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Interim Report of the Benthos Ecology Working Group (BEWG)

14–18 May 2018

Banyuls-sur-mer, France

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 2018 meeting of the Benthos Ecology Working Group (BEWG), chaired by Silvana Birchenough, UK, was held at the Observatoire océanologique, Banyuls-sur-mer, France, 14–18 May, and was attended by 24 experts, representing 10 countries. The agenda structure of the meeting followed the five main themes the BEWG continuously has worked on over the last years. These are under benthic long-term series and climate change, benthic indicators, species distribution modelling, the link between biodiversity and ecosystem functioning and the role of benthos within MPAs.

The group continued to provide insights on the field of applied benthic ecology, with main emphasis on:

- Long-term series and climate change, considering the methodological aspects of time-series;
- Participating on existing initiatives related to benthic ecology (e.g. long-term series, biological traits) being developed under ongoing programmes (e.g. EMODnet biology);
- Developing applied exercises with regards to species distribution modelling and mapping;
- Reviewing relevant literature to report on the linkages between ecosystem biodiversity and functioning;
- Developments in effective monitoring programmes (including design, harmonisation and quality assessments);
- Understanding benthic biodiversity and conservation under the role of MPAs;
- Evaluating the appropriateness of benthic indicators for ecosystem quality assessment;
- Providing input and reviewing the state and/or trends of the benthic communities/habitats in support of the ICES Ecosystem Overviews.

Seven ongoing initiatives are under development:

- Case study: "The value of long-term time-series: bringing science to support management decisions"
- 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: "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"

The BEWG are developing several case studies at present, some of these contributions could help to illustrate application of methods and applications (e.g. ecological modelling, indicator development and biological traits analysis).

1 Administrative details

Working Group name

Benthos Ecology Working Group (BEWG)

Year of Appointment within current cycle

2018

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

1

Chair(s)

Silvana Birchenough, United Kingdom

Meeting dates

14–16 May 2018

Meeting venue

Banyuls-sur-mer, France

2 Terms of Reference

a) Long-term benthic series and climate change

1. To identify methodological issues in long-term series comparability

b) Species distribution modelling and mapping

1. To report on ongoing case study: "Towards a benthic ecosystem functioning map: interregional comparison of two approaches

c) Benthos and legislative drivers

1. To report on the use of benthic indicators and ongoing initiatives
2. Variability and expert judgement of benthic species tolerances/ sensitivities
3. To review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments (e.g. MPAs). Case study developed under the Joint Monitoring Programme - JMP

d) Benthic biodiversity and ecosystem functioning

1. To report on the ongoing case studies to assess ecological responses across sediment gradients.
2. To consider new functional indicator needs to support MSFD requirements.

3. To identify links between benthic functions and ecosystem services.

e) Benthic biodiversity and conservation: to review the role of benthic ecology in MPAs

1. To review and report on the implications of the designation and management of Marine Protected Areas (MPAs) in relation to role of benthic ecology.

f) To explore the feasibility to undertake studies (e.g. laboratory or field experiments) to test ecologically relevant hypothesis in relation to benthic responses.

1. To explore funding opportunities and collaborative proposals for setting up and conducting experimental studies.

2. To compile a list of scientific ideas to develop research Master's thesis projects and promote co-supervision activities within BEWG members.

3 Summary of Work plan

2018	ToR	a.1	b.1	c.1–3	d.1–3	e.1	f.1–2
2019	ToR	a.1	b.1	c.1–3	d.1–3	e.1	f.1–2
2020	ToR	a.1	b.1	c.1–3	d.1–3	e.1	f.1–2

4 List of Outcomes and Achievements of the WG in this delivery period

The BEWG is currently developing several case studies. Some current outcomes are outlined below:

- Van Hoey, G., Wischnewski., J., Craeymeersch,J., Dannheim, J., Enserink, L., Marco-Rius, F., O'Connor, J., Reiss, H., Sell, A.F., Vanden Berghe, M., Zettler, M.L., Degraer, S. and Birchenough, S.N.R. (*in prep*.). Optimizing the spatial monitoring design to support regional benthic ecosystem assessments (journal TBD).
- A Theme Session was scoped and approved by the BEWG for the ASC 2018 in Hamburg, the session is entitled "Bottoms up- approaches: the contribution of marine benthos to management, conservation and monitoring, taking stock and setting research direction" (chairs: Silvana Birchenough, Cefas UK; Ingrid Kröncke, Senckenberg Institute, Germany and Steven Degraer, RBINS, Belgium).
- A compilation of survey information to support a potential request for advice on the occurrence of Haploops in the OSPAR region has been produced by members of the BEWG. There will be a likely request in 2019.
- A new Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), established by SCICOM in 2017, will be co-chaired by a member of the BEWG, Gert Van Hoey. This work will be closely aligned with the scientific work developed under the BEWG.

5 Progress report on ToRs and workplan

5.1 Opening of the meeting

Dr.Vincent Laudet, Director of the Observatoire Océanologique, welcomed the group and introduced his institute, followed by an overview of LECOB, the lab for Ecogeochemistry of benthic environment by Katell Guizien. Subsequently some introductory information was provided by our local host Céline Labrune and Silvana Birchenough, chair of the BEWG. After brief round table introductions of the (current and new) members, Hans Hillewaert was appointed as chief rapporteur. The agenda was accepted without major changes. All abstracts of the presentations are summarised in Annex 3.

5.2 Long-term benthic series and climate change

5.2.1 To identify methodological issues in long-term series comparability

S. Birchenough gave an introductory presentation on "Climate change impacts on biodiversity and ecosystem functioning of coastal and marine environments of Caribbean Small Island Developing States (SIDs)". The former UK Prime Minister committed to support regional fisheries, sustainable development, marine spatial planning-MSP, and socio-economic impacts across the Caribbean Community. Conch shell (*Lobatus gigas*) and Spiny lobster (*Panulirus argus*) landings are some examples of studies from Belize's Coastal and Marine Wealth.

C. Labrune presented "Long-term study of the relation between macrobenthic communities and climate variability in the Bay of Banyuls-sur-mer, NW Mediterranean Sea". The study aims to assess the impact of climatic oscillations, i.e. NAO (North Atlantic Oscillation) and WeMO (Western Mediterranean Oscillation). No cyclic patterns were found but an influence of Rhone river flow on benthic communities was demonstrated. Also, benthic communities better correlated with WeMO than NAO.

The scope and outline of a review paper on long-term benthic time-series with tentative title "The value of long-term time-series: bringing the science to support management decisions" was discussed. Issues were focused on why carry out long-term series, what are the benefits, and how to design sampling programs to meet the basic questions posed. Scientific and management objectives may typically differ, spanning from obtaining information on system dynamics to recording changes in environmental status for administering management actions. Several considerations were identified: e.g. the necessity of well-formulated objectives, what constitutes a significant change in a measurement variable, how time-series can support managers, the conflict between preserving methods and requests for changes, the implementation of new techniques, the total costs versus sampling frequency and spatial coverage. S. Birchenough led a subgroup discussing the skeleton of the paper. Members of the BEWG agreed to contribute to the authorship of specific sections of the paper intersessionally. It was agreed that a table of long-term benthic time-series examples would be devised to be incorporated into the paper. The table should also be structured to clarify the different objectives of long-term time-series and environmental monitoring assessing anthropogenic influences. A first version of the table containing some considerations is included as Annex 4 of this report. This information will be augmented with available peer review literature.

5.3 Species distribution modelling and mapping

5.3.1 To report on ongoing case study: "Towards a benthic ecosystem functioning map: interregional comparison of two approaches"

M. Gogina reported on this ongoing case study. The four main aims: key species, regional differences, test approaches, exploration of drivers of 'Bioturbation potential' were discussed. The subgroup discussed the open questions and allocated next tasks to progress. Text pieces to study area and sampling methods descriptions for each region are to be added by contributors (J. Dannheim, J. Vanaverbeke and N. Destroy). Belgium dataset was averaged by sampling event on a monthtly basis (J. Vanaverbeke). Sediment type data is to be harmonized based on measured median grain size after Wentworth (1922) to mud – fine sand (including vfS) – medium sand – coarse sand (contribution from J. Dannheim). Common problems, especially for inter-regional comparisons, that require attention in discussion: 1 - datasets unbalanced between areas: dataset size, years, N key species, sediment types - tradeoff between availability and consistency; 2 - low model accuracy for some species. Other comments to be considered: comparisons between depth ranges (to look if it can be the source of variability between regions & across datasets (L. Buhl-Mortensen). E. Oug, C. Van Colen: include in the discussion a short review section of recent studies that validated the performance of such indicators (e.g. against measured bioturbation Gogina *et al.*, 2017, bioirrigation potential Wrede *et al.*, 2018). Our expectation is that they are robust enough to be complementary, but are not an alternative to direct measurements or predictions (e.g. Wohlgemuth *et al.* 2017).

5.4 Benthos and legislative drivers

L. Guérin gave an introductory presentation "Update on the progress made on development and use of OSPAR Benthic Habitat indicators, and there integration, towards an ecosystem and risk-based approach".

Y. Griffiths presented "A risk-based approach to monitoring UK marine benthic ecosystems" related to assessing risk using spatial overlap.

A new request for ICES advice on *Haploops* in the OSPAR area was introduced by S. Birchenough. L. Buhl-Mortensen discussed the involvement of MAREANO on this initiative. Michael Zettler also will check German data sets available to support this request.

5.4.1 To report on the use of benthic indicators and ongoing initiatives

The work on indicators continues to be a priority for the BEWG. Several national updates were presented. A new Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), established by SCICOM in 2017, will be co-chaired by a member of the BEWG, Gert Van Hoey. This work will be closely aligned with the scientific work developed under the BEWG. The first meeting is planned for 12–16 November 2018 at ICES HQ, Copenhagen, Denmark.

5.4.2 To investigate the importance of species autecology in indicator development and application

S. Degraer presented the current state of the ongoing initiative investigating the variability in expert judgement of sensitivity of indicator species. A finalised species list was produced of four regions with 16 selected species each. The list of experts for each of the four oceanographic regions was updated and now is considered finalised. The initiative commenced in 2015 in Corsica with a view to analysing the variability in expert assessments of benthic indicator species to environmental stressors. At the outset of the current meeting the following outstanding tasks were identified:

- The development of the questionnaire, and invitation email for experts. Questionnaire should be phrased without making the hypothesis evident to study participants (biasing the survey).
- The development of a statistical model to analyse the data from collected sources will be scrutinised and checked against anticipated data collection.

The four regions (with responsible scientist) are North East Atlantic (N. Desroy), North Sea (H. Hillewaert), Baltic Sea (M. Zettler) and Mediterranean Sea (C. Labrune). The 16 species for each region were chosen to have a sensible spread of AMBI-index responses as well as a narrow and widely geographical distribution.

A list with 15 experts was compiled for every region. Selected experts are experienced for the species of their region and of separate schools. A good spread of countries along the coast of the region was compiled. A contact address for the expert and a contact person from the BEWG was identified to support in completing the table.

The format of the questionnaire was discussed. A sensitivity of three levels has been discussed, although expansion is still an option to improve the variability of the responses. The list of stressors against which experts will assess macrobenthic indicator species was expanded from 3 stressors (e.g. physical disturbance, nutrient enrichment and ocean warming) to 4 stressors (e.g. physical disturbance, nutrient enrichment, ocean warming and ocean acidification) to better reflect the major contemporary anthropogenic threats facing benthic species.

S. Degraer will draft the invitation email intersessionally and will be circulated to the particpants of the BEWG. The BEWG contact persons will then be requested to approach their respective expert(s) to have the questionnaire data before the end of 2018. Invited experts will be offered co-authorship to the anticipated paper. A preliminary data analysis and draft paper structure will be presented during the next BEWG meeting.

5.4.3 To review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments (e.g. MPAs). Case study developed under the Joint Monitoring Programme – JMP

S. Birchenough introduced the manuscript which G. Van Hoey had prepared for this initiative on "Optimizing spatial monitoring design to support regional assessments, using the North Sea Benthos project data". The paper was submitted to the ICES Journal of Marine Science, but rejected. ICES BEWG colleagues were asked to review the manuscript and reviewers' comments, and provide suggestions around how to take this initia-

tive forward. Following a discussion of the paper it was agreed for S. Birchenough to feedback to G. Van Hoey the following actions:

- Further clarification of the manuscripts aims, revision of the introduction was felt necessary
- The paper should provide a broader ecological viewpoint on monitoring and how international collaboration can improve sampling efficiency. The focus should shift away from addressing specific legislative drivers (these should be discussed as examples of how international coordination is necessary in benthic monitoring).
- G. Van Hoey will redraft the paper intersessionally with a view to targeting an ecology journal (suggestions included Ecological Indicators or Ecography).

5.5 Benthic biodiversity and ecosystem functioning

5.5.1 To report on the ongoing case studies to assess ecological responses across sediment gradients

The progress of this initiative was presented by J. Dannheim and A. Darr. The two scientific questions of this initiative are: (a) whether there are any differences in trait composition between different substrates and (b) if these are consistent between different regions. So far, this initiative has captured a total of six case studies covering the Baltic Sea, the Mediterranean Sea and the North Sea. Progress has been made in data cleaning with regards to the biological and sediment data. The initiative will be open to receive more data sets until end of June 2018. J. Dannheim will circulate a template for contributors to input their data sets. In a subgroup, the group will discuss more details on the analysis of the biological data, as well as the way forward concerning the biological trait information to be compiled in a database which is needed to fulfil the planned work.

5.5.2 To consider new functional indicator needs to support MSFD requirements

It was decided that a first step for this initiative is to include functional relevant indicators to be published as an appendix to the ICES BEWG report, providing a reference point from which future work could be planned. The group discussed the recently designed criteria for red listing of habitats and ecosystems by IUCN which are also in line with the habitat directive and MSFD descriptor 6. Thus, the group decided that there is an interest to continue with this initiative and formulate functional indicators which are linked with the new guidelines. The aim is to set up a summary table of MSFD habitat types and their specific ecosystem functional indicators to be published as an appendix in the report.

5.5.3 To identify links between benthic functions and ecosystem services

The session was started with five introductory presentations to the topics:

- "Benthos behavioural response to environmental change" (C. Colen)
- "High resolution modelling of ocean circulation can reveal retention spots important for benthic biodiversity conservation" (K. Guizien)

- "Genetics work done with benthos (macro and epi) at ILVO" (H. Hillewaert)
- "Taxonomic R&D conducted on *Macropodia* benthos" (H. Hillewaert)
- "Molecular inventories of meiofaunal diversity and its application in ecological benthic studies" (J. Orignac)

The BEWG discussed in plenary on how to proceed with the initiative on the literature review to link benthic biodiversity and ecosystem functioning which was initiated in 2012, and how to use the information gained from this initiative to support further research. The possibility to use the information in a viewpoint paper was rejected after evaluation by the experts. Thus, the group officially closed this initiative and decided that details, highlights and lessons-learned from this exercise, a summary is included below.

The BEWG initiative on linking biodiversity and marine ecosystem functioning was initiated during the BEWG meeting organized in 2012. Theory rooted in terrestrial ecology lead to the understanding that the functional composition and functional diversity where the principal drivers for ecosystem functioning, rather than structural aspects of biodiversity (species richness, species identify); (Tilman *et al.* 1997). Since then, it is accepted that management practices changing the functional aspects of communities can have a large effect on ecosystem functioning. This understanding was derived from rather large-scale field experiments where species diversity, functional diversity and functional composition were manipulated (Tilman *et al.* 1997). However, such experiments are not possible in the marine realm, and would be particularly challenging when investigating the contribution of structural and functional diversity to marine benthic ecosystem processes. As such, the debate on the importance of structural versus functional diversity for benthic ecosystem functioning was high on the agenda of ICES BEWG. Functional diversity (number of functional groups in a community) of marine benthos was scarcely investigated and often related to food-web properties (making use of feeding types) rather than to important ecosystem functions (i.e. nutrient cycling) of the benthic realm. There was pioneering research among BEWG members that investigated the link between certain functional properties of benthos and nutrient cycling based on single-species experiments (i.e. Braeckman *et al.* 2011) or indices based on the ability of benthic organisms to be mobile and rework sediment (Birchenough *et al.* 2012, using the Bioturbation Potential of a community, BPc). At the same time, community wide experiments and field studies linking macrofaunal activities to benthic ecosystem functioning were planned or ongoing by BEWG experts (meanwhile published as (Braeckman *et al.* 2010, Wrede *et al.* 2017, 2018). As such, the real knowledge gap was in the link between structural diversity aspects of marine benthos and benthic ecosystem functioning rates.

Therefore, the BEWG performed a literature review, to identify those papers relating structural aspects of benthic diversity to ecosystem functioning. The general aim was (1) to detect generalities in observed patterns and (2) detect gaps in research performed. As starting point, 4 influential papers (based on citation scores) were chosen as a starting point:

- Bolam SG, Fernandes T, Huxham M (2002) Diversity, biomass, and ecosystem processes in the marine benthos. Ecological Monographs 72:599–615
- Covich AP, Austen MC, Bärlocher F, Chauvet E, Cardinale BJ, Biles CL, Inchausti P, Dangles O, Solan M, Gessner MO (2004) The role of biodiversity in

the functioning of freshwater and marine benthic ecosystems. BioScience 54:767–775

- Gessner M, Inchausti P, Persson L, G Raffaelli D, S Giller P (2004) Biodiversity effects on ecosystem functioning: insights from aquatic systems. Oikos 104:419–422
- Wilsey BJ, Potvin C (2000) Biodiversity and ecosystem functioning: importance of species evenness in an old field. Ecology 81:887–892
- 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 for a search action to detect all papers citing one of the papers listed above. This action resulted in a list of 531 papers. This extensive list was first checked to remove double entries and papers not dealing with marine macrobenthos. The final list contained 162 papers. These papers were reviewed for relationships between any descriptor of structural diversity and any proxy for ecosystem functioning. When such relationship was reported, the direction of the response (positive, negative, neutral) was recorded.

From this literature review, it can be concluded that the relationship between macrofauna structural diversity aspects and ecosystem functioning has received very limited attention: the majority of the studies reported single species experiments, mainly in relation to fluxes of oxygen and/or nutrients across the sediment-water interface. Only two studies investigated a possible link between macrofaunal diversity and ecosystem functioning. Bolam *et al.* (2002) reported on an experiment, where structural and functional diversity of macrobenthos were manipulated, and only showed a positive effect of macrofaunal diversity on benthic oxygen consumption. However, this effect was mainly driven by the presence of the largest species (*Nepthys hombergii*) in their study. No other proxy for ecosystem functioning (sediment stabilization, nutrient fluxes) showed a relationship with macrofaunal diversity (or biomass). As such, the null hypothesis of this paper (No relationships between ecosystem functions and diversity and biomass) was accepted. Rakocinski (2012) used an extensive dataset (133 sampling events from 29 sites in the Gulf of Mexico over a 4 years period) and suggested an indirect link between macrofaunal taxonomic diversity and a benthic indicator integrating proxies for ecosystem functioning, where more diverse communities reflect higher maturity and a larger proportion of long-living, larger-bodied organisms. Here again, this relation can be explained by effect of the size and activity of the larger organisms, rather than by the structural diversity characteristics of the macrofaunal communities.

The results of the literature review do not suggest a link between structural diversity aspects of macrofaunal communities and benthic ecosystem functioning. This can be result from the very limited effort to investigate such link. However, both the results presented in Bolam *et al.* (2002) and Rakocinski (2012) are in line with more recent work (i.e. Braeckman *et al.* 2014) showing a higher importance of functional characteristics than structural characteristics. A meta-analysis of 110 marine experiments where species richness was manipulated across a range of taxa and trophic levels showed that mixture of species tend to increase the level of ecosystem functioning relative to the average compo-

nent species in monoculture. However, there was no effect or a negative effect when compared to the 'highest-performing species' (Gamfeldt *et al.* 2015).

In contrast, Norkko *et al.* (2015) found a clear relationship between macrofaunal structural diversity and benthic ecosystem functioning, over a large gradient of oxygen-stressed sediments in the Baltic Sea, suggesting that future studies, conducted on a large geographical area would contribute to the relative role of structural and functional diversity in maintaining ecosystem functioning. This confirms the finding of Godbold & Solan (2009) showing that the effect of macrofaunal species richness on ecosystem functioning decreased at low levels of diversity, and was related to the environmental context (e.g. Total Organic Carbon content).

In conclusion, our literature review did not reveal strong effects of structural macrofaunal biodiversity on ecosystem functioning. This is in line with the well-accepted idea that functional biodiversity is more important than structural biodiversity to maintain biodiversity. However, there is emerging evidence that this idea can be challenged when investigating the biodiversity-ecoystem link at larger geographical and temporal scales, taking into account context-dependency. It is relatively easy to include structural diversity characteristics in research investigating the (functional) biodiversity – ecosystem functioning link. As such, integrating such data in future research where the link between biodiversity and ecosystem functioning is investigated in a wide geographic area and taking into account entire communities (in contrast to single – species experiments) would have helped towards a better understanding of the relative role of structural and functional biodiversity.

References

Birchenough SNR, Parker RE, McManus E, Barry J (2012) Combining bioturbation and redox metrics: Potential tools for assessing seabed function. Ecol Indic 12:8–16

Bolam SG, Fernandes TF, Huxham M (2002) Diversity, Biomass, and Ecosystem Processes in the Marine Benthos. Ecol Monogr 72:599–615

Braeckman U, Colen van C, Soetaert KER, Vincx M, Vanaverbeke J (2011) Contrasting macrobenthic activities differentially affect nematode density and diversity in a shallow subtidal marine sediment. Mar Ecol Prog Ser 422

Braeckman U, Foshtomi MY, Van Gansbeke D, Meysman F, Soetaert K, Vincx M, Vanaverbeke J (2014) Variable Importance of Macrofaunal Functional Biodiversity for Biogeochemical Cycling in Temperate Coastal Sediments. Ecosystems

Braeckman U, Provoost P, Gribsholt B, Gansbeke D, Middelburg JJ, Soetaert KER, Vincx M, Vanaverbeke J (2010) Role of macrofauna functional traits and density in biogeochemical fluxes and bioturbation. Mar Ecol Prog Ser 399

Gamfeldt L, Lefcheck JS, Byrnes JEK, Cardinale BJ, Duffy JE, Griffin JN (2015) Marine biodiversity and ecosystem functioning: what's known and what's next? Oikos 124:252–265

Godbold J, Solan M (2009) Relative importance of biodiversity and the abiotic environment in mediating an ecosystem process. Mar Ecol Prog Ser 396:273–282

Norkko J, Gammal J, Hewitt JE, Josefson AB, Carstensen J, Norkko A (2015) Seafloor Ecosystem Function Relationships: In Situ Patterns of Change Across Gradients of Increasing Hypoxic Stress. Ecosystems 18:1424–1439

Rakocinski CF (2012) Evaluating macrobenthic process indicators in relation to organic enrichment and hypoxia. Ecol Indic 13:1–12

Tilman D, Knops J, Wedin D, Reich P, Ritchie M, Siemann E (1997) The Influence of Functional Diversity and Composition on Ecosystem Processes. Science 277:1300–1302

Wrede A, Beermann J, Dannheim J, Gutow L, Brey T (2018) Organism functional traits and ecosystem supporting services – A novel approach to predict bioirrigation. Ecol Indic 91:737–743

Wrede A, Dannheim J, Gutow L, Brey T (2017) Who really matters: Influence of German Bight key bioturbators on biogeochemical cycling and sediment turnover. J Exp Mar Biol Ecol 488:92–101

5.6 Benthic biodiversity and conservation: to review the role of benthic ecology in MPAs

5.6.1 To review and report on the implications of the designation and management of Marine Protected Areas in relation to role of benthic ecology

The progress of this initiative was presented P. Magni and C. Greathead. This ToR reflected concern within ICES-BEWG that the process of selecting MPAs within these networks did not adequately consider the unique conditions required for benthic habitats and species to achieve GES. In addition, benthic habitat and species are poorly considered when assessing the performance of MPAs and the effectiveness of conservation measures. A suite of MPA's objectives may include protection of benthic habitats and species, but pressures that affect these features are not removed. Also there may be a mismatch in an MPA's objectives and the use of measurements that are not adequate for assessing benthos.

A series of MPA case studies were summarised in a table (including the entries on MPA's adjustment, scoping, assessment, and performance measures). It was agreed that the initiative will consider those MPA's within European marine regions based on the expertise of the group. This allowed a neutral way for evaluating MPA management from a benthic ecology point of view, exploring whether benthos was tackled adequately. A new evaluation of the populated table will be conducted using a critical mass of case studies. A manuscript draft was developed on the issues highlighted in the table and subsequent analysis of responses.

Plenary discussions around this ToR also emphasised the importance of benthic ecological functions to the success of MPAs. Specifically, that conservation measures to reduce anthropogenic pressures in MPAs may not adequately consider the ecological functions and therefore services provided by benthic habitats and species.

This ToR has explored a benthic ecology perspective for evaluating the effectiveness of MPAs, to determine if the current MPAs sufficiently protect benthos. There is a growing belief that benthic habitat and species are poorly considered when creating, assessing the performance of MPAs and the effectiveness of conservation measures. An MPA's objectives may include protection of benthic habitats and species, but pressures that affect these features are not always considered. This initiative will be the first examination of how the benthos are represented in MPAs and will strengthen the case for focusing on the benthos.

During the BEWG 2017 the questionnaire that was to be used to collect data on MPAs was finalised. This was based on the framework developed by Stelzenmuller *et al.* (2013). Intersessionally, the questionnaire was completed by BEWG members from 9 countries, distributed across 6 Ecoregions based on ICES advice (Barents Sea, Norwegian Sea, North Sea, Baltic Sea, Celtic Sea and Mediterranean Sea). This resulted in entries for 103 MPA case studies. Summary descriptions of these case studies were formulated based on Buhl-Mortensen *et al.* (2017) and a scoring matrix was developed based on the pedigree matrix in Stelzenmuller *et al.* (2015) to enable an empirical assessment of the MPAs. During the BEWG 2018 meeting the contributors checked and updated the summary table and added their scores, based on the scoring matrix. The terminology used in both tables and the scoring levels in the scoring matrix benefitted from constructive discussions and a high level of consensus was reached. This process significantly increased the confidence of the "expert judgements" applied to filling in these tables. An outline of the manuscript was also drafted that included key messages to highlight, potential analyses that should be done and several key discussion points. A draft of the manuscript will be circulated by the ToR leads by the end of August 2018.

5.7 To explore the feasibility to undertake studies (e.g. laboratory or field experiments) to test ecologically relevant hypothesis in relation to benthic responses

This is a new ToR, the chair introduced the idea and the group decided to consider potential ideas via correspondence, as some ideas may require a multidisciplinary teams of experts.

5.7.1 To explore funding opportunities and collaborative proposals for setting up and conducting experimental studies

H. Hillewaert introduced the current state of the Marine Species Identification Portal which was originally developed by ETI BioInformatics and now under the management of the Software Development Department of Naturalis in the Netherlands.

The software is now outdated taxonomically and was never completely finished.

H. Hillewaert proposed to rally interested parties to update the online identification keys on a yearly basis. A mail to all BEWG members will be sent.

5.7.2 To compile a list of scientific ideas to develop research Master's thesis projects and promote co-supervision activities within BEWG members

The chair discussed in plenary the opportunity to collate ideas to support dedicated projects. The group will continue via correspondence and explore further opportunities as these become available via specific projects.

5.8 Changes/ Edits/ Additions to ToR

Not applicable.

5.9 Cooperation

5.9.1 With other ICES working groups

A new Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT) has been established by SCICOM. The group will be co-chaired by G. Van Hoey, so a direct link will facilitate a direct cooperation and integration.

The BEWG chair provided an overview of the work conducted by the BEWG in April to WGIPEM (Working Group on Integrative, Physical-biological and Ecosystem Modelling). The idea was to explore potential areas for collaboration. Further discussion will continue between both EGs via email.

ICES Working Group on Marine Benthal and offshore Renewable Energy Development– WGMBRED: summary on work progress (Galway, 06–09/03/2018)

J. Dannheim provided an overview of the ongoing work of the ICES working group on "Marine Benthal and Renewable Energy Developments" (WGMBRED) established in 2012. The group met in Galway, Ireland for the sixth time. The Galway meeting was thus the last meeting of the 3-year multi-annual cycle and was co-chaired by J. Dannheim (AWI, Germany) and Andrew B. Gill (PANGALIA Environmental, affiliated to Cranfield, UK). The meeting continued to work across the established terms of references.

Four multi-annual ToRs (2016–2018) have been tackled through the three years cycle, being the scale issues, the knowledge scheme, the network analysis and the identification of indicators:

g) Scale topic which aims at assessing relevant temporal and spatial scales in relation to MREDs effects on the benthic ecosystem and evaluating consequences in relation to environmental policy and decision-making;

h) Knowledge improvement which includes a review progress to fill knowledge gaps related to the benthic ecosystem particularly differentiation among MRE technologies;

i) Network and interactions analysis amongst WGMBRED and relevant groups (regulators, stakeholders, policy makers, scientists to evaluate the impact of MBRED science;

j) Indicator identification and operationalisation to assess ecosystem functioning and changes in relation to MBRED at scales defined through the scale topic.

ToR B aims at identifying knowledge gaps related to the benthic ecosystem by differentiating among different marine renewable energy technologies, i.e. wave and tidal energy devices, floating wind farm devices, compared to fixed offshore wind turbines. WGMBRED developed a matrix summarising the cause-effect relationships of different energy devices on benthos. The ToR C comprises a network and interaction analysis based on a questionnaire send out to experts working on renewable energy devices. The outcomes will be published in a peer-reviewed publication. ToR D and A were finished in combination. ToR D deals with assessing relevant indicators related to cause-effect relationships in the benthos by offshore renewable energy devices in order to link them to ecological functions and ecosystem services in order to assess ecosystem functioning with regards to observed changes in benthos. These changes are resulting from

WGMBRED defined scales which are ecologically relevant, i.e. the work developed under ToR A. Further information and a summary of WGMBRED final report can be found at:

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

5.9.2 With advisory structures

The BEWG provided *ad hoc* advice to ICES as requested. Members of the BEWG recently updated information on *Haploops* distribution, which will be a likely request to support advisory needs.

5.10 Science highlights

- Van Hoey, G., Wischnewski., J., Craeymeersch,J., Dannheim, J., Enserink, L., Marco-Rius, F., O'Connor, J., Reiss, H., Sell, A.F., Vanden Berghe, M., Zettler, M.L., Degraer, S. and Birchenough, S.N.R. (*in prep*.). Optimizing the spatial monitoring design to support regional benthic ecosystem assessments (journal TBD).
- A Theme session was scoped and approved by the BEWG for this years ASC in Hamburg, the session is entitled "Bottoms up- approaches: the contribution of marine benthos to management, conservation and monitoring, taking stock and setting research direction" (chairs: Silvana Birchenough, Cefas UK; Ingrid Kröncke, Senckenberg Institute, Germany and Steven Degraer, RBINS, Belgium
- A compilation of survey information to support a potential request for advice on the occurrence of *Haploops* for 2019 in the OSPAR region has been produced by members of the BEWG.
- A new Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), established by SCICOM in 2017, will be co-chaired by a member of the BEWG, G. Van Hoey. This work will be closely aligned with the scientific work developed under the BEWG.

6 Revisions to the work plan and justification

There are no revisions needed at present.

7 Next meetings

Ulster, Northern Ireland, 6–10 May 2019

Bergen, Norway, 4–8 May 2020

Annex 1: List of participants

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Annex 2: Recommendations

1. The BEWG will continue to work across the main ToRs and will react during ICES *ad hoc* requests for advice as necessary.	BEWG
2. The BEWG recognises the need for continual interaction with other EGs that can provide complementary knowledge and expertise. There are some EGs identified to support some of these active linkages (WGFBIT and WGIPEM).	BEWG
3. The BEWG are developing several case studies at present, some of these contributions could help to illustrate application of methods and applications (e.g. ecological modelling, indicator development and biological traits analysis).	SCICOM

Annex 3: Abstracts presented at the meeting

Climate change impacts on biodiversity and ecosystem functioning of coastal and marine environments of Caribbean Small Island Developing States (SIDs)

Silvana Birchenough

The Caribbean region has been recognised as a hot-spot for biodiversity worldwide. This review paper summarises the current evidence and the expected climate change effects on important marine habitats and species. The topics considered are targeting ecological assessments based on structures and functions of important species and habitats, namely, seagrasses coral reefs and mangroves. These key habitats are hosting a wide range of species and overall supporting the wider biodiversity in these areas. This review also covers the current risks and threats often altering the overall Caribbean biodiversity. Climate change effects is known to be also partly contributing to these changes. Clear effects have been observed in changes of sea surface temperature, sea level rise, coastal erosion and pH levels. The observed effects of climate change to date and expected future changes will act differently across species and habitats. Recent evidence suggests that some SIDS are already experiencing some of these changes and in some cases, there will be some site-specific effects manifested across these areas. Furthermore, it is expected that the effects of climate change on biodiversity will have synergistic interactions with other human activities (e.g. fishing, recreational sports, tourisms, sewage discharges) and will have repercussions for the ecology and ecosystems distributed in these areas. Climate change effects may have interactions with many other stressors and it is imperative to fully understand these wider effects, the current knowledge gaps and set priorities for climate change adaption in these areas.

Reconstructing the historic baseline or reference conditions of benthic communities in the southern North Sea

Steven Degraer

Current conservation efforts are focused on maintaining or restoring biodiversity and ecosystem values. Often the start of environmental monitoring data series in late 20th century are used as baseline, although by that time marine ecosystems were far from in good shape. RBINS used expert elucidation and limited historical data from the late 1800s to identify the recovery potential of macrobenthic communities in the Southern North Sea in case human activities at sea would be ceased. Even lacking historical data, experts can describe a pristine baseline and, use that to characterize the restoration potential knowing the range and the sensitivity of species to disturbance as well as historical and contemporary pressures.

Long-term study of the relation between macrobenthic communities and climate variability in the Bay of Banyuls-sur-Mer, NW Mediterranean Sea

Paulo Bonifacio, Antoine Grémare, Jean-Michel Amouroux, *Céline Labrune*

The relationship between climatic variability and the benthic macrofauna composition was assessed at 4 stations located in the Bay of Banyuls-sur-Mer (NW Mediterranean Sea). These stations were sampled each autumn/winter between 2004 and 2013 and analysed for sediment granulometry and benthic macrofauna composition, in terms of abundances and biomasses. Corresponding temporal changes were correlated with two climatic indices and a set of environmental parameters integrated over 3 different time periods (i.e., whole year, springtime and wintertime). Our results confirm the occurrence of major temporal changes in the composition of macrobenthic communities within the Gulf of Lions. They also show that: (1) WeMO is a better climatic index than NAO for describing changes in benthic macrofauna composition in the Bay of Banyuls-sur-Mer, (2) winter is a better integration period than spring or the whole year for describing those changes, and (3) Rhône River water flow is likely involved in the control of benthic macrofauna composition in the whole Gulf of Lions. The present study highlights the importance of WeMO as a regional proxy which can be used to evaluate changes in benthic macrofauna linked to climate variability

Update on the progress made on development and use of OSPAR benthic habitat indicators, and on them integration, towards an ecosystem and risk-based approaches

Guérin Laurent[1], Vina-Herbon Cristina[2], Serrano Alberto[3] and Nina Schroeder[4].

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Through work developed within the European funded EcApRHA project and within OSPAR's regional seas convention, several indicators where developed. Two of the five benthic habitat indicators have been adopted and used to contribute to OSPAR 2017 intermediate assessment, which was published online in June 2017, to support MSFD reporting.

A multi-year work plan of the OSPAR Benthic Habitat Expert Group have been updated and adopted at the Biodiversity Committee (Madeira, February 2018). According to currently available and potential future resources, 12 priority knowledge gaps are identified, dispatched in 7 overarching themes, including integration methods (combination of biodiversity indicators).

A risk-based approach to monitoring UK marine benthic ecosystems

Yessica Griffiths

The UK recognises the importance of understanding marine ecosystems and biodiversity to achieve its ambition of 'clean, healthy, safe and biologically diverse seas'. Yet comprehensive UK marine monitoring presents a considerable challenge in terms of the resources required, particularly for the large area of benthic habitats. The Joint Nature Conservation Committee has led the development of an ambitious framework for offshore and deep sea benthic habitats monitoring, using a risk-based approach and other prioritisation factors to focus monitoring effort. This framework acknowledges that it is not possible to monitor everything, everywhere, and that it is more beneficial to monitor fewer things well. Our approach to delivering monitoring options for UK Governments is based around risk to benthic biodiversity from human pressures and uses human pressures and activities data to create spatial risk assessments at multiple spatial scales. We have used these outputs alongside other considerations to create a method that focuses monitoring in those areas where we are most able to answer the important and emerging questions for benthic biodiversity. We have engaged both scientists and policy makers in the discussion on which option is preferable. This process will allow policy makers to decide on the level of resourcing required for marine monitoring that reflects the risk to biodiversity and the public's concerns for the marine environment and fulfils our national and international legislative obligations.

Changes in functional composition along sediment gradients (ToR D: Benthic diversity and ecosystem functioning)

Jennifer Dannheim

Environmental parameters determine macrozoobenthic communities by species occurrence and abundance. However, limited knowledge is available on the effects of major environmental drivers (e.g. substrates) on the benthic functional composition.

This initiative analyses whether (a) there are any differences in functional composition (by biological traits analysis, BTA) between different substrates (mud, fine sand, coarse sand) and (b) those are consistent between different regions (e.g. Mediterranean, North Sea, Baltic Sea). Currently, a common BTA-table is set up for the analysis between regions and substrates. The progress of this initiative will be presented and consecutive steps (i.e. intersessional work) discussed in a subgroup.

Benthos behavioral responses to environmental change

Carl Van Colen, Sebastiaan Mestdagh, Eezin Ong, Tom Moens

Coastal benthic habitats and their inhabitants are at the frontline of current environmental change. Behavioral change is often the first visible indication of organism disruption under stress and occurs well in advance of mortality or fitness consequences that are rarely demonstrated from short-term experimental incubations. Using the EMBRC experimental facilities at Ghent University we demonstrate alterations in macrobenthos behavior at the species and community level in response to a suite of environmental changes such as ocean warming, acidification and sediment change. Demonstrated changes in irrigation, particle mixing, and feeding behavior have cascading effects on community interactions and ecosystem functioning.

Molecular inventories of meiofaunal diversity and its application in ecological benthic studies

Jadwiga Orignac

Marine sediments are teeming with small metazoans (size 40–1000 μm) as Nematoda, Copepoda, Kinorhycha, Tardigrada. These meiofaunal communities perform essential roles in marine ecosystem processes. Fast and accurate assessments of meiofaunal communities are crucial requirements for ecological studies and routine monitoring of ecosystem status. This study scrutinizes the reliability of the molecular approach through a comparison of morphological and molecular inventories of meiofaunal diversity, with a special focus on nematodes. Metabarcoding analysis was performed using a nuclear marker (small subunit 18S ribosomal RNA) and compared to a morphological analysis performed on the same sample-cores. We have also applied the metabarcoding method to study the composition of bacteria and nematode communities in the sediments in the north-western Mediterranean Sea. High throughput sequencing combined to statistical analysis allowed us to identify, at the small "cm-scale", the community structures and the co-occurrence of nematodes and bacteria OTUs in the sediment cores. The present study highlights the importance of small-scale sampling for an accurate vision of benthic communities.

Macropodia, an underrated spider crab genus in the Belgian part of the North Sea

Hans Hillewaert

Spider crabs of the genus *Macropodia* Leach, 1814 comprise 20 species worldwide (Davie, 2016), of which nine species occur in the northeastern Atlantic and Mediter-ranean waters: *M. czernjawskii* (Brandt, 1880), *M. deflexa* Forest, 1978, *M. intermedia* Bou-vier, 1940, *M. linaresi* Forest & Zariquiey-Álvarez, 1964, *M. longipes* (Milne-Edwards & Bouvier, 1899), *M. longirostris* (Fabricius, 1775), *M. parva* Noort & Adema, 1985, *M. rostrata* (Linnaeus, 1761), and *M. tenuirostris* (Leach, 1814) (Marco-Herrero, Rodríguez, & Cuesta, 2012).

Until recently the genus *Macropodia* has been treated rather poorly in the sampling campaigns of the Belgian part of the North Sea because of difficulty in identification. Especially for *M. rostrata* and *M. parva*, morphological differences between both species are

generally very subtle and often difficult to spot, e.g. the length of the rostrum, the presence and size of spines on the fifth pereiopod and the curvature of the dactylus of the fifth pereiopod. (Van Noort & Adema, 1985). Due to the lack of microscope facilities on board, *Macropodia* species have almost automatically been assigned to the species *M. rostrata*. Recent occurrence of *M. parva* in macrobenthos samples indicated that animals which were routinely regarded as *Macropodia rostrata* were actually composed of a complex of several species. Amongst the 221 specimen that were collected during a routine campaign in 2017, the four species mentioned by (Adema, 1991): *M. linaresi, M. parva , M. rostrata* and *M. tenuirostris,* were found.

While *M. tenuirostris* and *M. linaresi* seem to prefer coarser sands, *M. parva* also inhabits finer sands and *M. rostrata* is even found on muddy substrates.

A fifth species (*M. deflexa*) is present west of the Belgian part of the North Sea and may conceivably, although not encountered till now, be part of our fauna.

With genetic analyses we will next try to unravel the taxonomic relationship between these four species.

DNA barcoding of benthic species from the Belgian part of the North Sea for diversity impact assessments

Sofie Derycke, Annelies De Backer, *Hans Hillewaert*, Jan Wittoeck, Naomi Breine, Sara Maes, Kris Hostens

Species living in or near the seafloor fulfill a variety of ecosystem functions. Understanding how benthic communities respond to human activities is crucial to determine how such activities impact the functioning of the benthic environment. In the Belgian part of the North Sea, ILVO is extensively monitoring different benthic ecosystem components, and explores new ways to characterize the structural and functional benthic diversity. DNA-based approaches such as metabarcoding may complement and speed up the characterisation of changes noted in these communities during impact assessments. Linking sequences to taxonomic data is indispensable when information on ecosystem functioning is the key concern. However, the taxonomic resolution of metabarcoding is still hampered by a lack of reliable reference sequence data to which the metabarcode sequences can be compared.

We compiled long-term monitoring data from soft sediment macrobenthic, epibenthic and pelagic fish communities in the Belgian part of the North Sea. For macrobenthos, 334 species belonging to nine phyla have been registered in the past 15 years. The classes Polychaeta, Malacostraca and Bivalvia are the most species rich and include 40%, 37% and 13% of all species, respectively. ILVO aims to barcode as many benthic species as possible to validate and - when proven to be reliable - to implement DNA-based methods for biodiversity impact assessments. To this end, ethanol preserved voucher specimens are morphologically identified, photographed and stored as reference material for DNA sequencing. Partial or whole specimens are subjected to DNA extraction and COI Sanger sequencing. At present, the genetic reference database contains 95 macrobenthic species, representing the aforementioned classes and phyla. In addition, 85 epibenthic species and demersal/benthopelagic fish have been barcoded. Collection and sequencing of additional species is an ongoing effort.

Next to DNA barcoding, we also explore new library preparation methods for high throughput sequencing of benthic communities by using different COI primer sets and primer free approaches such as long read 18S rRNA sequencing, on mock communities, ethanol fixatives and field samples. These methods will be compared to morphologically identified samples to assess whether comparable patterns in species and functional diversity patterns in impacted versus non-impacted sediments are found by the different approaches.

Towards a benthic ecosystem functioning map: interregional comparison of two approaches (ToR b: Issue 2.A Species distribution modelling and mapping)

Mayya Gogina, Alexa Wrede, Jennifer Dannheim, Jan Holstein, Henning Reiss, Jan Vanaverbeke, Gert van Hoey, Nicolas Destroy, Steven Degraer, Vera Van Lancker, Aurélie Foveau, Dario Fiorentino, Michael L. Zettler

The progress of this initiative was briefly reported, open questions and consecutive steps for further intersessional work were tackled in a subgroup.

Macrofaunal community bioturbation potential (BPc) is one of the few existing quantitative indicators of benthic faunal function that can be used to evaluate the quality of marine sediments. It is based on largely available benthic macrofaunal data, making it suitable for spatial full coverage estimates of ecosystem functioning.

Community bioturbation potential is estimated for the four regions: German Baltic Sea, German North Sea, Belgian North Sea and English Channel. Key species contributing to bioturbation at each of the study areas are identified. BPc is related to the sediment composition.

Different sets of relevant available environmental layers were used as predictors to model and map the spatial distribution of this indicator, separately for each area, to explore the drivers of BPc patterns, and to highlight the regional differences.

Results of two modelling approaches are to be compared: i) BPc initially calculated per station is treated as response variable for distribution modelling with random forest ensemble learning method; or ii) BPp of key species (responsible for 70–90 % of total BPc) used as response variables to predict their full coverage distributions, and these population estimates are subsequently summed up to the BPc.

The applications of the regionally derived maps, challenges of interregional biogeographical comparisons as well as the use and performance of estimates of such indicators across different sedimentary habitats are discussed.

High resolution modelling of ocean circulation can reveal retention spots important for benthic biodiversity conservation

Katell Guizien

Larval transport by ocean circulation and its emerging property at the population level, i.e. connectivity, have received increasing attention thanks to the Aichi target 11 of protecting 10% of ocean surfaces. Furthermore, it is also important to investigate retention within a site as it determines a population's self-persistence in an isolated marine protected area.

Mediterranean rocky substrates host a conspicuous and diverse biota, which explains that MPA designation targetted the rocky habitat. Retention rates in the fragmented rocky habitat of the Gulf of Lion were established at two spatial scales (10- and 1-km²) using dispersal simulations. To this end we computed three dimensionnal flow simulations with high spatial resolution nearshore (80 m) combined with a high density of release spots (every 100 m). This study shows that among the six rocky 10-km² patches, marine protected areas (MPAs) were designated in the four ones with highest average retention rates for Pelagic Larval Duration (PLD), of up to 42 days. Furthermore, within each MPA, small zones where special protection measures are applied correspond to 1-km 2 subpatches where highest local retention rates were found. Yet, the 2% most retentive subpatches of the rocky habitat do not exhibit retention rates large enough to ensure the local persistence of most species.

Annex 4: Initial compilation to support ToR A overview between long-term observations and monitoring effort

	LT - observations = basic monitoring / system monitoring	Monitoring = effect monitoring
Background/ motivation	Started with monitoring, either for scientific purposes or motivated by environmental problems. Continued for different reasons	Environmental problems,
		Management (Natura 2000, ...)
		Scientific purposes?
Goal	Global trends natural variation/indicators	Impact monitoring , EIA
	Understand ecosystem (processes) [integrated information : benthos, plankton, ...]	Monitoring effects of management decisions
	Early warning/check with example	Sweden: local monitoring