suspension, removal of target species are not considered).

Approach

1) Sensitivity matrix = MB102 (UK habitat sensitivity report) + BEWD + WGDEC

2) Habitat maps = Interim EMODnet habitat maps (5 out of 6 regions)

3) Fishing pressure = 6 year VMS average from WGFSD

4) Categorical expression for sensitivity used to attribute habitat classes (L/M/H)

5) Habitat classes also attributed with ecosystem services (P/A) Tempera *et al.* (2016)

6) VMS SAR translated to pressure bands using BH3 thresholds

7) BH3 'matrix-approach' used to combine sensitivity and pressure to predict disturbance

Representing benthic habitats – recommendations from the WGMHM

The analysis undertaken here used the most up-to-date habitat map available for the assessment area. In fact, the EMODnet seabed habitat maps are perhaps the only source of information with the required extent. Other products are available for large sea areas, but they both lack the necessary coverage and do not match the thematic level used to report habitat sensitivity. There are some caveats associated with the EMODnet maps that limit their value within this analysis – these include:

- The EMODnet interim maps were not provided with confidence layers (these will however be present in the final version of the maps). A dummy confidence layer was used in this analysis - all maps were assumed to have a low confidence. Providing this allowed investigators to address the potential design of an overall confidence assessment.

- Deep-water habitats were classified into biological zones only (i.e. broad bathymetric bands). A shortage of acoustic data sets and ground-truthing limits our ability to produce accurate maps for deep-water habitats.
- Habitats have typically been reported at EUNIS levels 3 and 4 although habitat classifications are available at lower levels. However it was not possible to use this information as the sensitivity scores were provided for EUNIS levels 3 and 4 only.

Specific recommendations and topics (associated with the habitat maps) for further work include:

- An informative and transparent method for calculating uncertainty must be developed. The uncertainty assessment would need to draw in uncertainty information from the habitat maps, sensitivity scores and VMS-derived information. This information must then be weighted and aggregated in a meaningful manner before being displayed in manner that allows users to assess whether the analysis outputs are fit for their purposes.
- In much of the deep-sea, a lack of substrate information means that deep-water habitats are expressed as depth zones only - this is clearly a generalization that limits the analysis. Based on this, the ICES Working Group on Marine Habitat Mapping have committed to working closer with the Working Group on Deep-water Ecology to highlight this issue and drive correct efforts. Future iterations of this analysis must be able to represent bathyal and abyssal habitats in more detail.
- The method for linking the habitats to the c-square needs to be refined. The four possible methods are: 1) reporting the habitat under the mid-point of the c-square (used in this analysis), 2) using the habitat with the greatest spatial majority within the c-square (most representative approach), 3) selection of the most sensitive habitat within the c-square (precautionary approach) and 4) report all habitats in square weighted by proportional presence (time consuming and complex but providing the most detailed output). Other possible approached may stem from using reconstructed fisheries tracks or raw 'pings' rather than c-square approaches.

Other recommendations not associated with the habitat maps include:

- Given the timescale and resources attached to this analysis, it is impressive that a complete list of sensitivities were provided for most of the EUNIS level 3 and 4 habitats. To ensure consistency in future scoring of sensitivity, it is necessary formalise this process. This may include criteria for assessing sensitivity, ecologically-relevant and observable thresholds for sensitivity.
- This analysis will underestimate the potential impact of fishing activity as the VMS data set does not represent the activity of smaller fishing vessels. This underestimation of impact is likely to be most pronounced within inshore coastal areas. It may be possible to include spatial zones (e.g. buffered coastal areas) that contain uncertainty penalties where it is presumed that the VMS activity does not represent the full range of activity. Alternatively, inshore areas could be completely removed from the analysis were it is known that the small, inshore fleet are dominant.

- It was recognised that the configuration of the final matric used to summarise the impact his also highly influential. Greater efforts are needed to ensure that the matrix is correctly configured.

4 Revisions to the work plan and justification

Two new ToRs are to be included for the 2017 meeting. These are:

- Sources of existing information to support habitat map production and method development
- Theoretical aspects of habitat mapping

5 Next meetings

Based on the dearth of mapping information for deep sea area and a suggestion from the Deep-water Ecology Working Group, the WGMHM wish to have a back to back meeting with DEWG 2017. Offers have been made to host the 2017 meeting, however, the venue for the 2017 meeting currently remains to be agreed.

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Annex 1: List of participants

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Annex 2: ToR B – National Progress Reports

Belgium – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	Belgium
Organisation completing NPR:	Royal Belgian Insitutue of Natural Sciences (Giacomo Montereale Gavazzi & Vera Van Lancker)
Map metadata uploaded into the ICES Geo-portal[1]:	NO
Cruise Summary Reports (CSR) uploaded[2]:	NO

Comments
Our cruises reports, metadata and data downloads (part of what we collect) are available at: http://odnature.naturalsciences.be/belgica/en/table/2015

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.)

Item	Organisation/Location
ROV[1]; VideoFrame[1]; Sediment Profile Imagery (SPI)[1]; STING (penetrometer)[2]	Provided by [1]VLIZ Flanders Marine Institute and [2]Belgian Navy

[1] http://geo.ices.dk/geonetwork/srv/en/main.home
[2] via either ICES or SeaDataNet

Table 3. Marine habitat mapping or modelling programmes.

Mapping programme	Purpose[3]	Location(s)[4]	Progress[5]	Comments	Reference or link

Table 4. Additional projects and products of interest.

Project name	Purpose[6]	Comments	Reference or link
Belspo - INDI67 Project Development of methods to improve the monitoring of MSFD indicators 6 and 7 WP3 Acoustic Seabed Mapping to Monitor Good Environmental Status PhD Giacomo Montereale Gavazzi	Research the discrimination potential of the EM3002D installed onboard RV Belgica. Research the effects of near-bed SPM concentrations on the continuous MBES backscatter measurement Assess the utility of MBES backscatter to monitor the benthic environment within a MSFD monitoring context (i.e. Seafloor Integrity) Establish a cooperative of seafloor mapping across Belgian Institutions (SEACOP)	Please contact me at gmontorealegavazzi@naturalsciences.be for any further information	**www.belspo.be**
Belspo – TILES project Transnational and Integrated Long-term Marine Exploitation Strategies	Creation of a 3D geological voxel model (up to -30m subsurface depth) of the Belgian and southern Netherlands part of the North Sea. The voxel model is further coupled to 4D numerical models to simulate erosion/deposition under various scenarios of exploitation.	Upper voxels contain detailed sediment information, and can be filled further with any habitat relevant parameter. Thresholds of habitat change will be determined based on acceptable variability of the lithological characteristics of the subsurface.	**www.belspo.be**; **www.odnature.naturalsciences.be/tiles** contact: vera.vanlancker@naturalsciences.be

[3] Habitats, physical seabed features, pressures etc.
[4] Sea area only.
[5] About to start, ongoing or complete.
[6] Technical development, mapping methods, data management, novel map products etc.

Denmark – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	Denmark
Organisation completing NPR:	DTU Aqua
Map metadata uploaded into the ICES Geo-portal[7]:	NO
Cruise Summary Reports (CSR) uploaded[8]:	NO

Comments

The following metadata records are available from the Danish national database (in Danish) http://data.geus.dk/geusmap/?mapname=marta#zoom=5.629124130280476&lat=6225000&lon=557500&visiblelayers=Topografisk&filter=&layers=&mapname=marta&filter=&epsg=25832&mode=map&map_imagetype=png&wkt=

Data on navigation lines, sea bed substrate, seismics, photo/video and additional data is available on the interactive map. Information is including habitate data gathered on several surveys during the period 2010-15 and before.

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.).

Item	Organisation/Location
Maritina is a 31-foot motor boat for marine geological cruises in Danish coastal waters. Equipped with hydraulics, fittings and a generator to handle and provide power for sample-taking equipment and geophysical instruments. To be used in water depths down to 2 m with a side scan sonar etc.	GEUS www.geus.dk
Lobstersledge equipped with a GoPro camera to be dragged on the sea bed used to identify Norway lobster caves and other sea bed features	DTU Aqua www.aqua.dtu.dk

[7] http://geo.ices.dk/geonetwork/srv/en/main.home
[8] Via either ICES or SeaDataNet

Table 3. Marine habitat mapping or modelling programmes.

Mapping programme	Purpose	Location(s)	Progress	Comments	Reference or link
National programme with the Danish Nature Agency as responsible	Danish Natura 2000 implementation	Danish waters	2011-15	Denmark has designated 97 marine Natura 2000 sites (28.500 km²) for marine species or habitats • 65 of these are designated for 1170 reef • 8 are designated for 1180 Submarine structures made by leaking gases	http://ec.europa.eu/environment/nature/natura2000/platform/documents/first_marine_biogeographical_process_seminar/theme_2/2_presentation_til_biogeografisk_seminar_en.pdf

Table 4. Additional projects and products of interest.

Project name	Purpose	Comments	Reference or link
Multidisciplinary mapping of fish habitats in the Sound, Denmark for maritime spatial planning	Mapping of fish habitats	DTU Aqua	http://naturstyrelsen.dk/media/179105/fiskehabitater-oeresund-dtu-aqua-opdateret-2016.pdf
Remore sensing based classification of structural elements of coastal habitats	Method development	DCE	http://dce2.au.dk/pub/SR144.pdf
Identifikation af potentielt velegnede områder for genetablering af stenrev i de	Identification of potential areas for reestablishment of stone reef in the south-eastern Great Belt	NIVA https://niva-denmark.dk	https://brage.bibsys.no/xmlui/handle/11250/2353278

Project name	Purpose	Comments	Reference or link
sydøstlige dele af Storebælt			

Additional points of interest (optional):

Part of the data mentioned is generated before 2015 being part of a major mapping exercise

Germany – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	Germany
Organisation completing NPR:	Federal Agency for Nature Conservation, Federal Maritime and Hydrographic Agency, Bioconsult Schuchardt & Scholl Gbr
Map metadata uploaded into the ICES Geo-portal[9]:	NO
Cruise Summary Reports (CSR) uploaded[10]:	partly

Comments

In German marine waters, biotope mapping is done for the EEZ and the coastal areas separately. Whereas the states are responsible for the Territorial Sea, the Federal Agency for Nature Conservation (BfN) deals with the German EEZ of the Baltic- and the North Seas. The biotope mapping here is done within two different projects, both funded by BfN. The Federal Maritime and Hydrographic Agency (BSH) thereby coordinates activities regarding sedimentological mapping on different spatial resolutions. Together with the company Bioconsult Schuchardt & Scholle Gbr and Alfred Wegener Institute (AWI) the Leibniz-Institute for Baltic Research, Warnemünde aims to use sedimentological and other abiotic data layers as well as benthic abundance information maps for the delineation of hard and soft bottom biotopes with the areas of interest.

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.)

Item	Organisation/Location
None	

[9] http://geo.ices.dk/geonetwork/srv/en/main.home
[10] via either ICES or SeaDataNet

Table 3. Marine habitat mapping or modelling programmes.

Mapping programme	Purpose[11]	Location(s)[12]	Progress[13]	Comments	Reference or link
Marine Biotope Mapping in Germany	Nature conservation issues and EU directives	German EEZ and coastal waters	Ongoing	Separate projects for EEZ and coastal waters: With the scope to map annex I habitats and legally protected as well as red listed biotopes	
SedAWZ II	Standardized sediment distribution maps	German EEZ	Ongoing	Area-covering sediment distribution maps are created primarily for the mapping and modelling of marine biotope (see other project)	Web-link to the standardised guideline in May 2016 (german;) & August 2016 (english))

Table 4. Additional projects and products of interest.

Project name	Purpose[14]	Comments	Reference or link
None			

Additional points of interest (optional):

Within the sediment mapping programme SedAWZII, the BSH and its project partners AWI, CAU, IOW and SaM have developed a specific technical guideline that includes requirements for the collection, processing and interpretation of backscatter data. Focus was put on the latter, whereby standardized strategies for the classification and discrimination were defined for different seafloor sediment types. An alignment of the guideline with similar efforts of other EU countries and projects is planned. Therefore, discussions and comments within and from the working group are welcome and needed.

[11] Habitats, physical seabed features, pressures etc.
[12] Sea area only.
[13] About to start, ongoing or complete.
[14] Technical development, mapping methods, data management, novel map products etc.

Iceland – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	Iceland
Organisation completing NPR:	Marine Research Institute
Map metadata uploaded into the ICES Geo-portal[15]:	NO
Cruise Summary Reports (CSR) uploaded[16]:	NO

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.)

Item	Organisation/Location
High definition cameras have been installed in our video platform.	

Additional points of interest (optional):

The Marine Research Institute is funding a habitat mapping cruise to be carried out in June, 2016. The objective of this cruise is to map *Geodia* spp. fields off north-western Iceland, and to quantify the effects of fishing pressure (mainly bottom trawlers) on the diversity and biomass of sponges and other megafauna. The main mapping tool will be underwater video and photographs.

15 http://geo.ices.dk/geonetwork/srv/en/main.home

16 via either ICES or SeaDataNet

Table 3. Marine habitat mapping or modelling programmes.

Programme	Purpose[17]	Location(s)[18]	Progress[19]	Comments	Reference or link
Multibeam Mapping Project, internal project of the Marine Research Institute.	Obtain high-resolution depth and backscatter data.	Iceland EEZ, focusing on areas holding important fishery resources or VMEs.	In recent years the project has focus on areas off the South and West of Iceland.	The project started in 2000. Mapping is carried out on board the Árni Fridriksson using a Simrad EM 300 echo sounder.	Marine Environment Section, Marine Research Institute, Iceland
Habitat Mapping Project, internal project of the Marine Research Institute.	General habitat mapping, identifying location of VMEs	The Icelandic continental shelf and slope, mainly on depths down to 700m. Focus on the southern and western shelves.	Habitat mapping surveys have been carried out in 2004, 2009, 2010, 2011 and 2012. A total of 116 dives have been carried out.	During the early phase of the project (until 2010) main focus was on Lophelia reefs off the southern coast. In recent years there has been a more wide focus, targeting other areas mainly off West Iceland. The next mapping objective are the Geodia fields off the Westfjors, NW Iceland. Small-scale habitats maps are in preparation for the Lonsdjúp and Hafadjúp areas in the southern shelf. In addition, broad-scale habitat maps based on the EUSeaMap project are being developed for the entire Icelandic shelf.	
Atumm Bottom Trawl Survey by-catch analysis	Use the by-catch on the annual Autumn Bottom Trawl Survey to obtain information on the species composition and broad scale distribution of benthic invertebrates.	The Icelandic continental shelf	Data was collected during the 2015 survey on 59 stations. Funds are secured to continue this work during the 2016 survey.	The project is partially funded by the AVS research and development fund of Ministry of Fisheries and Agriculture in Iceland	
Habitat mapping of	Obtain a broad-scale	The northern Dreki area,	Analysis of trawl data	This project is part of a Master's student thesis, in collaboration with the Univer-	

[17] Habitats, physical seabed features, pressures etc.
[18] Sea area only.
[19] About to start, ongoing or complete.

bathyal benthic habitats in the Dreki area	habitat map	Icelandic EEZ	suggested the existence of six habitats using Maxent.	sity of Iceland.	

Table 4. Additional projects and products of interest.

Project name	Purpose[20]	Comments	Reference or link
Iceland Seabed Map	*To compile and harmonise all available sea-bed substrate information withing Iceland's EEZ at a scale of 1:250 000.*	Project carried out by ISOR (Iceland Geosurvey) between 2013 and 2016.	http://isor.is/kortlagning-landgrunnssvaeda

[20] Technical development, mapping methods, data management, novel map products etc.

Portugal – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	Portugal
Organisation completing NPR:	IPMA - Portuguese Institute for the Ocean and Atmosphere
Map metadata uploaded into the ICES Geo-portal[21]:	NO
Cruise Summary Reports (CSR) uploaded[22]:	NO

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.).

Item	Organisation/Location
Ocean going research vessel "Mar Portugal"	IPMA/Lisbon
Multibeam (200–400 kHz) for seabed survey in the PT platform (~250m max.depth)	IPMA/Lisbon
Video Camera for seabed survey in coastal areas (up to ~120 m max. depth).	IPMA/Lisbon

[21] http://geo.ices.dk/geonetwork/srv/en/main.home
[22] via either ICES or SeaDataNet

Table 3. Marine habitat mapping or modelling programmes.

Mapping programme	Purpose[23]	Location(s)[24]	Progress[25]	Comments	Reference or link
BIOMETORE -Biodiversity in seamounts: The Madeira-Tore and Great Meteor	Biodiversity, Habitats	Northeast Atlantic seamounts in the Madeira-Tore and Great Meteor areas	Ongoing	This project aims to the increase knowledge on deep-sea ecosystems and biodiversity at the Atlantic seamounts of the Madeira-Tore and Great Meteor geological complexes. The project outputs will contribute to fulfil knowledge gaps on their biodiversity and thus will provide important information for understanding and improve management of the targeted seamount ecosystems.	www.biometore.pt
HABITMAP	Marine park management. Habitat mapping, Biodiversity	Portuguese SW coastal area	Complete	Small project, national funded, aiming to contribute with seabed information for a Portuguese SW coastal marine park management (PNSACV). Testing new equipment for seabed survey.	

Table 4. Additional projects and products of interest.

Project name	Purpose[26]	Comments	Reference or link

[23] Habitats, physical seabed features, pressures etc.
[24] Sea area only.
[25] About to start, ongoing or complete.
[26] Technical development, mapping methods, data management, novel map products etc.

Republic of Ireland – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	Ireland
Organisation completing NPR:	Marine Institute
Map metadata uploaded into the ICES Geo-portal[27]:	NO
Cruise Summary Reports (CSR) uploaded[28]:	NO

Comments
All new habitat maps generated are merged into the existing collated habitats shapefile generated as part of the MeshAtlantic project and stored on the Marine Atlas webGIS. Metadata is provided for all habitat maps with links to the Irish Spatial Data Exchange (ISDE) which is in turn linked to Geonetworks. These metadata can be shared and harvested using CSW.

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.)

Item	Organisation/Location
Small inshore vessel (Pilot House 20)	INFOMAR – Irish National Seabed Mapping Project
R.V. Celtic Explorer fitted with a new EM302 deep-water multi-beam, a shallow water EM2040 multi-beam and a new sub-bottom profiler	INFOMAR – Irish National Seabed Mapping Project
R. V. Celtic Voyager fitted with a new shallow water EM2040 multi-beam	INFOMAR – Irish National Seabed Mapping Project

[27] http://geo.ices.dk/geonetwork/srv/en/main.home
[28] via either ICES or SeaDataNet

Table 3. Marine habitat mapping or modelling programmes.

Mapping programme	Purpose[29]	Location(s)[30]	Progress[31]	Comments	Reference or link
INFOMAR	Hydrography and Physical Seabed Features and Habitats	26 priority bays in Irish coastal waters	Acquisition is complete.	Generation of habitat maps will commence as soon as the acquired data is post-processed and the bathymetry and backscatter products have been finalised.	http://www.infomar.ie/data/
Natura 2000 Sites Assessment	Habitat mapping	Special Areas of Conservation (SAC) sites in Irish coastal waters.	Ongoing	Sample data has been acquired for 70 SACs in coastal marine areas. These data are currently being used to create biotope complex maps that are the base layers used in: (1) Appropriate Assessments of aquaculture sites and (2) Risk Assessment of inshore fishing activity in the protected bays.	http://www.npws.ie/maps-and-data/habitat-and-species-data

Table 4. Additional projects and products of interest.

Project name	Purpose[32]	Comments	Reference or link
ProAtlantic	The Atlantic Checkpoint is a basin scale wide monitoring system assessment activity based upon targeted end-user applications. The outcome of this evaluation will be the assessment of fitness for purpose showing performance and	The Marine Institute (MI) is leading the Fisheries Impact Challenge which aims to produce gridded layers to quantitatively assess the impact of bottom contact fishing activity on the seafloor, and in	http://www.emodnet-atlantic.eu/

[29] Habitats, physical seabed features, pressures etc.
[30] Sea area only.
[31] About to start, ongoing or complete.
[32] Technical development, mapping methods, data management, novel map products etc.

	gaps within the present monitoring systems	particular the damage to sensitive and declining habitats.	
MIM – Sampling Design Group	To develop optimal sampling designs for ground-truthing.	The group has just recently been formed and comprises scientists from MAREANO, INFOMAR and MAREMAP. The MI will aim to test the applicability of the Environmental Variability Index (developed by MAREANO) in guiding sampling effort.	

United Kingdom – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	United Kingdom
Organisation completing NPR:	Joint Nature Conservation Committee (JNCC) Agri-Food and Biosciences Institute (AFBI) Marine Scotland Science (MSS) Centre for Environment, Fisheries and Rural Affairs (Cefas)
Map metadata uploaded into the ICES Geo-portal[33]:	YES
Cruise Summary Reports (CSR) uploaded[34]:	NO

Comments

The following map metadata records have been uploaded into the ICES Geo-portal:

- Broadscale Habitat (EUNIS Level 3) for East Of Celtic Deep Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level 3) for Farnes East Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level 3) for North East Of Farnes Deep Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level 3) for East Of Haig Fras Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level 3) for Markham's Triangle Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level 3) for South East Of Falmouth Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level 3) for Western Channel Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level 3) for Fulmar Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level3) for the Offshore Brighton Recommended Marine Conservation Zone (RMCZ)
- Broadscale Habitat (EUNIS Level3) for the Mid St George's Channel Recommended Marine Conservation Zone (RMCZ)
- Seabed Habitats west of the Isle of Lewis in Scotland

Cruise Summary Reports are not currently uploaded by most organisations as a matter of course. This policy is currently under review by senior management at AFBI.

[33] http://geo.ices.dk/geonetwork/srv/en/main.home
[34] Via either ICES or SeaDataNet

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.)

Item	Organisation/Location
Updated camera frame to HD with deep water capability	Cefas
PORSMV v5 upgrade	Marine Scotland Science
Upgrade of underwater video system - New HD camera purchase- integrated onto towed sledge and optimised first for Nephrops UWTV surveys	AFBI

Table 3. Marine habitat mapping or modelling programmes.

Mapping programme	Purpose	Location(s)	Progress	Comments	Reference or link
Data and Evidence Coordination Programme for recommended Marine Protected Areas - MB0129	To produce broad-scale physical habitat maps (EUNIS level 3) to support designation of MCZs in UK Secretary of State waters.	UK Secretary of State waters, which comprises all English inshore waters (within 12nm), plus offshore waters (beyond 12nm) around England, Wales and NI.	Ongoing	~15 habitat maps completed or in progress in the last 12 months. Funded by Department of Environment, Food and Rural Affairs; coordinated by Cefas.	http://randd.defra.gov.uk/Default.aspx?&Module=More&ProjectID=18983
Nearshore habitat mapping ad-hoc programme in Northern Ireland for Marine Conservation Zones designation	To produce EUNIS levels 3 and 4 habitat maps to support designation of MCZs in NI.	NI inshore waters, specifically: Strangford Lough Dundrum Bay (Murlough) Belfast Lough Offshore Rathlin Island	Complete	Part-funded by Department of Environment NI (DOENI – now DAERA) with match funding from AFBI. Full coverage maps for Strangford Lough and Dundrum Bay; Acoustic facies map for Belfast Lough with classified ground-truthing; Classified ground-truthing for offshore Rathlin Island.	https://www.afbini.gov.uk/articles/seabed-habitat-mapping
MAREMAP	To bring together Natural Environment Research Council (NERC) organisations with common geoscience objectives to integrate their research and inform practical applications such as marine planning, conservation and industry.	All UK	Ongoing		www.maremap.ac.uk
Annual NI seed mussel stock assessment	Seed mussel bed extent to determine fishery conditions (tonnage) for NI Department of Agriculture and Rural Development (now 'DAERA')	Ards Peninsula	Ongoing	RoxAnn acoustic ground discrimination system coupled with dredges, video and grab surveys. Once or twice yearly surveys.	https://www.daera-ni.gov.uk/articles/mussel-seed-fishery
Updating UK priority	To compile the best available data for	All UK	Ongoing	Work carried out by JNCC, Natural England, NRW, SNH,	http://jncc.defra.gov.uk/seabedhabitatm

Mapping programme	Purpose	Location(s)	Progress	Comments	Reference or link
habitat compilations	OSPAR threatened and/or declining habitats, Habitats Directive Annex I habitats and nationally listed priority habitats.			DOENI. OSPAR habitats updated March 16 Habitats Directive habitats update in progress Semi-automated mapping of rock at the seabed at a regional scale – North Sea completed June 2016 (awaiting publication).	apdata OSPAR habitats: http://jncc.defra.gov.uk/page-1583 Habitats Directive habitats: http://jncc.defra.gov.uk/page-1447 Semi-automated mapping of rock: http://jncc.defra.gov.uk/page-7074

Table 4. Additional projects and products of interest.

Project name	Purpose[35]	Comments	Reference or link
Habitat mapping standardisation	To identify priorities for further standardisation of habitat mapping methods.	No funding allocated.	Workshop report
Natural England Evidence Base	To catalogue and standardise Natural England's seabed habitat data holdings and to make it available for staff.	Natural England	
Marine Scotland Interactive	For sharing spatial data, such as bathymetric data, backscatter,	Marine Scotland Science	http://www.gov.scot/Topics/marine/science/MSInteractive

[35] Technical development, mapping methods, data management, novel map products etc.

Project name	Purpose[35]	Comments	Reference or link
website	sub-bottom profiling, videos and photographs.	Data is available in many formats and can be viewed on freely available software such as Google Earth or ArcGIS Explorer.	
BGS Seabed Mapping Toolbox	To allow the systematic application of a sequence of tools available in ArcGIS to recognise, spatially delineate and characterise morphometrically seabed mounds and pockmarks.	Developed by the British Geological Survey (BGS).	Stewart, H.; Gafeira, J. 2016 Quantitative analysis of mini-mounds from the Explorer and Dangeard canyons area: an automated approach. [Poster] In: *Marine Geological and Biological Habitat Mapping (GeoHab) 15th International Symposium, Winchester, UK, 2-6 May 2016*. British Geological Survey http://nora.nerc.ac.uk/513511/ Gafeira, J.; Long, D.; Diaz-Doce, D.. 2012 Semi-automated characterisation of seabed pockmarks in the central North Sea. *Near Surface Geophysics*, 10 (4). 303-314. http://nora.nerc.ac.uk/19728/
A new classification system for seabed geomorphology	To create a complete and consistent classification system for seabed morphological features in order to begin a new map series on Seabed Geomorphology.	Developed by the BGS.	
R tool development: - Data exploration tool for habitat mapping - Developing a tool for automated benthic habitat mapping and accuracy assessment using bootstrap aggregation	To provide easily accessible tools for supporting a standardised workflow for data exploration and habitat suitability modelling, including a spatial representation of accuracy.	Developed by Cefas, who are hoping to make the tools available through GeoHab website.	
Complex Deep-sea Environments: Mapping habitat heterogeneity As Proxy for	To develop a robust, integrated and fully 3D methodology to map complex deep-sea habitats, using a combination of acous-	CODEMAP is a Starting Grant project supported by the European Research Council (ERC) and being carried out	http://www.codemap.eu/

Project name	Purpose[35]	Comments	Reference or link
biodiversity (CODEMAP)	tic and visual techniques To quantify the heterogeneity of those habitats at a variety of scales, and establish statistical relationships between those scales To test the potential of habitat heterogeneity as proxy for epibenthic megafauna biodiversity.	by the National Oceanography Centre.	
Irish Sea mud Marine Conservation Zone alternative site development	To support designation of Marine Conservation Zones in the Irish Sea with stakeholder (fishing industry)-suggested alternative sites evaluated	Analysis of all available grab and video data from potential MCZ sites in the western Irish Sea for habitat type and condition; development of map for"Queenie Corner". Funded in part by Seafish, match funding by AFBI (complete)	http://www.seafish.org/media/Publications/Evidence_base_mud_MCZs_IrishSea_v1_2-FINAL.pdf (not yet uploaded to ICES GeoPortal – need to check with data owner)
Collaborative mapping of Belfast Lough (AFBI, British Geological Survey, Belfast Harbour)	EUNIS level 3 (& 4 where possible) and surficial sediment maps	New MBES data collected for inner Lough, backscatter and bathymetry stitched together with existing outer Lough data. Surficial sediment map completed, habitat map near completion (expected 12/2016)	
Mapping of *Modiolus modiolus* biogenic reefs in the Ards peninsular	EC Habitats Directive Annex I habitat extent and mapping for DOENI (now DAERA) to support SAC designation	Analysis of UKHO Civil Hydrography Programme and AFBI MBES with additional ground-truthing (ongoing)	

United States of America – ICES Working Group Marine Habitat Mapping: National Progress Report (2015–2016)

Table 1. National progress report (NRP) source and uploads.

Country:	USA
Organisation completing NPR:	National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center (AFSC), Juneau, Alaska, USA
Map metadata uploaded into the ICES Geo-portal[36]:	NO
Cruise Summary Reports (CSR) uploaded[37]:	NO

Comments

Habitat mapping programs reported for the 2015/2016 US National Progress Report include activities of the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean Exploration and Research (OER), and the NOAA Joint Hydrographic Center (JHC) at the University of New Hampshire Center for Coastal and Ocean Mapping (UNH CCOM). NOAA National Marine Fisheries Service (NMFS) habitat modeling for Essential Fish Habitat is reported for the North Pacific Region, following the programatic update for 2015/2016.

[36] http://geo.ices.dk/geonetwork/srv/en/main.home
[37] Via either ICES or SeaDataNet

Table 2. New mapping infrastructure (significant items such as ships, sonars, ROVs etc.).

Item	Organisation/Location

Comments: none

Table 3. Marine habitat mapping or modelling programmes.

Mapping programme	Purpose[38]	Location(s)[39]	Progress[40]	Comments	Reference or link
NOAA Office of Ocean Exploration and Research (OER), NOAA ship *Okeanos Explorer*	Mapping for ocean exploration.			General program information reference and contact.	http://oceanexplorer.noaa.gov/okeanos/welcome.html Elizabeth (Meme) Lobecker, Physical Scientist, Integrated Ocean and Coastal Mapping (IOCM) center at University of New Hampshire (UNH) Joint Hydrographic Center (JHC) meme.lobecker@noaa.gov
NOAA OER NOAA ship *Okeanos Explorer* 2015 field season.	Mapping for ocean exploration.	Caribbean Basin, Hawaiian Islands, Pacific Islands National Monuments.	Complete.	2015 field season overview.	http://oceanexplorer.noaa.gov/okeanos/explorations/2015-overview/welcome.html
NOAA OER NOAA ship *Okeanos Explorer* Caribbean Trenchs and Seamounts February 18 - April 30, 2015.	Map and explore deepwater habitats. Conduct high resolution multibeam seafloor mapping in areas without existing data. Explore the Puerto Rico	Continental shelf and slope, and deeper areas of interest in the vicinity of Puerto Rico, St Croix, and the US Virgin Islands, including the Puerto Rico Trench.	Complete.	Seafloor bathymetry, seafloor backscatter, water column backscatter, sub-bottom stratigraphic profiles, and XBT casts at regular intervals. Continuous underwater video and photographic images collected during ROV operations.	http://oceanexplorer.noaa.gov/okeanos/explorations/ex1502/welcome.html

[38] Habitats, physical seabed features, pressures etc.
[39] Sea area only.
[40] About to start, ongoing or complete.

	Trench with the ROV *Deep Discoverer* to 6,000 m depth.				
NOAA OER NOAA ship *Okeanos Explorer* Transit from San Juan, Puerto Rico to Eastern Pacific Islands May 8 - June 12, 2015.	Conduct continuous mapping along ship trackline in transit.	Areas in transit between San Juan, Puerto Rico, Panama City, Panama, and Pearl Harbor, Hawaii, along the Clipperton Fracture Zone.	Complete.	Seafloor bathymetry, seafloor backscatter, water column backscatter, split-beam sonar, sub-bottom stratigraphic profiles, and XBT casts at regular intervals.	http://oceanexplorer.noaa.gov/okeanos/explorations/ex1503/background/plan/welcome.html
NOAA OER NOAA ship *Okeanos Explorer* Hohonu Moana, Exploring Deep Waters off Hawaii July 10 - September 30, 2015.	Map and explore deepwater habitats.	Papahānaumokuākea Marine National Monument in the Northwestern Hawaiian Islands, Johnston Atoll in the Pacific Remote Islands Marine National Monument, the Geologists Seamounts group, and the Main Hawaiian Islands.	Complete.	Seafloor bathymetry, seafloor backscatter, water column backscatter, sub-bottom stratigraphic profiles, and XBT casts at regular intervals. Continuous underwater video and photographic images collected during ROV operations.	http://oceanexplorer.noaa.gov/okeanos/explorations/ex1504/background/plan/welcome.html
NOAA OER NOAA ship *Okeanos Explorer* 2016 field season.	Mapping for ocean exploration.	Hawaiian Islands, Commonwealth of the Northern Marianas Islands, Marianas Trench	In Progress.	2016 field season overview.	http://oceanexplorer.noaa.gov/okeanos/explorations/2016-overview/welcome.html

		Marine National Monument, and Wake Atoll section of the Pacific Remote Islands Marine National Monument.			
NOAA OER NOAA ship *Okeanos Explorer* Hohonu Moana, Exploring Deep Waters off Hawaii February 25 - March 15, 2016.	Map and explore deepwater habitats. Collect baseline inforamtion from previously unexplored areas. Continuation of 2015 mapping expidition to the area.	Papahānaumokuākea Marine National Monument in the Northwestern Hawaiian Islands.	Complete.	Seafloor bathymetry, seafloor backscatter, water column backscatter, sub-bottom stratigraphic profiles, and XBT casts at regular intervals. Continuous underwater video and photographic images collected during ROV operations.	http://oceanexplorer.noaa.gov/okeanos/explorations/ex1603/background/plan/welcome.html
NOAA OER NOAA ship *Okeanos Explorer* Mapping in the Pacific Remote Islands Marine National Monument March 23 - April 18, 2016.	Map and explore deepwater habitats. Collect baseline inforamtion from previously unexplored areas. Continuation of 2015 mapping expidition to the area.	Wake Atoll section of the Pacific Remote Islands Marine National Monument.	Complete.	Seafloor bathymetry, seafloor backscatter, water column backscatter, sub-bottom stratigraphic profiles, and XBT casts at regular intervals. Continuous underwater video and photographic images collected during ROV operations.	http://oceanexplorer.noaa.gov/okeanos/explorations/ex1604/welcome.html
NOAA OER NOAA ship *Okeanos Explorer*	Map and explore deepwater habitats. Collect	Marianas Trench Marine National Monument and the	In Progress.	Seafloor bathymetry, seafloor backscatter, water column backscatter, sub-bottom strati-	http://oceanexplorer.noaa.gov/okeanos/explorations/ex1605/background/plan/welcome.html

Deepwater Exploration of the Marianas April 20 - July 10, 2016.	baseline inforamtion from previously unexplored areas. Continuation of 2015 mapping expidition to the area.	Commonwealth of the Northern Mariana Islands.		graphic profiles, and XBT casts at regular intervals. Continuous underwater video and photographic images collected during ROV operations.	
University of New Hampshire (UNH), Center for Coastal and Ocean Mapping (CCOM), NOAA Joint Hydrographic Center (JHC), Chase Ocean Engineering Lab, Durham, New Hampshire, USA				General program information reference and contact.	Paul Johnson, Data Manager, pjohnson@ccom.unh.edu Larry Mayer, CCOM Director, JHC Co-Director, larry@ccom.unh.edu Andy Armstrong, JHC Co-Director, andy.armstrong@noaa.gov http://ccom.unh.edu http://ccom.unh.edu/reports
UNH, CCOM, NOAA JHC UNCLOS Atlantic Margin Mapping, R/V Marcus Langseth 2015	US Law of the Sea Cruise to Map the Foot of the Slope of the Northeast U.S. Atlantic Continental Margin.	US Atlantic Margin.	Complete.	Seafloor bathymetry, seafloor backscatter, and sub-bottom stratigraphic profiles.	http://ccom.unh.edu/publications/us-law-sea-cruise-map-foot-slope-northeast-us-atlantic-continental-margin-leg-8
UNH, CCOM, NOAA JHC UNCLOS Kingman Reef-Palmyra Atoll	US Law of the Sea Cruise to Map the Western Flank of the	Kingman Reef-Palmyra Atoll, Line Islands, Equatorial Pacific Ocean.	Complete.	Seafloor bathymetry, seafloor backscatter, and sub-bottom stratigraphic profiles.	http://ccom.unh.edu/publications/us-law-sea-cruise-map-western-flank-kingman-reef-palmyra-atoll-section-line-

Mapping R/V Kilo Moana, KM15-20, 2015	Kingman Reef-Palmyra Atoll Section of the Line Islands, Equatorial Pacific Ocean.				islands
UNH, CCOM, NOAA JHC UNCLOS Kingman Reef-Palmyra Atoll Mapping R/V Ron Brown, RB16-01, 2016	US Law of the Sea Cruise to Map the Western Flank of the Kingman Reef-Palmyra Atoll Section of the Line Islands, Equatorial Pacific Ocean.	Kingman Reef-Palmyra Atoll, Line Islands, Equatorial Pacific Ocean.	In Progress.	Seafloor bathymetry, seafloor backscatter, and sub-bottom stratigraphic profiles.	

Table 4. Additional projects and products of interest.

Project name	Purpose[41]	Comments	Reference or link
Essential Fish Habitat (EFH) 2015/2016 Update.	Review and update EFH definitions for species in a fishery management plan (FMP) for the North Pacific Region, including the Gulf of Alaska, Bering Sea, and Aleutian Islands. Update the Fishing Effects Model for	EFH definitions for FMP species are required to be updated and approved by the North Pacific Fishery Management Council (NPFMC) in accordance with the Magnuson-Stevens Fishery Conservation and	John Olson, NOAA, Alaska Region (AKR), Habitat Conservation Division (HCD), john.olson@noaa.gov Jodi Pirtle, NOAA, Alaska Fisheries Science Center (AFSC), jodi.pirtle@noaa.gov

[41] Technical development, mapping methods, data management, novel map products etc.

	the North Pacific to estimate fishing impacts to EFH, including estimates of seafloor contact from all bottom-contacting gear types.	Management Act. The update for 2015/2016 applied a species distribution modeling approach, which was the first incorporation of a modeling approach to EFH since the first definitions were adopted in 2005. EFH updates were reviewed by NOAA stock assessment authors and accepted by the NPFMC. The Fishing Effects Model is currently in review with the NPFMC. The next EFH review and update is scheduled for 2020, where the Chukchi Sea and waters of the US Artic will be included.	Chris Rooper, NOAA, AFSC, chris.rooper@noaa.gov https://alaskafisheries.noaa.gov/habitat/efh

Additional points of interest (optional): none

Annex 3: ToR C – Habitat mapping techniques and modelling

Workshop on Marine Biotope Mapping for Conservation Purposes

30 November to 2 December 2015, BfN, Isle of Vilm, Germany

Introduction and German mapping activities

Welcome and introduction to the background and aims of the workshop (Henning von Nordheim, BfN)

- There is a lot of habitat mapping work going on in Germany at the moment. The workshop is to discuss common issues and to learn from each other.

New definitions and classifications for red listed marine biotopes in the German Baltic Sea and North Sea (Karin Fürhaupter, MARILIM, Germany)

- There is a big, coordinated mapping project going on in German offshore waters (North Sea and Baltic Sea).
- First they had to choose a habitat classification system to use so they set some criteria for the requirements of a German habitat classification, including: hierarchical, including biotic and abiotic factors, consistent approach in N Sea and Baltic Sea.
- They chose to align with HELCOM HUB (hierarchy on website) as EUNIS was under development.
- She said the vertical zones are split by eulittoral (NS), hydrolittoral (B), sublittoral (both); however, on the website the distinctions are photic benthos, aphotic benthos, photic pelagic, aphotic pelagic and seasonal ice – different versions? Or was she talking about the German adaption of HUB?
- At the substrate level they use strict definitions, including a biogenic category.
- They have created a national 'red list' with different category names and different definitions compared with IUCN, e.g. trend over 10 years rather than 50, area <500 ha for rarity.
- Results in N Sea: 130 biotopes analysed, 12 classed as 'collapsed' (e.g. oyster beds, Sabellaria reefs), 68 'red listed', 24 'least concern'.
- This analysis is rerun periodically – this is the third iteration.
- Question: why is salinity not included in the abiotic levels of the classification system? Answer: the communities give you the salinity, and many communities span several regimes so didn't want to split – same principle for all abiotic factors where possible.
- Question (me, afterward): are there many HUB communities spread across multiple sediment types? If so, do they repeat the communities in multiple sediment classes? Answer: yes, and yes. Also have a 'mixed substrate' class to account for the problems with mapping – there is lots of this feature in the Baltic. The communities in the mixed substrate section are all epibenthic.

Seabed sediment mapping in the German Exclusive Economic Zone (Claudia Propp, BSH, Germany)

- As a prior step to habitat mapping, they have first been carrying out dedicated surveys and analysis for sediment mapping. They have used both Folk (simplified to 4 EUNIS level 3 classes with 9:1 boundary where there is limited ground-truthing) and Figge (to give more detail in the sand fraction, because the German EEZ in the Northsea is very sandy).
- Manual delineation of sediment types from backscatter with the support of GIS-segmanetation tools
- Heterogeneous areas more difficult, have to set rules for standardised interpretation, including:
    - Structure/polygon > 100 m across
    - Editing scale of 1:10k
- Gradual transitions also difficult (diffuse boundaries), so they distinguish between distinct and diffuse boundaries visually by having an additional polyline layer contain a mixture of hard and dashed lines. This is possible because the classification is done manually using expert judgement.
- In German EEZ there are lots of patchy areas at a higher resolution than the minimum mapping unit of 100 m and there are lots of areas where there are disagreeing points closer than the minimum mapping unit. So:
    - Patchy areas with more of sediment A than sediment B: put this all in one polygon and call it "sediment A *and* sediment B".
    - Areas within which it is difficult to see boundaries but have sample points indicating presence of both sediment A and sediment B: put this all in one polygon and call it "sediment A *to* sediment B".
- Challenges:
    - Need a definition for stone fields (geogenic reefs)
    - Automated classification of stones
    - Shallow environments, dynamic areas, very patchy areas may need higher minimum mapping units
    - Want consistency with other countries
- Question: could compare results from multiple interpreters to give the confidence interval around diffuse boundaries and therefore determine a posteriori whether it is diffuse based on agreement rather than a priori. Answer: nice idea but not enough time.

Biotope modelling in German offshore waters (EEZ of Baltic Sea and North Sea) at different spatial scales (Roland Pesch, BIOCONSULT, Germany)

- After the sediment mapping described above they started with the habitat/biotope mapping.
- Mapping occurred at a relatively broad scale: 1nmx1nm grid
- Used HELCOM HUB (2013) in Baltic Sea. For N Sea, German classification system wasn't ready yet so used a fusion of HELCOM HUB and EUNIS.
- Have an Access database with benthic records: 84k species, 1,500 sediment records, 3244 stations.

- Predictive modelling of communities/biotopes: mainly decision tree, e.g. Random Forest.
- Schiele *et al.* (2015) – resultant infaunal map in Baltic – various HUB levels (not always possible to go to the most detailed level). No map for epibenthos.
- N Sea level 5 communities – cluster analysis to classify, then modelling – 6 communities for whole EEZ.
- Now looking at high resolution mapping of small areas.
- Question (Vera, Belgium): is there an MSFD application? Answer: the community map was included in the physical damage indicator assessment.

Habitat mapping in coastal waters of the German State of Schleswig-Holstein – where are we? (Hans-Christian Reimers, LLUR-SH, Germany)

- Responsibility for territorial waters lies with the federal states. This is an update from the state of Schleswig-Holstein, which is the one bordering Denmark.
- Parametric sediment echo sounder profiles used for vertical structure – e.g. helps with sandbank mapping.
- Surveying 250 km^2 takes about 50 good days. Roughly €2000–3000 km^{-2}.
- Mapped sediment distribution in one layer, and bed forms and benthos in another layer.
- Last year started a new project for mapping the white ribbon around the coast. There is less understanding about sedimentological development in these areas, especially where waves are breaking. Maps don't exist.
- Challenges:
    - Identification and definition of stone fields in shallow water.
    - Identification of stone fields in stable versus mobile sand areas.
    - Do macrophytes and macrozoobenthos affect detection and identification of stones with acoustic methods?
    - Others.

Biotope mapping in the Baltic Sea

HUB-maps of selected biotopes covering the whole Finnish seafloor (Matti Sahla, Metsähallitus, Finland)

- Lots of point data, containing species observations and many have things like height of macrophytes. Mainly macroscopic algae and macrophytes due to mostly using video data.
- 1–10 000 records of around 300 species.
- Point data transformed to biotopes (HUB) – wrote scripts to do this automatically using information in the database.
- Map portal to open in early 2016, data will be public; so will the R code for the modelling.
- Making maps – used point data to match optimal physical conditions for species. Used modelling but allowed for expert judgement when data wasn't available. Doing this biotope-by-biotope (done 7 so far, e.g. emergent vegetation, epibenthic bivalves, filamentous algae, *Fucus* spp.) for the whole sea area.

- Used their own model that allows for a lot of expert intervention when the statistics aren't making sense.
- 20x20m resolution (high enough for planning purposes) but will publish at a lower resolution to reflect the uncertainty.
- Use of substrate – models don't take substrate into account but when mapping it is considered. E.g. *Fucus* spp. are modelled, and then clipped to the extent of hard substrate from geological surveys.
- Individual models can be combined to show dominant biotope.
- Question: could we get to a point where expert judgement is not needed? Answer: there is not enough data at the moment but in theory, yes.
- Question (Roland): will the model be available? Answer: yes – everything will be made public. Although it's possibly not very user-friendly at the moment but an ArcToolbox could be created, for example.

Status of marine biotope mapping in Sweden including scales (Mona Naeslund, Swedish Species Information Centre, SLU)

- Interpolation when they have evenly dispersed point data, e.g. depth, used as background data for modelling.
- Have modelled Zostera beds, Mytilus edulis beds, all Annex I – used substrate, depth and curvature for sandbanks and reefs. Done this for 6/14 counties, where substrate data is available. Mainly GAM but also tried Random Forest.

Status of marine biotope mapping in Lithuania (Andrius Syaulis, Klaipeda University, Lithuania)

- Note that Lithuania has a tiny sea area – coastline about the length of Cumbria's.
- Have a full coverage substrate map and DEM.
- Got a good idea of the distribution of soft bottom communities, e.g. variation with depth – 5 main communities. Have point records of these.
- Hard bottom communities are not as well understood. They don't usually come to the shore and only have a few boulder areas.
- Biotope maps for inshore area and some offshore areas = substrate + community.
- Challenges:
    - Habitats change over time, e.g. mytilus beds have almost completely gone over the last 5 years.

Current status and methodology used in Estonia for marine habitat mapping (Georg Martin, Estonian Marine Institute)

- EBHAB classification system developed for Eastern Baltic (Estonia and Lithuania) – 25 classes, with 18 in Estonia – not hierarchical.
- Divided into soft vs hard and sheltered vs moderately exposed, then named based on dominant community.
- These classes correlate with Annex I habitats.
- Also modelling, using point data from video and scuba. Modelling methods tested – GAM, RF, boosted regression trees.
- Modelled several species, including zostera, mytilus beds, balanus.
- Also tried modelling reef and sandbanks.

- In future will try to use HUB.
- Have currently mapped about 50 % of EEZ, with most in territorial waters.

Lessons learnt from new approaches for mapping submerged macrophytes (Kolja Beisiegel, Leibniz Institute for Baltic Sea Research Warnemünde, Germany)

- Modelling macroalgae biotopes from HUB using hard substrate and photic zone was modelled.
- HUB works well for soft sediment but less developed for hard bottoms (epibenthos) because it's difficult to get quantitative data using towed video (oblique angle).
- Now using new methods to get more quantitative results:
    - Diver frame sampling – 0.1m^2 scrape everything off and take away for analysis (including biomass). Didn't do transects because quite deep so didn't have much time underwater.
    - Referenced imaging (video and photo) (1 vertical view and 1 oblique view (to see what's coming)) - Baltic seafloor imaging system (BASIS). 30s photo intervals (at 0.5 knot). Use CPC software to analyse – scaling (e.g. 0.4m^2), add random points (e.g. 50) and assign species at these points. Use multiple quadrats for one site and summarise overall results.
- Best to use a combination of diver operations as ground-truthing (assessment basis) and photo platform for areal and temporal assessment and mapping.
- Biovolume of more use than biomass for HUB. Fauna weigh more, but the classification focuses on surface cover.
- Comment (Karin): HUB is based on quite obvious species, which can usually be picked up in photos and video quite easily.

Biotope mapping in the North Sea

Compilation of European wide biotope maps for the North East Atlantic in Emodnet – Different mapping scales and classification hierarchies in one system (Helen Lillis, JNCC, UK)

- I gave an overview of the EMODnet project, with a focus on EMODnet Seabed Habitats.
- I went into more detail about some of the issues encountered when trying to classify biological zones – namely all the decisions to make about which variables to use, which data (e.g. time period and whether to include extreme values) and what threshold values.
- I invited expressions of interest in the phase 3 consortium and also requested maps for the portal.

Biotope mapping in the Netherlands and Belgium (Vera Van Lancker, Royal Belgian Inst. of Natural Science and Sytze van Heteren, Geological Survey of the Netherlands)

- In Belgium they have set MSFD targets related to the habitat extent and distribution indicators:

    - no change in extent or distribution of EUNIS level 3 habitats, e.g. mud change to sand, with reference to the Initial Assessment.
    - ratio of hard substrate surface area versus soft sediment surface area does not show a negative trend. E.g. gravel is smothered by sand.
- So need to monitor these things. Note: using 4:1 sand:mud ratio to distinguish between A5.2 and A5.3.
- HSM in 2008-9, but too detailed for monitoring.
- Potential anthropogenic pressures:
    - Long-term disposal of dredged material (risk of smothering). Have found mud accumulation between sand waves with opportunistic species.
    - Intensive aggregate extraction (risk of smothering of gravel). Seems to be moving from sG to msG but not sure if it's natural. Surface doesn't look muddy but it appears if you stir it up. Also have witnessed G > sG > S with a loss of biodiversity; not 100% sure if aggregate extraction is to blame but will follow up.
- Hypothesis: there has been a multi-step cumulative impact – 150 years of trawling.
- Overall effects:
    - Gravel --> mud – aggregate extraction
    - Coarse --> sand – trawling
    - Sand --> mud – aggregate dumping.
- Way forward:
    - want to map sediment types with multibeam; currently investigating quantifying external sources of variance in the acoustic signature (e.g. near-bed and water column suspensions).
    - Systematic mapping of the entire area. E.g. fixed transects to survey with multibeam every six years. Plus risk-based ground-truth sampling.
- They are organising a conference next year, which we are invited to attend: North Sea Open Science Conference 7-10 November 2016. Themes: Scientific fundamentals and Science for management and policy.
- Question (me, afterwards): are they concerned with the new EUSeaMap sand:mud ratio, or do they just ignore EUSeaMap because they have their own map? Answer: not concerned (not sure but she might have been saying that it's early days so they can adapt to the 9:1 definition if necessary).

Mapping stone reef habitats in the Natura2000 areas in the Danish waters (Zyad Al-Hamdani, GEUS, DK)

- Lots of surveys of Natura 2000 sites between 2011 and 2015.
- Cheap and cheerful approach for shallow areas – a small boat with a GoPro on a stick.
- Only recently found some bubbling reef in North Sea; needs further information to investigate the origins of these reefs.
- Challenges:
    - EUNIS or HUB?
    - Are salinity, energy and geological setting important?

Biotope mapping in Norway (Thijs Christiaan van Son, NGU, Norway (MAREANO project)

- Norway has a different approach to most other countries – rather than developing a classification system then trying to fit new survey data to existing biotopes, they do a survey, identify clusters for that site based on the survey data, then carry out modelling to predict the distribution of each cluster/community. This means:
    - They don't bother too much about what to call these communities or how to classify them in terms of physical parameters.
    - They don't try to fit them into any sort of hierarchy.
    - Another survey could result in a similar cluster, but they don't try to work out if they are the same or not. They are not trying to create a master list that is consistent across all of Norway.
- There is a joint project between Norway and Russia in the Barents Sea: Cluster analysis of bottom trawl data (~1km), stations 65 km apart regular grid. 10 biotopes defined. (Technical summary / full paper Jorgensen *et al.* 2015).
- Then predicted the distribution of these 10 biotopes using various physical predictor variables (multibeam derived variables, geology and oceanography) and MAXENT.
- In the MAREANO project area they have four regional maps so far, with more to come. In this area they do 10 video transects per 1000 km^2 – more data and more biotopes than in Barents Sea. (Gonzalez and Buhl-Mortensen, 2015)
- Method for identifying biotopes:
    - Unconstrained ordination based on species composition. Not restricted by available environmental data.
    - 'Tongue effect' in DCA – parallel ordinations preferred...
    - Many options to split the point cloud into groups (k-means at the moment, but looking at alternatives (Thijs doesn't like k-means as it is a 'cold' approach with the number of cluster pre-defined))
    - Ordination can reach its limits over large biogeographical areas
    - Naming challenge, within and between areas (biotope approach)
- Challenges:
    - Ordination/cluster analysis versus biotopes/habitats.
    - Lack of unambiguous biotopes. Is it possible to achieve? Not representing a steady state.
    - Same scale, different extent -> different biotope.
    - Move towards pre-defined classes?
    - Move towards functional groups? E.g. Costello *et al.* (2015) "biological and ecological traits of marine species" Peer J.
    - Warton, *et al.* (in press) "So many variables: joint modelling in community ecology" – important paper.
- Nature types in Norway – not sure how this relates to the biotope work described above. Website says "Nature types in Norway" (NiN) was designed to recognize that most of the variation in nature derives from a more or less gradual variation in species composition in response to gradual variations along ecological gradients". He showed a diagram with mud content on one axis and resistance to erosion on the other, and had some categories described as a function

of these two factors, describing it as a sort of ordination diagram, as these two factors are complicated combinations of multiple environmental gradients.
- **Manyglm** in R – this is a good package for modelling nature types
- They still need to decide how to create a consistent system across Norway – NiN seems to be the way to go.
- Biotope maps on mareano website and NGU website.
- Question (Roland): how did they describe the clusters? E.g. characteristic species? Answer: describe the kind of environment based on the variables, and look at the dominating species. Result gives long names that are difficult to interpret.
- Question to Genoveva (me, afterwards): How did they standardise the taxa list for video data, e.g. species versus genus, or sponge morpho-types. Answer: removed if not identified to species level, but included morpho-species (have also tried ranking data according to taxonomic detail, which worked quite well). Didn't translate any species to morpho-species.
- Question to Genoveva (me, afterwards): SACFOR? PA? Counts? Answer: counts and percent cover. Per 'frame' of seabed, converted to density. She is currently interested in the CATAMI classification (website), which recognises that taxonomy is not suitable for video analysis. It focuses on things that can be recognised in video footage. According the website: "CATAMI ... has devised a common language for identifying and naming marine life pictured in underwater photographs and video. The system employs a standardised combination of high-level taxonomy (phylum, order, class) and morphological (shape, growth-form) characteristics that can be determined from a picture. This provides greater consistency than traditional classification approaches that rely on the handling of specimens."

Development and operationalization of habitat mapping in coastal waters of the German State of Lower Saxony (Francesco Mascioli, Coastal Research Station, Norderney, Germany)

- Backscatter dB response varies depending on incidence angle. They plotted the curves for different sediment types, and selected to use only around 30-60^{o} as this showed the biggest difference between each sediment type.

Working groups and final discussion

Attendees split into two groups:

1. Hard substrate mapping
2. Soft substrate mapping

Working group 2 – Roland Pesch (BioConsult) and Pedro Martinez Arbizu (SENCKENBERG)

Sediment mapping

- If we could give an indication of sediment mobility it would give an idea of the uncertainty in the boundaries between sediments due to movement over time. "Sediment mobility number" is used in Belgium (which is defined on p340 of this doc online).

- Although Germany distinguishes between sand fractions, Belgium doesn't – they are not interested in changes between types of sand as this can happen naturally, so it is not important for management and for assessing the impact of human activities.

Cluster analysis/habitat classification

- The discussion was mainly between Thijs (NGU but says actual work is done at IMR), Roland (BioConsult) and Dario (Alfred Wegner Institute).
- Pedro: how do you know what a community is? Which species need to be present or not?
- How best to describe the characterising species in the resultant clusters?
    - Roland: In an analysis in the N Sea, the Alfred Wegner Institute used 5 rules based on "fidelity in abundance, presence, fidelity in presence, numerical dominance and rank of species contributing to dissimilarity (against all other stations)" (Rachor *et al.*, 2007)
    - Thijs: SIMPER has been shown to not be too reliable, **mvabund** package in R is good – it shows which species are causing differences and then lists by deviance explained.
- Does it make sense to describe characteristic species at all?
    - Dario: isn't dominant species enough?
    - H Christian: not always – in a meadow, a small but rare flower could be what makes it special.
- Dario: Does it make any sense to assign communities at all based on e.g. grabs? Too much uncertainty in defining communities based on cluster analysis – susceptible to human error, changes over time, etc. Biotopes are so artificial.
- Thijs is starting to think that describing functional traits would make more sense – you can have different species composition but same ecosystem service – does it matter what the species are or what's happening?
    - Dario: there is limited knowledge about the traits, so we might not be able to fully describe these.
- Pedro: both specific species and communities are important, e.g. if 90% of an oyster bed recovered, but not the oysters, then that would be unacceptable.
- Note than in HUB, level 5 is community and level 6 is a single dominant species.
- Dario: does biotope mapping make any sense in dynamic areas?
- Thijs: we need to move beyond describing dominant or characteristic species, e.g. look at beta diversity.
- Vera: different species in a community can react differently to different activities. (Note: that is the reason for JNCC's move towards assessing sensitivity of 'ecological groups' (e.g. "Temporary or permanently attached surface dwelling or shallowly buried larger bivalves") rather than biotopes (although there is the obvious problem of how to map that) (see JNCC reports 512A and 512B))
- When deciding how to describe the benthos we need to think about what people need for management, monitoring, assessment, etc. and what is feasible to determine from the data.

Survey design

- Many people expressed the desire for a better way for determining appropriate sample positions and number of replicates when surveying the seabed.
- MAREANO use the stratified sampling approach summarised below (and described in this report; the R scripts are in the appendix):

1. Bring in raster layers of various relevant environmental variables.
2. Use k-means or iso cluster in ArcGIS to classify the study area.
3. Then say how many stations you have time/money for.
4. Then calculate:
    a. Area of each class, e.g. 0.4 of whole site.
    b. Variability of each class:
        i. Put all variables on the same scale – 5-260 not 0-255 because zeros cause problems.
        ii. Calculate coefficient of variation for each.
        iii. Find the mean coefficient of variation (could be weighted if preferred).
    c. Other things if you think they're important.
5. Then calculate the proportion of samples for each class: (area*variation)/number of classes.
6. Then he said something about grids allocation to determine where to put the samples within the classes.

Also need to make sure that all ranges are considered, e.g. plot all variables against each other and make sure all combinations of conditions are sampled, e.g. plot depth versus backscatter intensity.

- Thijs: can't remember the details of the AFBI optimum allocation analysis (OAA) tool, which does a similar thing. But seems to remember it gives an unachieveably high number of samples required.
- So perhaps the OOA tools gives the optimum number while the MAREANO tool tells you the best way to divide the number of samples you can afford. Both are important; as the former will give an indication of how confident you can be in your results.

Other comments

- Sytze: the OpenEarth wiki is a really good resource. The website says "OpenEarth is a free and open source initiative to deal with Data, Models and Tools in earth science & engineering projects, currently mainly marine & coastal". It contains many tutorials, including QGIS, python, R, geoserver, PostgreSQL.
- Vera's last experience of ICES WGMHM (Copenhagen, 2013) was that it lacks focus. But with the new chair things might improve.
- A free extension for ArcGIS has been developed by Tim le Bas that does object-based image analysis.

Working group 1 – feedback (Dieter Boedecker)

The group came up with minimum sizes for hard substrate habitats in each of Northern Baltic and N Sea, Southern Baltic Sea and Southern N Sea. They started to come up with minimum mapping units too, but ran out of time.

They agreed on some follow-on work to produce a table for each region describing mapping strategy and methods used, and MMU and mapping scale for biological mapping. They request comments by 23 Dec. They will compile answers and complete tables by mid-Feb.

Ideas for more focused workshops/working groups in future

- Sampling strategy – how many grabs per station. Thijs has a paper coming out soon in Marine Ecology that gives evidence that a single grab at a site gives similar results in an ordination diagram as four or five replicates. Roland has found this too
- Modelling

Annex 4: ToR C – Review of seabed habitat classification schemes

Introduction

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

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

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

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

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

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

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

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

HELCOM HUB (Habitat classification schemes)

Roland Pesch gave a talk on the HELCOM Underwater Biotope and Habitat classification system (HUB) for the Baltic Sea which was part of a HELCOM project on "RED LIST of Baltic Sea underwater biotopes, habitats and biotope complexes" (HELCOM 2013a). HUB is a follow up of the first HELCOM "Red List of marine and coastal biotopes and biotope complexes of the Baltic Sea, Belt Sea and Kattegat" (HELCOM 1998) which included a first Baltic Sea wide classification scheme for marine biotopes. The part for benthic biotopes of this 1998 classification was based on substrate type and bathymetry, the classification rules mainly relied on expert judgement. Biological classification criteria were very poorly accounted for (only if dominated by macrophytes or not). In 2007, the goal was set to update classification system by a HELCOM Expert Group. The classification was to be eco-logically relevant, logical and practical and to be compatible with EUNIS. Available biological information on marine biotopes was to be accounted for. HUB was finished in 2013 (HELCOM 2013b) giving a comprehensive classification system for the Baltic Sea region differentiating 328 underwater biotopes and ten biotope complexes.

HUB is very similar to EUNIS as it consists of a six level hierarchy with abiotic classification criteria in the upper and biological criteria in the lower levels. A great advantage of the system relies on distinct classification rules and splitting criteria linking each of the six levels. Starting with biogeographical regions in level 1 the benthic environment is structured into either photic or aphotic classes in level 2. Substrate types are then differentiated into different hard bottom types, mixed sediments and three soft sediment types (muddy, coarse and sandy substrates) in level 3. The classification rules thereby rely on spatial coverage criteria and grain size composition. In level 4 biotopes structures are then defined in terms of epifauna / macrophyte or infauna dominated areas followed by the definition of soft and hard bottom biotope types in level 5. Here, the definition relies on the spatial coverage (regarding epibenthos) or biomass dominance (regarding the infauna) of higher taxonomic groups. Where separate benthic species are showing a dominant spatial coverage or biomass proportion, level 5 biotope types are furthermore classified into level 6 sub-biotope types.

HUB was successfully applied for the first time by Schiele *et al.* (2014), who produced a marine biotope map for the German Baltic Sea. The structure of HUB was also used for

the classification of Red List biotopes for the German Baltic Sea and North Sea areas (Führhäupter *et al.* 2015).

The European Nature Information System (EUNIS) habitat classification

Introduction

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

Definitions within EUNIS

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

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

Structure

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

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

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

Level 1 – coastal influence separates coastal and marine realms.

Level 2 – Substratum (superficial and underlying), aerial exposure, presence of continental shelf and macroalgal separate level 2 classes

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

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

Geographic Extent

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

Value of Classification for Management

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

Classifications lack quality variations due to disturbance and damage.

Compatibility with Scientific Data

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

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

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

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

Potential habitat characterization scheme (Greene *et al.* 2005, 2007)

Introduction

- Specifically designed to aid in the interpretation of datasets from acoustic and direct observations.
- Attributions used to classify seafloor are mainly based on physical parameters and features.
- The scheme is also clear that it deals with 'potential habitat'.
- The classification scheme is unusual in that it recognises four spatial scales, i.e. mega-habitat (1:1000000 or greater), mesohabitat (1:250000 or less), macrohabitat (1:50,000 or less) and microhabitat (1 m2 or less).

Assumptions

- Many of the geological and physical seafloor features are biologically relevant for ground fish and sessile communities.
- Classes are mutually, and hence spatially, exclusive.

Geographic extent

- This classification was initially developed for use in specific deep water habitats with-in North America (Greene *et al.* 1999, 2005, 2007).
- It has been expanded to include shallow water habitats, arctic to tropical regions, including Antarctica (Vietti *et al.*, 2001) and estuaries (Greene *et al.*, 2007b).

Outputs and usage

The classification provides (i) geological maps, (ii) seafloor physical feature maps, (iii) benthic habitat maps and (iv) essential fish habitat maps.

Structure

Separate attribution pathways for the classification of (i) broad-scale (megahabitats and mesohabitats) and (ii) fine-scale (macrohabitats and microhabitats).

- The broad-scale classification uses the following parameters, in order, to provide increasingly finer thematic classes: physiography/depth, seafloor induration (hardness), geomorphology, texture (slope and rugosity) and geological age.
- The fine-scale pathway initially attributes the seafloor according to geological and coarse biological classes, and then followed again by textural attributes.

Strengths and weaknesses

Ease of use: More detailed attributes require a moderately level of familiarity with geological and hydrological features - biologists may require assistance with some levels of attribution. The inclusion of optional attributes provides flexibility within the classification scheme.

Compatibility with survey parameters / data requirements

The scheme is intended for use in the interpretation of multibeam bathymetry and backscatter, sidescan sonar, underwater video and photographic stills and seafloor samples (e.g. grabs and cores). Several of the classification attributes are generated specifically from common acoustic parameters such as depth (for bathymetric zones, slope and rugosity) and backscatter (for hardness).

Confidence assessment: As with most scheme, this classification is not associated with a specific assessment of map confidence nor does it include a specific method for the expression of confidence associated with each map.

Quantitative definitions of classes: The classification scheme uses objective methods to calculate specific attributes (e.g. rugosity and slope) and thereby reduces subjective attribution and delineation. Equally, other attributes are provided with clear thresholds that separate classes (e.g. depth ranges for megahabitats or particle size for substrata). However, other attribute classes lack quantitative definitions which could lead to subjectivity, and hence variation, during the manual delineation of features.

Method of development: This scheme was originally devised for the classification of benthic habitats of rockfish in deep water along the west coast of America. The generation of classes within most of the attributes appears to align with specific and easily identifiable geological and physical seafloor features. The biological classes are use arbitrary and taxonomically discrete animal groups that appear to be generated using expert judgement.

Overall value for habitat mapping

- The resulting classes are mostly defined by their geological character.

- The biological classes are coarse, exclusively epifaunal and taxonomically distinct.
- A biological classification is only possible for macro- and microhabitat scales.
- The use of the potential habitat characterization scheme for biological mapping of sessile communities appears limited.

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Annex 5: WGMHM 2016 agenda

2016 ICES Working Group Marine Habitat Mapping Meeting: Agenda

9th May – 11th May, 2016

Winchester, UK

Point of Contact: James Strong +44 (0) 7984110201

Time	Day 1: 9th May
09:00	Meeting starts at Cromwell House (Natural England office) meeting room 2, 15 Andover Road, Winchester, Hampshire, SO23 7BT, UK
09:15	Introductions, refinement of the agenda and overview of the ToRs.
9:45	ToR (A): International programmes Report on progress in international mapping programmes (including OSPAR and HELCOM Conventions, EMODNET, EC and EEA initiatives, CHARM, Mesh-Atlantic and other projects);
10:30	Coffee break
10:40	Topic for tea 1: "Map reading".
10:45	ToR (B) National programmes (National Status Reports) Present and review important results from national habitat mapping during the preceding year, as well as new on-going and planned projects focusing on particular issues of relevance to the rest of the meeting. Provide National Status Report updates in geographic display in the ICES webGIS. 10:50 Marion Harrald (Marine Scotland Science) – mapping in Scottish waters 11:20 Eimear O'Keeffe (Marine Institute) – mapping in the Republic of Ireland
12:30	Lunch
13:30	ToR (B) National programmes (National Status Reports) continued Discussion topics: • Use of the National Status Reporting Template • Summarising the National Status Reports • Reporting of progress Report writing session to summarise ToRs A&B

15:30	Coffee break
15:40	Topic for tea: "What is it?"
"15:45	ToR I: Habitat mapping techniques and modelling (i) Survey methods and processing techniques 15:50 Helen Lillis (JNCC): A summary of a recent workshop addressing uncertainty in habitat mapping methods. 16:30 Dieter Boedeker: Workshop on Marine Biotope Mapping for Conservation Purposes: an overview
17:15	End of day 1

Time	Day 2: 10th May
09:00	Meeting starts at Cromwell House (Natural England office) meeting room 2, 15 Andover Road, Winchester, Hampshire, SO23 7BT, UK
09:15	ToR I: Habitat mapping techniques and modelling continued (i) Survey methods and processing techniques 09:20 Anna Downie: (1) Deep sea VME habitat modelling; and (2) Intertidal remote sensing.
10:30	Coffee break
10:40	Topic for tea: "It's 2116! What to measure?"
10:45	ToR (C): Habitat mapping techniques and modelling continued (ii) Analysis and modelling techniques Claudia Propp: Objective rules for the interpretation of backscatter mosaics within a standardized mapping procedure
12:30	Lunch
13:30	ToR (C): Habitat mapping techniques and modelling continued (ii) Analysis and modelling techniques
15:30	Coffee break
15:40	Topic for tea: "What is?"
15:45	Report writing session to summarise ToR C © & ii

17:15	End of day 2

Time	Day 3: 11th May
09:00	Meeting starts at Cromwell House (Natural England office) meeting room 2, 15 Andover Road, Winchester, Hampshire, SO23 7BT, UK
09:15	ToR ©: Habitat mapping techniques and modelling (ii) Classification scheme in habitat mapping. 09:30 onwards: short presentations (~5 mins) on: • EUNIS • Helcom HUBS • CMECS • Integrated Australian Classification Scheme • Potential habitat characterization scheme (Greene *et al.* 2005, 2007) • Classification of sublittoral habitats (Valentine *et al.*, 2005) Possible discussion points following presentations: • Strengths and weakness of specific schemes • Capturing and expressing confidence • Other thematic classes, e.g. condition, function, ecosystem services • Objectivity within classification schemes • Compatibility of schemes with marine management
10:30	Coffee break
10:40	Topic for tea: "What if?"
10:45	ToR (C): Habitat mapping techniques and modelling continued (iii) Classification scheme in habitat mapping - discussion continues
12:30	Lunch
13:30	ToR (D): Review the use of habitat maps 13:40 James Strong: Update on the ICES request from DGENV 14:00 Helen Lillis: The use of broad scale habitat maps – a perspective from those working in the EMODnet project. Topics can include mapping for management (marine spatial planning and the ability to use habitat maps for monitoring of the environment), presentation and use of confidence maps and the use of habitat maps in the modelling of other parameters (ecosystem services etc.).
15:30	Coffee break

15:40	Topic for tea: "What concerns me most about mapping is…"
15:45	Discussion - intersessional work, events or discussion topics James Strong: Working with WGDEC (Deepwater Ecology) - discussion[42] Report writing session to summarise ToR C iii & ToR D
17:15	End of meeting

[42] Potentially create smaller scale vulnerability maps based on the WKFBI method to make use of VME data and revised sensitivity assessments. This may overlap with the VME weighting system so some review is needed as to whether this is worthwhile. The idea is to demonstrate to ICES/DGENV that coarse scale maps are not of use to the deep-sea but at a finer resolution we may be able to better identify vulnerable areas.

GES - deep sea habitats. Start addressing MSFD with respect to GES of deep sea habitats and start reviewing indicators that have been proposed for deep sea - collaborations with other Working Groups.

Review geo-statistical approaches to quantifying VME patchiness and explore whether this could be developed as a basis to inform spatial management decisions such as closure boundaries and move-on rules.