ICES BEWG REPORT 2014

SCICOM Steering Group on Ecosystem Processes and Dynamics

ICES CM 2014/SSGEF:11

Ref. SCICOM

Report of the Benthos Ecology Working Group (BEWG)

28 April – 2 May 2014

Dinard, France

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2014. Report of the Benthos Ecology Working Group (BEWG), 28 April - 2 May 2014, Dinard, France. ICES CM 2014/SSGEF:11. 54 pp. https://doi.org/10.17895/ices.pub.8851

Contents

Executive summary

The Benthos Ecology Working Group (BEWG) was hosted by Ifremer and held its 2014 meeting at the Station marine de Dinard - CRESCO, both in Dinard, France. The meeting was attended by 26 participants, representing 10 countries.

The meeting was structured along the four BEWG core business issues: Benthic long-term series and climate change, benthic indicators, species distribution modelling and disentanglement of the link between biodiversity and ecosystem functioning.

Six initiatives were further developed during the workshop:

- Further planning of the ongoing work already initiated under the SGCBNS.
- Getting the Benthic Long-term Series Network (BeLTS-net) launched.
- Initiation of the investigation of benthic indicators' comparability and complementarity.
- Final revision of the BEWG review paper: "Species distribution modelling and mapping in the marine environment and its relevance for ecosystem management".
- Further development of the link between ecosystem functioning and benthic diversity.
- Further development of the position paper on "Linking benthic ecology to ecosystem services".

Four new initiatives (case studies) were developed and launched during the workshop:

- Case study: "Towards the quantitative benthic species distribution modeling for ecosystem functioning: linking bioturbation potential with nitrate cycling".
- Case study: "On the variability in expert assessment of benthic species tolerances / sensitivities, as used in several multimetric indices".
- Case study: "Towards efficient and effective monitoring programmes for benthic multrimetric indices".
- Case study: "On biological trait analysis in benthic ecology".

1 Opening of the meeting

The Chair, Steven Degraer, opened the meeting at the Station Ifremer de Dinard in France. S. Degraer welcomed the participants and gave a brief summary on the recent work carried out by the Benthos Ecology Working Group. Four main themes the BEWG continuously has worked on over the last years were introduced:

- Benthic long-term series and climate change
- benthic indicators
- species distribution modelling
- the link between biodiversity and ecosystem functioning

H. Hillewaert was appointed to take the lead as editorial rapporteur.

30 participants from 10 countries attended the meeting (Belgium, France, Germany, Italy, Norway, Poland, Sweden, the Netherlands, United Kingdom and the United States).

N. Desroy welcomed the participants on behalf of the Ifremer.

2 Adoption of the agenda

The group unanimously adopted the agenda without changes (Annex 2).

3 Long-term series and climate change (ToR A)

3.1 Progress towards an understanding change in the benthos, e.g. regime shifts, seasonality, fine spatial scale variability

Coordination: Silvana Birchenough

Three introductory and two overview presentations were given (Abstracts in Annex 4):

- S. Birchenough. Overview presentation to progress towards an understanding change in the benthos, e.g. regime shifts, seasonality, fine spatial scale variability
- J.-C. Dauvin. Long-term changes (1977–2010) in a fine sand macrobenthic community from the Bay of Morlaix (western English Channel)
- F. Gaudin. Distribution of benthic invertebrates and sea water temperature increase in the English Channel
- O. Gauthier. Statistical methods for temporal analysis of community composition data: Case study of 13 years of benthic surveys in Chesapeake Bay
- S. Birchenough. Overview presentation on the current research programme "Placing Ocean Acidification into a wider Fisheries Context (PLACID)"

Intersessional work progress

3.1.1 SGCBNS paper on Spatial variation in BPc and vulnerability of ecosystem functioning in the North Sea

S. Birchenough, Cefas, UK

Outcome

The position paper on Benthos and climate change was discussed, as this manuscript was still under review at the time of the meeting. The publication is now published on the Wiley Climate Change Journal. The paper highlights current and future trends on climate change research priorities. This publication is also available at:

http://onlinelibrary.wiley.com/doi/10.1002/wcc.330/abstract;jsessionid=A5BED72BABA574EF6AAA9F66072A889B.f04t04?deniedAccessCustomisedMessage=&userIsAuthenticated=false

Progress made

A sub-group discussed the current time-series work which started back in 2009. There is an ongoing initiative developed by S. Birchenough (Cefas) and C. Van Colen (University of Gent) to assess benthic changes observed over two time series, one located in the UK (Tyne and Thames) and the other in Belgium. Data have been used to distinguish benthic patterns and changes in relation to climate variables (e.g. NAO index) and environmental conditions (e.g. sediment types). S. Birchenough additionally introduced the planned work also developed as part of the "Study Group on climate benthic related processes in the North Sea"(SGCBNS). There is planned work for CS1: Assessment of the fine scale temporal variability in coastal sediment bioturbation (lead by S. Birchenough) and CS2- Bioturbation potential as a key ecosystem function on a large spatial scale (lead by G. Van Hoey). Additionally, a methods paper was published containing all of the coded benthic data sets (~1000 species) for calculating bioturbation potential (Queiros, *et al.*, 2013). This publication is available at:

http://onlinelibrary.wiley.com/doi/10.1002/ece3.769/full

A further discussion related to methodologies when looking at time-series and what the current published methods are that this group could consider for further work. J. Craeymeersch at IMARES has also made a summary table that could be further populated to summarise existing methodological analyses of benthic time-series, including assessments of trends, data gaps, number of replicates etc. This idea will be pursued for the next year at the BEWG.

Planning for future work

To complete existing work already initiated under the SGCBNS as well as the initiatives on time-series mentioned above.

3.1.2 Revisiting research ideas, prioritisation and planning.

S. Birchenough, Cefas, UK

Climate change is an area of work that has been discussed by the group since 2009. The overall background to climate change and effects observed on the different ecosystem components (e.g. plankton, fish and benthos) have been discussed on differ-

ent peer review publications, there clearly is still further work needed to understand benthic changes and variability in relation to climate change across different areas, pressures and habitat types. Some of the clear links from this area of work will be with BELTS-net and expanding on the methodological aspects of working with time-series. It is also highly relevant to take account of the current tools available when looking at climate change effects and the level of data required run and validate these models.

The PICES/ICES/IOC 3rd International Climate Change Symposium on the world's ocean, i.e. focussing on climate change impacts on marine biodiversity and resilience as well as ocean acidification was announced. See Symposium web site:

http://www.pices.int/meetings/international_symposia/2015/2015-Climate-Change/scope.aspx

3.2 Facilitate collaboration by further development and promotion of the BEWG Benthic Long-Term Series network (BELTSnet)

Coordination: J. Craeymeersch, IMARES, The Netherlands & H. Hillewaert, ILVO, Belgium

Progress made within BELTSnet and identification of further actions

An online release of the website was presented. Both site and forum are life but need some esthetical tweaking. The structure of the site provides for a general introduction on the aims and targets of the project as well as a layout of the concept. A comparison with other initiatives is given, focussing on the differences in concept and the relations to other networks. The mainstay of the site is a member-only forum which will facilitate exchange of information. On this forum new initiatives will be advertised and members will have access to existing contributions when they submit their results.

The site uses Joomla, an open source content management system (CMS) and Kunena, a forum extension for the former. It is currently hosted by Siteground Hosting Service.

A domain name (beltsnet.info) has been registered.

Planning for future promotion and work

- H. Hillewaert & S. Birchenough: Drafting a flyer and poster on BELTSnet
- H. Hillewaert: Fine-tuning the BELTSnet website and assigning admins and mods to the forum.
- P. Montagna: North-American long-term series (metadata) list to be included in BELTSnet
- C. Greathead: Potential sources for Canadian long-term series data (after launch of BELTSnet)
- J. Craeymeersch: e.g. to work towards the identification of methodological issues in long-term series comparability.

4 Species distribution modelling and mapping (ToR B)

4.1 Performance and exploration of the applicability of different qualitative and quantitative species distribution modelling methods, e.g. methods validity, limitations, purposes, knowledge gaps

Coordination: H. Reiss & M. Gogina

Four introductory presentations were given (Abstracts in Annex 4.4):

- M. Gogina. Different quantitative modelling approaches and recent experience of their application
- A. Darr, M. Gogina & M. L. Zettler. Detecting hot-spots of bivalve biomass in the south-western Baltic Sea
- C. Greathead. Distribution and environmental requirements for three sea pen species and the implications for marine protected areas
- J. Holstein & J. Dannheim. Practical species distribution modelling: validation and performance metrics

Outcome

H. Reiss reported on state-of-the-art of the BEWG review paper: Species distribution modelling and mapping in the marine environment and its relevance for ecosystem management.

The paper passed through the review process for publication in the ICES Journal of Marine Science and is now being revised within BEWG.

Progress made

The group agreed to launch a case study with working title "Towards the quantitative benthic species distribution modeling for ecosystem functioning: linking bioturbation potential with nitrate cycling".

M. Gogina volunteered to pull the initiative. The study is open for participation, suggestions and contribution.

Two approaches will be followed: i) initial separate calculation predicting the distribution of bioturbation potential (BP) on a species level with latter summation to bioturbation potential of the community (BPc) and ii) initial calculation of BPc per station that is latter treated as response variable for distribution modeling

Three subareas will be investigated: i) Belgian North Sea, ii) German North Sea and iii) the Baltic Sea. Data will first be collected from the Belgian North Sea, after which comparable datasets from the German North Sea and the Baltic Sea will be extracted. No temporal window is a priori defined: all suitable data (preferably with abundance and directly measured biomass), as well as relevant environmental predictors for each region will be considered at the start.

Issues to be considered while developing the case study:

- Uncertainty will not be the same for all species for the first approach, and will be huge after add-up. BPc should be related to drivers that are relevant for it, such as sediment composition.
- Test the first approach only with key species of the community; investigate where most causality is among predictors. Focus on key players of BPc (see

the presentation from J. Vanaverbeke) – model abundance and biomass of them and then recalculate to BPc (include variability for stations).

- Wet weight will be used as biomass metric. If no biomass data is available, average biomass accounted for season can be used to a specific extent.
- See what approach can provide a better solution for different regions even though drivers can be different among areas.

Planning for future work

- H. Reiss, S. Birchenough & S. Degraer: Practical agreements on the finalization of the revision of the BEWG review paper: Species distribution modelling and mapping in the marine environment and its relevance for ecosystem management were made.
- J. Vanaverbeke: Responsible for the Belgian North Sea dataset for the new case study
- J. Dannheim & H. Reiss: Responsible for the German North Sea dataset for the new case study
- M. Gogina & colleagues: Responsible for the Baltic Sea dataset for the new case study

5 Benthos and legislative drivers (ToR C)

5.1 To report on the use of benthic indicators and targets for management: Compatibility and complementarity

Coordination: G. Van Hoey

Three introductory presentations were given (Abstracts in Annex 4):

- C. Labrune. A multivariate approach to be used as a biotic index witin the BenthoVal project
- L. Guérin. Overview of the OSPAR common approach for benthic habitat assessment.
- G. Van Hoey. Estimating the biological value of soft-bottom sediments with sediment profile imaging (SPI) and grab sampling

Progress made

With this initiative BEWG contributes to the integration of knowledge and ongoing work on indicators (benthic assessment tools) within some EU environmental directives, such as WFD, MSFD, Habitats Directive. The work focuses on two aspects:

1) the position of benthos in the above mentioned directives and the related assessment tools

2) the demands of some of those benthic indicators, their feasibility and redundancy.

In relation to the position of benthos in the above mentioned directives and the related assessment tools, BEWG focused on the benthic assessment tools proposed by the different EU member states in function of the MSFD. We explored some information to reflect on the kind of assessment tools (indicators) that exist and were proposed by the EU member states for defining Good Environmental Status (GES) for benthic habitats (benthos populations [species] and habitats) under descriptors 1, 4 and 6; this to

have a view on: what type of approaches was selected and whether or not there are common approaches between member states. To explore complementarity, an overview table (not exhaustive) of the benthic assessment tools for the EU countries Spain, UK, Germany, France, Belgium, The Netherlands and Denmark was made (Annex 5). The following main conclusions were drawn:

- A high number of benthic related assessment tools are defined by the above mentioned member states. However, the majority are descriptive and very generally defined, which indicates that most member states are still in the process of defining and developing smart benthic assessment tools. Only three Member states (BE, NL and UK) have defined specific thresholds and baselines for the selection of targets (seldom for benthic related ones).
- There is a mix of state (majority, focusing on species [sometimes] or habitat [mainly] aspects) and pressure (less disturbance) indicators.
- No common benthic assessment tool could be identified. Nevertheless, there are some tools focusing on the same aspect of the benthos (or have a similar goal), but in a slightly different manner. This shows the need to continue working on harmonized or complementary approaches for benthic assessment on a regional scale.
- In our test case, there were only a few member states (Denmark, UK and Belgium) which selected a WFD benthic assessment tool, as an evaluation tool under the MSFD. This indicates a weak synergy between MSFD and WFD implementation.
- The DEVOTool box summarizes a wide variety of benthic assessment tools (indicators), mainly developed to serve the implementation of the WFD. Mainly the WFD related (multi-metric benthic) benthic indicators defined in the MSFD member state reports, were found in the DEVOTool.

This exercise showed the need to work towards a more common approach for benthos assessment, which is on the agenda of the ICG-COBAM (OSPAR intersessional correspondence group on the coordination of biodiversity assessment and monitoring). Therefore, the work presented here can support the work on benthos within the ICG-COBAM group.

The information resources used for this issue, were the reports of the European Commission on the MSFD member state reports and Teixeira *et al.*, 2014 Existing biodiversity, non-indigeneous species, food-web and seafloor integrity GES indicators. Deliverable 3.1 of the Devotes project (www.devotes-project.eu).

In relation to the demands of those benthic indicators, their feasibility and redundancy, two issues were tackled: (1) criteria for the evaluation of the applicability of the benthic assessment tools and (2) the investigation of the feasibility, effectiveness and redundancy of benthic indicators.

To select appropriate (smart) benthic assessment tools, the applicability and effectiveness of the proposed benthic assessment tools needed to be evaluated. To this objective, a range of criteria, defined for the purpose of testing if an indicator is appropriate or not, can be used. BEWG choose to use the criteria list developed by WGBIODIV to test the appropriateness of the MSFD proposed benthic assessment tools (Annex 6). A first application of the criteria to some benthic assessment tools (Annex 5), already revealed some classes, reflecting the appropriateness of the benthic assessment tools (Annex 7).

- Common WFD benthic indicators show the highest applicability and effectiveness. This type of indicators is fulfilling most of the required needs for an appropriate indicator.
- Assessment tools focusing on habitat or biogenic structure related aspects (areal surface, trends, …) show a moderate performance.
- Assessment tools related to species (density, trends, occurrence, …) show a lower performance.
- Most of the proposed benthic assessment tools (inclusive the pressure indicators) are not smart (not specified) and not ready at all to be used as benthic assessment tool.

This exercise may help steering the selection of appropriate common indicators for benthos and the testing of these indicators.

Also the application of the criteria list on the evaluation of the appropriateness of benthic assessment tools already revealed some considerations:

- Some of the proposed criteria are difficult to evaluate in relation to the proposed tool (e.g. number 2 and 5).
- Some criteria are somewhat strange as general criteria (e.g. indicator on early warning, which is difficult for state indicators. We consider early warning indicators as another type). Indicators are capable of picking up of signals, but the indicator that is capable to pick up specified pressures and without being influenced by natural changes does not exist, especially not for benthos. Therefore the guideline of criteria 6 seems not to be feasible.

The application of evaluation criteria to test the applicability of benthic assessment tools is ideally also founded by real test on field data. This type of work will be taken into account within the French CF Benthoval project (Annex 4.7: Labrune *et al.*).

Planning for future work

- BEWG-members to send the necessary data (benthic data accompanied with quantitative pressure data) for their participation in the Benthoval initiative.
- Benthoval project consortium: to provide feedback on their project during the BEWG 2015 meeting, with focus on the outcomes on the indicator-pressure relations, complementarity of benthic indicators and the new benthic indicator.
- G. Van Hoey: follow-up of the benthic indicator work in relation to the WFD and MSFD in 2014-2015 and to provide feedback during the BEWG 2015 meeting.

5.2 On the myths on indicators: To investigate the importance of species autecology in indicator development and application

Coordination: M. Zettler

Outcome

The BEWG initiated and facilitated the paper:

Zettler, M.L., C.E. Profitt, A. Darr, S. Degraer, L. Devriese, C. Greathead, J. Kotta, P. Magni, G. Martin, H. Reiss, J. Speybroeck, D. Tagliapietra, G. Van Hoey, T. Ysebaert (2013) On the Myths of Indicator Species: Issues and Further Consideration in the Use of Static Concepts for Ecological Applications. *PLoS ONE* **8(10)**: e78219. doi:10.1371/journal.pone.0078219

The use of static indicator species, in which species are expected to have a similar sensitivity or tolerance to either natural or human-induced stressors, does not account for possible shifts in tolerance along natural environmental gradients and between biogeographic regions. Their indicative value may therefore be considered at least questionable. In this paper we demonstrate how species responses (i.e. abundance) to changes in sediment grain size and organic matter (OM) alter along a salinity gradient and conclude with a plea for prudency when interpreting static indicator-based quality indices. Six model species (three polychaetes, one amphipod and two bivalves) from the North Sea, Baltic Sea and the Mediterranean Sea region were selected. Our study demonstrated that there were no generic relationships between environment and biota and half of the studied species showed different responses in different seas. Consequently, the following points have to be carefully considered when applying static indicator-based quality indices: (1) species tolerances and preferences may change along environmental gradients and between different biogeographic regions, (2) as environment modifies species autecology, there is a need to adjust indicator species lists along major environmental gradients and (3) there is a risk of including sibling or cryptic species in calculating the index value of a species.

Progress made

A discussion on the most appropriate follow-up initiative(s) tackled the issue of possible variability in expert assessment of benthic species tolerances / sensitivities, as used in several multimetric indices. It was hypothesised that more widely distributed species show a higher variability in expert assessment on tolerance / sensitivity. BEWG will test this hypothesis taking account of e.g. the following reflections:

- Graphical presentation of the relationship via geographical distribution (metrics: latitudinal, longitudal, max. distance) on x-axis and tolerance / sensitivity average and variability on y-axis
- Geographical distribution metrics to be based on a gridding approach focusing on species occurrence
- Environmental gradients such as depth, salinity possibly to be considered as co-covariate information to possibly be included.
- Biogeographic regions: North-East Atlantic, Mediterranean Sea, North Sea, Baltic Sea (excluding the atypical northern Bothnian Bay)
- Sensitivity against pressures / activities: physical pressures, organic enrichment and a third pressure
- Sensitivity classes: AMBI classes
- Independency of regional experts: Same experts to be used for all species considered and nicely distributed throughout Europe. Experts to be nominated by interested BEWG members.
- Species selection: Focus on selected taxonomic groups (i.e. echinoderms, polychaetes, bivalves). Only the rarest species are to be excluded, since experts may lack the expertise necessary to adequately assess tolerance / sensitivity. Sensitivity to be assessed at species level (not at a higher taxonomic level). Species to be nominated by interested BEWG members.

Planning for future work:

- S. Degraer: to take the initiative to further develop the study intersessionally (expert selection, species selection, data gathering / questionnaire; possibly: preliminary data-analysis).
- All interested BEWG members: to nominate experts to participate in testing the variability of species sensitivity assessments
- S. Degraer: to plan for the work to be done during the BEWG 2015 meeting (e.g. data-analysis, interpretation).

5.3 To review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments

Coordination: S. Degraer & G. Van Hoey

Two introductory presentations were given (Abstracts in Annex 4):

- S. Degraer. Towards a joint MSFD monitoring programme for the North and Celtic Sea, JMP-NSCS: Project outline and state-of-the-art
- T. Moum & H. Reiss. Biodiversity assessment of benthic communities using high-throughput DNA metabarcoding

Progress made

Benthic habitat condition is an important aspect taken into account by all EU Member States (MSs) under the different nature directives, including MSFD. A few EC MSs (i.e. UK, Belgium, and Denmark) already mentioned multi-metric benthic indicators in their MSFD Articles 9 and 10 reports to the EC. Others are expected to implement the use of such indicators within their MSFD 1st cycle assessments. The (draft) OSPAR ICG-COBAM common approach for benthic habitat assessment identifies that benthic multi-metric indicators (wide variety available) are essential for determining habitat condition. This common approach does not define a common benthic indicator for all OSPAR regions.

A brainstorm on the EC (DG Environment) "Towards a Joint Monitoring Program for the North Sea and Celtic Sea, JMP NSCS"" case study on efficient benthic multimetric indices monitoring, making use of the BEWG NSBP1987 and NSBS2000 data led to the definition of research questions, concepts and a possible way forward. The case study will contribute to the development of an efficient regional approach to monitoring benthic habitat condition assessment. It will as such inform on:

- the applicability of a wide set of analytical tools in developing efficient monitoring programmes
- the potential of complementarity of monitoring designs (cross-boundary) throughout the greater North Sea (and Celtic Sea)
- the possibilities to integrate that sampling effort (minimally) needed into interdisciplinary monitoring campaigns

The following research questions were identified:

- Q1: To what extent does the level of aggregation of habitat types influence the sampling design?

  - Level of aggregation to be used in this exercise: EUNIS level 3 habitat types and NSBS2000 / NSBP1986 communities (~ EUNIS level 5 habitat types).
- Q2: What sampling intensity [number of samples] is required for different habitat types?
  - What is the difference in sampling intensity for heterogeneous or more homogeneous habitat types?
- Q3: What is the optimal spatial design of the benthic monitoring programme?
  - Fixed or random (stratified) sampling, and/or a combination of fixed and random sampling.
- Q4. Focus area/habitat selection
  - Focal areas, habitats at risk, high pressure areas: how does a monitoring focus on selected areas influence assessment efficiency? Which criteria can be used to discriminate between focal habitats or areas to monitor?
  - Is a different monitoring design needed in coastal benthic habitats compared to offshore benthic habitats.

The following considerations were identified:

- Not to use the multi-metric indicators themselves, but the underlying variables and parameters (i.e. species abundance, species richness, bray-curtis similarity (measures of species composition (turnover) / community hetero-/homogeneity), biomass, species sensitivity [AMBI, sum(ES500.05)]). This will allow for drawing conclusions that are applicable to a wide set of multi-metric indicators.
- To run the analyses at the level of selected multi-metric benthic indicators. Indicators defined under WFD, MSFD, Habitats Directive, OSPAR or HELCOM can be selected for this purpose.
- The following (non-exhaustive) list of issues is relevant for the definition of the monitoring design and related quality assessment of benthic habitats:
  - Level of detail in habitat definition: a broader definition of a benthic habitat type (e.g. EUNIS A5: sublittoral sediment) can lead to a higher variability in its characteristics than a narrow definition (e.g. EUNIS A5.2 sublittoral sand).
  - Areal extent of the habitat type: the difference in spatial distribution of a habitat (widely distributed versus local) may have an influence on the monitoring design needed.
  - Habitat heterogeneity/homogeneity: community composition heterogeneity may differ between different habitat types. Therefore, heterogeneous habitat types will have other monitoring requirements than homogeneous habitat types (less variable characteristics).
  - Sampling techniques: benthic habitats can be surveyed by different grab, core or even dredge sampling techniques and benthic samples may be handled differently (e.g. sieve mesh size, sieving alive or after fixation).

- Period of sampling (more than once a year, yearly, every 2-3 years, …): the benthos shows a clear seasonal and year-to-year variability, which will influence the monitoring design.
- Variables /indicator demands: different variables will show different value ranges, sensitivity to outlier values (maxima) and levels of variability, which has its effect for example on the sample intensity requirements. For example, you need more samples to scope the variability in biomass (values highly variable among species) than number of species to reach a certain statistical power.

The following spatial datasets of the greater North Sea will be used to tackle spatially-oriented research questions. These datasets, compiled by the Study Group on the North Sea Benthos Project (SGBPNS) and BEWG, are readily and publicly available, and have been scrutinised for consistency during earlier work by SGCBNS.

- The North Sea Benthos Survey 1986 data (NSBS 1986): macrobenthos samples were collected in a standardised way, on a regular grid covering the whole of the North Sea, and analysed by scientists from 10 laboratories (http://www.vliz.be/vmdcdata/nsbs/about.php).
- The North Sea Benthos Project 2000 data (NSBP 2000): integrating macrobenthic infaunal data (1999-2001) available from various sources, including national monitoring surveys, in North Sea soft bottom sediments (http://www.vliz.be/vmdcdata/nsbp/datasets.php).

Data analyses of the above mentioned datasets (and other datasets, if available in time) will allow tackling various research questions, highly important for developing efficient and effective benthic monitoring programmes. The main analytical principle behind these analyses is to investigate the relationship between monitoring efficiency and sample size. The main assessment criteria for monitoring efficiency (and effectiveness) will be quality assessment accuracy (average of quality) and reliability (variance in quality). Given the nature of the data, these questions are all related to the spatial scale-dependency of sampling designs:

Planning for future work

- S. Degraer, S. Birchenough and G. Van Hoey: to further develop the case study in consultation with the JMP NSCS project leads intersessionally.

6 Benthic biodiversity and ecosystem functioning (ToR D)

6.1 To identify the links between benthic biodiversity and ecosystem functioning, e.g. literature review, ecological processes, biological traits.

6.1.1 Literature review on the links between benthic biodiversity and ecosystem functioning

Coordination: J. Vanaverbeke

Two introductory presentations were given (Abstracts in Annex 4):

- J. Vanaverbeke. Variable importance of macrofaunal functional biodiversity for biogeochemical cycling in temperate coastal sediments
- N. Desroy & S. Dubois. On the functional role of *Sabellaria alveolata* reefs

Progress made

During the BEWG meeting in Sandgerdi-Iceland (2012), an initiative was set up to conduct a literature overview on the link between macrobenthic diversity and ecosystem functioning. During the period 2000–2010, a number of experimental and field studies on the link between macrofaunal diversity, density, and functional diversity have been published. These studies revealed that a link between macrobenthic functional diversity and ecosystem functioning indeed exists in many of the experiments, where aspects of densities and species identity were less reported of being of great importance. BEWG found it of high interest to summarise the existing information, to (1) detect generalities in the observed patters and (2) detect gaps in the research performed so far.

During the BEWG meeting of 2012; 4 general papers dealing with the link biodiversity – ecosystem functioning were identified:

- Bolam SG, Fernandes T, Huxham M (2002) Diversity, biomass, and ecosystem processes in the marine benthos. Ecological Monographs 72:599-615
- Covich AP, Austen MC, Bärlocher F, Chauvet E, Cardinale BJ, Biles CL, Inchausti P, Dangles O, Solan M, Gessner MO (2004) The role of biodiversity in the functioning of freshwater and marine benthic ecosystems. BioScience 54:767-775
- Gessner M, Inchausti P, Persson L, G Raffaelli D, S Giller P (2004) Biodiversity effects on ecosystem functioning: insights from aquatic systems. Oikos 104:419-422
- Wilsey BJ, Potvin C (2000) Biodiversity and ecosystem functioning: importance of species evenness in an old field. Ecology 81:887-892

During the BEWG meeting of 2013 in A Coruna, 1 additional, strongly inflentual, marine ecological paper was added to the list of key papers:

- Aller RC, Aller JY (1998). The effect of biogenic irrigation intensity and solute exchange on diagenetic reaction rates in marine sediments. Journal of Marine Research 56: 905-936.

Web of Science was used to run a search for all the papers that cited on of the 5 papers listed above. This resulted in a list of 531 papers. During the meeting in A Coru-

na, and in between the meeting in A Coruna and the 2014 meeting in Dinard, this extensive list was checked, and all papers not related to macrofauna in marine environments were omitted from the list. The final list contained 162 papers.

During the meeting in Dinard, BEWG members scanned the papers from the final list, to check whether the relationship between macrobenthos and ecosystem functioning was indeed investigated. When this was indeed the case, the investigated aspects of the macrofauna (species names, functional groups, density, diversity, functional diversity), the investigated (proxy for) ecosystem functioning (i.e. nutrient flux, oxygen consumption) and the direction of the effect (positive, negative, no effect) was noted. Furthermore, the nature of the experiment (field versus lab) was noted as well. The work was not fully completed during the meeting in Dinard to due (1) time constraints and (2) the unavailability of some of the papers.

Planning for future work

- Interested BEWG members: completing the literature review, sending the information to Jan Vanaverbeke.
- J. Vanaverbeke: compiling the available information from the literature review in the final review table.
- J. Vanaverbeke: provide a preliminary analysis of the available literature for next BEWG meeting. Following questions will be tackled: (1) is there indeed a relationship between the macrobenthos and ecosystem functioning, (2) what aspects of macrofauna have generally been investigated (densities, diversity, functional diversity); (3) what are the ecosystem functions that have been investigated; (4) what was the direction of the eventual response.

6.1.2 Biological trait analysis

Coordination: A. Darr & M. Zettler

Three introductory presentations were given (Abstracts in Annex 4):

- M. Zettler. Salinity gradients and their effects on benthic diversity, autecology of species and relevant assessment tools.
- A. Darr, M. Gogina & M. L. Zettler. Functional changes in benthic communities along a salinity gradient - a western Baltic case study.
- M. Gogina & A. Darr. Approach to assess consequence of hypoxia disturbance events for benthic ecosystem functioning.

Progress made

BEWG defined a new initiative on biological trait analysis (BTA). The hypotheses behind the initiative are that (a) the functional composition of soft-bottom macrozoobenthic communities differs between different substrates (mud, fine sand, coarse sand) and that (b) same functional pattern within a sediment type can be found in different regions (Mediterranean, North Sea, Baltic,....). This initiative will be tackled stepwise:

Step 1: To build a common traits table

This is an essential and probably the most difficult part of the work. A common set of traits featuring a common set of categories and a common scoring system have to be agreed upon. However, the scoring per category may differ between the regions if

there is evidence for different behaviour / different life history. This procedure will be started via email, but a workshop will be required to discuss the crucial parts. We plan to apply for the ICES Science Fund next year, thus the workshop will most likely not take place before April next year (maybe in combination with next year's BEWG meeting).

Step 2: The second step will cover the actual case study.

Three distinct sediment classes (mud, fine sand, coarse sand) will be selected instead of covering the full gradient to make interpretation "easier". Up to now, "only" data from around Europe seems to be available, but we are still free to add expertise to our initiative.

Potentially, in a third step we will treat the functional composition in a more conceptual framework, which will be discussed during the next meeting.

Planning for future work

- A. Darr: to prepare for a questionnaire to collect information on (regional) BTA-approaches already existing within BEWG and to scope for the differences/ similarities between these.
- All: to reply to the questionnaire by 04/07/2014.
- A. Darr: to prepare for the follow-up plan for this initiative (including follow-up workshop to be organised in 2015).

6.2 To identify the links between benthic functions and ecosystem services

Coordination: P. Montagna, Harte Research Institute, USA

Progress made

An initiative was started during the 2013 meeting in A Coruña, Spain, for the Benthic Ecology Workgroup to write a paper entitled, "Ecosystem Function and Ecosystem Services Provided by Benthos". An outline was created during the 2013 meeting and during the inter-sessional period it was determined that we required some new data on ecosystem services provided by benthos. A plan was created to survey members of the workgroup to determine their views on which ecosystem services are provided by which habitats. The group settled on the definition of ecosystem services as the benefits that benthic environments provide that support human health and well-being.

P. Montagna provided a brief plenary presentation on defining ecosystem services and progress to date on the manuscript. A major goal of the current workshop was to obtain expert opinion on the perceived values of the ecosystem services provided by different benthic habitats. In performing a review of benthic habitat classification systems, it was discovered that different classification schemes are found based on the scale of the biosphere discussed. For example, at a global level many schemes distinguish hard-bottom habitats from biogenic reefs; but at a local scale there may be as many as six different kinds of hard-bottom habitats identified and mapped.

The first decision by the group was to adopt a classification system at the global scale and to use the European Nature Information System (EUNIS) classification system as a starting point. We started with the EUNIS habitat types, hierarchical view

http://eunis.eea.europa.eu/habitats-code-browser.jsp which provides the following "high-level" list of marine and coastal habitats:

A : Marine habitats

A1 : Littoral rock and other hard substrata

A2 : Littoral sediment

A3 : Infralittoral rock and other hard substrata

A4 : Circalittoral rock and other hard substrata

A5 : Sublittoral sediment

A6 : Deep-sea bed

A7 : Pelagic water column

A8 : Ice-associated marine habitats

B : Coastal habitats

B1 : Coastal dunes and sandy shores

B2 : Coastal shingle

B3 : Rock cliffs, ledges and shores, including the supralittoral

This list above was modified to be exclusively benthos, and to provide more of a global view. The new list is provided below:

BEWG Category	EUNIS Category	Habitat Description
1	A1	Littoral hard ground (rocky intertidal)
2	A2a	Littoral unvegetated (intertidal flats)
3	A2b	Littoral vegetated (marsh)
4	A5/A6	Biogenic reef (oyster, coral)
5	A5a	Sublittoral (bay bottoms, estuary bottoms)
6	A5b	Sublittoral vegetated (seagrass beds)
7	B1	Beaches
8	A5	Shelf
9	A6	Deep-sea

The group then filled out a survey to identify which ecosystem services will be found at which of the above benthic habitat types.

Planning for future work

The surveys will be analyzed and the new data will be incorporated into the manuscript. The data will provide expert opinion values on the ecosystem services provided by benthic habitats. This information will be used to identify the key services provided by each habitat, which is a justification for the conservation or restoration of these benthic habitats. A team has been formed to participate in writing the manuscript and this includes: Paul Montagna (lead), Johan Craeymeersch, Steven Degraer,

Clare Greathead, Paolo Magni, Patrick Mao, and Jan Vanaverbeke. During inter-seesion the group will work primarily through email communication.

7 Other business

Coordination: S. Degraer

7.1 Election of BEWG chair (2015–2017)

The group unanimously elected Silvana Birchenough, UK, to be proposed to become the BEWG Chair for the period 2015–2017.

7.2 Update BEWG research plan: Multi-annual ToRs

Progress made

The group discussed the ToRs' fitness-for-purpose to be used as multi-annual ToRs. All ToRs already on the BEWG list since 2013 were reconfirmed to be fit-for-purpose.

The presentation on using a species distribution model for sea pens to assess the effectiveness of MPAs however triggered a discussion on ecological issues surrounding the development/proposal of MPAs and how effective MPAs are going to be for the conservation of priority benthic species. Many WG members have concerns that the levels of protection (i.e. management measures) being applied within MPAs may not be adequate to protect the species in need of protection, which may put at risk the ecosystem function and traits in specific habitats. BEWG considered this issue to be a candidate extra multi-annual ToR to be further developed during its next meeting.

An initial discussion on the subject was held during the meeting:

The following questions were detailed:

- Q1: Can BEWG provide information on the effectiveness of MPAs to maintain or conserve ecosystem function and traits in specific habitats (context of MSFD requirements for protection)?
- Q2: Can BEWG inform best practice for using SDM to assess MPA effectiveness/ mapping potential recovery?
- Q3: Can BEWG collate a consensus of concerns of the group?

Key highlights from the discussion are:

- Conservation/restoration "issues"
    - There are different legislation and protection levels for MPAs across different countries, which reflect on the conservation of endangered/key species.
    - Evaluation of the effectiveness of MPAs as a tool for biodiversity conservation.
    - Are protection measures to solve the conservation crisis efficient?
    - Are surveillance/monitoring plans of MPAs effective?
    - Currently, there is no agreement about the total percentage of a feature that needs to be protected
    - Methods to quantify the size and location of suitable habitat across MPA networks have not been standardised – e.g. best practice for SDMs

  - MPAs need to address the potential for species re-population/habitat recovery – link to traits and function and connectivity
  - Effectiveness of protection may depend on MPA size (Walters 2000, Roberts *et al.* 2003)
- Autecological/environmental "issues"
  - Multi-annual datasets and monitoring of endangered/key species are important in defining the state of conservation of target species. The analysis of temporal series is essential to explain the population dynamic and other biological and ecological aspects of the considered species and to suggest suitable conservation measures.
  - Furthering our knowledge of the effect of environmental variables is a fundamental prerequisite for understanding the autecology of endangered species and for planning conservation strategies.
  - Low/high presence of small sizes as an indication of the reproductive and recruitment success (e.g. *Patella ferruginea* (Coppa *et al.* 2012); *Gracilechinus acutus* (Gonzalez-Irusta *et al.* 2014)).
  - Information is needed on the total area or degree of consolidation /patchiness/ connectivity required by a priority species or habitat to maintain or conserve ecosystem function and traits
- Human impact "issues"
  - Fisheries are one of the major worldwide threats for the conservation of intertidal and subtidal species. How should we deal with this critical issue?
  - Poaching (and cultural issues).
  - By protecting only a small proportion of a habitat within a network of multiple MPAs it is possible that the protected habitats may be too small to be viable for some species

Work is currently ongoing elsewhere (e.g. OSPAR) on the effectiveness of the MPA network as a whole (i.e. Representativity, Replication and Resilience, Connectivity and Adequacy/viability). Therefore BEWG should concentrate specifically on the links between the protected features and their ecological function. This can then form the basis of a cause – effect analysis of the main pressures that would affect these features and the effect or lack of effect any proposed measures will have.

Planning for future work

- C. Greathead and P. Magni: to prepare for a guidance document and a discussion on the subject during the next BEWG meeting.
- BEWG: to develop a new ToR e: Benthic Biodiversity and conservation: to review the role of benthic ecology in relation to MPAs

7.3 BEWG Outreach initiatives

7.3.1 BEWG webpage on www.ices.dk

Planning for future work

- S. Degraer, H. Hillewaert & S. Birchenough: to draft short description of the group and the group's work, including a two or three sentence introduction.

7.3.2 Conference contributions, workshop organization, etc.

Summary presentation (Abstract in Annex 4):

- J. Dannheim. ICES Working Group on Marine Benthal and offshore Renewable Energy Development (25-28/03/2014)

Future opportunities

- ASLO 2015 (22-27/02/2015): Call for sessions (deadline: 10/05)
- ICES ASC 2015
- Benthic Ecology Meeting 2015 (https://www.facebook.com/benthics2015)

7.3.3 BEWG's publications: guidelines for authorship

Given the recent concerns about the long list of co-authors on BEWG papers as expressed by journal editors, BEWG will further develop guidelines for co-authorship. Criteria for co-authorship will be based on the German example of "Safeguarding Good Scientific Practice"(Recommendations of the German Commission on Professional Self Regulation in Science): "Authors of an original scientific publication shall be all those, and only those, who have made significant contributions to the conception of studies or experiments, to the generation, analysis and interpretation of the data, and to preparing the manuscript, and who have consented to its publication, thereby assuming responsibility for it".

Planning for future work

- S. Degraer and S. Birchenough: to prepare for a draft guidance document to be discussed and adopted during the next meeting.

7.4 Any other business

The ICES Science Fund provides new opportunities for collaborative intersessional work on BEWG initiatives. A. Darr will prepare for a proposal to the ICES science fund for the organisation of a workshop to further develop the case study "On biological trait analysis in benthic ecology", foreseen in spring 2015.

7.5 Meeting conclusions

The group opted to hold its next year's meeting on 4–8 May in Calvi, France. A. Donnay will host the meeting.

The Chair thanked the local host and his team for their excellent hospitality and generosity. Especially the excursion to the *Sabellaria* reefs and the Mont-Saint-Michel, and the dinner were very much appreciated.

He also thanked BEWG for the excellent collaboration during the past six years and the participants for their active participation in the meeting, and closed the meeting on Friday, 16:30 hours.

Annex 1: List of participants

Name	Address	Phone/Fax	Email
Silvana Birchenough	CEFAS Lowestoft Laboratory Pakefield Road Lowestoft Suffolk NR33 0HT United Kingdom	Phone: +44 1502 527786 Fax: +44 1502 513865	silvana.birchenough@cefas.co.uk
Mats Blomqvist	Hafok AB 17961 Stenhamra Sweden	Phone: +46 107037210	mb@hafok.se
Johan Craeymeersch	Institute for Marine Resources and Ecosystem Studies (Wageningen IMARES) Po Box 77 4400 AB Yerseke the Netherlands	Phone: +31 317 487 075 Fax: +31 317 487 359	johan.craeymeersch@wur.nl
Jennifer Dannheim	Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research P.O. Box 120161 D-27570 Bremerhaven Germany	Phone: +49 471 4831 1734 Fax: +49 471 4831 1425	jennifer.dannheim@awi.de
Alexander Darr	Leibniz-Institute for Baltic Sea Research Seestr. 15 D-18119 Rostock Germany	Phone: +381 51973450 Fax: +381 5197440	alexander.darr@io-warnemuende.de
Jean-Claude Dauvin	Laboratoire Morphodynamique Continentale Et côtiere (UMR CNRS M2C) Caen University 24 rue des Tilleuls F-14000 Caen	Phone +33 231565722	jean-claude.dauvin@unicaen.fr
Steven Degraer (Chair)	RBINS, Operational Directorate Natural Environment Gulledelle 100 B-1200 Brussels Belgium	Phone: +32 2 773 2103	steven.degraer@mumm.ac.be
Nicolas Desroy	Ifremer, Laboratoire Bretagne Nord 38 rue du port blanc BP 70134 35801 Dinard France	Phone: +33 223185862	nicolas.desroy@ifremer.fr
Annick Donnay	STARESO Pointe de la Revellata BP 33 F-20260 Calvi France	Phone: +33 672521247 Fax: +33 495650134	annick.donnay@stareso.com
François Gaudin	Station Biologique de Roscoff - Team DivCo Place Georges Teissier CS 90074 F-29688 Roscoff Cedex France	Phone: +33298292341	francois.gaudin@sb-roscoff.fr
Olivier Gauthier	LEMAR UMR6539 CNRS|UBO|IRD|IFREMER Institut Universitaire Européen de la Mer Rue Dumont d'Urville F-29280 Plouzané France	Phone: +33298915362	olivier.gauthier@univ-brest.fr
Mayya Gogina	Leibniz-Institute for Baltic Sea Research Seestr. 15 D-18119 Rostock Germany	Phone: +381 5197393 Fax: +381 5197440	mayya.gogina@io-warnemuende.de

Name	Address	Phone/Fax	Email
Jacques Grall	Fauna & Flora Observatory Institut Universitaire Européen de la Mer Technopôle Brest-Iroise Place Nicolas Copernic F-29280 Plouzané France	Phone: +33 298498631	jgrall@univ-brest.fr
Clare Greathead	Marine Scotland Science Marine Laboratory 375, Victoria Road Aberdeen, AB12 4XB United Kingdom	Phone: +44 224 295526	greatheadc@marlab.ac.uk
Laurent Guérin	Muséum National d'Histoire Naturelle (MNHN) Station marine de Dinard 38 rue de Port-Blanc BP 70134 F-35801 Dinard Cedex France	Phone: +33 223185884	lguerin@mnhn.fr
Hans Hillewaert	ILVO-Fisheries Ankerstraat 1 B-8400 Oostende Belgium	Phone: +32 59 569832 Fax: +32 59 330629	hans.hillewaert@ilvo.vlaanderen.be
Jan Holstein	Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research P.O. Box 120161 27570 Bremerhaven Germany	Phone: +49 471 4831 2134 Fax: +49 471 4831 1425	jan.holstein@awi.de
Urszula Janas	Institute of Oceanography University of Gdansk Al.Marsz. J. Pilsudskiego 46, 81-378 Gdynia Poland	Phone: +48 523 68 67	oceuj@univ.gda.pl
Céline Labrune	LECOB UMR8222 Laboratoire Arago 66650 Banyuls-sur-Mer France	Phone: +334 68 88 73 62	labrune@obs-banyuls.fr
Sandrine Laurand	Institut Universitaire Européen de la Mer Observatoire des Sciences de l'Univers Technopôle Brest-Iroise Place Nicolas Copernic 29280 Plouzané France	Phone: +33298498605	sandrine.laurand@univ-brest.fr
Paul Montagna	Harte Research Insitute Texas A*M University-Corpus Christi 6300 Ocean Drive, Unit 5869 Corpus Christi, Texas 78412 USA	Phone: +1 361.825.2040	paul.montagna@tamucc.edu
Paolo Magni	CNR-IAMC National Research Council Institute for Coastal Marine Environment Loc. Sa Mardini, Torregrande 09170 Oristano Italy	Phone: +39 0783 229139 Fax : +39 0783 229135	paolo.magni@cnr.it
Henning Reiss	University of Nordland Faculty of Aquaculture and Biosciences PO box 1490 8049 Bodø Norway	Phone: +47 7551 7576	henning.reiss@uin.no
Jan Vanaverbeke	Ghent University Marine Biology Research Group	Phone: +3292648530	jan.vanaverbeke@ugent.be

Name	Address	Phone/Fax	Email
	Krijgslaan 281/S8 B-9000 Gent Belgium		
Gert Van Hoey	ILVO-Fisheries Ankerstraat 1 B-8400 Oostende Belgium	Phone: +32 59 569847 Fax: +32 59 330629	gert.vanhoey@ilvo.vlaanderen.be
Michael L. Zettler	Leibniz-Institute for Baltic Sea Research Seestr. 15 D-18119 Rostock Germany	Phone: +381 5197236 Fax: +381 5197440	michael.zettler@io-warnemuende.de

Annex 2: Agenda

MEETING OBJECTIVES

ToR a) Long-term benthic series and climate change

- To progress towards an understanding of change in the benthos, e.g. regime shifts, seasonality, fine spatial scale variability
- Facilitate collaboration by further development and promotion of the BEWG Benthic Long-Term Series network (BeLTS-net)
- To identify methodological issues in long-term series comparability

ToR b) Species distribution modelling and mapping

- To compare and report on the performance of different qualitative and quantitative species distribution modelling methods, e.g. methods validity
- To explore the applicability of different qualitative and quantitative species distribution modelling methods, e.g. limitations, purposes, knowledge gaps

ToR c) Benthos and legislative drivers

- To report on the use of benthic indicators and targets for management: Compatibility and complementarity
- On the myths on indicators: To investigate the importance of species autecology in indicator development and application
- To review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments

ToR d) Benthic biodiversity and ecosystem functioning

- To identify the links between benthic biodiversity and ecosystem functioning, e.g. literature review, ecological processes, biological traits.
- To identify the links between benthic functions and ecosystem services.

MEETING PROGRAMME

THEME 1: LONG-TERM BENTHIC SERIES AND CLIMATE CHANGE (ToR a)

- **ISSUE 1.A:** To progress towards an understanding change in the benthos, e.g. regime shifts, seasonality, fine spatial scale variability
    - Coordination: Silvana Birchenough
    - Introductory presentations
        - Jean-Claude Dauvin: "Long-term changes (1977-2010) in a fine sand macrobenthic community from the Bay of Morlaix (western English Channel)".
        - François Gaudin: "Distribution of benthic invertebrates and sea water temperature increase in the English Channel".
        - Olivier Gauthier: "Statistical methods for temporal analysis of community composition data: Case study of 13 years of benthic surveys in Chesapeake Bay".
    - Intersessional work progress
        - Silvana Birchenough: "SGCBNS paper on Spatial variation in BPc and vulnerability of ecosystem functioning in the North Sea"
    - Planning for future work
        - Silvana Birchenough: revisiting research ideas, prioritisation and planning…

- **ISSUE 1.B:** To facilitate collaboration by further development and promotion of the BEWG Benthic Long-Term Series network (BeLTS-net)
    - Coordination: Johan Craeymeersch & Hans Hillewaert
    - Intersessional work progress
        - Johan Craeymeersch: "drafting an electronic flyer on BeLTS-net"
        - Hans Hillewaert: "launching the BeLTS-net website"
        - Paul Montagna: "North-American long-term series (metadata) list to be included in BeLTS-net"
        - Clare Greathead: "potential sources for Canadian long-term series data (after launch of BELTS-net)"
    - Planning for future promotion and work
        - Johan Craeymeersch: e.g. to work towards the identification of methodological issues in long-term series comparability.

THEME 2. SPECIES DISTRIBUTION MODELLING AND MAPPING (ToR b)

- **ISSUE 2.A:** To compare and report on the performance and explore the applicability of different qualitative and quantitative species distribution modelling methods, e.g. methods validity, limitations, purposes, knowledge gaps
    - Coordination: Henning Reiss, Mayya Gogina
    - Introductory presentations

- Mayya Gogina: "Different quantitative modelling approaches and recent experience of their application"
- Henning Reiss: "Species distribution modelling and mapping in the marine environment and its relevance for ecosystem management – State-of-the-art".
- Alexander Darr: "Detecting hot-spots of bivalve biomass in the south-western Baltic Sea".
- Clare Greathead: "Distribution and environmental requirements for three sea pen species and the implications for marine protected areas"
- Jan Holstein: "Species distribution modelling work at AWI, Bremerhaven".

▪ Planning for future work
- Henning Reiss: to catch up with this, brainstorm about potential new activities, prioritise and plan for future work.
- Mayya Gogina: BEWG's interests, feasibility of further developing such initiative and how to progress
- Mayya Gogina: workplan to compare and report on the performance of different quantitative species distribution modelling techniques.

THEME 3. BENTHOS AND LEGISLATIVE DRIVERS (ToR c)

- **ISSUE 3.A:** To report on the use of benthic indicators and targets for management: Compatibility and complementarity
  - Coordination: Gert Van Hoey
  - Introductory presentations
    - Céline Labrune, Olivier Gauthier: "New benthic indicator development: ANR Benthoval project and phylosophy of the approach".
    - Laurent Guérin: "OSPAR's benthic habitat assessment initiatives"
    - Gert Van Hoey, Silvana Birchenough: Estimating the biological value of soft-bottom sediments with sediment profile imaging (SPI) and grab sampling".
  - Intersessional work progress
    - Gert Van Hoey: "intersessional compilation of an overview table on benthos indicators covering the entire ICES area".
  - Planning for future work
    - Gert Van Hoey: establishing a work plan to report on the "use of benthic indicators and targets for management: Compatibility and complementarity" (including redundancy)"
      - Key issues: Appropriate datasets?; Appropriate indicators?; Allocation of work and timing.

- **ISSUE 3.B:** On the myths on indicators: To investigate the importance of species autecology in indicator development and application
    - Coordination: Michael Zettler
    - Introductory presentation
        - Michael Zettler: "Summary of the PLOSONE paper on the myths of (static) indicators".
    - Planning for future work:
        - Michael Zettler: Revisiting BEWG's research plans, scanning for new ones and deciding on how to pursue".

- **ISSUE 3.C:** To review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments
    - Coordination: Steven Degraer
    - Introductory presentations
        - Steven Degraer: "Towards a joint MSFD monitoring programme for the North and Celtic Sea, JMP-NSCS: Project outline and state-of-the-art".
        - Henning Reiss: "about metabarcoding of benthos samples".
        - Gerard Duineveld: "…".
    - Planning for future work:
        - Steven Degraer: Brainstorm on the JMP NSCS case study on efficient benthic multimetric indices monitoring, making use of the BEWG NSBP1987 and NSBS2000 data: research questions, concepts and way forward

THEME 4: BENTHIC BIODIVERSITY AND ECOSYSTEM FUNCTIONING (ToR d)

- **ISSUE 4.A:** To identify the links between benthic biodiversity and ecosystem functioning, e.g. literature review, ecological processes, biological traits.

    - 4.A.1. Literature review on the links between benthic biodiversity and ecosystem functioning
        - Coordination: Jan Vanaverbeke
        - Introductory presentations
            - Jan Vanaverbeke: Variable importance of macrofaunal functional biodiversity for biogeochemical cycling in temperate coastal sediments
            - Stanislas Dubois: "On the functional role of *Sabellaria alveolata* reefs".
        - Intersessional work
            - Jan Vanaverbeke: "to finalise the reference list review, lead on the initial analysis of the-se lists and prepare for a work plan for the 2014 meeting"
        - Planning for future work
            - Jan Vanaverbeke: defining and starting to explore the next steps towards the literature review

    - 4.A.2 Biological trait analysis

- Coordination: Michael Zettler
- Introductory presentations
  - Alexander Darr, Mayya Gogina: "Functional changes in benthic communities along a salinity gradient - a western Baltic case study"
  - Alexander Darr, Mayya Gogina: "Approach to assess consequence of hypoxia disturbance events for benthic ecosystem functioning"
- Planning for future work:
  - Michael Zettler: What questions and issues are considered priority within the issue and how to proceed as BEWG?
    - Key issues to be considered: Functional diversity cannot be measured directly so surrogates should be used as indicators of it; White paper on "Does structure affect functioning?"; Clear definition on what part of biodiversity are we talking about"; Introducing functional approach to regime shift analysis".

- **ISSUE 4.B:** To identify the links between benthic functions and ecosystem services.
  - Coordination: Paul Montagna
    - Introductory presentation: where we were last year…
    - Workshop on linking ecosystem services to benthic habitats
    - Plan for wrapping up the paper on "Linking ecosystem functions and ecosystem services: misconceptions and benthos matters"

<u>THEME 5: OTHER BUSINESS</u>

- **ISSUE 5.A**: Election of BEWG chair (2015-2017)
  - Coordination: Steven Degraer

- **ISSUE 5.B**: Update BEWG's research plan: Multi-annual ToRs…
  - Coordination: Steven Degraer

- **ISSUE 5.C**: BEWG Outreach initiatives

  - 5.C.1 BEWG's webpage on www.ices.dk
    - Coordination: Steven Degraer
      - to draft short description of the group and the group's work, including a two or three sentence introduction

  - 5.C.2 Conference contributions, workshop organization, etc.
    - Coordination: Steven Degraer
    - Summary presentations

- Lene Buhl-Mortensen: "Effects of fishing on benthic fauna and habitat: Change in ecosystem composition and functioning in response to fishing intensity, gear type and discard" (16-19/06/2014)
- Jennifer Dannheim: "ICES Working Group on Marine Benthal and offshore Renewable Energy Development (25-28/03/2014)".

▪ Future opportunities
- ASLO 2015 (22-27/02/2015): Call for sessions (deadline: 10/05)
- ICES ASC 2015

o 5.C.3 BEWG's publications: guidelines for authorship

- **ISSUE 5.D** Any other business
  - ▪ Coordination: Steven Degraer
  - ▪ ICES Science Fund

- **ISSUE 5.E**: Meeting conclusions
  - ▪ Coordination: Steven Degraer
  - ▪ Selection of next year's meeting place and date
  - ▪ Summary of action points (incl. responsibilities and time lines), recommendations and Multi-Annual Terms of Reference

TIME SCHEDULE

Monday 28/04

09h45 – 10h00 Arrival of participants
10h00 – 11h00 Welcome and practicalities
Icebreaker: Nicolas Desroy: Marine benthos research at IFREMER
11h00 – 12h00 Theme 1: Long-term series and climate change
12h00 – 13h00 Topic 4.A.1: Benthic biodiversity and ecosystem functioning: plenary intro
13h00 – 14h00 Lunch
14h00 – 15h30 Issue 3.A: Benthic indicators: plenary intro
15h30 – 16h00 Coffee break
16h00 – 17h00 Breakout groups

- Issue 3.A: Benthic indicators
- Topic 4.A.1: Benthic biodiversity and ecosystem functioning

17h00 – 18h00 Breakout groups

- Theme 1, incl. Skype participation by Carl Van Colen.
- Issue 3.A: Benthic indicators (ctd.)
- Topic 4.A.1: Benthic biodiversity and ecosystem functioning (ctd.)

Tuesday 29/04

09h00 – 11h00 Issue 2.A: Species distribution modelling: plenary intro
11h00 – 11h30 Coffee break
11h30 – 12h00 Issue 3.A: Benthic indicators: plenary intro
12h00 – 13h00 Issue 4.B: Ecosystem functioning and services: plenary intro
13h00 – 14h00 Lunch
14h00 – 15h30 Breakout groups

- Issue 2.A: Species distribution modelling
- Issue 3.A: Benthic indicators

15h30 – 16h00 Coffee break
16h00 – 18h00 Breakout groups

- Issue 2.A: Species distribution modelling (ctd.)
- Issue 4.B: Ecosystem functioning and services

19h00 – … Social event: "Diner de gala"

Wednesday 30/04

09h00 – 10h00 Issue 5.A: Election of BEWG chair 2015 - 2017
10h00 – 10h30 Coffee break
10h30 – … Social event: Visit to the Bay de Mont Saint-Michel and the *Sabellaria alveolata* reefs of Champeaux.

Thursday 01/05

09h00 – 10h00 Issue 3.C: Benthic indicators and monitoring: plenary intro
10h00 – 11h00 Topic 4.A.2: Ecosystem functioning and biological trait: plenary intro
11h00 – 11h30 Coffee break
11h30 – 13h00 Breakout groups

- Issue 3.C: Benthic indicators and monitoring
- Topic 4.A.2: Ecosystem functioning and biological trait

13h00 – 14h00 Lunch
14h00 – 15h00 Issue 3.B: On the myths of indicators, the sequel: plenary intro
15h00 – 15h300 Coffee break
16h00 – 18h00 Breakout groups

- Issue 3.B: On the myths of indicators, the sequel
- Topic 4.A.2: Ecosystem functioning and biological trait (ctd.)

Friday 02/05

09h00 – 11h00 Breakout groups

- Outstanding work

11h00 – 11h30 Coffee break
11h30 – 12h30 Issue 5.C: BEWG outreach activities
12h30 – 13h00 Issue 5.B: (Re) defining BEWG's multi-annual ToRs
13h00 – 14h00 Lunch
14h00 – 14h30 Issue 5.B: (Re) defining BEWG's multi-annual ToRs (ctd.)
14h30 - 15h30 Issue 5.D: Any other business
15h30 – 16h00 Issue 5.E: Meeting wrap up and closure

Annex 3: BEWG Terms of Reference for the next meeting

The **Benthos Ecology Working Group** (BEWG), chaired by Silvana Birchenough*, UK, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2015	4–8 May	Calvi, Corsica, France	Interim report by 30 June to SSGEPD	
Year 2016			Interim report by DATE to SSGEPD, SCICOM…	
Year 2017			Final report by DATE to SSGEPD, SCICOM…	

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
A	Long-term benthic series and climate change 1. To progress towards an understanding change in the benthos, e.g. regime shifts, seasonality, fine spatial scale variability 2. Facilitate collaboration by further development and promotion of the BEWG Benthic Long-Term Series network (BeLTS-net) 3. To identify methodological issues in long-term series comparability	BELTS-net will aid creating the forum for further identification of major ecosystem regime shifts, seasonality and fine scale spatial variability, and as such for further consideration of the impact of climate change onto the benthos. Given the need to compile, combine and integrate different databases the identification of methodological issues in long-term series comparability is considered most important.		Years 1-3 Years 1-3 Years 1-2	Research paper(s) Website and dicussion forum Position paper
B	Species distribution modelling and mapping 1. To compare and report on the perfor-	Species distribution modelling (SDM) helps understanding the distribution of species and communities. As such, it helps elaborating a		Years 1-2	Review paper

	mance of different qualitative and quantitative species distribution modelling methods, e.g. methods validity 2. To explore the applicability of different qualitative and quantitative species distribution modelling methods, e.g. limitations, purposes, knowledge gaps	scientifically-sound management of the marine ecosystem. While qualitative SDM (i.e. modelling the likelihood of occurrence of benthic feature) has been regularly applied, today attention is needed to quantitative modelling techniques (e.g. modelling densities or biomass. BEWG will therefore compare and report on the performance of different qualitative and quantitative species distribution modelling methods, e.g. methods validity, and explore the applicability of different qualitative and quantitative species distribution modelling methods, e.g. limitations, purposes, knowledge gaps.	Years 2-3	Position paper
C	Benthos and legislative drivers 1. To report on the use of benthic indicators and targets for management: Compatibility and complementarity 2. On the myths on indicators: To investigate the importance of species autecology in indicator development and application 3. To review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments	A wide suite of benthic quality indicators were developed, intercalibrated and applied within the framework of several international regulations. At present, the most relevant directives within the Northatlantic realm are the Water Framework Directive, the Habitats Directive and the Marine Strategy Framework Directive. BEWG will invetigate the Compatibility and complementarity within the use of benthic indicators and targets for management. It will further continue scientifically investigating the importance of species autecology in indicator development and application and review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments.	Years 1-2 Years 1-3 Years 1-2	Position paper Research paper(s) Review paper
D	Benthic biodiversity and ecosystem func-	Disentangling the link between biodiversity and ecosystem functioning is		

	tioning 1. To identify the links between benthic biodiversity and ecosystem functioning, e.g. literature review, ecological processes, biological traits. 2. To identify the links between benthic functions and ecosystem services.	currently considered key to a full understanding of the health of marine ecosystems. This topic hence became a cross-cutting theme since the BEWG 2012 meeting. BEWG will therefore review and identify benthic indicators to reflect the link between biodiversity and ecosystem functioning and review how ecological function and diversity relates to different parts of the benthic communities at different spatial scales, taking account of e.g. ecological processes and biological traits. BEWG will also scope for research on the functional diversity of macrobenthos in relation to ecosystem functioning, for which a first data compilation will be dealt with intersessionally. From a more conceptual perspective, BEWG will continue investigating the link between ecosystem functioning and ecosystem services.	Years 1-3 Year 1	Research paper(s) Viewpoint paper
E	Benthic Biodiversity and conservation: to review the role of benthic ecology in relation to MPAs To identify the links between protected features and their ecological function To relate the functions of protected marine features to the main pressures that would affect these features (cause-effect analysis) To consider the effect of not excluding key pressures that affect the designating feature from MPAs (i.e. no take zones).	Understanding ecological issues surrounding the development/proposal of MPAs and how effective MPAs are going to be for the conservation of priority benthic species. Many WG members seemed to have concerns that the levels of protection (i.e. management measures) being applied within MPAs may not be adequate to protect the species in need of protection, which may put at risk the ecosystem function and traits in specific habitats. This ToR will consider issues associated with conservation/restoration, Autecological/environmental as well as human issues.	Years 1-3 Years 1-3 Years 1-3	Review paper Review paper
F	[OSPAR request, to be confirmed and maybe amended] Evaluate existing approaches to analyse habitat sensitivity information, includ-			

	ing approaches based on ecological traits and eco-groupings. Aspects around the resolution of the habitat data and the feasibility of the information to be used for assessments at regional scale need to be included within the comparative analysis. Provide a recommended set of sensitivity to abrasion scores for Eunis [3/4] level habitats in the North Sea for use by WGMHM.		
G	Produce four short paragraphs for the ICES Ecosystem Overviews on the benthic habitat (geology, dynamics and diversity), one paragraph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea.	Each paragraph should be maximum 150 words in length and can be support by one figure. Paragraphs for each ecoregion should be similar in style and address the overall state and comment on the pressures accounting for changes in state. These will go in section four of the ecosystem overviews and not supposed to be long descriptions, but a short synopsis of important points for managers and policy developers. (Template and Guidelines for Ecosystem Overviews)	
H	Produce four short paragraphs for the ICES Ecosystem Overviews on the benthic community, one paragraph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea.	Each paragraph should be maximum 150 words in length and can be support by one figure. Paragraphs for each ecoregion should be similar in style and address the overall state and comment on the pressures accounting for changes in state. These will go in section four of the ecosystem overviews and not supposed to be long descriptions, but a short synopsis of important points for managers and policy developers. (Template and Guidelines for Ecosystem Overviews)	

Summary of the Work Plan

Year 1	ToRs a.1-3, b.1, c.1-2, d.1-2, e.1-3
Year 2	ToRs a.1-3, b.1-2, c.1-3, d.1**, E.1-3**

Year 3	ToRs a.1-2, b.2, c.2-3, d.1, **E.1-3**

Supporting information

Priority	The current activities of BEWG will continue along the three major vertical axes of priority within BEWG: long-term series and climate change, benthic indicators and EU directives, and species distribution modelling, and one cross-cutting (horizontal) axis on benthic biodiversity and ecosystem functioning (including issues directly in connection to MPAs). All issues mentioned fit the ICES Science Programme and are considered to be of high priority. The BEWG are active contirbutors and aim to report their outcomes directly to ICES in their annual report as well as in the peer reviewed literature, some of the outputs can be seen in ICES JMS, PLOS One, Marine Pollution Bulleting, etc.)
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 15-30 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There is a possibility for interaction of several ICES expert groups, among which WGMHM and WGEXT.
Linkages to other organizations	The group has had also interaction with OSPAR IGC-COBAM.

Annex 4: Abstracts of introductory and other presentations

Long-term changes (1977–2010) in a fine sand macrobenthic community from the Bay of Morlaix (western English Channel)

J.-C. Dauvin, UNICAEN, France

Reported on work done by Dauvin J.-C., Thiébaut E., Gentil F., Houbin, C. & Somerfield P.J.S.

In the Bay of Morlaix, at Pierre Noire Station (fine sand *Abra alba* community) at 17 m depth, benthic samples with a Smith-McIntyre grab (0.1 m^2) were collected each month from April 1977 to March 1982, then at a rhythm of five observations per year over a thirty-year period (1977 to nowadays). In parallel, different environmental variables measured at different frequencies are available to describe climate variability (i.e. sea surface temperature, wind speed and direction, and freshwater inputs) as well as large-scale hydroclimatic indices (NAO, AMO, NHT). The site was also strongly affected by the Amoco Cadiz oil spill during which 220 000 tons of hydrocarbons were discharged in April 1978. Data were analysed to identify inter-annual variability and long-term trends in the densities of the dominant species and the community structure in response to both anthropogenic disturbances and climate change. A typology was proposed to classify the species according to their temporal variations corresponding to different types of ecological responses to environmental changes (e.g. erratic proliferations of opportunistic species, multi-year cycles, and positive trends). Our results highlight the importance of long-term observations for the understanding of temporal dynamics of coastal benthic communities and disentangle the relative role of natural and human-induced changes. The disappearance of the dominant amphipod group (*Ampelisca*) in 1978 can be related to the pollution of the bottom by hydrocarbons; their colonisation was long (> 10 years) in relation to their holobenthic type of development; but, the high decrease of their population at the middle of the 2000s which continues to now remains enigmatic. For managers, they raise the question of a reference status of a habitat and the shifting of baselines.

Distribution of benthic invertebrates and sea water temperature increase in the English Channel

F. Gaudin, Station Biologique de Roscoff, France

Work done by F. Gaudin, E. Thiebaut & N. Desroy

In the North East Atlantic, the English Channel is situated at the biogeographical crossroads of two provinces: the cold-temperate boreal province in the North and the warm-temperate Lusitanian province in the South. Historical works carried out during the 1950s and the 1970s have shown that the distribution of benthic invertebrates in the Channel is influenced by edaphism and/or thermal gradients. As a consequence, many species are in their southern or northern limits of distribution in this biogeographic transition area. In parallel, physical data highlighted an increase in the surface temperature of 0.6 °C per decade during the last 20 years and a thermal regime shift in North-West Europe since the 1980s.

The aims of the project are (1) to develop predictive habitat models for a selection of species based on historical data to quantify the respective role of climate and edaphism on the distribution of the macrofauna and (2) to assess modifications in their dis-

tribution limits regarding climate change by comparing historical data and present data. The association of several data sets collected at different periods will represent a unique opportunity to improve, validate and test the relevance of species distribution models to predict the response of macrobenthic invertebrates to climate change. The present data will be the result of the sampling of 250 stations distributed along three transects from the Iroise Sea to the central Channel. Habitat models will then be used to predict the diversity distribution at the end of the 21st century.

Preliminary results observed on the 71 stations already sampled along the southernmost transect seem to confirm the observations made in the 1950s and 70s. For example, cold-water stenothermal Western species like *Astarte sulcata* remain limited to the West of a line North of the Bay of Morlaix whereas Sarnian species (warm-water species) like *Venus verrucosa* remain localized in the Normand Breton Gulf. These preliminary trends will be completed by the sampling of the 178 remaining stations in September 2014.

Statistical methods for temporal analysis of community composition data: Case study of 13 years of benthic surveys in Chesapeake Bay

O. Gauthier, Ifremer, France

This presentation focused on applying and studying the concept of beta diversity, the variation in community composition, in the temporal setting.

In this context, temporal beta diversity is measured by the variance of the multivariate community composition time series and that variance can be partitioned using appropriate statistical methods. Particular emphasis was put on methods of temporal eigenfunction analysis developed for multiscale exploration (i.e. addressing several scales of variation) of univariate or multivariate response data. These methods are illustrated with ecological data from 13 years of benthic surveys in Chesapeake Bay, USA. This presentation draws from the review by Legendre and Gauthier (2014) which also addresses other methods of analysis for temporal analysis of community composition and includes a tutorial detailing the analyses in the R language.

Different quantitative modelling approaches and recent experience of their application

M. Gogina, Leibniz-Institute for Baltic Sea Research, Germany

Most papers in marine benthic realm related to correlative species distribution modeling are still focused on species occurrence. Yet models able to draw predictions for quantitative metrics of species distribution (exploring response of e.g. abundance, biomass, and % cover to environmental factors) are gaining increasing attention as more informative for ecosystem functioning research. Conclusions from few recent relevant publications were briefly presented (see the references below). To summarize the overall impression Random Forest nearly always evidences best performance. This method seems to be more intended for mapping purposes than for testing hypotheses or drawing out ecologically meaningful conclusions due to less straightforward interpretability. On the other hand GLM, including its extensions like Quantile regression and GAM, provide simpler visualisation of responses and more straightforward ecologically meaningful interpretation. Accuracy increases

with sample size and reduced variance in the response, highlighting the importance of comprehensive dataset that encompassed appropriate environmental gradients within meaningful spatial scales for the modelled response. The use of geostatistics to interpolate (e.g. universal kriging, as an inherently spatial model) remains an option mapping when sampling density and design are appropriate. This should be considered as a quick overview and by no means a throughout review.

Šiaulys, A., Bučas, M., (2012). Species distribution modelling of benthic invertebrates in the south-eastern Baltic Sea. *Baltica*, **25**(2), 163-170.

Bucas, M., Bergström, U., Downie, A.L., Sundblad, G., Gullström, M., von Numers, M., Siaulys, A., Lindegarth, M., (2013). Empirical modelling of benthic species distribution, abundance, and diversity in the Baltic Sea: evaluating the scope for predictive mapping using different modelling approaches. *ICES Journal of Marine Science*, **70**(6): 1054-3139.

Carpentier, A., Vaz, S., Martin, C.S., Coppin, F., Dauvin, J-C., Desroy, N., Dewarumez, J-M., Eastwood, P.D., Ernande, B., Harrop, S., Kemp, Z., Koubbi, P., Leader-Williams, N., Lefebvre, A., Lemoine, M., Loots, C., Meaden, G.J., Ryan, N. & Walkey, M. 2005. Eastern Channel Habitat Atlas for Marine Resource Management (CHARM).

Knudby, A., Jupiter, S., Roelfsema, C., Lyons, M., Phinn, S., (2013). Mapping Coral Reef Resilience Indicators Using Field and Remotely Sensed Data. *Remote Sens*. **5**: 1311-1334.

Nyström Sandman, A., Wikström, S. A., Blomqvist, M., Kautsky, H. and Isaeus, M. (2013). Scale-dependent influence of environmental variables on species distribution: a case study on five coastal benthic species in the Baltic Sea. *Ecography*, **36**: 354–363.

Darr, A., Gogina, M., Zettler, M.L., (2014). Detecting hot-spots of bivalve biomass in the south-western Baltic Sea. *Journal of Marine Systems*, **134**: 69-80.

Detecting hot-spots of bivalve biomass in the south-western Baltic Sea

A. Darr, M. Gogina & M. L. Zettler, Leibniz-Institute for Baltic Sea Research, Germany

Bivalves are among the most important taxonomic groups in marine benthic communities in nutrient cycling via benthic–pelagic coupling and as food source for higher trophic levels. Additionally, bivalve species combine several autecological features with potential value for assessment and management purposes. Therefore, the demand for quantitative distribution maps of bivalves is high both in research with focus on functional ecology of marine benthos and in policy. In our study, we modelled and mapped the distribution of biomass of soft- and hard-bottom bivalves in the south-western Baltic Sea using Random Forest algorithms. Models were achieved for ten of the most frequent of overall 29 identified species. The distribution of bivalve biomass was mainly influenced by the abiotic parameters salinity, water depths, sediment characteristics and the amount of detritus as a proxy for food availability. Three hot-spots of bivalve biomass dominated by different species were detected: the oxygen-rich deeper parts of the Kiel Bay dominated by *Arctica islandica*, the shallow areas close to the mouth of the river Oder dominated by *Mya arenaria* and the hard-substrates around Rügen Island and the shallow Adlergrund dominated by *Mytilus* spp. The attained maps provide a good basis for further functional and applied analysis.

Distribution and environmental requirements for three sea pen species and the implications for marine protected areas

C. Greathead, Marine Scotland Science, UK

The driver for this study was to inform the development and management of MPAs for the burrowed mud habitat in Scotland and modelled the environmental requirements for three sea pen species: *Funiculina quadrangularis*, *Virgularia mirabilis* and *Pennatula phosphorea*. *Funiculina quadrangularis* and the habitat associated with *V. mirabilis* and *P. phosphorea* are key components of the burrowed mud habitat and the OSPAR listed habitat "Sea pens and burrowing megafauna". These habitats are recommended for protection by spatial measures such as marine protected areas. Empirical evidence about the environmental requirements of these species is scant and only provides information on a small sub-set of the potential distribution. This study models these sea pens potential distributions using the MAXimum ENTropy (MAXENT) algorithm. These areas were compared to the location of five possible marine protected areas (pMPAs) proposed for Scottish waters. Metrics which are relevant to assessing the efficacy of MPAs are also presented.

There were four environmental variables of prime importance for predicting presence for all three species: mud, minimum salinity, depth and gravel. The response curves for all species showed that the habitat suitability index increased with mud content. The modelled distribution of *F. quadrangularis* showed a preference for deeper water than *V. mirabilis* or *P. phosphorea* and was not present in sediment with gravel content above 30 %. *Pennatula phosphorea* had the smallest area of suitable habitat whilst *V. mirabilis* had the largest. Some of the largest areas for *F. quadrangularis* lay outside the pMPAs. The percentage of the predicted suitable area for each species that was encompassed by the five pMPAs ranged from 11 % for *F. quadrangularis* to 15 % for *P. phosphorea*.

By identifying the environmental requirements, the study provides an estimate of the distribution, extent and patchiness of the three sea pens and demonstrates the links between these preferences and differences in autecology of each species. Higher model accuracy suggests a narrower ecological niche (High AUC and kappa); *F. quadrangularis* had the highest AUC values in this study and *V. mirabilis*, which recorded the lowest values of AUC had tolerance to a wide range of environmental conditions. Sea pens are generally found in soft sediments that facilitate a sea pens' ability to establish an attachment to the sea bed. High mud content indicates low hydrodynamic energy. The large filtering surface area of *F. quadrangularis* is a disadvantage in strong currents but is potentially an advantage in deeper quiescent waters as the concentration of organic matter in the water column generally attenuates with depth. High flow rates will cause individuals to become detached from the substrate. However the large 'muscular' peduncle of *V. mirabilis* allows it to inhabit harder substrates with higher sand and gravel component and higher flow rates.

The results for the MPA assessment suggest that the MPA coverage for the burrowed mud with sea pens habitat in the study region is probably adequate but could be improved for *F. quadrangularis*.

A multivariate approach to be used as a biotic index within the BenthoVal project

C. Labrune, Laboratoire Arago, Fance

C. Labrune reported on work by C. Labrune, A. Grémare, N. Lavesque, A. Romero, P. Bonifacio, J. Grall, S. Laurand & O. Gauthier

In order to answer to the European Directives such as the WFD and the MSFD, many indicators have been proposed to assess ecological status of the soft-sediment benthic habitat.

There are different families of indicators which all present different flaws:

1. Indicators that classify species in group of sensitivity or trophic group. These indicators were developed for a particular disturbance and in consequences are often not efficient to detect any type of disturbance. Furthermore, the concept of sensitivity/tolerance is not easy to address, particularly when the ecological group of a dominant species is not clear.

2. The multi metric indices such as the Norwegian Quality index or the Danish Quality Index are based on the AMBI and present the flaws of the sensitivity indices.

3. Indices based on deviation between reference stations and tested stations. The computed deviation depends on the variability within the reference conditions. Therefore there is a need of a lot of data and several references to be able to compute these indices, which is not always possible. Furthermore, these indices often resume the fauna as one or several univariate measure such as species richness or H', which reduce the importance of fauna composition.

4. Indices based on multivariate analyses can be more difficult to communicate and are less tested than the other indices.

Several authors showed that multivariate analysis reflects well the ecological quality. Within the BenthoVal project, we would like to test a benthic indicator based on the Bray-Curtis similarity matrix. The idea is to take as reference either the reference station if there is only one reference or the centroid of several reference stations if there are different references. The value of the proposed BC index is the Bray-Curtis similarity between the station of reference (either the true station or the centroid of several stations) and each of the tested station. This exercise is conducted per habitat. Applying this method, Menu (2013) showed that the Bray-Curtis similarity was closely related with the intensity of the pressure on two examples which were organic enrichment and oil disturbance respectively.

Even if the Bray-Curtis similarity shows consistent results, other distance/similarity indices will be tested within the BenthoVal project. Once the best indicator will be identified, the challenge will be to convert the value of the indicator in classes of Ecological Quality Status requested by the European Directives with the associated boundaries between classes. To do that, there is a need to collect datasets with macrofauna associated with pressure gradient, particularly physical gradients which have proved to be problematic to detect by traditional indices.

Practical species distribution modelling: validation and performance metrics

J. Holstein & J. Dannheim, AWI, Germany

Good model validation is essential for sound model quality assessment. For this, both state-of-the-art methods and sound model performance metrics are required. The technique of "k-fold cross validation" (KCV) is elaborated. KCV strongly recom-

mends to replace the very popular simple split of the data set into two subsets—one for model building and the remainder for validation. KCV is arguably superior, since both model building and model validation are carried out on the full data set. Additionally, the uncertainty of the model performance metrics is obtained. KCV is however computationally more demanding.

The possibility of drawing abundance information from presence/absence models (APM) was investigated. Being contained in empirical data when plotted against environmental parameters, that correlation is still present in predicted prevalence. However, the extent of this correlation was found not be deducible from APM performance metrics such as AUC or Cohen's Kappa, which relate to the modes ability to discriminate species occurrence form non-occurrence. Implications are seen for the use of predicted prevalence as a Habitat Suitability Index which seems to have questionable soundness if species abundance is not necessarily higher at areas with high habitat suitability.

OSPAR's benthic habitat assessment initiatives

L. Guérin, MNHN, France

L. Guérin presented an overview of the work led, and in progress, by the Benthic expert group of ICG-COBAM (OSPAR Committee: L. Guérin, C. Herbon, S. Arrieta & A. Serrano).

The approach developed to assess benthic habitat include "indicators" and monitoring guidelines, and is based on several years background works, including several expert workshops. The set of indicators (BH1 to BH5) has been elaborated to be complementary and answers to assessment requirements (which habitat, where, how much and how long impacted?). These indicators are still under development and should be tested in 2014 to conclude on them soundness and sensitivity to reflect anthropic pressures. A risk based approach, involving pressure data and environmental data, and MSFD issues, are the main drivers to optimize both monitoring and assessment methodologies.

Estimating the biological value of soft-bottom sediments with sediment profile imaging (SPI) and grab sampling

G. Van Hoey, ILVO, Belgium & S. Birchenough, Cefas, UK

Biological value estimation is based on a set of assessment questions and several thresholds to delineate areas of ecological importance (e.g. biodiversity). An existing framework, that was specifically designed to assess the ecosystem biodiversity, was expanded by adding new questions on the productivity, functionality and biogeochemical status of benthic habitats. The additional ecological and sedimentological information was collected by using sediment profile imagery (SPI) and grab sampling. Additionally, information on the performance and comparability of both techniques is provided in this study. The research idea was tested at a site near the harbour of Zeebrugge, an area under consideration as a new disposal site for dredged material from the harbour entrance.

The sedimentology of the area can be adequately described based on the information from both SPI and Van Veen grab samples, but only the SPI revealed structural in-

formation on the physical habitat (layering, a-RPD). The latter information represented the current status of the benthic habitat, which was confirmed by the Van Veen grab samples. All information was summarized through the biological valuation framework, and provided clear evidence of the differences in biological value for the different sediment types within the area. We concluded that the installation of a new dredged material disposal site in this area was not in conflict with the benthic ecology. This area has a low biological value and the benthic system is adapted to changing conditions, which was signalled by the dominance of mobile, short living and opportunistic species.

This study showed that suitable sedimentological and ecological information can be gathered by these traditional and complementary techniques, to estimate the biological value of an area in the light of marine spatial planning and environmental impact assessments.

Van Hoey, Gert; Silvana N.R. Birchenough, Kris Hostens, (2014). Estimating the biological value of soft-bottom sediments with sediment profile imaging (SPI) and grab sampling. *Journal of Sea Research*, **86**, 1-12

Towards a joint MSFD monitoring programme for the North and Celtic Sea, JMP-NSCS: Project outline and state-of-the-art

S. Degraer, Royal Belgian Institute of Natural Sciences, Belgium

Successful and cost-effective implementation of the MSFD depends on regional cooperation between EU Member States and third countries. This project develops a proposal for a joint monitoring programme for the North Sea and for the Celtic Sea. It will be based on an analysis of all ongoing monitoring in these subregions and the requirements of the MSFD, taking into account other legal frameworks and agreements.

Using existing and new planning tools, integration will be sought between types of monitoring in order to efficiently use monitoring platforms, i.e. ships, permanent stations and aerial surveys. Innovative and proven technology and current practices in integrated monitoring will serve as building blocks and examples. Since the project covers two subregions with different characteristics, transferability of approaches to other subregions and identification of opportunities to trial integrated ecosystem surveys are major aspects of the work.

Perhaps the main aim of this project is to build a constructive network between all institutions that are responsible for monitoring in these subregions, concerning both fisheries and environmental monitoring. The consortium consists of all relevant institutes. MSFD policy leads support the work and actively contribute to it. The consortium works towards lasting cross-border cooperation for current and future implementation of the MSFD.

Biodiversity assessment of benthic communities using high-throughput DNA metabarcoding

Truls Moum & Henning Reiss, University of Nordland, Norway

There is a need to expand our knowledge of marine ecosystems in north Norwegian waters. The project Metabenthomics specifically focuses on the demand for cost effec-

tive and representative of benthic communities in habitat types of particular concern, as a basis for sustainable ecosystem management. Current marine management policies are strictly based on the maintenance of biological diversity, and there is an urgent need to monitor marine ecosystems in the face of environmental change.

Traditional methods for identification of benthic organisms are exceedingly labour-intensive and time-consuming, and therefore, expensive. Also, diversity assessments require extensive taxonomic expertise, and are usually limited to a part of the existing biodiversity, typically the macro fraction of the biota. As a result, there is an obvious mismatch between the need for representative biodiversity assessments and the resources at hand. DNA based methods offer the beginning of a possible solution to these shortcomings. The current project applies DNA barcoding and high-throughput sequencing technologies to analyse the benthic communities from bulk sediment samples, from a natural depth gradient in a fjord basin, and from environments influenced by aquaculture and oil production. We will further contribute to holistic and coherent methods for biodiversity assessment and monitoring. We aim to significantly expand our knowledge on the benthic biodiversity in boreal waters and contribute to molecular reference databases, in particular focusing on an important taxonomic group, the marine nematodes.

Variable importance of macrofaunal functional biodiversity for bio-geochemical cycling in temperate coastal sediments

J. Vanaverbeke, Ghent University, Belgium

J. Vanaverbeke introduced recent research on the relationship between macrofaunal functional diversity and benthic ecosystem functioning (sediment community oxygen consumption, nitrification and denitrification). Macrofaunal functional diversity was calculated as the Bioturbation Potential of the community (BPc). Sedimentary biogeochemical cycling was investigated in 10 stations on the Belgian Part of the North Sea on a monthly basis from February to October 2011. We explored the spatio-temporal variability in oxygen consumption, dissolved inorganic nitrogen and alkalinity fluxes, and estimated rates of nitrification and denitrification from a mass budget. Our results show that the cohesive, muddy sediments were poor in functional macrobenthic diversity and displayed intermediate oxygen consumption rates, but the highest ammonium effluxes. These muddy sites also showed an elevated alkalinity release from the sediment, which can be explained by the elevated rate of anaerobic processes taking place. Fine sandy sediments were rich in functional macrobenthic diversity and had the maximum oxygen consumption and estimated denitrification rates. Permeable sediments were also poor in macrobenthic functional diversity and showed the lowest oxygen consumption rates and only small fluxes of ammonium and alkalinity. Macrobenthic functional biodiversity as estimated from bioturbation potential appeared a better variable than macrobenthic density in explaining oxygen consumption, ammonium and alkalinity fluxes, and estimated denitrification. However, this importance of functional biodiversity was manifested particularly in fine sandy sediments, to a lesser account in permeable sediments, but not in muddy sediments.

On the functional role of *Sabellaria alveolata* reefs

Work done by N. Desroy & S. Dubois

Engineer species creates unique and discrete habitats in ecosystems. Commonly, engineered habitats host a more diverse species richness and play key functions in ecosystems. The honeycomb worm *Sabellaria alveolata* is a gregarious tubiculous species which builds large bio-constructions. *Sabellaria* reefs habitats are frequently degraded by human activities, especially by trampling and shell harvesting. While several investigations already focused on associated fauna, very little is known about the functions played by *Sabellaria* reefs, and particularly their roles in trophic webs and their trophic interactions with surrounding habitats. In order to help managing the reefs health status, this project focus on the functional diversity of these engineered habitats by addressing the link between species richness and functional richness. Because *Sabellaria* reefs are more speciose, does it mean they fulfil more functions in ecosystems? How does degraded reef compare with healthy reef in terms of functioning and functional richness? The field study is carried out in the bay of Mont-Saint-Michel where several reef habitats occur, with a gradient in human pressure. Functional diversity will be assessed using direct measurements of functions (primary and secondary production, benthic respiration, water-sediment fluxes etc.) using complementary techniques including — but not limited to — stable isotopes and fatty acids markers. Indirect estimations of functional diversity will be performed using indices calculations based on biological trait analyses of associated fauna. Degraded reefs and healthy reefs habitat will be compared to surrounding sedimentary habitats.

Salinity gradients and their effects on benthic diversity, autecology of species and relevant assessment tools

M. Zettler, Leibniz-Institute for Baltic Sea Research, Germany *et al.*

In Seas with strong salinity gradient like in the Baltic a general assumption of an exponentially positive relationship between species richness and salinity for marine species exists, and a negative relationship for freshwater species. In 1934, Remane produced a diagram to describe the hypothetical distribution of benthic invertebrate diversity along a marine–freshwater salinity gradient. Recent results clearly indicated the validity of this theory for the macrozoobenthic diversity pattern within the Baltic Sea. The use of static indicator species, in which species are expected to have a similar sensitivity or tolerance to either natural or human-induced stressors, does not account for possible shifts in tolerance along natural environmental gradients and between biogeographic regions. Their indicative value may therefore be considered at least questionable. We demonstrate how species responses (i.e. abundance) to changes in sediment grain size and organic matter (OM) alter along a salinity gradient and conclude with a plea for prudency when interpreting static indicator-based quality indices. Model species from the North Sea, Baltic Sea and the Mediterranean Sea region were selected. There were no generic relationships between environment and biota and half of the studied species showed different responses in different seas. Consequently, the following points have to be carefully considered when applying static indicator-based quality indices: (1) species tolerances and preferences may change along environmental gradients and between different biogeographic regions, (2) as environment modifies species autecology, there is a need to adjust indicator species lists along major environmental gradients and (3) there is a risk of including sibling or cryptic species in calculating the index value of a species.

Zettler M.L., Proffitt C.E., Darr A., Degraer S., Devriese L., Greathead C., Kotta J., Magni P., Martin G., Reiss H., Speybroeck J., Tagliapietra D., Van Hoey G., Ysebaert T. (2013): On the Myths of Indicator Species: Issues and Further Consideration in the Use of Static Concepts for Ecological Applications. *PLoS ONE* **8**(10): e78219. doi:10.1371/journal.pone.0078219

Zettler M.L., Karlsson A., Kontula T., Gruszka P., Laine A., Herkül K., Schiele K., Maximov A., Haldin J. (2014): Biodiversity gradient in the Baltic Sea: A comprehensive inventory of macrozoobenthos data. *Helgoland Marine Research* **68**: 49-57

Functional changes in benthic communities along a salinity gradient – a western Baltic case study

A. Darr, M. Gogina & M. L. Zettler, Leibniz-Institute for Baltic Sea Research, Germany

The study investigates the effect of the salinity gradient on the functional composition, functional diversity and functional redundancy of soft-bottom communities in the south-western Baltic Sea. For this purpose, three different areas were selected and compared using a biological trait approach. Functional diversity was calculated by using Rao's Quadratic Entropy as a measure and functional redundancy by the ratio between functional and species diversity.

Despite a high variability due to different other occurring environmental gradients, a clear shift in functional composition was visible using the BTA approach. The changes were most distinct for the traits, longevity and larvae type if the analyses were based on the biomass of the species, whereas abundance-based analyses tend to show less clear results.

Along the same gradient, functional diversity and functional redundancy tended to increase if biomass data were used in the analysis. On the other hand no changes could be observed in the functional diversity when the abundance of the species was used. The result of the BTA showed a trend from long-lived and highly specialised species towards short-lived ubiquitous species with decreasing salinity. However, dominance of ubiquitous species in brackish waters seems to buffer the functional loss. Therefore it can be followed that by gaining functional redundancy the robustness of the benthic ecosystem to environmental changes increases.

Approach to assess consequence of hypoxia disturbance events for benthic ecosystem functioning

M. Gogina & A. Darr, Leibniz-Institute for Baltic Sea Research, Germany

Our study challenges the functional approach for its usefulness in assessing the consequences of hypoxia disturbance events on macrofaunal communities in the south-western Baltic Sea. Time series for two decades of observations from two monitoring stations, one in the Fehmarnbelt (exposed to aperiodic hypoxia), and another in the Darss Rise (normoxic conditions) is used. Our results designate differences of functional structure of benthic fauna communities between sites based on biological traits that characterise species role in modifying the environment, behavioural strategies, morphology and life history, thus suggesting differences in functioning. Hypoxic years reveal sharp increase of the role of sedentary species, suspension filter feeders, epibenthic structures, globulose form, medium/large size of individuals, preponderance of species with long lifespan (caused for instance by remaining ocean quahog).

The link of functional and species diversity to the stagnation periods is proposed for the Darss station that exhibit continuous changes and low temporal variability of traits distribution. Before the major inflow in 1993 the increased role of small size organisms, containing calcium carbonate, filter feeders and grazers, higher presence of semi-pelagic species is observed. The hypoxic events and water renewal processes impact the communities not only in respect to species composition but also functionally.

Gogina, M., Darr, A., Zettler, M.L. (2014). Approach to assess consequences of hypoxia disturbance events for benthic ecosystem functioning. *Journal of Marine Systems* **129**: 203-213.

ICES Working Group on Marine Benthal and offshore Renewable Energy Development (25–28/03/2014)

J. Dannheim, AWI, Germany

J. Dannheim reported on the ICES working group on "Marine Benthal and Renewable Energy Developments" (WGMBRED) established in 2012. The group met the second time in Tallinn, Estonia (25-28 March 2014) and was co-chaired by J. Dannheim (AWI, Germany) and Andrew B. Gill (Cranfield University, UK). The meeting was attended by 19 experts, representing nine countries. The meeting focused on three topics summarizing each two terms of references. The ToRs within the group were basically dealt with in two subgroups with plenary feedback sessions: (a) a 'knowledge group' evaluating and reviewing existing knowledge on the effects of offshore renewable constructions and related topics (e.g. artificial reefs), (b) a 'monitoring group' reviewing and evaluating sampling techniques and the scientific efficiency of ongoing monitoring programmes. The 'metadatabase topic', i.e. developing a database of metadata that will help to cross-foster research and target monitoring, as well as future modelling approaches was dealt in plenary. More details on its achievements may be found at:

http://www.ices.dk/community/groups/Pages/WGMBRED.aspx.

The next WGMBRED meeting will be hold in Oban, Scotland (21–24 April 2015).

Annex 5: Abstracts of introductory and other presentations

				Denmark		Spain		UK		Germany		France		Netherlands		Belgium	
		Benthos	Devotool	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD
D1: biodiversity	Species	Aggregated indicators for distribution, occurence and condition of exponents of long-living benthos species and biogenic structures sensitive to seabed disturbance												X			
		By-catch rates of target and nontarget species, marine birds, marine mammals and benthic species								X							
		Discard rates of target and nontarget species, marine birds, marine mammals and benthic species								X							
		Mean adult density (or frequency or occurence) of the long-lived and/or slowly reproducing; and key engineering benthic species groups; larger gallery-dwelling organisms (positive trend)														X	
		Median colony/body size of the species Buccinum undatum, Mytilus edulis, Flustra foliacea, Haliclona oculata and Alcyonium digitatum (positive trend)														X	
		Frequency of occurence and median adult density of the species Ostrea edulis, Sabellaria spinulosa, mytilus edulis, buccinum undatum, Haliclona oculata, Alcyonium digitatum and Alcyonidium spp. (positive trend)														X	
		Species richness within the key hard substrate taxa Porifera, Cnidaria, Bryozoa, Polychaeta, Malacostraca, Maxilopoda, Gastropoda, Bivalvia, Echinodermata and Ascidiacea (no loss or positive trend)														X	
		Relative frequency of occurence of damaged Asterias rubens and tube clusters of Pomatoceros triqueter (decreasing)														X	

				Denmark		Spain		UK		Germany		France		Netherlands		Belgium	
			Devotool	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD
D1: biodiversity	Habitats	Occurence of horse mussel beds in the Kattegat and the Danish Straits		X													
		Study of possible occurence of horse mussel beds in the North Sea		X													
		The occurence of Haploops (tube dwelling crustaceans) communities in Kattegat and are not deteriorating further		X													
		Maintain positive or stable trends in the area of distribution of the biogenic habitats and/or protected habitats and unique habitats				X											
		Improve and complete the existing knowledge on the extent, distribution, structure and status of the coastal habitats (until 50m) and their long-term trends, with special attention to sub and near littoral rock communities and to the coastal soft bottom communtities				X											
		Area of sediment habitat (predominant)						X									
		Area of sediment habitat (listed)						X									
		Area of subtidal biogenic structures						X									
		Ratio of hard substrate surface area over soft sediment surface area in the test zones in the gravel beds														X	
		Distribution and size of common habitats (EUNIS level 3) and habitats under the Habitats Directive (NL) and the gravel bes (BE)												X		X	
		Monitoring of the extent of human-induced physical disturbance of the sea pen community in selected areas		X													
		Maintain the parameters and trends of the descriptors of state or condition of the benthic communities within values that ensure their sutainability and functioning, as well as the maintenance of its characteristic species, key species and unique species				X											

				Denmark		Spain		UK		Germany		France		Netherlands		Belgium	
			Devotool	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD
D1: biodiversity	Habitats	DKI (soft bottom comunities)	X	X	X												
		Average number of species per sample		X													
		Diversity index		X													
		m-AMBI (Basque, France, Germany)	X				X				X		X				
		BOPA (Andalusia)	X				X										
		QSB (Cantabria)	X				X										
		Infaunal Quality Index (IQI)	X					X	X								
		Indicator to develop Benthic habitat quality derived from Sediment profile imaging						X									
		Density of biogenic reef forming species						X									
		Indices for the composition of benthic communties													X		
		Indicators for the quality of the different habitats at EUNIS level 3													X		
		BEQI2													X		
		Ecological quality ratio determined by BEQI	X													X	X
		Median benthic bioturbation potential in the Abra alba habitat type														X	

			Denmark		Spain		UK		Germany		France		Netherlands		Belgium	
		Devotool	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD
D4: food webs	Population development of target and nontarget species, marine birds, marine mammals and benthic species								X							
	Maintain key links in the trophic chain: forage species, benthos, filtering species, plankton										X					
	Presence of sensitive and/or tolerant species in areas with offshore activity		X													
	biomass of benthic fauna in the national monitoring programme. It need to be stable or increasing		X													
	Mean species diversity per sample in national monitoring program		X													

				Denmark		Spain		UK		Germany		France		Netherlands		Belgium	
		Benthos	Devotool	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD	MSFD	WFD
D6: seafloor integrity		The combined human-induced impact on sea-floor integrity is stable or decreasing (bottom trawling, dumping, raw material extraction, major construction works)		X													
		Reduce the intensity and the area of influence of the significant anthropogenic pressures on the benthic habitats, especially the biogenic or protected				X											
		Increase knowledge on the effect of human activities on habitats, in particular on biogenic and protected habitats, and their species, population and communties… related with fishing activities, infrastructure construction, dredging, extraction of non-renewable marine resources, polluton, and the interaction with climate change effects				X											
		Seabed area that is not disturbed												X			
		Percentage of sea floor surface permanently devoid of bottom-contacting fishing gear disturbance within each of the benthic habitat types														X	
		Percentage of sea floor surface disturbed only by alternative, environmentally-friendly fishing gear within each of the benthic habitat types														X	
		There are sufficient geographic and temporal withdrawing and resting areas for ecossytem components. (Benthos not directly mentioned)								X							
		Ensure the sustainability of benthic habitats (Bay of Biscay, Celtic Sea)										X					
		Allow benthic ecosystems to maintain their structure, function and dynamics (Bay of Biscay, Celtic Sea)										X					
		Maintain benthic habitats, especially those with a key functional role in the ecosystem (North Sea)										X					

Annex 6: Abstracts of introductory and other presentations

Benthos	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	sum
		3	3	2	3	3	2	2	2	2	2	1	2	3	2	2	all
m-AMBI (Basque, France, Germany)	1		1	1		0.5	1	0.5	0.5	1	0.5	1	1	1	1	0.5	**11.50**
Infaunal Quality Index (IQI)	1		1	1		0.5	1	0.5	0.5	0.5	0.5	1	1	1	1	0.5	**11.00**
Ecological quality ratio determined by BEQI	1		1	1		0.5	1	0.5	0.5	0.5	0.5	1	1	1	1	0.5	**11.00**
DKI (soft bottom comunities)	1		1	1		0.5	1	0.5	0.5	0.5	0.5	1	1	1	1	0.5	**11.00**
BOPA (Andalusia)	1		1	1		0.5	1	0.5	0.5	0.5	0.5	1	1	1	1	0.5	**11.00**
QSB (Cantabria)	1		1	1		0.5	1	0.5	0.5	0.5	0.5	1	0.5	1	1	0.5	**10.50**
Diversity index	1		1	1		0.5	0	0.5	0.5	0.5	0.5	1	1	1	1	1	**10.50**
BEQI2	1		1	1		0.5	1	0.5	0.5	0.5	0.5	1	0.5	1	1	0.5	**10.50**
Average number of species per sample	1		1	1		0.5	0	0.5	0.5	0.5	0.5	1	1	1	1	1	**10.50**
Median benthic bioturbation potential in the Abra alba habitat type	1		0.5	1		0.5	1	0.5	0.5	0.5	0.5	1	0.5	1	1	0.5	**10.00**
Occurence of horse mussel beds in the Kattegat and the Danish Straits	1		0.5	0.5		0	0.5	0.5	1	0.5	0	0	0.5	1	1	1	**8.00**
Mean species diversity per sample in national monitoring program	1		0.5	1		0	0	0	0.5	0	0	1	1	1	1	1	**8.00**
biomass of benthic fauna in the national monitoring programme. It need to be stable or increasing	1		0.5	0.5		0	0.5	0	0.5	0	0	1	1	1	1	1	**8.00**
The occurence of Haploops (tube dwelling crustaceans) communities in Kattegat and are not deteriorating further	1		0.5	0.5		0	0.5	0.5	1	0	0	0	0.5	1	1	1	**7.50**
Study of possible occurence of horse mussel beds in the North Sea	1		0.5	0.5		0	0	0.5	1	0.5	0	0	0.5	1	1	1	**7.50**
Discard rates of target and nontarget species, marine birds, marine mammals and benthic species	1		0.5	1		0	0	0.5	1	0	0.5	0	0	1	1	1	**7.50**
By-catch rates of target and nontarget species, marine birds, marine mammals and benthic species	1		0.5	1		0	0	0.5	1	0	0.5	0	0	1	1	1	**7.50**
Presence of sensitive and/or tolerant species in areas with offshore activity	1		0.5	0.5		0	0.5	0.5	0.5	0	0	1	0	1	1	0.5	**7.00**
Maintain positive or stable trends in the area of distribution of the biogenic habitats and/or protected habitats and unique habitats	1		0.5	0.5		0	0.5	0.5	1	0	0	0	0	1	1	1	**7.00**
Area of subtidal biogenic structures	1		0.5	1		0	0.5	0	0.5	0.5	0	0	0	1	1	1	**7.00**
Area of sediment habitat (predominant)	1		0.5	1		0	0.5	0	0.5	0.5	0	0	0	1	1	1	**7.00**
Area of sediment habitat (listed)	1		0.5	1		0	0.5	0	0.5	0.5	0	0	0	1	1	1	**7.00**
Species richness within the key hard substrate taxa Porifera, Cnidaria, Bryozoa, Polychaeta, Malacostraca, Maxilopoda, Gastropoda, Bivalvia, Echinodermata and Ascidiacea (no loss or positive trend)	1		0.5	1		0	0.5	0	0.5	0	0	0	0	1	1	1	**6.50**
Ratio of hard substrate surface area over soft sediment surface area in the test zones in the gravel beds	1		0.5	1		0	0.5	0	0.5	0	0	0	0	1	1	1	**6.50**
Median colony/body size of the species Buccinum undatum, Mytilus edulis, Flustra foliacea, Haliclona oculata and Alcyonium digitatum (positive trend)	1		0.5	1		0	0.5	0	0.5	0	0	0	0	1	1	1	**6.50**
Mean adult density (or frequency or occurence) of the long-lived and/or slowly reproducing; and key engineering benthic species groups; larger gallery-dwelling organisms (positive trend)	1		0.5	1		0	0.5	0	0.5	0	0	0	0	1	1	1	**6.50**
Distribution and size of common habitats (EUNIS level 3) and habitats under the Habitats Directive (NL) and the gravel bes (BE)	1		0.5	0.5		0	0.5	0	0.5	0.5	0	0	0	1	1	1	**6.50**
Density of biogenic reef forming species	1		0.5	1		0	0	0	0.5	0.5	0	0	0	1	1	1	**6.50**
Relative frequency of occurence of damaged Asterias rubens and tube clusters of Pomatoceros triqueter (decreasing)	1		0.5	0.5		0	0.5	0	0.5	0	0	0	0	1	1	1	**6.00**
Frequency of occurence and median adult density of the species Ostrea edulis, Sabellaria spinulosa, mytilus edulis, buccinum undatum, Haliclona oculata, Alcyonium digitatum and Alcyonidium spp. (positive trend)	1		0.5	0.5		0	0.5	0	0.5	0	0	0	0	1	1	1	**6.00**
Population development of target and nontarget species, marine birds, marine mammals and benthic species	1		0	0		0	0	0	0.5	0	0	0	0	1	1	0.5	**4.00**
Percentage of sea floor surface permanently devoid of bottom-contacting fishing gear disturbance within each of the benthic habitat types	0			1		0	0.5	0	0.5	0	0	0	0	1	0	1	**4.00**
Percentage of sea floor surface disturbed only by alternative, environmentally-friendly fishing gear within each of the benthic habitat types	0			1		0	0.5	0	0.5	0	0	0	0	1	0	1	**4.00**
There are sufficient geographic and temporal withdrawing and resting areas for ecossytem components. (Benthos not directly mentioned)	0		0	0.5		0	0.5	0	0.5	0	0	0	0	1	0	1	**3.50**

Benthos	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	sum
		3	3	2	3	3	2	2	2	2	2	1	2	3	2	2	all
Monitoring of the extent of human-induced physical disturbance of the sea pen community in selected areas	0		0.5	0		0	0.5	0	0.5	0	0	0	0	1	0	1	**3.50**
Maintain key links in the trophic chain: forage species, benthos, filtering species, plankton	1		0	0		0	0	0	0	0	0	0	0	1	1	0.5	**3.50**
Indices for the composition of benthic communties	1		0	0		0	0	0	0	0	0	0	0	1	1	0.5	**3.50**
Indicators for the quality of the different habitats at EUNIS level 3	1		0	0		0	0	0	0	0	0	0	0	1	1	0.5	**3.50**
The combined human-induced impact on sea-floor integrity is stable or decreasing (bottom trawling, dumping, raw material extraction, major	0		0	0.5		0	0.5	0	0.5	0	0	0	0	1	0	0.5	**3.00**
Reduce the intensity and the area of influence of the significant anthropogenic pressures on the benthic habitats, especially the biogenic or protected	0		0	0.5		0	0.5	0	0.5	0	0	0	0	1	0	0.5	**3.00**
Maintain the parameters and trends of the descriptors of state or condition of the benthic communities within values that ensure their sutainability and functioning, as well as the maintenance of its characteristic species, key species and unique species	1		0	0		0	0	0	0	0	0	0	0	1	1	0	**3.00**
Maintain benthic habitats, especially those with a key functional role in the ecosystem (North Sea)	1		0	0		0	0	0	0	0	0	0	0	1	1	0	**3.00**
Indicator to develop Benthic habitat quality derived from Sediment profile imaging	1		0	0		0	0	0	0	0	0	0	0	1	1	0	**3.00**
Improve and complete the existing knowledge on the extent, distribution, structure and status of the coastal habitats (until 50m) and their long-term trends, with special attention to sub and near littoral rock communities and to	1		0	0		0	0	0	0	0	0	0	0	1	1	0	**3.00**
Ensure the sustainability of benthic habitats (Bay of Biscay, Celtic Sea)	1		0	0		0	0	0	0	0	0	0	0	1	1	0	**3.00**
Allow benthic ecosystems to maintain their structure, function and dynamics (Bay of Biscay, Celtic Sea)	1		0	0		0	0	0	0	0	0	0	0	1	1	0	**3.00**
Aggregated indicators for distribution, occurence and condition of exponents of long-living benthos species and biogenic structures sensitive to seabed disturbance	1		0	0		0	0	0	0	0	0	0	0	1	1	0	**3.00**
Seabed area that is not disturbed	0		0	0		0	0	0	0.5	0	0	0	0	1	0	1	**2.50**
Increase knowledge on the effect of human activities on habitats, in particular on biogenic and protected habitats, and their species, population and communties… related with fishing activities, infrastructure construction, dredging, extraction of non-renewable marine resources, polluton, and the interaction with climate change effects	0		0	0		0	0	0	0.5	0	0	0	0	1	0	0	**1.50**

Annex 7: Indicator performance scoring

Scoring of indicator performance based on WGECO/WGBIODIV evaluation criteria						
1	Type of indicator	State or pressure	Is indicator a "pressure" indicator being used for want of an appropriate "state" indicator?			Fully met (1): indicator is a "state" indicator; Not met (0): indicator is actually a "pressure" indicator.
2	Quality of underlying data	Existing and ongoing data	Indicators must be supported by current or planned monitoring programmes that provide the data necessary to derive the indicator. Ideal monitoring programmes should have a time-series capable of supporting baselines and reference point setting. Data should be collected on mul-tiple sequential occasions using consistent protocols, which account for spatial and temporal heterogeneity.	core	3	Fully met (1): long-term and ongoing data from which historic reference levels can be derived and past and future trends deter-mined; Partially met (0.5): no baseline information, but ongoing monitoring or historic data available, but monitoring programme discontinued, however potential to re-establish the programme exists; Not met (0): data sources are fragmented, no planned monitoring programme in the future.
3	Quality of underlying data	Indicators should be concrete	Indicators should ideally be easily and accurately determined using technically feasible and quality assured methods, and have high signal to noise ratio.	core	3	Fully met (1): data and methods are techni-cally feasible, widely adopted and quality assured in all aspects, signal to noise ratio is high; Partially met (0.5): potential issues with quality assurance, or methods not widely adopted, poor signal to noise ratio; Not met (0): indicator is not concrete or doubtful; noise excessively high due either to poor data quality or the indicator is un-duly sensitive to environmental drivers
4	Quality of underlying data	Quantitative vs. Qualitative	Quantitative measurements are preferred over qualitative, categorical measure-ments, which in turn are preferred over expert opinions and professional judg-ments.	Desirable	2	Fully met (1): all data for the indicator are quantitative; Partially met (0.5): data for the indicator are semi-quantitative or largely qualitative; Not met (0): the indicator is largely based on expert judgement.
5	Quality of underlying data	Relevant spatial coverage	Data should be derived from a large pro-portion of the MSFD subregion, at appro-priate spatial resolution and sampling design, to which the indicator will apply.	core	3	Fully met (1): spatially extensive monitor-ing is undertaken across the subregion; Partially met (0.5): monitoring does not cover the full subregion, but is considered adequate to assess status at subregional scale; Not met (0): monitoring is undertak-en across a limited fraction of the subregion and considered inadequate to assess status at subregional scale.
6	Quality of underlying data	Reflects changes in ecosystem component that are caused by variation in any	The indicator reflects change in the state of an ecological component that is caused by specific significant manageable pres-sures (e.g. fishing mortality, habitat de-struction). The indicator should therefore respond sensitively to particular changes in pressure. The response should be un-ambiguous and in a predictable direction, based on theoretical or empirical knowledge, thus reflecting the effect of	core	3	IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0. Otherwise: Fully met (1): the indicator is primarily respon-sive to a single or multiple pressures and all the pressure-state1 relationships are fully understood and defined, both under the disturbance and recovery phases of the relationship; Partially met (0.5): the indica-tor's response to one or more pressures are understood, but the indicator is also likely to be significantly influenced by other non-anthropogenic (e.g. environmental) drivers, and perhaps additional pressures, in a way that is not clearly defined. Response under recovery conditions may not be well under-stood; Not met (0): no clear pressure-state
7	Management	Relevant to MSFD managemen t targets	Clear targets that meet appropriate target criteria (absolute values or trend direc-tions) for the indicator can be specified that reflect management objectives, such as achieving GES.	Desirable	2	Fully met (1): an absolute target value for the indicator is set; Partially met (0.5): no absolute target set for the indicator, but a target trend direction for the indicator is established; Not met (0): targets or trends unknown.

8	Management	Relevant to managemen t measures	Indicator links directly to management response. The relationship between hu-man activity and resulting pressure on the ecological component is clearly un-derstood.	Desirable	2	IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0. Otherwise: Fully met (1): both response-activity and activity-pressure relationships2 are well defined - advise can provided on both the direction AND extent of any change in human activi-ty required and the precise management measures required to achieve this; Partially met (0.5): response-activity and activity pressure relationships are not well under-stood, or only one of the relationships is defined, but not the other, so that the pre-cise changes in pressure resulting from particular management actions cannot be predicted with certainty; Not met (0): no clear understanding of either relationship, so that the link between management re-sponse and pressure is completely obscure.
9	Management	comprehensi ble	Indicators should be interpretable in a way that is easily understandable by poli-cy-makers and other non-scientists (e.g. stakeholders) alike, and the consequences of variation in the indicator should be easy to communicate.	Desirable	2	Fully met (1): the indicator is easy to under-stand and communicate; Partially met (0.5): a more complex and difficult to understand indicator, but one for which the meaning of change in the indicator value is easy to communicate; Not met (0): the indicator is neither easy to understand or communica-ble.
10	Management	Established indicator	Indicators used in established manage-ment frameworks (e.g. EcoQO indicators) are preferred over novel indicators that perform the same role. Internationally used indicators should have	Desirable	2	Fully met (1): the indicator is established and used in international policy frame-works; Partially met (0.5): the indicator is established as a national indicator; Not met (0): the indicator has not previously been used in a management framework.
11	Management	costeffective ness	Sampling, measuring, processing, analys-ing indicator data, and reporting assess-ment outcomes, should make effective use of limited financial resources.	Desirable	2	Fully met (1): little additional costs (no additional sampling is needed); Partially met (0.5): new sampling on already existing programmes is required; Not met (0): new sampling on new monitoring programs is necessary.
12	Management	early warning	Indicators that signal potential future change in an ecosystem attribute before actual harm is indicated are advanta-geous. These could facilitate preventive management, which could be less costly than restorative management.	informative	1	IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0. Otherwise: Fully met (1): indicator provides early warning because of its high sensitivity to a pressure or environmental driver with short re-sponse time; Not met (0): relatively insen-sitive indicator that is slow to respond.
13	conceptual	scientific credibility	Scientific, peer-reviewed findings should underpin the assertion that the indicator provides a true representation of varia-tion in the ecosystem attribute in ques-tion.	Desirable	2	IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0. Otherwise: Fully met (1): peer-reviewed literature; Partially met (0.5): documented but not peer-reviewed; Not met (0): not documented or peer-reviewed literature is contradictory.
14	conceptual	Metrics relevance to MSFD indicator	For D1 and D6, metrics should fit the indicator function stated in the 2010 MSFD Decision document. This require-ment can be relaxed for D4 indicators because the Decision document stipulates the need for indicator development in respect of this Descriptor (but any newly proposed D4 indicators must still fulfil the overall goals stated for D4).	core	3	Fully met (1): the metric complies with indicator function; Not met (0): the metric does not comply with indicator function.
15	conceptual	crossapplicat ion	Metrics that are applicable to more than one MSFD indicator are preferable.	Desirable	2	Fully met (1): metric is applicable across several MSFD indicators; Not met (0): no cross-application.
16	indicator suites	indicator correlation	Different indicators making up a suite of indicators should each reflect variation in different attributes of the ecosystem com-ponent and thus be complementary. Po-tential correlation between indicators should be avoided.	Desirable	2	Fully met (1): the indicators are un-correlated; Partially met (0.5): correlation between some indicators; Not met (0): all indicators are correlated.