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Interim Report of the Benthos Ecology Working Group (BEWG)

9–13 May 2016

Lisbon, Portugal

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The Benthos Ecology Working Group (BEWG) was hosted by the Instituto Português do Mar e da Atmosfera (IPMA) and held its 2016 meeting at IPMA's Department of Sea and Marine Resources in Lisbon, Portugal. The meeting was attended by 28 participants, representing eleven countries.

The meeting was structured along the four BEWG core business issues. The group continues to provide insights on the field of benthic ecology, with main emphasis on:

- Long-term series and climate change considering the methodological aspects of time-series;
- Ensuring that the Benthic Long-term Series Network (BELT-Net) engages with existing initiatives (e.g. EMODnet);
- Further developments of species distribution modelling and mapping;
- Enhanced understanding on the linkages between ecosystem biodiversity and functioning;
- Developments in effective monitoring programmes (including design, harmonisation and quality assessments);
- Understanding benthic biodiversity and conservation: the role of MPA's;
- Providing expert advice and support to the OSPAR COBAM's request in relation to the sensitivity of benthic habitats to fishing effects.

There are also eight ongoing initiatives developed and discussed during the meeting:

- Case study: "Potential methodological issues in long-term comparability";
- Case study: "Towards a benthic ecosystem functioning map: interregional comparison of two approaches";
- Case study: "Variability in expert assessment of benthic species tolerances /sensitivities";
- Case study: "Proposal for a joint /co-ordinated monitoring: outcomes of the benthic work under the Joint Monitoring Programme";
- Case study: "Changes in functional composition along sediment gradients";
- Case study: "To identify the links between benthic functions and ecosystems services";
- Case study: "Meeting benthic functional indicator needs of the MSFD";
- Case study: "A benthic ecology perspective for evaluating the effectiveness of MPA's".

There were also dedicated recommendations for consideration under the ICES Council, these are provided in detail in Annex 3.

1 Administrative details

Working Group name

Benthos Ecology Working Group (BEWG)

Year of Appointment within current cycle

2015

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

2

Chair(s)

Silvana Birchenough, UK

Meeting venue

Lisbon, Portugal

Meeting dates

9–13 May 2015

2 Terms of Reference and Summary of Work plan

ToR	Description
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
B	Species distribution modelling and mapping 1. To compare and report on the performance 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
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
D	Benthic biodiversity and ecosystem functioning 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.
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).
F	**2015/4 Support for the development of common and candidate OSPAR biodiversity indicators for benthic habitats: Benthic habitats** ICES is requested to support on-going OSPAR indicators work on benthic habitats, in support of the requirements under the MSFD[1]. a) Using mobile bottom contacting gear data, produce fishing abrasion pressure maps[2] (2009-2014) using the BH3 approach as a follow-up of the OSPAR request to ICES (Request 5/2014). Fishing abrasion pressure maps should be analysed by gear distribution, and type, in the OSPAR maritime area and be based on the methodology propose on the physical damage indicator (BH3). Specifically ICES is requested to: i) collate relevant national VMS and logbook data; ii) estimate the proportions of total fisheries represented by the data; iii) using methods developed in Request 5/2014, where possible, collect other non-VMS data to cover other types of fisheries (e.g. fishing boats < 12m length); iv) prepare maps for the OSPAR maritime area (including ABNJ) on the spatial and temporal intensity of fishing using mobile bottom contacting gears (BH3 approach); b) Evaluate the applicability of a reduced list of habitats in support the development of Typical Species indicator (BH1)[3]. This work should consider those habitats that have previously been identified by the COBAM Benthic experts group. Evaluation should consider data availability, and suggest possible prioritisation of habitats already included in the OSPAR list of threatened and declining habitats. c) Evaluate monitoring and assessment requirements for multimetric indicator (BH2)[2] and/or typical species (BH1)[2], by providing: i) overview of existing monitoring programmes with associated benthic sampling stations (e.g. WFD, MPA, Natura2000, impact assessment studies, etc.), taking into account the work done under the JMP project/art 11 reporting by countries. ii) overview of existing network of sampling stations and monitoring frequency across all

[1] Any analysis relating to main threats and development of abrasion maps should not be applied to the Portuguese continental shelf

[2] There should be consultation with OSPAR in the drafting of the data call that will be required to deliver of this request. This should build on the experience and lessons learned from the 2014 VMS/Log book data call.

[3] In the implementation of this request ICES should ensure that there is a dialogue established between the relevant Working Group chairs and coordinators of the relevant OSPAR subsidiary bodies, including the ICG-COBAM Expert group for Benthic Habitats and ICG-Cumulative Effects. This is to ensure consistent interpretation of the request to meet the needs of OSPAR and avoid duplication in supporting the development and testing of OSPAR common indicators. Where data has been analysed as part of the work to deliver this request, the advice should be delivered in a form that will enable its use in subsequent analyses (including spatial analysis).

	OSPAR regions. iii) evaluation of on-going monitoring with regard to, geographical coverage, parameters consistently measured across the whole network, monitoring design and sampling strategy for assessment requirements (BH2/BH1). Evaluation should identify any gaps and indicate how they could be completed (monitoring sampling strategy and/or methods).
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.
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.
I	1) Recommend a scoring process (or relevant options for processes) for sensitivity of habitats, which should also include rules on: i. How to scale-up sensitivity to a c-square resolution of 0.05° x 0.05° ii. How to treat variation in habitat type when evaluating sensitivity within c-square resolution of 0.05° x 0.05° iii. How to interpolate and/or extrapolate information on sensitivity when habitat data is missing 2) Based on ToR 1), provide input to WGMHM.

Summary of 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**

Opening of the meeting

The Chair, S. Birchenough, opened the meeting at the Instituto Português do Mar e da Atmosfera (IPMA) in Lisbon, Portugal. S. Birchenough welcomed the participants. Antonina dos Santos, Director of the Department of Sea and Marine Resources of Portuguese Institute for Sea and Atmosphere-IPMA, welcomed the participants on behalf of IPMA and presented the work done at the institute. The local host Miriam Tuaty Guerra then gave some practical information for the course of the meeting and presented the current activities of IPMA's benthos group.

An ICES SharePoint was made available before and during the meeting. This has as before proved to be a valuable tool to speed up the work and make exchange of information more efficient. Further, practicalities for the meeting and reporting were introduced to all participants. H. Hillewaert was appointed as editorial rapporteur. Afterwards, the participants introduced themselves and gave a brief review of their scientific activities. A total of 28 participants from eleven countries (e.g. Belgium, France, Germany, Italy, the Netherlands, Norway, Poland, Portugal, Sweden, the United King-

dom and the United States) participated at the meeting and two participants also contributed by correspondence.

S. Birchenough and H. Hillewaert gave an overview of 35-years history of the Benthos Ecology Working Group. Please see a summary of this presentation available at:

http://www.slideshare.net/ICES_ASC/ices-bewg-benthos-ecology-working-group-bewg-history-19812015

ICES blogs: https://www.facebook.com/ICES.Marine

3 Long-term benthic 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

3.1.1 Impact of different methods applied on the results of long-term Studies in the southern Baltic

By Jan Warzocha

The basic problem which appeared when comparing data from various periods was to determine impact of methods applied on the results. An attempt was made to dig up the methodologies applied in the past and carry out calibration in order to minimize any differences created by different methodologies used in various periods. The first quantitative studies, dealing with the abundance and biomass, were carried out in the Polish zone of the southern Baltic since the 1920s. The methodologies which were applied over the years differed mainly in types of grabs, and the way of biomass determination. During the years 1923–1952 a Petersen grab was used, followed by van Veen grabs of different shape and weight, a box corer (Reineck type) and in the shallow lagoon an Ekman grab and Hand Operated Haps. The calibration of various types of grabs showed statistically significant differences in the abundance and biomass of macrofauna, especially on the sandy bottom. There were also differences in biomass values calculated with different methods in the past and now. These differences resulted first of all from the application, in the past, of weight factors, being calculated either without taking into account size of individuals or with the size classes included but in very wide ranges (e.g. for *Mytilus edulis*: < 20 mm and > 20 mm). In many cases it makes comparisons of biomass impossible.

3.1.2 Understanding the role of multiple stressors: What will be the future for benthic species?

Silvana Birchenough, John, K. Pinnegar and Matthew B. Sanders

Evidence indicates that absorption of atmospheric carbon dioxide (CO_2) in the ocean has already decreased pH levels by 0.1 pH units since 1750, and CO_2 concentrations are projected to rise further by the end of the century as fossil fuel reserves continue to be exploited. To date, the majority of ocean acidification (OA) research undertaken has tended to concentrate on benthic or planktonic species which are of limited direct importance to fisheries and aquaculture. Furthermore, some of the available evidence is contradictory with some studies demonstrating that species are robust to lower pH whilst others show

marked sensitivity. There is still much research needed to understand some of the observed organisms' responses to changes in pH under laboratory and under their natural environment. In the UK, fisheries generate more than £800 million of revenue per year and support 30 000 jobs. Aquaculture generates £350 million and supports a further 4 200 jobs. It is important to document the effects of ocean acidification on species of commercial importance. This presentation concentrates mainly on experimental work conducted on lobsters, cockles and scallops, providing further understanding on the effects of ocean acidification in connection to co-stressors, such as temperature and/or food availability. This work considers the main changes in the growth, development and shell composition of different species. The outcomes of this research are paramount to understand the future climate change scenarios, which could have important economic and environmental consequences in commercially important shellfish.

3.2 Do we further develop the BEWG Benthic Long-Term Series network (BeLTS-net) to facilitate collaboration?

BeLTS-net was initiated few years ago by members of the BEWG. There is an available catalogue of current long-term benthic time series and the idea will be to integrate with other ongoing initiatives. S. Birchenough has been in contact with Mark Costello working on GEOBON (Biodiversity Observation Network) and will revisit if there are further opportunities to continue with this activity.

4 Species distribution modelling and mapping (ToR b)

4.1 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

The progress in the ongoing case study "Towards a benthic ecosystem functioning map: interregional comparison of two approaches" was summarised in an introductory presentation by Mayya Gogina. Most data sets were compiled already intersessionally and preliminary results were presented for the Baltic. The open issues regarding methodology and scope of the case study were discussed in a sub-group.

4.1.1 Towards a benthic ecosystem functioning maps: quantifying bioturbation potential of the German Baltic Sea

By Mayya Gogina (presenting), Claudia Morys, Stefan Forster, Ulf Gräwe, René Friedland & Michael L. Zettler

Community bioturbation potential (BPc), an indicator of benthic faunal function based on bioturbation, was estimated for the German Baltic Sea. The usefulness of bioturbation potential calculations was justified by moderate correlation between its estimates and in situ measurements of bioturbation rates based on chlorophyll a. In the next step we have identified key species contributing to bioturbation at the study area and assessed the seasonal and interannual variation of BPc. To accurately map the spatial differences of this expression of ecosystem functioning and to investigate its predictability based on 13 selected abiotic parameters, we have tested 3 different methodological approaches. First, benthic macrofauna community bioturbation potential (BPc) was initially calculated per

station and treated as response variable for species distribution modeling technique (RandomForest, RF) with relevant available environmental layers used as predictors. For the second approach 36 key species were selected as those most contributing to BPc (responsible for 90 % of total BPc), their BPp were used as response variables for a zero-inflated regression models with two-step process (first to predict areas of occurrence of target species, and then to predict continuous BPp only where species is present) to predict their full coverage distributions, that were subsequently summed up to the BPc. Third, the BPc values at stations were interpolated to a raster surface using a natural neighbour technique. The model validation based on the stations not used for model building/interpolation indicated that map derived by natural neighbour interpolation most accurately reflected observed values, at least at considered resolution of 1 × 1 km. However, both modelling approaches also provide satisfactory representation for distribution of potential bioturbation intensity hot spots and can be more useful were data availability is low.

Discussion

During the subgroup discussion regarding methodology and scope of the case study, it was agreed that:

- Lists with species scored M=R=1 will be sent to contributors to approve that they do not significantly contribute to sediment transport (**deadline: 30 June**).
- List of the 18 most important predictors in BS were sent out to other contributors to check if any not yet provided layers are available, with an aim to have the most comparable list of predictors
- **Deadline**: only data sent before the end of **30 June** will be used in case study (though importance / significance of same drivers is expected to deviate between regions).
- No scaling of model results to the range of observed values is regarded as feasible.
- Main scope of the paper is to test the performance of approaches in different regions, explore and compare between regions the drivers of BPc, its patterns and key species. In the discussion part of the paper it is intended to particularly elaborate on what the regionally derived maps for each region could be good for, e.g.:
    - Ecosystem functioning maps published until now are mainly based on sedimentological studies. There is a potential for biological perspectives here. For the Belgian part – published regressions can be used for estimates of spatial distribution of geochemical fluxes with BPc serving as a proxy.
    - For risk assessment based on e.g. key species decline (expected impact on the ecosystem functioning defined by factors/pressures these species are sensitive to)
    - Scenarios (e.g. extinction of key species, test the impact of *Marenzelleria* spp. or other invasive species, i.e. "what if there was no invasion")
- Calculations for each approach and each region must be performed. (internal **deadline: 30 September**)

- Paper structure will be shaped intersessionally, tasks on texts for possible applications are to be allocated.

4.1.2 Planning for future work

S. Degraer announced the upcoming North Sea open science conference taking place in Ostend (Belgium) from the 7–10 November 2016. The deadline for abstract submission was on the 15 May.

5 Benthos and legislative drivers (ToR c)

5.1 The use of benthic indicators and targets for management: Compatibility and complementarity

This issue within ToR c is a continuation of previous work of BEWG on indicators and G. Van Hoey gave a brief overview of this year's focus points. The topic was introduced by a series of presentations on various aspects of indicator development and implementation.

5.1.1 Discussion and advice on the way to define baseline datasets.

By G. Van Hoey (presented)

Definition: "A dataset for comparison" …

For the definition of baseline datasets there is need for (i) coverage of the right temporal window (long-term series) in relation to prevailing climatic conditions; (ii) adequate coverage of the spatial component, i.e. sampling design, amount of samples, distribution of samples, replication, inter and intra variation ; (iii) a pressure window of the dataset (cf benchmarking WFD); large scale pressure problem; local pressures easily to deal with; (iv) environmental conditions and local specifications: habitat types, waterbody-types-subtypes (a method to overcome this environmental variation can be through modelling (Leonardsson*et al.* 2016; cf depth)).

To derive reference values from such baseline dataset there is need for or (i) a reference value (= one value out of the dataset to compare with; e.g. percentile, expert judgement; e.g. m-AMBI, BEQI2); or (ii) a reference condition (expected condition = in GES= resilience; e.g. pBQI, BEQI and Benthoval approach) = using the entire dataset; or (iii) a model.

A short communication or even a review paper might be useful to develop to bring the scattered information on baselines as a review. A few steps will have to be met for this.

- Check literature, to assess if this work could be a novel contribution
- Further develop the ideas (e.g. write a paragraph for every point) to set the context and address the relevance thereof.
- Collect the relevant metadata (e.g. list of relevant papers per topic)
- If all of the information is suitable, then compile a peer review paper

Options are (i) a short, 'state of the art' paper to summarize what is available and possible approaches (based solely on ecological approaches); (ii) a wide approach synthesis, considering broad senses scales aspects.

5.1.2 Applying ecosystem and risk-based approaches, toward an integrated assessment of benthic habitats communities at regional sea scales

By Elliott Sophie, Guérin Laurent (presenting), Vina-Herbon Cristina, Meakins Bryony, Pesch Roland & Serrano Alberto

The Marine Strategy Framework Directive (MSFD) aims to implement an integrated ecosystem-based and a risk-based approach, to manage of the anthropogenic pressures on the marine environment within European Union waters. Reporting on the MSFD by Member States is facilitated using 11 'Descriptors', made up of numerous indicators which help quantify the state, pressure or impact on components of the marine environment. Unfortunately, this process has led to overlaps between indicators under the different descriptors, which have consequently been criticised for double counting and poor coherence. In addition, there are many unknowns about the marine environment including the extent and condition of benthic habitats and the effect of cumulative pressures and impacts on benthic habitats from anthropogenic activities. Such knowledge gaps can make it difficult to set baselines required for monitoring and assessment processes under the MSFD.

Through work developed within the European funded EcApRHA project in conjunction with the development of indicators within OSPAR's regional seas convention, we propose an integrated cyclical approach to assess the state of the seabed and benthic communities with the use of best available evidence at a sub-regional scale but applicable to all MSFD regions. This method integrates indicators relating biodiversity (D1), seafloor integrity (D6) and potentially food web (D4) descriptors in a cyclical process, with transversal implications on other descriptors depending on the pressure types to be assessed (e.g. fisheries activity, eutrophication, hydrological changes, etc.). Through this integrated cyclical process, multi-metric indices are used to assess changes in the condition of the seabed and its communities at a site scale to provide quantitative feedback to set thresholds, seafloor disturbance levels and habitat sensitivity assessments at a sub-regional scale. This method not only integrates biodiversity and seafloor integrity related indicators, but also provides a mechanism to strengthen and improve confidence in indicator assessment, where prior information is missing or expert judgement is used. This integrated cyclical approach to assess the state of the seabed is an innovative method, based on actual monitoring and assessment methods.

Discussion

The limited contribution of data from these three countries allowed only to develop a 'proof of concept' to support a benthic habitat sensitivity assessment.

5.1.3 BH2 Multi-Metric Index assessment of Benthos in the Southern North Sea

By Willem van Loon (presenting), Dennis Walvoort, and the Southern North Sea project group

For OSPAR common indicator BH2, Multi-Metric Index assessment of benthos, a partial Intermediate Assessment is currently finalized within the Southern North Sea (SNS) project group.

The goals of this project are: (a) to develop an MMI, which is sensitive to especially abrasion of the sea floor, but also to other pressures such as organic matter/oxygen depletion

and sedimentation due to dumping activities; (b) to apply this optimized MMI to the available SNS benthos data and calculate Ecological Quality Ratios (EQRs) per national area-habitat combination; and (c) to report these results in an OSPAR partial Intermediate Assessment in august 2016.

To achieve the first goal, a benthos index optimization tool BENMMI (in R) was developed. This tool contains a suite of approx. 10 commonly used benthos indexes (e.g. species richness, Margalef D, Shannon index, Simpson index, N2, SN, SNA, AMBI and ITI), which can be combined by the tool using Multi-Linear Regression and tested for their performance (sensitivity and precision) to indicate a pressure index. The pressure data are introduced into the BENMMI tool combined with the benthos data at the sample level. The ICES fisheries activity data from January 2016, and oxygen-benthos data from the Gullmarfjord, were used for pressure-impact testing.

The benthos index optimization results show that of the diversity indexes, Margalef D shows the best sensitivity (slope) and precision (R2) for the pressure fisheries; and is also sensitive for oxygen depletion pressure. Margalef D appears to effectively correct for small differences in sample size and volume due to different sampling devices, which is especially noticeable in the UK results.

Of the species sensitivity/biological trait indicators, the Infaunal Trophic Index (ITI) shows the best sensitivity and precision for fisheries.

The MMI optimization results, in which a maximum of three indexes are combined for pressure-impact testing by the BENMMI tool, surprisingly show that the index Margalef D alone gives the best sensitivity and precision for fisheries pressure at the SNS level, and is also useful to indicate oxygen depletion. Therefore, the use of Margalef D alone appears to be optimal for the OSPAR BH2 MMI assessment.

The SNS MMI assessment using Margalef D is then organized as follows:

- For each national area (OBJECTID) combined with a EUNIS 3 habitat (Sand, Mud, Coarse, Mixed) reference values are estimated using the 99 percentile value of a sufficiently large indicator set (preferably 10 data years, minimum of 100 indicator values). Reference values are compared within the SNS biogeographical area to check for plausibility.
- Using these reference values, EQR values are calculated for each OBJECTID-Habitat-Year.
- Then, for the period 2010–2015 the average EQR value per OBJECTID-Habitat-Year is calculated.

All the results obtained above will be reported in a final Report by the end of June 2016; in the OSPAR Intermediate Assessment in august 2016; and submitted for publication in a scientific journal in autumn 2016. After acceptance of this manuscript, the BENMMI tool will be made freely available.

Discussion

This new index was optimised for fisheries pressure, sedimentation and organic matter and worked well in most cases. The distinction between epi- and endofauna was briefly discussed (The index only uses endofauna).

5.1.4 Simplified methodology to study soft-bottom macrofauna in Corsica, France – Fish farming influence study case

By Annick Donnay (reporting) & Corinne Pelaprat

Coastal waters around Corsica are known to be oligotrophic and weakly impacted in comparison of continental coastal waters.

In the framework of the STARE-CAPMED research program, facilitations and simplifications for soft-bottom macrobenthos studies are researched. The main results are reference values necessary to calculate the M'AMBI for each of eight identified habitat types, an adapted M'AMBI index, called the J'MAMBI given an Ecological Quality Ratio (EQR) and the family identification sufficiency. An application of this methodology on the fish farming impact is presented.

For each of the six fish farms situated around Corsica, two stations have been sampled (one just below the farm and another at 300 m of the concession in the main current direction) to evaluate the impacts on soft-bottom macrobenthos population. EQR values are calculated for each envisaged taxonomical level (species, genus, family). Comparison between them and influence from the source are evaluated.

Fish farms by an organic matter enrichment of the soft-bottom negatively influence the soft-bottom macrobenthos assemblages mainly under the cages. The effect of the influence varies with natural environmental factors of the area (e.g.: bay type, currentology, depth under the cages) and with the size and the productivity of the fish farm.

For each station, the EQR values at the different taxonomical levels are comparable. The difference of EQR between source and 300 m station give same tendency. And the applicability of the J'MAMBI at the family level identification is sufficient for a rapid evaluation of the ecological quality status and for decision makers.

Discussion

It was pointed out that the observed differences in the response of macrofauna to fish farming might be partly caused by differences in fish production or in the abiotic conditions around the farm (e.g. currents, depth). The use of sensitivity values per family as an average of species sensitivity was seen as problematic.

5.1.5 Progress update on the development of a new Biotic Index in the Bentho-VAL Project

By Celine Labrune (reporting), Gauthier O., Conde A., Grall J. & Grémare A.

There is an overall goal and agreement among European Union member states to achieve a 'Good Ecological Status' for water bodies in accordance to the Water Framework and the Marine Strategy Framework Directives. As such, ecologists have been using different biotic indices for the assessment of benthic habitat quality during the last two decades. The currently available biological indices for the marine realm are mostly based on lists that provide scores for species reflecting their degree of sensitiveness or tolerance in relation to organic enrichment gradients. A new biotic index, independent from any predetermined lists, and based on the concept of multidimensional deviation from a set of reference sites is proposed. This index is based on the Bray-Curtis dissimilarity that cap-

tures the divergent distribution of species along anthropogenic stress gradients. A particular attention is given to the part of the measure of dissimilarity due to species loss in term of abundance for species that (i) disappeared between the reference stations and the tested stations and (ii) Are present in both stations and only decrease in abundance.

The performance of the different components of the BC dissimilarity is evaluated with datasets related to various pressures types, such as organic waste, tailing disposal and primary metals refined by a factory. The part of the measure of dissimilarity due to species loss appears to reflect correctly anthropogenic gradient.

Discussion

The need for new indices was briefly discussed. Most sensitivity lists used to calculate indices are based on organic enrichment effects, but may not respond to physical pressures. The suggested BenthoVAL index is always using reference areas to include different pressures. This has led to a discussion about reference areas, which are often difficult to assign. Theoretical/hypothetical reference condition based on expert judgement might be a way forward in cases where undisturbed areas are lacking.

5.1.6 A probability based index for assessment of benthic invertebrates in the Baltic Sea

By Mats Blomqvist (reporting) & Kjell Leonardsson

The ecological status of benthic fauna in Swedish marine waters is assessed by means of the Benthic Quality Index (BQI) based on species richness, species sensitivities and abundance. We have re-analysed the components of BQI and also evaluated biomass as an additional component in the index. Prior to the analysis we have adjusted the components with a method based on sampling depth and sample volume to reduce the variation and the dependency of depth and sediment characteristics, i.e. to reduce the effects of where in a water body samples are taken.

We have developed a novel way to combine the components in an indicator based on a conversion of the components to probabilities approximated from reference frequencies derived from a baseline dataset. The resulting index is named probability based BQI, pBQI, and is calculated as the arithmetic mean of the four component probabilities. A method for setting of WFD status class boundaries with focus on the good-moderate and high-good boundaries is presented and exemplified within a complete assessment procedure resulting in a final water body benthic status classification with likelihood estimates for each of the five status classes.

Discussion

It was concluded that the pBQI has many advantages over the standard BQI. Again, the baseline conditions, where the pBQI is based on, were discussed focusing of several baselines for different coastal types versus one baseline for the entire coast. It was suggested that BEWG might provide criteria or guidance for defining reference conditions, since baseline/reference conditions are highly important in most assessment approaches.

5.1.7 Planning for future work

Sub-group meeting, chaired by G. Van Hoey (presented)

There was one common discussion item after the presentations and that was on defining appropriate baseline conditions/dataset for each study. Therefore, we organized a sub-group meeting on this subject to explore what we can advise on this matter.

A very general definition for a baseline dataset is "A dataset for comparison" …

For the delineation of baseline datasets the following aspects need to be considered (i) coverage of the right temporal window (long-term series) in relation to prevailing climatic conditions; (ii) adequate coverage of the spatial component (i.e. sampling design, amount of samples, distribution of samples, replication, inter and intra variation) ; (iii) a pressure window of the dataset (cf benchmarking WFD) (large scale pressure problem; local pressures easily to deal with); (iv) environmental conditions and local specifications: habitat types, waterbody-types-subtypes (a method to overcome this environmental variation can be through modelling (Leonardsson*et al.* 2016; cf depth)).

To derive reference values from such baseline dataset there is need for or (i) a reference value (= one value out of the dataset to compare with; e.g. percentile, expert judgement; e.g. m-AMBI, BEQI2); or (ii) a reference condition (expected condition = in GES= resilience; e.g. pBQI, BEQI and Benthoval way) = using the entire dataset; or (iii) a model.

A short communication or even a review paper might be useful to bring the scattered information on baselines together. A few conditions have to be met for this.

- Check literature whether this is a more or less novel contribution
- Write a paragraph for every point to set the context and touch on the relevance thereof. Collect the metadata (list of relevant papers per topic)
- If OK, write it in a paper

Options are (i) a short, sharp paper with state-of-the-art to ICES to summarize what is available and possible approaches (ecological approach, no political aspects); (ii) a wide approach, not getting lost in small-scale opinions. This will be taken forward towards the next BEWG meeting.

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

5.2.1 Up-date on variability in expert assessments of benthic species tolerances/ sensitivities

This initiative aims at testing the hypothesis that the variability of expert assessment of sensitivity is high for widely distributed species, compared with species with a restricted geographical distribution. A subgroup detailed the preliminary selection of independent experts from four sea regions (10 experts from Baltic Sea, Greater North Sea, North East Atlantic (incorporating Lusitanian, Celtic Seas and Norwegian Seas) and Mediterranean Sea). The methods for species selection (15 species varying from widely to narrowly distributed) remains to be refined as is a suitable species database for each region (e.g. BTA and substrate type to be considered). Two primary and two secondary pressures (deci-

sion on the uptake of the second category pending) were reconfirmed. The benchmark for each pressure considered was very broadly defined as not to lead the participating experts too much. The questionnaire's scales for sensitivity and confidence, and format were fixed. Once fully developed, the questionnaires and the (analytical) method will be checked by social scientists with expertise in questionnaire-based research. Outstanding tasks for intersessional work include: (1) finalising the list of experts for the four regions, (2) methods for species selection to be refined and a suitable species database identified for each region, (3) questionnaires to be developed and the (analytical) method checked by colleagues with expertise in social research.

This exercise is led by S. Degraer and will be executed with the help of regional coordinators, i.e. C. Labrune and P. Magni (Mediterranean Sea, N. Desroy, O. Gauthier, L. Buhl-Mortensen and B. Hunter (NE-Atlantic), U. Janas and M. Gogina (Baltic Sea). North Sea coordinators are yet to be identified.

5.3 Review of the development of effective monitoring programmes, e.g. design, techniques, improvements, harmonisation and quality assessments

As a starting point, H. Hillewaert presented the first results of a project led by L. Devriese using molecular tools for benthic biodiversity assessment.

5.3.1 A DNA (meta)barcoding approach to tackle marine benthic biodiversity

By Devriese Lisa, Haegeman Annelies, Maes Sara, Ruttink Tom, De Backer Annelies, Van Hoey Gert, Wittoeck Jan, Hillewaert Hans (presenting), De Tender Caroline & Hostens Kris

Macrobenthos is recognized as a good biological indicator to measure changes in marine ecosystems. However, biodiversity assessments require accurate species identifications, which are commonly based on morphological features. DNA barcoding (species) and metabarcoding (communities) may provide a fast alternative. We developed a DNA metabarcoding method using Illumina MiSeq technology. Various barcoding primers were checked against publicly available sequences to select the most optimal barcode region and primer sequences for the macrobenthos species present in our study area. Next, amplicon sequencing was executed using barcoding primers designed for the 18S target region. DNA extracts of individual species, and of pooled samples in which tissues or DNA extracts of different species were mixed, were amplified using this method. This setup allowed us to check the effectiveness of the primers to detect species in single or mixed samples, and to investigate the relationship between read counts per species and the proportion of species in mixed samples. Based on the 18S target region, 39 of the 50 macrobenthos species were detected. For some species (e.g. *Nephtys* sp.) this setup will not allow us to discriminate between species of the same genus. As species of the order Amphipoda were not detected, an additional target region (COI) was included. COI amplicons of individual species were Sanger sequenced in anticipation of our COI metabarcoding results. This setup allowed us to evaluate which DNA barcode provides the best taxonomic resolution for the collected macrobenthos species. First results of the COI barcoding approach revealed an advanced taxonomic resolution for species of the order Amphipoda. The 18S and COI barcode sequences were added to our DNA reference library.

Discussion

Several questions were raised after the presentation concerning detection limits and future perspectives of metabarcoding methods. Presence/absence determination is functioning well for most groups (except Amphipoda based on 18S RNA), but the quantification of biomass (or abundance) is still unsolved. Over- or underestimation of biomass could be caused by interspecific differences in DNA content or by PCR bias. The analytical procedures with bioinformatics are still time consuming and might be a bottle neck for a fast sample processing, but that changes fast with technological progress. Other research groups work on direct extraction of DNA from bulk sediment samples.

5.3.2 A summary of the benthic case study selected under the Joint Monitoring Programme: NS/CS

This work is currently in preparation in a peer-review manuscript. The work deals with benthic habitat condition is considered under various environmental directives, but there is no common indicator, assessment or monitoring protocol for most regions, including the North Sea. Differences between benthic assessment methods of the member states are not an obstacle for integrated monitoring, because most of them rely on species-abundance data, which can be collected in a standardized manner. Usually, the benthic system is monitored as part of national monitoring programs, environmental impact assessment, and some institutional engagements. More often than not, these programs are characterized by different objectives, differing in strategy, sampling designs and protocols. Therefore, this paper aims to provide scientific guidance on how designing a benthic monitoring program on a regional scale in an appropriate and efficient way, meeting different monitoring purposes. For determining the requirements (stratification, allocation of samples, sample effort) of such program, we used the data of the North Sea Benthos Survey of 1986 (NSBS 1986) and the North Sea Benthos Project of 2000 (NSBP 2000). The analyses show that an optimal large scale benthic sampling design can be obtained by distributing the sampling effort across North Sea ecosystem strata. This should be performed according to the Neyman allocation principle, which takes into account the variance of the benthic characteristics and the size of the strata. Based on the relation between the benthic parameters variance and sampling effort, we are able to give guidance on sample effort requirements. Cost-effective monitoring can be achieved by the usage and, where possible adaptation of existing national programs, in order to serve multiple uses and thus increase the scientific and monetary values of each dataset. Therefore, the cooperation between the countries need to be strengthened and an official, international coordination body need to work towards agreed protocols and align broad scale monitoring with ongoing national monitoring.

5.3.3 Planning for future work

G. Van Hoey reported on the progress on the paper "Design a monitoring program for the marine benthic ecosystem: steps to be taken", which was initiated in 2015. A second draft including the final results was circulated prior to the meeting. In the brief plenary discussion, it was pointed out that it needs to be mentioned in the paper that several aspects of monitoring such as temporal changes and responses on specific pressures might not be captured by the approach used in this study. A power analyses to determine the number of samples needed to detect temporal changes was suggested, but might be be-

yond the scope of this paper, which is mainly focusing on the assessment of ecosystem status.

Major concerns were discussed and resolved in a subgroup. Comments are to be sent until the end of May. Meanwhile a suitable journal for publication will be decided. There was an agreement to go rather for a view point paper than a dedicated scientific analysis paper. Draft deadline is summer 2016.

6 Benthic biodiversity and ecosystem functioning (ToR d)

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

6.1.1 Discussion on literature review on the links between benthic biodiversity and ecosystem functioning and plans for this information

Starting in the Iceland 2012 BEWG meeting an initiative was launched to study links between biodiversity & ecosystem functioning based on a literature review. Aspects related to species identity, density, ecosystem function, direction of response (pos/neg) and linkage with M & R score were compiled into a large table.

That linkage apparently has not really been tackled yet, as predominantly single species studies were encountered, mainly dealing with linkage with fluxes (nutrients/oxygen).

The results of the literature review (initiated during BEWG 2012) where summarized. The initial idea of this initiative was to investigate whether clear relationships between structural descriptors of benthic communities (e.g. biomass, density, diversity) and any proxy for ecosystem functioning have been described in the literature so far. The literature search started from 4 influential papers, identified during BEWG 2012 (Iceland):

- 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 81:887-892g

During the BEWG meeting of 2013 in Spain, a fifth paper was added:

- 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 find all papers citing one of these 5 papers. This resulted in a list of 531 citing papers. This list was reviewed and cleaned by (1) removing double entries; (2) excluding papers dealing with terrestrial or freshwater habitats and (3) exclud-

ing papers obviously not dealing with marine benthos. This resulted in a final list of 162 papers that were reviewed for information on descriptors of benthic community structure, ecosystem functions, and the possible direction (possible/negative) of the effect of the fauna on ecosystem functioning.

As research has focused on the effects of single species on ecosystem functioning, the question at hand here (is there a link between biodiversity and ecosystem functioning) cannot be answered. Recent literature is also not evolving into assessing whole community effects on ecosystem functioning. Therefore, the group discussed on how to safeguard the efforts made by BEWG. It was decided that the table, and the rationale would be published in the extended scientific ICES 2017 report of BEWG.

6.1.1.1 Influence of German Bight top bioturbators on biogeochemical cycling and sediment turnover

By Alexa Wrede (presenting), Jennifer Dannheim, Lars Gutow & Thomas Brey

Macrofaunal bioturbation and bioirrigation activity strongly enhances benthic biogeochemical cycling and may thus play a key role in ecosystem functioning. To identify top bioturbators in the German Bight the trait based bioturbation potential (BPc) was mapped for 423 North Sea stations. BPc mapping identified *Amphiura filiformis*, *Echinocardium cordatum* and *Nucula nitidosa* to be major bioturbating species in the German Bight. Functional effects of these three species on silicate, ammonium and nitrate flux were investigated in laboratory experiments as well as species bioturbation rate (Db) and bioirrigation activity. *E. cordatum* significantly influenced biogeochemical cycling, while effects of *A. filiformis* remained inconclusive due to arm regeneration and *N. nitidosa* showed little impact on biogeochemical cycling, albeit being an important bioturbator. *E. cordatum* may thus be considered one of the most important mediators of ecological functioning in the German Bight sediment water interface.

Discussion

Larger surfaces in the laboratory experiments were suggested for better survival of *A. filiformis* which would also increase the mobility of *E. cordatum*.

6.1.1.2 Identification and biological traits of endangered species in the North Sea

By Jennifer Dannheim (reporting), Lars Gutow, Jan Holstein, Dario Fiorentino & Thomas Brey

Biodiversity is seen as a core-service of marine ecosystems, and rare and endangered species play a crucial role in maintaining biodiversity. In shallow shelf seas such as the North Sea, benthic organisms contribute significantly to overall biodiversity. Hence, knowledge of biological characteristics and spatial distribution of benthic biodiversity and of benthic rare species is essential for sustainable ecosystem management and for the conservation of endangered species. In 2013, the status of endangered species was revised and published via the new "red list". Regarding the marine benthic species on this list, the evidence used to judge them "endangered" is quite often scientifically unsatisfying by insufficient data and an imperfectly picture on their spatial occurrence.

We use an extensive information system on benthic invertebrates in the German EEZ of the North Sea (> 9000 stations × > 740 species) for a high-resolution and large-scale analy-

sis of occurrence and spatial distribution of "red list" species. For the first time, we evaluate the functional role of endangered species by means of their biological traits and analyse their spatial distribution in the EEZ. Finally, we identify potentially sensitive areas where endangered species cluster. This information constitutes a sound scientific base for a sustainable ecosystem management.

Discussion

The group commented on following aspects:

- We should be aware that rarity is not the main/only target for red-list assessment;
- Comparability of different approaches might be limited due to different targets;
- Red listing and rarity are often a matter of scale….;
- Comparing traits of Red List species with full species list to identify which traits pop up might yield interesting results.

6.1.1.3 Atlas of the benthic invertebrate distribution in the Normano-Breton gulf

By Le Mao P., Desroy N. (reporting), Chambers P., Godet L., Fournier J., & Thiébaut E.

With the participation of Cabioch L., Gentil F. & Retière C.

At a period when pressures applied on coastal environments increase, inventories and mappings of biological diversity are approach allowing to (i) improve knowledge on distribution and spatio-temporal changes (regression, extension, introduction) of species on a geographical area and (ii) identify diversity hotspots. Faunistic (or floral) atlas are then tools necessary and essential to correctly understand species dynamics and to develop effective protection policy of the biological diversity.

The normano-breton gulf has been investigated by naturalists since the beginning of the XVIIIth century. This area is characterized by singular environmental conditions, among which:

- a tidal range reaching 15 m in the Mont-Saint-Michel bay during spring tides;
- The existence of large systems of rotating currents around islands and archipelagos, which largely influence the particle dispersion;
- a low depth which, combined to the existence of large flats, is responsible for (i) an important hydro-climatic gradient located from the south-east to the north-western, in summer as well as in winter, and (ii) a strong thermal range between this two seasons.

In the normano-breton gulf, the distribution of species, which some (Lusitanian and boreo-arctic) are in their limit of (north or south) distribution area, depends of climatic factors but also of edaphic characteristics, themselves controlled by the intensity of hydrodynamics.

In this context, we develop the project of an atlas of the benthic diversity in the normano-breton gulf (area of more than 26 000 km^2, north coasts of Brittany, France) aims to:

- do the most precise inventory of the invertebrate benthic macrofauna;
- assess the distribution of all the species recorded on this area, characterized by specific environmental conditions;
- increase the knowledge of temporal variations of the distribution of some species, during the 200 past years.

The atlas will be articulated around three actions: inventory the biodiversity (actually, more than 2000 species have been considered), map their distribution and detail the temporal evolution of a selection of 50 species.

Discussion

The atlas was well received by the group and the BEWG is keen to start a wider initiative covering the seas between Brittany and Denmark, possibly also including the Celtic and Baltic Seas.

A start could be made in 2018 and a search for funding should be started as soon as possible, including European funding (e.g. EmodNET was considered).

6.1.1.4 Towards answering the "so what" question in marine renewables environmental impact assessment

By Steven Degraer (reporting), Silvana N.R. Birchenough, Ulrike Braeckman, Joop Coolen, Jennifer Dannheim, Ilse De Mesel, Marilaure Grégoire, Francis Kerckhof, Geneviève Lacroix, Han Lindeboom, Tom Moens, Karline Soetaert, Jan Vanaverbeke and Gert Van Hoey

Marine renewable energy (MRE) projects are increasingly occupying the European North-Atlantic coasts and this is clearly observed in the North Sea. Given the expected impacts on the marine environment, each individual project is accompanied by a legally mandatory, environmental monitoring programme. These programmes are focused on the resultant effects on ecosystem components. The detection of these effects seem to be concentrated on structure (e.g. species composition, numbers and densities) attributes of a single industrial project. To date, there is a tendency to narrow down to only a selection of ecosystem components (e.g. marine mammals and birds). While a wide knowledge based understanding of structural impacts (of a selection) of ecosystem components exists, when undertaking impact assessments at the ecosystem functioning level (e.g. trophic interactions, nutrient cycling and dispersion) this evidence is largely lacking. This critical knowledge gap compromises a scientifically-underpinned answer to the "so what" question of environmental impacts. This level of evidence is fundamental to ascertain whether the observed impacts are considered to be positive or negative, or acceptable or unacceptable. The importance of ecosystem functioning is further acknowledged in the descriptors 4 and 6 of the Marine Strategy Framework Directive (EU MSFD) and is at the heart of a sustainable use and management of our marine resources. There is a fundamental need to focus on ecosystem functioning when assessing MRE impacts at the relevant spatial scales at which marine ecosystems function. Here, we make a plea for an increased investment over large (spatial) scale impact assessments of MRE projects focused on ecosystem functioning.

This presentation will cover a selection of examples from North Sea MRE monitoring programmes, where the current knowledge has limited conclusions on the "so what"

question. Furthermore, this presentation will demonstrate how an ecosystem functioning-focused approach at an appropriate spatial scale could advance our current understanding, whilst assessing these issues. These examples will cover biogeochemical cycling, food webs and connectivity in a cumulative MRE impact assessment context. This presentation will highlight both the available knowledge base and further elaborate on the knowledge gaps. We will offer guidance on how these knowledge gaps could be further investigated, based on examples taken from the recently started projects FaCE-It, Functional biodiversity in a changing sedimentary environment: implications for biogeochemistry and food webs in a managerial setting (financed by the Belgian Science Policy) and UNDINE, Understanding the influence of man-made structures on the ecosystem functions of the North Sea (financed by Oil & Gas UK). This presentation will set the scene and offer further thinking on the current issues associated to MRE monitoring, particularly beyond the level of ecological structure and individual industrial projects. The overall message will help to advance and strength a collaborative MRE monitoring, helping scientists, managers and regulators to answer the much needed "so what question" to support environmental assessments.

6.1.2 Biological trait analysis

6.1.2.1 Changes in functional composition along sediment gradient

By Alexander Darr (presenting)

Understanding the influence of environmental parameter on macrobenthic communities is a core area in marine benthic research. Besides biodiversity, functional aspects became focal points supported by the application of biological traits analysis (BTA) during the last decade. But limited knowledge is available on the influence of major environmental drivers (e.g. substrate) on the functional composition of marine macrozoobenthic communities. Consequently, BEWG defined a new initiative at 2014s meeting in Dinard. The aim of this initiative is to analyze whether there are any differences in traits composition in BTA between different substrates (mud, fine sand, coarse sand) and whether those are consistent between different regions/seas (Mediterranean, North Sea, Baltic, etc.). The initiative is tackled in a stepwise approach. In a first step, a common BTA-table will be set up to allow for common analysis whereas the in depth analysis will be done in a second step.

Limited intersessional work took place since the last meeting. It is proposed to decide whether this initiative still can provide substantial gain of knowledge to scientific community. If this is the case, substantial progress is planned in sub-group work for the BTA-table.

Discussion

A Subgroup on the BTA initiative lead by A. Darr, explored an overlap of the initiative with the BENTHIS (Deliverable D3.4)-report on BTA within EUNIS level 3 habitats (fishing pressures focus) which was finalized in Dec 2014. While there is no data overlap, regional overlap exists.

The BEWG initiative is considered unique in its planned focus on comparison between regions not tackled by BENTHIS. Belgian median grain size has to be confirmed for use

in the BTA case study. Clear questions to be addressed should be formulated, probably by Webex/Skype by the end of September

6.1.2.2 Meeting new functional indicators needs of the MSFD

Biological indicators currently provide the main approach for monitoring and assessment of the environmental status of the benthos. Most indicators focus on aspects of community structure, however, the MSFD defines good environmental status both in terms of biological diversity (Descriptor 1) and seafloor integrity (Descriptor 6). At present we lack a common approach to assess ecosystem functioning (and associated ecosystem services) within different benthic habitats. As the BEWG, we would seek to address this gap in indicator availability by considering and identifying key approaches / methodologies that could be used to monitor and assess different seabed types. This will allow us to offer guidance on agreed methodological standards and feed into the regional and cross regional assessments under the Regional Seas Conventions (RSC) implementing the MSFD. Specifically, we seek to review the new amendments to the MSFD criteria for D1 and D6, and the long list of (400+) indicators within D6 workshop and identify which indicators relate to ecosystem processes and functioning. This will allow the BEWG to identify and evaluate methodologies that could effectively monitor these ecosystem functioning, and compliment the current range of indicators e.g. Biological Traits Analysis (BTA), Bioturbation Potential (BPc).

Discussion

A subgroup focused on the planned work to assess ecosystem functioning indicators in the context of MSFD implementation. The list of actions for consideration included looking at functional indicators, reviewing existing lists, and populating a table summarizing existing indicators that have a link to ecosystem functioning.

6.2 Identify the links between benthic functions and ecosystem services.

6.2.1 Linking ecosystem functions and ecosystem services: misconceptions and benthos matters

S. Birchenough on behalf of P. Montagna informed the group about the update on the paper 'Ecosystem functions and ecosystem services: misconceptions and benthos matters' planned to be drafted by end of June, and after intersessional circulation between involved contributors finalized by the end of August.

7 Benthic Biodiversity and conservation: to review the role of benthic ecology in MPA's (ToR e)

7.1 Review the role of benthic ecology in relation to Marine Protected Areas

The work on MPA's has been summarised into one document and further details are covered in the section below.

7.2 Discuss the development of effective (e.g. design, scale, coverage, etc.) MPA's

7.2.1 A benthic ecology perspective for evaluating the effectiveness of MPAs – are the current MPAs enough to protect endangered benthic species?

This issue within ToR e is a continuation of previous work of BEWG started in Dinar and continued in Corsica. A manuscript draft was actively circulated during the intersessional work before this year's meeting. P. Magni gave a brief overview presentation.

By Paolo Magni (presenting) & Clare Greathead

Implementation of the MSFD will ultimately require programmes of measures that balance human activity with a functioning marine ecosystem. MPAs can be viewed as one of the many management tools available to reach Good Environmental Status (GES). Therefore, EU Member States are required to provide a coherent and representative network of Marine Protected Areas (MPAs) that adequately cover the diversity of the constituent ecosystems. These MPAs should, if utilised correctly, contribute to an ecosystem's resilience to further anthropogenic pressures such as climate change.

This paper reflects concern within ICES-BEWG that the process of selecting MPAs within these networks has not adequately considered the unique requirements of benthic habitats and species. In addition, benthic habitat and species are poorly considered when assessing the performance of MPAs and the effectiveness of conservation measures. Criteria for the selection of MPAs that have been designated to protect and/or conserve benthic species and habitats need to consider ecological issues such as: the structure and function of the main habitats as well as species of conservation concern; species life cycle/distribution or size frequency distribution; spatial-temporal pattern of structural variables of benthic communities, propagule/larval dispersal, recruitment, predation, migration, habitat/refuge provision, trophic interactions (Frid*et al.*, 2008), as well as fecundity and longevity (Edgar*et al.*, 2014). Case studies will be used to highlight both successful and less successful strategies, selected by predetermined criteria.

References

Edgar, G.J., Stuart-Smith, R.D., Willis, T.J., Kininmonth, S., Baker, S.C., Banks, S., Barrett, N.S., Becerro, M. A, Bernard, A.T.F., Berkhout, J., Buxton, C.D., Campbell, S.J., Cooper, A.T., Davey, M., Edgar, S.C., Försterra, G., Galván, D.E., Irigoyen, A.J., Kushner, D.J., Moura, R., Parnell, P.E., Shears, N.T., Soler, G., Strain, E.M., Thomson, R.J., 2014. Global conservation outcomes depend on marine protected areas with five key features. *Nature* **506**:216–220. doi:10.1038/nature13022.

Frid, C.L.J., Paramor O.A.L., Brockington, S., Bremner J., 2008. Incorporating ecological functioning into the designation and management of marine protected areas. *Hydrobiologia* **606**:69–7.

Discussion

Subsequent plenary discussion produced some major remarks: the initiative aims at a view point paper exploring the use of MPA's concept, ecological models for their establishment, and their features (from structure to ecosystem functioning and services). The critical comments on the latest version of the draft (done from a conservational point of view, and concerning the observed evolution from establishment methods to implemen-

tation of monitoring) were considered. This highlighted the need to provide not only management background, but a more unbiased review from an ecological point of view with illustrative case studies as the core of the initiative. There was an agreement that legislation perspectives (which differ largely between regions) require some recommendations to proceed, but major focus of BEWG should be on ecological knowledge, including an overview of ecological knowledge gaps which is also very useful for managers.

There was a proposal to adapt the scheme from the Duncan 2015 paper (based on complex linkages involved in final ES delivery) to shape the paper, and to use different case studies to illustrate different functions. An observed shift from designation to management and from biodiversity to services was discussed. Formerly benthos was not much involved in the establishment of MPA's, but recently it is a steering force for newly designed MPA's. There was a note that Horizon 2020 will address the way MPA's protected by fisheries management are threatened by abrasion, non-selected extraction of species, etc. MPA's may be labelled such that benthos is protected, but pressures are not removed, or — as an example from the North Sea — removed, but only those that have no impact on benthos. BACI design is needed to investigate such issues, i.e. if there is a mismatch in how MPA's are labelled, and measurements that are not adequate for assessing benthos.

Finally, it was decided to summarize case studies in a table (including the entries on MPA's adjustment, scoping, assessment, performance measures), using the conceptual scheme published by Stelzenmüller*et al.* 2013 as a starting point. An MPA is a spatially managed area. It was agreed that to assure objectiveness, no selection of included case studies should be done. Rather the initiative will only tackle those European marine regions the BEWG has experts for, but still all case studies (MPA's) within the defined selected regions should be considered. This allows a neutral way for evaluating proper management from an ecological point of view, exploring whether benthos was tackled adequately.

The need for critical mass of case studies was discussed as there are so many objective reasons for creation of MPA's. This was left open as this initiative is not aiming at meta-analysis, and only analysis of a populated table can reveal the sufficiency of data for statistical evaluation.

There is a need to clearly define the idea of what is evaluated: whether it is the proof of concept on MPAs or whether the benthos is properly taken on board, was stressed (if the latter - need as much cases as possible). It is important to distinguish between evaluations of MPAs if the objective of MPAs is to effectively protect, or if it is not designed to do so, whether it protects it.

Responsible contributors for text pieces are to be allocated and a suitable journal is to be decided upon. Timelines should be defined. Questions addressed will be drafted during intersessional work, Webex, etc.

Coordinated by P. Magni the group formally agreed on an objective way to include MPA's – e.g. all in Portugal, NE Atlantic or Sardinian waters (no restriction to specific case study), with an aim at regions to be generically defined (e.g. Italian part of W Mediterranean).

A table template was drafted (sharepoint) with list of areas to be covered – and responsible contributors named (all present regional expertise within the group all over European NE Atlantic coast included). The scheme from Stelzenmüller*et al.* 2013 was expanded and adapted.

The MSFD list was considered for a drop down list on benthic ecosystem components, pressures and impacts. It was suggested to use the Natura 2000 network to screen MPA's full lists.

A deadline of end of June was put forward to complete a full list of names of all existing MPA's within each regional area.

A definition of MPA was agreed upon (*sensu* IUCN), as well as definition of benthos (including flora and fish). This information will be disseminated through the sharepoint.

Coordinates (e.g. latitude and longitude) will be collected (as points) for each case studied MPAs from the completed overview table, to enable the compilation of an overview map.

References

Duncan C, Thompson JR and Pettorelli N. 2015 The quest for a mechanistic understanding of biodiversity–ecosystem services relationships. *Proc. R. Soc. B* **282**(1817):20151348. http://dx.doi.org/10.1098/rspb.2015.1348

Stelzenmüller, V., Breen, P., Stamford, T., Thomsen, F., Badalamenti, F., Borja, Á., ... & Degraer, S. (2013). Monitoring and evaluation of spatially managed areas: a generic framework for implementation of ecosystem based marine management and its application. *Marine Policy*, **37**:149-164.

8 2015/4 Support for the development of common and candidate OSPAR biodiversity indicators for benthic habitats: Benthic habitats (ToR f)

Overall presentations were carried out to provide up-date on currents developments. However, most of the work conducted during 2015 is summarized in the BEWG 2015 report:

http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPD/2015/01%20BEWG%20-%20Report%20of%20the%20Benthos%20Ecology%20Working%20Group.pdf

9 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 (ToR g)

This request was dealt with in the ICES BEWG 2015 report, please see link below:

http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPD/2015/01%20BEWG%20-%20Report%20of%20the%20Benthos%20Ecology%20Working%20Group.pdf

10 Produce four short paragraphs for the ICES Ecosystem Overviews on the benthic community, one para-graph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea (ToR h)

This request was dealt with in the ICES BEWG 2015 report, please see link below:

http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGEPD/2015/01%20BEWG%20-%20Report%20of%20the%20Benthos%20Ecology%20Working%20Group.pdf

11 Recommend a scoring process (or relevant options for processes) for sensitivity of habitats and provide input to WGMHM (ToR i)

The Workshop on guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats (WKFBI), will meet in Copenhagen, Denmark, 31 May – 1 June 2016.

ICES has been asked by the EU (DGENV) to provide guidance in the interpretation of fishing pressure maps in relation to impacts on benthic habitats and the related indicators.

The BEWG was asked to recommend a scoring process (or relevant options for processes) for sensitivity of habitats, which should also include rules on:

i. How to scale-up sensitivity to a c-square resolution of 0.05° × 0.05°
ii. How to treat variation in habitat type when evaluating sensitivity within c-square resolution of 0.05° × 0.05°
iii. How to interpolate and/or extrapolate information on sensitivity when habitat data is missing

Based on the above, the BEWG is asked to provide input to WGMHM.

WGMHM will then incorporate information on sensitivity of the benthic community of the various seafloor habitats, and will produce habitat sensitivity maps for at least one demonstration area of NW European waters (MSFD region/subregion). WGFSD will combine and evaluate the benthic information and fishing pressure maps, taking into account differences in benthic impact of the various fishing gears / metiers (including if possible consideration of weight and value of landed catch in relation to habitats and habitat sensitivity). Following this, an ICES Workshop on guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats (WKFBI) on 7–8 June 2016 will develop indicator principles and good practices for use regionally when assessing the impact of fishing on the seafloor. The workshop outputs will then be used in the ICES advisory process.

11.1 Available maps

The BEWG had a look at the available maps and formulated following comments:

- A habitat map is missing (including salinity classification) which poses a problem to evaluate the sensitivity map
- For the sensitivity map, only surface sensitivity is available. Subsurface maps might be more important for mainly infauna-dominated habitats
- Quality and resolution of the used habitat map is assumed low (it is not available, hence the assumption).
- Scoring on actual habitat condition is not taking the precautionary principle into account as most sensitive species are already lost.
- The use of different approaches (mixing methods!) for shallow and deep waters really stands out especially in fjords/estuaries but also in the greater North Sea
- Looking at the different seas in detail produced some major remarks:
    - Baltic: what are all the white & red areas? Why are large areas not assessed? Areas where hard substrates occur should be white as they are not assessed
    - North Sea: rough and differing resolutions, areas with hard substrates should be white as they are not assessed
    - Mediterranean: matrix was done specifically for Sardinia and should not be extrapolated (unfortunately Sardinia is mainly missing on the map)
- Were the same standards used for excluding/including data as a basis for habitats and pressures maps?
- Will there be a combined map for surface and subsurface abrasion?
- Uncertainty/confidence map is required.
- Proposal/Suggestion: MPAs might be a proxy for sensitive habitats in areas where data availability is low and could in general be treated as "highly sensitive".

Dedicated advice was also provided in relation to Deep-water habitats and with further information from areas mapped by Mareano.

Considering all habitats together 38 % of the offshore environment is covered by vulnerable habitats (but see table below).

The habitats included are: Umbellula Stands, Radicipes Meadows, Hard bottom Demosponges, Soft bottom Demosponges (=ostur), Other Deep Sea Sponges, including Glass Sponges, Seapens and Burrowing Megafauna, and Hard Bottom Coral Gardens.

These were defined on the basis of their species composition and a threshold for predicted density (the details have been published see attachment)

Area of fishing footprint area defined by VMS pings for years 2003–2007, filtered for fishing speed (between 1 and 4 knots) (methodology Buhl-Mortensen*et al.* 2016).

Cells where average ping density was greater than 1 was used for footprint estimate and the area of overlap with vulnerable habitat layer is 2359.7 km2 corresponding to **9 % of the surface covered by vulnerable habitats**.

The cover of the different habitat types is shown in the table below (see also attached map). This is in total 10 percent less because all the small patches are not included.

Habitat type	% of tot area
Soft bottom sponge aggregations (Ostur)	16.1
Hard bottom sponge aggregation (Sponge garden)	5.3
Hardbottom coral garden	0.15
Soft bottom coral garden	0.8
Umbellula	1.8
Seapen & burrowing megafauna	1.2
Cold water sponge aggregations (Hexactinellida)	2.9
Lophelia reefs	<0.01
All	28.3

11.2 Advice

- The BEWG has acknowledge that the scoring sensitivity of benthic habitats to fishing pressure was done as a first step (cf. proof of concept) rather than an in depth analysis of true sensitivity. This exercise has illustrated on a broad sense the methodology that could be adopted to cover large areas and to score benthic habitats;
- The adopted classification of biotopes may not be appropriate for all areas. There are some clear inconsistencies and should be checked prior to the workshop and distribution of the resulting maps;
- Scoring the sensitivity of deep-sea biotopes cannot be crossed with fisheries pressures, this is mainly due to the fact that these data sets do not seem not to be available (e.g. fisheries data there is only a small area included). Therefore, the linkages should only be done where the data layers correspond to the same level of coverage, rather than extrapolating on these two types of layers.
- Considering the adopted spatial resolution, at a EUNIS level 3, the BEWG accepts that not all biotopes are relative for a proper sensitivity assessment are clearly distinguished in this exercise;

- The BEWG also considered that the sensitivity assessment was based on the current status of the seafloor communities, which by definition are already very much disturbed. Therefore, there is a lack of true representation of the seabed system. The MAFCONS project (web: http://www.mafcons.org/) may be able to provide further information on how to best deal with the absence of reference conditions, this is important to consider and discuss during the FBI workshop;
- The adoption of mapping "uncertainty and/or confidence scoring" may offer a solution, on how to deal with many sources of uncertainty, e.g. number of habitats in a cell, number of experts involved, etc.
- Different métiers of trawling will score different sensitivities, therefore, it is important to consider these different aspects whilst mapping and overall representation;
- Finally, the BEWG reiterated that this exercise is solely "a proof of concept" and there is a need to allocate and score values of sensitivity of benthic habitats is a research project in itself, and caution should be given, when looking at the data or maps ready for fisheries management purposes, resulting from this exercise.

The final report from this workshop (WKFBI) activity can be found in the ICES on-line library.

12 Other Business

12.1 Update BEWG's research plan (Multi-annual ToRs) and other ICES requests

12.2 BEWG Outreach initiatives

12.2.1 BEWG's webpage on www.ices.dk

The activities of the ICES BEWG continue to be posted on the ICES web site, with Celine Byrne helping to include all of our relevant outputs.

12.2.2 Conference contributions, workshop organization, etc.

12.2.2.1 ICES Working Group on Marine Benthal and offshore Renewable Energy Development-WGMBRED (Delft, 14-18/03/2016)

J. Dannheim reported on the ICES working group on "Marine Benthal and Renewable Energy Developments" (WGMBRED) established in 2012. The group met the fourth time in Delft, the Netherlands (14–18 March 2016) for its first meeting within the second 3-year multi-annual cycle and was co-chaired by J. Dannheim (AWI, Germany) and Andrew B. Gill (Cranfield University, UK). The meeting was attended by 22 experts, representing seven countries. WGMBRED has four new terms of references.

In terms of the ToR b, WGMBRED will fill the knowledge gaps related to the benthic ecosystem by differentiating among different marine renewable energy technologies, i.e. particularly wave, tidal and tidal stream energy devices in contrast to offshore wind farms. The group will make use of the knowledge gaps review paper on offshore wind

farms from the first multi-annual ToRs. The outcome will be a matrix that differentiates the cause-effect relationships of different energy devices on benthos. A network and interaction analysis will be carried out (ToR c) amongst WGMBRED and relevant groups (regulators, stakeholders, policy makers, scientists) in order to evaluate the impact of MBRED science. First analysis has been carried out and network analysis will be specified by using a questionnaire (to be developed) which will be sent to relevant people. The ToR c focuses on the assessment of ecologically relevant temporal and spatial scales in relation to MREDs effects on the benthic system and the evaluation of the consequences in relation to environmental policy and decision-making. The aim of ToR d is to identify relevant indicators and make them operable to assess ecosystem functioning and the change of benthos in relation to MBRED at scales related to ToR a. WGMBRED decided to tackle scale issues (ToR a) and indicators (ToR d) together. A proof of concept on scale and indicator development was developed which will be used in three case studies (North Sea, Baltic Sea, West of Scotland). The aim of the concept is to analyse exemplary the effect of MRED on important benthic ecosystem functions for societally important issues (biodiversity, food provision and biogeochemical services) to identify relevant indicators on ecologically relevant scales.

More details on its achievements may be found at:
www.ices.dk/community/groups/Pages/WGMBRED.aspx.

12.2.2.2 ICES/PICES Workshop on understanding the impacts and consequences of ocean acidification for commercial species and end-users

S. Birchenough chaired the OA session last year at the ICES ASC 2015 in Copenhagen. A recommendation form this session was to draft a potential workshop among ICES/PICES colleague in 2016. The ToRs for this activity have been drafted and the submission is with SCICOM for further consideration. The date of this event is still to be confirmed.

12.2.3 Future opportunities

12.2.3.1 Priorities for BEWG with other EG's

Considering recent advisory requests to the BEWG, there is a clear need to integrate better some our current work and enable further discussions with relevant ICES EGs on the ongoing activities. Some suggestions for further discussions were with regards to: WGMBRED, WGMG, WGECO and WGDEC. S. Birchenough will discuss these ideas with the chair of SSGEPD, Graham Pierce, and will provide feedback to the group.

12.2.3.2 ICES ASC 2016 (21–25 September, Riga): Marine Spatial Planning and sand and gravel extraction.

S. Birchenough suggested presenting an example of how the BEWG interacts with other groups on the open session of the next ICES ASC devoted to Drivers interactions. The group had no objections, leaving details to be solved intersessionally.

12.3 Closure of the meeting

The group opted to hold next year's meeting on 8–12 May 2017 in Gdynia, Poland. Jan Warzocha of the Morski Instytut Rybacki will host the meeting.

The Chair thanked the local host and her team for their excellent hospitality and generosity. She also thanked the participants for their input and closed the meeting on Friday, 15:00 hours.

12.4 Any other business

12.4.1 EuroMarine 2016 call

This opportunity was briefly discussed and the group felt that these types of initiatives could be explored to support a dedicated workshop or to continue with an ongoing paper development. The BEWG did not agree on a clear idea for this call at this time.

Annex 1: List of participants

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Annex 2: Agenda

AGENDA

Monday 09/05

09h00-09h30	Arrival of participants
09h30-10h00	Welcome from Antonina dos Santos (Director of the Department of Sea and Marine Resources of Portuguese Institute for Sea and Atmosphere-IPMA).
10h00 – 10h30	Welcome by our local host Miriam Guerra (IPMA) Brief round table introductions Appointing rapporteurs for the week. Main Rapporteur Hans Hillewaert
11h00 – 12h00	The history of the BEWG… (Silvana Birchenough & Hans Hillewaert)
12h00 – 12h30	ToR I: Scoring benthic sensitivity to fishing effects. Overview of the request, discussion based on intersessional work and overall outcomes (Coordination: Silvana Birchenough)
12h30 – 14h00	Lunch
13h30 – 14h30	ToR I: WGFBI: Drafting advice and discussion on current methodologies, see share point BEWG (folder WGBFI)
14h30 – 15h30	ToR I: WGFBI: plenary discussions and wrap up session to feed to WGFBI (May-June)
15h30 – 16h00	Coffee break
16h00 – 17h00	ToR A: Long-term trends and climate change (Coordination: Silvana Birchenough): introductory presentations and up-dates.
17h00 – 18h00	ToR A: Discussion on paper draft structure addressing 'methodological aspects' when comparing long-term series.

Tuesday 10/05

09h30 – 11h00	ToR B: Introductory presentations, up-date and discussions on ongoing work (Mayya Gogina)
11h00 – 11h30	Coffee break
11h30 – 12h30	ToR C: Issue 3.A (Coordination Gert Van Hoey): introductory presentations on ongoing indicator work
12h30 – 13h30	Lunch
13h30 – 14h30	TOR C: Issue 3.A outstanding presentations and further discussions on way forward (needed for future advice? What are the opportunities for linking with other EG's)
14h30 – 15h30	ToR C: Issue 3.B (Coordination: Steven Degraer and Michael Zettler): introduction and way forward
15h30 - 16h00	Coffee break

16h00 - 17h00 ToR C: Issue 3.C (Coordination: Gert Van Hoey): introductory presentations and plenary discussion

17h00 - 18h00 Breakout groups

- ToR B: To identify outstanding work and needs to support ongoing case study (Maya)
- Tor C Issue 3.B to plan and progress with planned work (Steven Degraer)
- Tor C Issue 3.C to review and discuss monitoring draft paper (Gert Van Hoey)

19h00 – 21h30 Local dinner- details to be provided during the meeting.

Wednesday 11/05

09h30 -10h30 Plenary discussion and overall up-dates on breakout groups (ToR B and ToR C: 3.B &3.C)

10h30 -11h00 Coffee break

10h30 -11h30 ToR D: Introductory presentations (Coordination: Jan Vanaverbeke)

11h30- 12h30 ToR D: Issue A.A.1 up-date overview and current plans (Jan Vanaverbeke)
ToR D: Issue 4.A. 2 up-date on ongoing case study "Changes in functional composition along a sediment gradient" (Coordination: Alexander Darr)
ToR D: Issue 4.A. 3 up-date on planned work assessing new functional indicator needs to support MSFD requirements (Billy Hunter)
ToR D: Issue 4.A. 4 up-date on paper draft 'ecosystem functions and ecosystem services: misconceptions and benthos matters' (Coordination: Silvana B on behalf of Paul Montagna)

12h30 – 13h30 Lunch

1200h- 18h00 Local excursion "exploring Lisbon" (participants will need to pay 18 €)

Thursday 12/05

09h30 – 10h30 Plenary discussion and overall up-dates on breakout groups (ToR D: Issue 4 A.2)

10h30 – 11h00 Coffee break

11h00 – 12h30 ToR E: overview and update on ongoing paper entitled: "benthic ecology perspective for evaluating the effectiveness of MPAs – are the current MPAs enough to protect endangered benthic species?" (Coordination: Paolo Magni and Clare Greathead)

12h30 – 13h30 Lunch

14h00 – 15h30 Breakout groups

- Issue 2.A: discussion on priority tasks and way forward.
- Outstanding issues: TORs

15h30 – 16h00 Coffee break

15h30 – 16h30 ToR: Plenary discussion and plan for paper preparation

16h30 – 17h30 Breakout groups to finalise work (including your abstracts, minutes, actions, etc.)

17h30 – 18h00	Plenary discussion (if needed to discuss outstanding issues)
Friday 13/05	
09h30 – 11h00	Issue 8.A: Update BEWG's research plan (BEWG contribution to WKFBI)
11h00 – 11h30	Coffee break
11h30 – 12h30	Issue 8.B: BEWG Outreach initiatives (ICES Facebook and ICES webpage)
	Set date for next year meeting at Gdynia (Host: Jan Warzocha).
	ICES Theme sessions for next year ICES ASC (Florida 2017, 4-days and fewer sessions)
	Further linkages with other EG's (WGDEC/WGECO/WGMHM)
12h30- 13h30	Lunch
14h00 –15h00	Issue 8.C: Any other business and rapping up contributions to Hans.
	Final conclusions, BEWG report (due on the 30th June) and actions.
15h00	Meeting ends

Annex 3: Recommendations

RECOMMENDATION	ADRESSED TO
1. A dedicated request (e.g. ToR I) to provide scores of benthic habitat sensitivity to fishing pressure was discussed and included on the Mutli-ToRs for the BEWG this year. Most of the work was conducted intersessionally over a very tight deadline as this work will be part of a series of steps. The BEWG worked directly with other EG's and actively dicussed the methodology and the work to enable scoring and production of outputs within the agreed times. The overall process was considered to be a 'proof of concept' and given the type of assessment and the level of effrot needed, there would be a much efficient way to deal with these type of overall requests if needed . The BEWG suggests that in the near furture, if other further requests that may be added to the current ToRs, there need to consider: the timings, level of effort requiered to produce the outputs and the dleivery dates. A further recommedation will be that these type of products are dealt over diffetnt EG's over an initial workshop rather that providing most of the discussion online and via e-mails, this way of working will help to improve the outputs. The overal process provided a useful approach, promoting integration and brignign the science across ICES EG's for a final set of evidence.	The BEWG recognises that more clear linkages for these types of excercises are valued and needed. There is a need to support wider and active collaboration with other EG's (WGMHM, WGDEC, WGVMS-Records, Data centre, etc.) and the drafting group ensure that the final output is cascaded among BEWG members for informaiton as well as to those who actively contributed to this process.
2.The BEWG has been working on development of indicators with dedicated efforts on setting baselines, cost-effective monitoring practices, data-sharing exercises and targeted need to support legislation requirements (e.g. under MSFD) to support the assessment of impacts on benthic habitats from anthropogenic activities. **BEWG recommends** that ICES will discuss these gaps and engage with relevant experts group to avoid duplication of efforts and complementary knowledge to be applied to these initiatives.	ICES will be aware of the relevant groups, some suggestions will be under data centre, WGECO, WGDEC, WGMBRED, WGMSFD, WKPIMP and via active engagement from the secretariat to assist this process.
3. An area identified by the BEWG is with regards to structural and functional indicators (relevant to many aspects of the MSFD, mainly D1-biodiversity and D6 seabed integrity), particularly linking damage and functional attributes to support seabed integrity assessments. BEWG has been working on several aspects of indicators, monitoring and assess-ment. The BEWG suggests that better integration is fostered across EG's (e.g. workshop or a targeted session for the next ICES in 2017). This activity will help to cascade ongoing developments and highlight the gaps for future work.	ICES EG's with an interest in developing science to support the Marine Strategy Framework Directive (MSFD), mainly WGBIOD, WGECO, and others to be identified by ICES secretariat and cascade options.
4. Provide a feedback loop to the EG's that have actively responded to dedicated ToRs, with the understanding on the final end-point of this process (e.g. final product) as well as the customer that required the work (e.g. OSPAR, HELCOM, etc.)	SICOM, ACOM, relevant ADG drafting advice groups via the secretariat.

Method	Background	Thematic level	Format	Pros	Cons	reference
MB0102 (DEFRA, UK)	The sensitivity assessment methodology has been adapted from a number of approaches, based on the review of approaches. The approach considers the resistance (tolerance) and resilience (recovery) of a feature to assess sensitivity to pressures. The final sensitivity assessment methodology was developed to address the requirement to make rapid assessments using an expert-based approach and that could be applied at a range of feature scales - species, habitat, broad scale habitat level. Confidence scores were also assigned to the individual pressure-feature sensitivity assessments based on the quality of evidence that was available to support the assessments.	~14 broadly equivalent to EUNIS level 3 classes (shelf only) / predominant habitats	Pressure-feature sensitivity matrix including 4,320 individual assessments: 4 point categorical scale for sensitivity	Despite poor thematic resolution, use the MB0102 (Table 2, item 1) sensitivity matrix. It is the only matrix that is complete and provides the greatest coverage of habitat classes included in the maps; confidence assessments;	Poor thematic resolution (i.e. EUNIS level 3); only initial broad-brush risk assessments; the magnitude of pressures but do not take account of spatial or temporal scale; sensitive to the chosen benchmark level of pressure; does not consider the cumulative risks;	Tillin*et al.*, 2010
DEVOTES	DEVOTES project has developed a Nested Environmental status Assessment Tool (NEAT), to assess the status within the Marine Strategy Framework Directive (www.devotes-proejct.eu/neat). This tool has been tested in 10 case-studies across the four European region-	No information available	No information available	Not assessed	Not assessed	*pers. comm.* A. Borja

Method	Background	Thematic level	Format	Pros	Cons	reference
	al seas. To test the sensitivity of the case study assessments to the selection and number of indicator values, an analysis was performed in which the assessment was run using randomly selected indicator values. The number of indicator values included into the assessment varied from 1 to the maximum number of indicators in the case study minus one. This process was repeated 100 times for each number of indicator values. For example, in a case study with 120 indicator values. First, one random indicator value is selected and the assessment is done using only that indicator. This procedure is repeated 100 times. Then, two indicator values are picked at random, and the assessment is run using them; this again is repeated 100 times. This procedure is repeated for all numbers of indicator values up to 119. This results in a large number of values whose divergence can be analyzed to see if any patterns can be identified.					

Method	Background	Thematic level	Format	Pros	Cons	reference
VME index (WGDEC)	Developed as a multi-criteria approach in 2014 to evaluate vulnerable marine ecosystems, the index was further developed in 2015 to overcome inconsistencies in spatial representation (changed to spatially gridded data), to differentiate indicator species according to their vulnerability to human impacts, and to include a data-uncertainty estimate.	Not applicable	Vulnerable marine species-driven	Uncertainty estimate is included mainly based on data quality and reliability; tested for different regions in the NE-Atlantic; Potential for combining observational and modelled data (not tested)	Deep water habitats only (but that was the purpose); Based on nine indicator types (higher taxonomic groups/habitat builders; not species) only, with relatively high threshold levels (without gradual weighing); Known VMEs either not considered (cold seeps) or causing bias in the uncertainty estimate?	ICES. 2015. Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 16–20 February 2015, Horta, Azores, Portugal. ICES CM 2015/ACOM:27. 113 pp
Baltic BOOST	still under development and largely referring to the BENTHIS approach	No information available	No information available	Will be adapted to the Baltic Sea ecosystem / HELCOM approaches	Not evaluated	No information available
BH3	Concept, methods, testing and (partial) assessment was developed step by step since 2011 by OSPAR Benthic Habitat Expert Group. This indicator is actually part of the commonly agreed set of biodiversity indicators for monitoring and assessment of OSPAR area, notably with BH2 for benthic habitat. It was developed through many workshops and inter-sessionnaly, and specific issues regularly submitted	All (available) relevant spatial data; minimum = EUNIS level 3 (EUSeaMap), but data at finer scale (both at biological level e.g. EUNIS 4 or 5, and/or finer spatial	"Uses three main key matrices to cross and compute layers/maps and analyses: * Activity/pressure (activity type versus pressure type = to transform activities in pressure distribution + intensity layers) * Sensitivity matrix per habitat type (resistance versus resilience = to score habitat type sensitivity against a pressure type, to	"* Use and testing (prove of concept) of BH3 under OSPAR process = agreed as common indicator by Contracting Parties; To be reported for partial assessment in august 2016, for adoption by BDC committee in September * Designed to assess all habitat types * useful to analyze larger sea areas based on actual best available knowledge (models	"* Actually assess only effects of abrasion pressure by bottom trawling, but could be adapted conceptually to other pressure types as long as pressure layer are available at relevant resolution; * VMS data actually only available to considers abrasion caused by fishing activities by	CEMAP guideline of BH3 (shared on ICES/BEWG 2016 sharepoint/Background document/BH3_Technical_specifications_V2015_10_22.pdf)

Method	Background	Thematic level	Format	Pros	Cons	reference
	or reviewed by other expert groups (notably in ICES).	resolution) can be incorporated or specifically analyzed	transform habitat map to sensitivity map) * Disturbance matrix, per habitat type and pressure (sub)type (sensitivity versus pressure intensity = to cross pressure and sensitivity layers and score resulting layer with disturbance values)"	and ground-truthing) * No additional monitoring requirements apart from those associated with BH1 and BH2; * Underlying Habitat/communities may be different in different marine regions due to biogeographic variation and of environmental factors and the characteristics of local populations and their role in the benthic assemblage * Each country may be free to carry out their sensitivity assessment for characteristic species in the way they consider most appropriate (Physical damage index related to total area assessed): can be applied to Regional Sea, National waters or e.g. MPA; * Use of habitat + pressure layers = risk-based approach: may guide optimized monitoring in risk or reference area depending on habitat and pressure type overlaps, for a positive feedback loop."	vessels over 15 m length; * Actually only tested on OSPAR areas, but could be conceptually and methodologically adapted to other regional sea; * Matrix based on best available knowledge (with actual many gaps due to lack of offshore monitoring of habitats and inshore availability of pressure data) and expert judgment mainly; * Difficulty to have reference areas (not or low impacted) for each habitat type in the same biogeographical area; * Physical Damage index to be calibrated and associate to confidence level (related to spatial resolution and coverage of data layers available)."	

Method	Background	Thematic level	Format	Pros	Cons	reference
BENTHIS	Developed as a multi-criteria approach in 2014 to evaluate vulnerable marine ecosystems, the index was further developed in 2015 to overcome inconsistencies in spatial representation (changed to spatially gridded data), to differentiate indicator species according to their vulnerability to human impacts, and to include a data-uncertainty estimate.	EUNIS level 3		Gear-dependent impact assessment; usefully for scenario testing (evaluate status with different (not necessary realized) trawling intensities). This allows comparison of recovery times in different areas; trait based	Status/impact assessment, not sensitivity assessment (i.e. sensitivity assessment dependent on trawling intensity)	Rijnsdorp*et al.*, 2016
Kostylev/ Desroy approach	The method developed by Kostylev and Hannah (2007) takes into account physical disturbances and food availability as structuring factors for benthic communities (Kube*et al.*, 1996). Kostylev and Hannah's model is a conceptual model, relating species' life history traits to environmental properties.	No information available	The model developed by Kostylev and Hannah (2007) is based on two axes of selected environmental forces: 1- The "Disturbance" (Dist) axis reflects the magnitude of change (destruction) of habitats (i.e. the stability through time of habitats), due to the single natural processes influencing the seabed and which are responsible for the selection of life history traits; 2- The "Scope for Growth" (SfG) axis takes into account environmental stresses inducing a physiological cost to organisms	This conceptual point of view has already been argued in several works (Southwood, 1977, 1988; Grime, 1977, 1979; Margale*et al.*, 1979; Huston, 1994; Reynolds, 1999). This model was used in several systems or with different biological groups (Kostylev*et al.*, 2005 and Kostylev and Hannah, 2007 for Nova Scotia coasts; Galparsoro*et al.* for north Spain coasts; Gregr, 2008 for invertebrates in Alaska; Fisher*et al.*, 2011 for fishes).	No information available	Kostylev V.E., Hannah, C.G. (2007). Process-Driven Characterization and Mapping of Seabed Habitats. In Todd, B.J., and Greene, H.G., eds., Mapping the Seafloor for Habitat Characterization: Geological Association of Canada, Special Paper 47, p. 171-184.

Method	Background	Thematic level	Format	Pros	Cons	reference
			and limiting their growth and reproduction potential. This axis estimates the remaining energy available for growth and reproduction of a species (the energy spent on adapting itself to the environment being already taken into account). The process-driven sensitivity (PDS) can be seen as a risk map that combines the two previous axis			