

BENTHOS ECOLOGY WORKING GROUP (BEWG; outputs from 2019 meeting)

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i Executive summary

Benthos Ecology Working Group (BEWG) focuses primarily on 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 the science to support management decisions”
- Case study: “Interregional comparison of benthic ecosystem functioning: community bioturbation potential in four regions along the NE Atlantic shelf”
- 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”

ii Expert group information

Expert group name	Benthos Ecology Working Group (BEWG)
Expert group cycle	multiannual
Year cycle started	2018
Reporting year in cycle	2/3
Chair(s)	Silvana Birchenough, UK
Meeting venue and dates	6–10 May 2019, Coleraine, Northern Ireland, UK, 17 participants

1 Long-term benthic series and climate change

Introductory presentation by Silvana Birchenough

“Physical and nutritional impacts of ocean acidification are linked to social preferences in Chilean mussels”

Ocean Acidification (OA) has become one of the most studied global stressors in marine science during the last fifteen years. Despite the variety of studies on the biological effects of OA with marine commercial species, estimations of these impacts over consumers' preferences have not been studied in detail, compromising our ability to undertake an assessment of market and economic impacts resulting from OA at local scales. Here, we use a novel and interdisciplinary approach to fill this gap. We experimentally test the impact of OA on commercially relevant physical and nutritional attributes of mussels, and then we use economic discrete choice models to assess the marginal effects of these impacts over consumers' preferences and wellbeing. Results showed that attributes, which were significantly affected by OA, are also those preferred by consumers. Consumers are willing to pay on average 52% less for mussels with evidences of OA and are willing to increase the price they pay to avoid negative changes in attributes due to OA. The interdisciplinary approach developed here, complements research conducted on OA by effectively informing how OA economic impacts can be analysed under the lens of marginal changes in market price and consumer' welfare. Thereby, linking global phenomena to consumers' wellbeing, and shifting the focus of OA impacts to assess the effects of local vulnerabilities in a wider context of people and businesses. The work is published:

San Martin, V.A., Gelcich, S., Hernández, I., Vasquez, F., Ponce, R. Lagos, N.A., **Birchenough, S.N.R.** and Vargas, C.A. (2019). Physical and nutritional impacts of ocean acidification are linked to social preferences in Chilean mussels. *Nature Scientific Reports*. Doi.org/10.1038/s41598-019-41104-5

Work under ToR A between group members was agreed that there is an important message to convey with regards to benthic time-series. The group has supported the idea to scope an opinion document. An overview table with key aspects to consider in order to summarise this work is presented in Annex 4.

The group effectively discussed and populated a document, some of the work will be done intersessionally to effectively gather the literature and details. A tentative title has been agreed:

Birchenough, S.N.R., Reiss, H., Craeymeersch, J., Montagna, P., Dannheim, J., Vanaverbeke, J., Labrune, C., Blomquist, M., Guerin, L., Oug, E., Donnay, A., Degraer, S., Hunter, B. and Jan Beermann, J. (*in prep.*) The value of long-term time-series: bringing the science to support management decisions. Journal TBD. Letter style contribution.

1B: Belts-NET/EMODNET

A proposal has been received from Dr Vincent Bouchet to collaborate on a new initiative for a network of benthic sampling networks/stations – BenthOBS. This will include 20 stations from Belgium to Italy with the intention to sample these bi-annually using standardised methods. It will also include ring-tests, Inter-calibration and to scientifically analyse the data. The BEWG can link this initiative into the review paper from 1A. The chair will invite Vincent to the meeting next year to update the group and to disseminate this initiative further with the group.

2 Species distribution modelling and mapping

2.1 Report on ongoing case study: “Towards a benthic ecosystem functioning map: interregional comparison of two approaches”

M. Gogina updated on this ongoing case study. The four main aims from this work were to assess: i) key species and its distribution; ii) regional differences; iii) test approaches; iv) exploration of drivers of ‘bioturbation potential’. Several sub-group and plenary discussions took place at the meeting.

In short, bioturbation is one of the key mediators of biogeochemical processes in benthic habitats that can have high contribution to seafloor functioning and benthic pelagic coupling in coastal waters. Previous studies on bioturbation were limited to point locations and extrapolations in single regions but have not accounted for regional differences under changing conditions, though there are indications that species contributions will differ across regions or with biotic and abiotic context. To capture those differences and assess global patterns and commonalities, multi-regional analysis is imperative. Here for the first time, bioturbation potential (BP_c), a functional indicator of benthic community bioturbation, was estimated based on macrofauna data from four regions (i.e. German Baltic Sea, German North Sea, Belgian part of the North Sea and the Eastern English Channel). For each region and sediment type we identified key species contributing to BP_c . Comparison within and across regions demonstrated regional differences, and both overlap and mismatch between species that are functionally important and those that are dominant in biomass. The identification of these species, is fundamental in terms of their functional contributions, rather than biomass dominance, which is central to the protection of certain ecosystem functions. Available environmental layers were used as predictors to model the spatial distribution of BP_c for each area, explore the drivers and highlight regional differences. Random forest models were trained using as response variables either i) BP_c initially calculated per station; or ii) BP_p – the species-specific contribution to BP_c – for key species (with subsequent summation of their predicted full-coverage distributions to BP_c). Maps of BP_c distribution predicted by random forest were compared with those generated using natural neighbour interpolation. Overall, derived BP_c values decreased towards the Eastern English Channel. The relevance of BP_c for ecosystem processes and functions, however, varies with biotic and abiotic settings. Results revealed strong association of BP_c with species diversity and region, but less with sediment grain size. A large range of BP_c occurred even along the low species richness values, suggesting that provisioning of high bioturbation activity is possible also under low diversity, but the functioning of the system might be more vulnerable due to reduced resilience. The regionally derived maps clearly highlight the areas where the benthic community plays an important (dominant) role in the functioning of the seafloor system. The executed multi-regional analysis allowed identifying regional differences in performance of macrofauna, suggesting the need for region-specific conservation and management strategies.

This work has been drafted as a scientific paper. The citation is as follows:

Gogina, M., Zettler, M.L., Vanaverbeke, J., Dannheim, J., Van Hoey, G., Desroy, N., Wrede, A., Reiss, H., Degraer, S., Van Lancker, V., Foveau, A., Braeckman, U., Fiorentino, D., Holstein, J., Birchenough, S. N.R. (2020) Interregional comparison of benthic ecosystem functioning: community bioturbation potential in four regions along the NE Atlantic shelf". *Ecological Indicators* <https://doi.org/10.1016/j.ecolind.2019.105945>

3 Benthos and legislative drivers

Benthic indicators continue to be a very important area of work across several members of the BEWG. A series of national updates with regards to benthic indicator developments and MSFD (e.g. from Germany, Sweden, France and Belgium) were presented during the meeting.

Following from these national introductions, the group intensively discussed the different approaches to assess benthic habitats with respect to D6 MSFD and the potential role of ICES BEWG as an additional expert group besides OSPAR BHEG, HELCOM EN BENTHIC and EU TG SeaBed. The main conclusion was the current issue associated with assessments. At present, this aspect is largely lacking by other expert groups. One drawback was associated with the question on how to interpret the EU MSFD D6 criteria from an ecological viewpoint to enable this aspect to then be linked with ongoing monitoring strategies. It was agreed to open a sub-ToR on this task and to include a recommendation list for a better integration with other relevant expert groups.

Presentation: European Invertebrate Atlas initiative

N. Desroy presented an ongoing initiative, which is a detailed invertebrate atlas. The work was well received and the BEWG members also were supportive of enhancing this idea with a North Sea wide initiative. The next step will be to explore opportunities of funding for a potential North Sea atlas initiative. A letter of support and identification of stakeholders was drafted to see who might have an interest in funding such an initiative. The work will be developed by a post-doc and supported by BEWG members. The discussion also covered if a book and/or an online atlas should be compiled and produced. It was agreed that we should aim for an ecologically sound book and disseminate data by adding the data to an existing website.

L. Guérin gave an introductory presentation “Update on the progress made on development and use of OSPAR Benthic Habitat indicators, and their integration, towards an ecosystem and risk-based approach” see abstract in Annex 3.

A. Darr and J. Beermann also summarized the approach and the results adopted to support the German national report on the state of the benthic habitats (D6) in the North Sea and the Baltic Sea (Art. 8, 9, 10 MSFD) as published in December 2018. Further details are provided in their abstract in Annex 3.

P. Magni also presented online an overview of ongoing work to support EU MSFD requirements in Italy. The aim is to outline a series of ecological indicators capable of describing the vulnerability at multiple levels (single species, groups of species with significant ecological characteristics or communities) and which can potentially provide information both independently and within a multiparametric composite environmental status index that could be validated against a specific pressure index. The abstract of this presentation is included in Annex 3.

3.1 Report on the use of benthic indicators and ongoing initiatives

The Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), established in 2018, is currently co-chaired by one of the BEWG members, Gert Van Hoey. This work will be closely aligned with the scientific work developed under the BEWG. Gert Van Hoey provided an update

on the work and ongoing initiatives. For more details on the group ToRs, activities and contacts with other EG, visit their website: <https://www.ices.dk/community/groups/Pages/WGFBIT.aspx>

3.2 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. The expert list is finally fixed and closed. A discussion was also on gender balance which is not fully reached, but it was agreed not to re-open the list again as this was a secondary selection criterion of 4 experts (primary angle considered was the ample knowledge)

The next steps for this work are to produce an invitation letter. A draft will be prepared by Steven which will be commented by Silvana Birchenough and Jennifer Dannheim. The work on questionnaire will be done intersessionally. An online questionnaire is the preferred option to support this work.

3.3 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

G. Van Hoey led this initiative in collaboration with several BEWG members that participated during the EU funded Joint Monitoring Programme of the North Sea and Celtic Sea.

Benthic habitat condition assessments are a requirement under various environmental European directives. However, there is still a lack of a common assessment or monitoring protocol for most regions. Therefore, this paper aims to provide a methodology to guide and optimise the spatial benthic monitoring component over a regional context. This work will support several environmental requirements, notably the revision process of the Marine Strategy Framework Directive monitoring requirements by 2020. This work has used the North Sea ecosystem as a case study to test the applicability of an ecosystem stratification within the region. A series of, different sample allocation principles and a change of point analyses, has been used to provide guidance on total sampling effort. These analyses were based on data from two previous large-scale benthic North Sea surveys (1986 and 2000). The stratification needed to consider the spatial heterogeneity of the entire ecosystem in combination with spatial management units (E.g. spatial domain structure of North Sea ATLANTIS model). The sample effort allocation process was the most optimal, when the total sample effort was distributed within the area considering the size and benthic variability within those strata (Neyman allocation principle). Change point analyses helped a sample programmer is a tool to find a balance between sampling effort and survey precision. A regional spatial sampling design was generated by sharing ongoing member states efforts and where possible adaptation of existing national programmes. This serve a joint or co-ordinated, region-wide, benthic condition status assessment and help to strengthening regional cooperation to fulfil multiple monitoring uses, with a scientifically underpinned common approach.

This work is now available as a peer reviewed publication. The full reference is available below:

Van Hoey, G., Wischniewski, J., Craeymeersch, J., Dannheim, J., Enserink, L., Guerin, L., Marco-Rius, F., O'Connor, J., Reiss, H., Sell, A.F, Vanden Berghe, M., Zettler, M.L., Degraer, S., Birchenough, S.N.R. (2019). Methodological elements for optimising the spatial monitoring design to support regional benthic ecosystem assessments. Environmental monitoring and assessment DOI: 10.1007/s10661-019-7550-9

3.4 Report on the ongoing case study to assess ecological responses across sediment gradients

J. Dannheim presented the overall progress on this initiative. 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 ten case studies covering the Baltic Sea, the Mediterranean Sea, the Norwegian Sea and the North Sea. Progress has been made in data cleaning with regards to the biological and sediment data. The initiative is now closed. During the meeting, a detailed discussion on the selection and definitions of biological traits, traits modalities and coding was carried out and a final set of biological traits was decided on. A collation of biological traits data bases will be compiled by Mats Blomqvist. The traits work will continue by BEWG experts intersessionally and an update will be given next year at the BEWG meeting.

3.5 Consider new functional indicator needs to support MSFD requirements

BEWG decided that a first steps for this initiative is to include functional relevant indicators. The discussion also supported the compilation of links between benthic functions and ecosystem services.

There are several ideas on how to progress and integrate with other ongoing indicatives (e.g. WGMRED). A discussion was held during the meeting on existing conceptual frameworks. The work will be developed over a draft document scoped at the meeting, bringing the new knowledge and current gaps associated with functional indicators under MSFD. Billy Hunter is leading on this work; further intersessional discussion will be conducted during 2019 and 2020. The intention is to report on progress at the next BEWG meeting in May 2020.

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

4.1 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 C. Greathead and P. Magni. 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 allows 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.

Marine Protected Areas (MPAs) hold species and habitats protected under law. There is concern across the ICES region that consideration of vulnerable components and wider support mechanisms underpinning benthic marine ecosystems may not be as accurate under the process of MPA designation, management and monitoring. In this study, MPAs across six European ecoregions were assessed from a benthic ecology perspective, to highlight issues regarding the representation and protection of benthic ecosystems in MPAs. The assessment comprised 102 MPAs, designated by ten countries, and focused on three aspects regarding the role of the benthos in: (i) the designation of the MPA (ii) management measures, and (iii) monitoring and assessment. A pedigree matrix was applied with a numerical scale to a set of qualitative entries collected by 19 benthic experts (active members of the ICES Benthic Ecology Working Group (BEWG)) in a dedicated questionnaire.

The results showed clear differences in scores between ecoregions and between criteria. The designation phase criteria generally achieved higher scores than the implementation phase criteria and the regional differences in scores were not consistent between the designation and implementation phases. Over 70% of the MPA case studies were found to consider the benthos to some extent during selection and designation, there were clear gaps with the appropriate management measures and good practice during the implementation phase. Poor designation scores were reiterated later in the MPA process, with low implementation scores caused by poor spatial and temporal coverage of monitoring, using selected indicators. Poor spatial and temporal coverage of monitoring and ineffective indicators is unlikely to pick up any changes caused by management measures in the MPA. However, without adequate monitoring and adaptive management frameworks, there is concern that MPAs will be compromised. Particularly, to the benthos, as they will fail to meet their conservation objectives. This assessment was successful in highlighting issues related to the representation and protection of the benthos in MPAs and where improvements, such as expanding the characterisation and monitoring of benthic species or habitats of interest, needs to be made. These issues could be attributable to an ongoing process and/or indication that some MPAs only have a superficial level of 'paper protection'.

A plan was agreed to draft this work into a manuscript intersessionally. A tentative citation for this work is as follows:

Clare Greathead, Paolo Magni, Jan Vanaverbeke, Lene Buhl-Mortensen, Ursula Janas, Mats Blomqvist, Johan Craeymeersch, Jennifer Dannheim, Alexander Darr, Steven Degraer, Nicolas Desroy, Annick Donnay, Yessica Griffiths, Ivan Guala, Laurent Guerin, Hayley Hinchin, Celine Labrune, Henning Reiss

and Gert Van Hoey, Silvana N.R. Birchenough (*submitted.*) Exploring the use of a generic framework to illustrate the importance of benthic marine ecosystems to the effectiveness of MPAs. Aquatic Conservation.

Recommendations for BEWG consideration

WKDATR-NSCS recommends for the BEWG to agree on approach to by-catch species, in particular, benthic animals (taxonomic level/grouping, species validity, count/weight/observation data?)

The BEWG discussed this request. The group decided to seek further information on the request, particularly on the uses of the data and then need to aggregate data sets. At present, the work under the BEWG on indicators for MSFD uses the whole species list, as the idea is to have a full representative estimate of the species/ community present in samples/ areas. The BEWG will liaise with the secretariat to seek further details on the background information and the request.

WKBEDPRES1 recommends that BEWG review what the effects of smothering are for the benthos and suggest a mechanistic relationship between increased pressure and benthic response (e.g. biomass relative to carrying capacity)

BEWG discussed this request with our experts. The smothering of benthic organism can be due to (i) the redeposition of sediment in areas situated on the plume of the extraction or (ii) the screening on board of sediment. There are other impacts on seagrasses from dredging and sand mining which include physical removal and/or burial of vegetation and effects of increased turbidity and sedimentation (Erftemeijer & Lewis 2006).

High levels of suspended material can lead to reduced vitality or death in benthic fauna associated with seagrass beds through clogging of their feeding mechanisms (cilia and siphons) and smothering, especially in filter-feeding organisms such as mussels, oysters and other bivalves (Erftemeijer & Lewis 2006).

Regarding the first interaction, effects of redeposition of sediments during extraction operations are regularly underestimated, due inadequate sampling strategies (e.g. too few stations located outside of the extraction area and under the influence of the plume). However, the effect can be similar in areas extracted and exposed to plume deposits. Impacts linked to the plume are very variable between sites. According to Hitchcock & Drucker (1996), the intensity depends on (i) the fine particle rate in the sediments extracted, (ii) the local hydrodynamical conditions and (iii) the quantity of sediment rejected by dredges. Aggregate extraction may impact benthic communities beyond the extraction area *sensu stricto* by the surveyed waters. Newell *et al.* (2004) showed that the spatial extension of the impact on benthic macrofauna can reach 4 km from the dredging area (example of the site A122/3, English Channel - France). In the site of Dieppe (English Channel – France), stations far from 2 km of extraction areas and exposed to turbid plume were characterized by reductions ranging from 56 to 94% for species richness, 43 to 98% for abundances and 57 to 86% for the biomass compared to control areas (undredged and outside of the plume). These results suggest that the impact of the plume outside the extraction area can be as important as inside.

Regarding the screening activity, Frojan *et al.* (2011) did not observe, on the site “Area 408” (English Channel, UK) where this technic is operated, differences in the faunal composition between a site with an intensive dredging and a neighbouring site with low dredging pressure. Deposits of fine sediments occurring during the dredging could cover some parts of the area in the surrounding which were not or low dredged and induce disproportionated effects regarding the

perception level of perturbation. On-board screening considerably increases the volume of suspended sediment that is released with overflow waters (Newell *et al.*, 1998) and subsequently the spatial extent of modifications of the nature of the seabed. There are few data available on the effect of invertebrate survival rates but the impact on growth is unknown. On-board screening is not authorized in France and such a striking example as Granulats Marins de Dieppe (English Channel – France) shows the relevance of this mitigation measure.

The knowledge available is sparse and there is a need to concentrate dedicated experts to discuss the approach and limitations in details. The effects of dredging and consequences of smothering are broad, therefore the BEWG recommends that a targeted workshop is planned to advance with this work.

References

- Erftemeijer PLA, Lewis RRR (2006) Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin* 52:1553–1572. Doi: 10.1016/j.marpolbul.2006.09.006.
- Froján, C.R.B., Cooper, K.M., Bremner, J., Defew, E.C., Hussin, W.M.W., Paterson, D.M., 2011. Assessing the recovery of functional diversity after sustained sediment screening at an aggregate dredging site in the North Sea. *Estuar. Coast. Shelf Sci.* 92, 358–366.
- Hitchcock, D., Drucker, B., 1996. Investigation of benthic and surface plumes associated with marine aggregates mining in the United Kingdom. *Glob. Ocean. Oper. Oceanogr.* 221–284.
- Newell, R., Seiderer, L., Hitchcock, D., 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. *Oceanogr. Mar. Biol. Annu. Rev.* 36, 127–178.
- Newell, R., Seiderer, L., Simpson, N., Robinson, J., 2004. Impacts of marine aggregate dredging on benthic macrofauna off the south coast of the United Kingdom. *J. Coast. Res.* 115–125.

4.2 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 discussed potential avenues such as Euromarine (<https://www.euromarinenetwork.eu/calls>) or Assemble plus (<http://www.assembleplus.eu/>). The potential ideas for projects will be supported by dedicated funded and individual members which will continue to check the websites for information. Also, Annick Donnay offered the option to work on a potential collaboration at the Marine Station in Stareso, Corsica (<http://www.stareso.com/>).

4.3 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. The discussion also suggested when funding calls are opened to update to all BEWG members.

Annex 1: List of participants

Name	Institute/ Country	Email
Silvana Birchenough (Chair)	CEFAS Lowestoft Laboratory United Kingdom	silvana.birchenough@cefass.co.uk
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Annex 2: BEWG Resolution

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

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2018	14–18 May	Banyuls-sur-Mer, France	Interim report by 30 June	
Year 2019	6–10 May	Ulster, Northern Ireland, UK	Interim report by 30 June	
Year 2020	11–15 May	by corresp/ webex	Final report by 30 June	physical meeting cancelled - remote work

ToR descriptors

TOR	DESCRIPTION	BACKGROUND	SCIENCE PLAN CODES	DURATION	EXPECTED DELIVERABLES
A	Long-term benthic series and climate change 1. To identify methodological issues in long-term series comparability	The need for the BEWG to work on current tools and techniques associated with the understanding of natural variability and climate change on the benthos is of importance. There is a need to review and compile methodological issues associated with long-term series comparability in marine assessments.	2.1	1–3 years	Review paper on current methodological applications
B	Species distribution modelling and mapping 1. To report on ongoing case study: “Towards a benthic ecosystem functioning map: interregional comparison of two approaches	Distributional modelling (SDM) helps the understanding of the distribution of species and communities. These are considered to be robust tools in support of a scientifically-sound management of the marine ecosystem. While qualitative SDM (i.e. modelling the likelihood of occurrence of benthic feature) has been regularly applied, there is a need to focus on quantitative modelling techniques (e.g. modelling densities or biomass) over environmental drivers (e.g. sediment type, organic matter content and other relevant parameters) and processes. BEWG will report on the performance of different qualitative and quantitative species distribution modelling methods, e.g. methods validity and with hypothesis driven case studies to showcase the use, benefits and further gaps associated with these tools.	1.3; 1.5; 1.7	Year 1-3	Position paper (with a case study example).
C	Benthos and legislative drivers 1. To report on	A wide suite of benthic quality indicators were developed, intercalibrated and applied within the framework of several international regulations. At present, the most relevant directives within the North	1.5; 2.4	Years 1-2	Position paper

	the use of benthic indicators and ongoing initiatives	Atlantic realm are the Water Framework Directive, the Habitats Directive and the Marine Strategy Framework Directive. BEWG will investigate the Compatibility and complementarity within the use of benthic indicators and targets for management applications. Further work will concentrate on investigating the importance of species autecology in indicator development and application and review the development of effective monitoring programmes, e.g. design, harmonisation and quality assessments.		Years 1-3	Research paper(s)
	2. Variability and expert judgement of benthic species tolerances/ sensitivities			Years 1-2	Review paper
	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	Disentangling the link between biodiversity and ecosystem functioning is currently considered to be key to fully understand the health of marine ecosystems. This topic hence became a cross-cutting theme since the BEWG 2012 meeting. BEWG will therefore review and identify benthic indicators to reflect the link between biodiversity and ecosystem functioning and review how ecological function and diversity relates to different parts of the benthic communities at different spatial scales, taking account of e.g. ecological processes and biological traits. BEWG will also scope for research on the functional diversity of macrobenthos in relation to ecosystem functioning. This work has been an important topic and an overview of current and recent research gaps and priorities will be discussed. The ongoing discussion will be based on a conceptual perspective, BEWG will continue investigating the link between ecosystem functioning and ecosystem services.	1.3; 1.7; 1.9		
	1. To report on the ongoing case studies to assess ecological responses across sediment gradients.			Years 1-3	Research paper to report on a selected case study.
	2. To consider new functional indicator needs to support MSFD requirements.			Year 1-3	Viewpoint paper
	3. To identify links between benthic functions and ecosystem services.			Year 1-2	Viewpoint paper

E	<p>Benthic biodiversity and conservation: to review the role of benthic ecology in MPAs</p> <p>Understanding ecological issues associated to the development/proposal of MPAs and of how effective MPAs are going to be for the conservation of priority benthic species is key to support conservation and management strategies. This work has been developed to understand the different levels of protection (i.e. management measures) being applied within MPAs. The exercise will help to assess whether the designation process in place are adequate to protect the species in need of protection, creating further repercussions to the ecosystem function and processes in specific habitats and species.</p> <p>This ToR will consider issues associated with conservation/restoration, Autecological/environmental as well as human issues.</p>	6.1; 6.2; 6.4	Years 1-3	Review paper
F	<p>To explore the feasibility to undertake studies (e.g. laboratory or field experiments) to test ecologically relevant hypothesis in relation to benthic responses.</p> <p>Conducting applied science to test direct hypothesis driven questions, which can help to support and validate dedicated case studies</p> <p>Similarly BEWG recognises the need to widen its scientific scope and a way to support this activity is by jointly supervising specific research projects. This type of further research will help for extending its remit, build dedicated set of skills and widen its influence across different networks. The BEWG also recognises the need to invite and include early career scientists in to our annual meetings, helping to shape the new round of ecologists.</p>	tbc	Years 1-3	Review paper
	<p>1. To explore funding opportunities and collaborative proposals for setting up and conducting experimental studies;</p> <p>2. To compile a list of scientific ideas to develop research Master's thesis projects and promote co-supervision activities within BEWG members.</p>		Year 1-3	Thesis preparation and invitation to meetings.

Summary of the Work Plan

Year 1	ToRs a., b.1, c.1-3, d.1-3, e.1, f. 1-3
Year 2	ToRs a., B.1, C.1-3, D.1-3 , e.1, F. 1-3
Year 3	ToRs A., B.1, C.1-3, D.1-3 , e.1, F. 1-3

Supporting information

Priority	The current activities of BEWG will continue along the main priority within BEWG ToRs, based on: long-term series and climate change, benthic indicators and EU directives, and species distribution modelling, and one cross-cutting (horizontal) axis on benthic biodiversity and ecosystem functioning (including issues directly in connection to MPAs). All issues mentioned fit the ICES Science Programme and are considered to be of high priority. The BEWG are active contributors and aim to report their outcomes directly to ICES in their annual report and in parallel as peer reviewed literature. Some of the outputs will be submitted to ICES JMS, Ecological Indicators, Marine Pollution Bulletin, etc.)
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 20-30 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There is a possibility for interaction of several ICES expert groups, among which WGDEC, WGSFD, WGECCO, WGMHM and WGEXT.
Linkages to other organizations	The group has had also interaction with OSPAR IGC-COBAM.

Annex 3: Abstracts presented at the meeting

What factors control the distribution of seapens in the Kattegat?

Mats Blomqvist

Extensive drop-video inventories have revealed distinct distributions of the seapens *Virgularia mirabilis* and *Pennatula phosphorea* in the Kattegat. Within the area sharp gradients in depth, salinity, exposure, substrate and bottom trawling for *Nephrops norvegicus* exists. During 2019 we will analyse these data to evaluate the role of bottom trawling in explaining the distribution of the seapens. I will present a short background and some initial results.

Implementation of MSFD D6 in Germany: national report 2018 and monitoring perspectives

Alexander Darr & Jan Beermann

We briefly summarize the approach and the results of the German national report on the state of the benthic habitats (D6) in the North Sea and the Baltic Sea (Art. 8, 9, 10 MSFD) as published in December 2018. In coastal waters, the assessment was based on WFD indicators. While in off-shore areas of the North Sea the assessment mainly based on the assessment of D6C3 using an OSPAR indicator developed, D6C5 was the only criterion in the Baltic that was assessed (using HELCOM BQI). However, no assessment at all was conducted for mixed and coarse substrates and HD assessment was used for hard substrates. We will also provide a short overview of prioritized current / future tasks such as the development/ adaptation of monitoring programs and the development of additional indicators.

Description of the logical framework for the definition of ecological indicators for the D6 GES assessment for Italian MSFD subregions

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The D6 aims to ensure that the pressures generated by anthropogenic activities on the seabed do not negatively affect the components of the marine ecosystem, in particular on the benthic communities. The Italian definition of GES for D6 is: "There is no significant pressure due to: a) physical disturbances caused by human activities that actively operate on the seabed and b) physical loss on biogenic substrates connected to human activities." This GES is intended to be achieved at the marine subregional scale. The Italian marine waters are divided in three marine subregions: Adriatic Sea, Western Mediterranean Sea and Ionian Sea. The pressures "physical disturbance" is intended mainly due by trawling fishing activities. The biogenic substrates potentially subject to significant pressure (from physical disruption and/or physical loss) are mainly the *Maerl* habitats and the *Posidonia oceanica* meadows. The pressures physical disturbance and physical loss on other types of biogenic substrates, such as the biocenosis of the *Coralligenous* and deep Corals, the *Tegmæ*, are generally rather occasional.

The data available from the Italian Monitoring Program (2015-2016), did not allow to establish a threshold beyond which a significant impact is found. In particular, data on the extension of biogenic substrates (*Maerl* habitat) are still yet not available at marine subregion scale; therefore it is not possible to establish whether the benthic substrates are subjected to a pressure that generates physical perturbation/physical loss, nor is it possible to establish a significant pressure threshold.

The Italian National Monitoring Program planned for 2019-2020 aims at achieving data and information to fill the gaps identified on biogenic substrates and to develop operational environmental assessment tools. About the impact of fishing activities on benthic bottom communities there is the need to obtain comparable information on the state of conservation of ecosystems on a wide geographical scale and thus carry forward ecosystem-based management strategies of the territory and its resources. To define the significant pressure on soft bottom communities due to trawling activities the next activities aim to define a list of epimegabenthic species closely related to trawling assign to each taxon a sensitivity index that reflects its vulnerability to the impact of the fishing gear. In parallel geophysical surveys will be carried out to define a specific pressure index. The aim is to outline a series of ecological indicators capable of describing the vulnerability at multiple levels (single species, groups of species with significant ecological characteristics or communities) and which can potentially provide information both independently and within a multiparametric composite environmental status index that could be validated against a specific pressure index.

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, ei- ther for scientific purposes or motivated by environmental problems. Continued for different reasons	Environmental problems,
		Management (Natura 2000, ...)
		Scientific purposes?
Goal	Global trends natural varia- tion/indicators	Impact monitoring , EIA
	Understand ecosystem (processes) [integrated information : benthos, plankton,]	Monitoring effects of man- agement decisions
	Early warning/check with ex- ample	Sweden: local monitoring