ICES WGMBRED REPORT 2016

SCICOM STEERING GROUP ON ECOSYSTEM PRESSURES AND IMPACTS

ICES CM 2016/SSGEPI:03

REF. SCICOM

Interim Report of the Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED)

14–18 March 2016

Delft, the Netherlands

ICES CIEM

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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

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

Recommended format for purposes of citation:

ICES. 2016. Interim Report of the Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED), 14–18 March 2016, Delft, the Netherlands. ICES CM 2016/SSGEPI:03. 42 pp.

For permission to reproduce material from this publication, please apply to the General Secretary.

The document is a report of an Expert Group under the auspices of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council.

Contents

Executive summary

The 2016 meeting of the Working Group on Marine Benthal and Renewable Energy developments was attended by 22 experts, representing seven countries (Belgium, France, Germany, Ireland, Poland, United Kingdom, and Netherlands) and was held in Delft, the Netherlands, 14–18 March. The meeting was co-chaired by Jennifer Dannheim (Alfred Wegener Institute, Germany) and Andrew B. Gill (Cranfield University, United Kingdom).

As this was the first meeting of the WGMBRED new 3-year cycle, we began with a recap of where the WGMBRED had come from, its position and relevance within the ICES family and the recent ICES science plan. We then looked towards the next three years with a focus on our new ToRs:

a) Critically assess relevant temporal and spatial scales in relation to the effects of MREDs on the benthic ecosystem and evaluate the consequences in relation to environmental policy and decision-making;

b) Review progress on filling knowledge gaps relating to the benthic ecosystem including differentiation among MRE technologies using e.g. reports of national activities;

c) Analysis of network and interactions amongst WGMBRED and other relevant groups including regulators, stakeholders, policy makers and scientists, in order to evaluate the impact of MBRED science;

d) Identifying and operationalising relevant indicators in relation to assessing ecosystem functioning and change in relation to MBRED at scales related to ToR A.

To begin to address these ToRs we looked at what the WGMBRED had achieved in its first period to then build on and develop these initiatives. We considered the status of the expected outputs, which related to two review papers, one dealing with knowledge (in final draft stage) and the other monitoring (to be revised and resubmitted to another journal) in relation to benthic ecosystems and MRE and how these were to be finalised and feed into the new ToRs. We also agreed on the final stages to get these papers submitted to appropriate journals.

During the remainder of the meeting we focussed on the new ToRs. We first went through a country update to provide the most up to date information of where benthic research in relation to MRE was across WG member countries. This was followed by discussions and activities for each of the ToRs.

For the ToR A (Scale): our goal is to scale up from small-scale effects (in space and time) and see where this may become relevant for policy and management, mostly by thought experiments, but validation would be needed (perhaps through modelling): from concept to practice.

With ToR B (Knowledge): building on the previous knowledge activities we will exemplify knowledge gaps relating to the benthic ecosystem including differentiation among MRE technologies, such as tidal stream and wave energy devices, as well as floating wind farm devices. Based on the hypotheses developed during the last 3 years

(WGMBRED, ICES 2015), the group carried out a preliminary scoring of the cause-effect-relationships.

For ToR C (Network): we initially identified the linkages among members of WGMBRED with other groups within ICES and other groups outside of ICES community. The next phase, to be started intersessionally is to work to establish the strength of these links with a view to identifying network gaps through Network Analysis and then continue at next year's WG meeting.

With ToR D (Indicators): we considered indicator categorisation and application in the context of what was already known about benthic indicators. Discussions included the application of indicators to determine when a functional ecosystem was established over a temporal scale. This brought into question what would be defined as a functional eco-system and the need for a sensible and useful end point in an analysis. A meta-analysis was suggested where the different indicators in use in different MRED developments were identified. As a start to the indicator ToR, the group split into three covering differ-ent geographical regions of interest in the development of marine renewable energy. The regions provided case studies for the application of indicators relating to the Societally Important Issues (SII's= biogeochemical reactor, food resources and biodiversity, ICES 2015) whilst incorporating cumulative effects, connectivity and scale. We chose three regions: the Baltic Sea, the area of western British coasts and Ireland (the Irish Sea) and the southern North Sea, which were characterized and the initial outcomes were dis-cussed. The exercise demonstrated well the use of the SII's as a structure and identifying the potential indicators of important changes. The group agreed that the case studies should remain focused on the aims and that there is a need to collect information availa-ble (literature review intersessionally) to support of them in preparation for the next meeting.

The group agreed that the meeting in 2017 will take place on 6–10 March 2017 in Gdynia, Poland. The meeting in 2018 will be held in Galway, Ireland.

1 Administrative details

Working Group name
Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED)
Year of Appointment within current cycle
2016
Reporting year within current cycle (1, 2 or 3)
1
Chair(s)
Jennifer Dannheim, Germany
Andrew B. Gill, United Kingdom
Meeting venue
Delft, the Netherlands
Meeting dates
14–18 March 2016

2 Terms of Reference a) – z)

a) Critically assess relevant temporal and spatial scales in relation to the effects of MREDs on the benthic ecosystem and evaluate the consequences in relation to environmental policy and decision-making;

b) Review progress on filling knowledge gaps relating to the benthic ecosystem including differentiation among MRE technologies using e.g. reports of national activities;

c) Analysis of network and interactions amongst WGMBRED and other relevant groups including regulators, stakeholders, policy makers and scientists, in order to evaluate the impact of MBRED science;

d) Identifying and operationalising relevant indicators in relation to assessing ecosystem functioning and change in relation to MBRED at scales related to ToR A.

3 Summary of Work plan

Year 1   ToR – A, B, C, D

Year 2   ToR – A, B, C, D

Year 3   ToR – A, B, D

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

WGMBRED discussed several aspects in the WG and evaluated which will lead to publications, datasets, methodological developments and advisory products.

- Four main themes were discussed during the meeting, which address the main ToRs of the expert group
    - o scale issues
    - o knowledge improvement related to other devices than offshore wind farms
    - o network analysis of the impact of WGMBRED expert group
    - o the use of indicators
- Significant progress on these topics was made particularly in relation to potential publications and advisory products
- ToR A on scale issues and ToR D on indicators were related to each other and discussed in an complementary way

ToR A: Scale

Current activity:

- Identification and discussion of the relevant temporal and spatial scales in relation to the effects of MREDs on the benthic ecosystem
- Initial consideration of concept to practice, using concrete examples, working towards ecosystem services by tackling spatial and indicator issues first for the three societally important issues defined previously by WGMBRED: biodiversity, biogeochemical reactor and food resources.

Expected output:

- Determination of essential attributes related to scaling up from small-scale effects (in space and time) to see where and when scale becomes relevant for policy and management.
- Evaluation of potential consequences in relation to environmental policy and decision-making

Expected output (year 3):

- Review paper

ToR B: Knowledge improvement

Current activity:

- Review of progress on filling knowledge gaps related to the effects of energy devices on the benthic ecosystem, differentiation between different marine renewable energy device groups: tidal stream and wave energy devices, floating wind farm devices

- Literature review on the three energy device groups to collect available information to ground truth the preliminary prioritisation and to identify knowledge gaps

Expected output:

- Evaluation of the magnitude of the cause-effect relationships of the three device groups on the benthos
- Analysis of potential knowledge gaps via literature review

Expected output (year 3):

- Matrices – updated knowledge base

ToR C: Network

Current activity:

- Initiation of network analysis to evaluate linkages among members of WGMBRED with other groups within ICES and beyond and to identify network gaps of WGMBRED
- Development of a survey to collect information on standard attributes and categories of members according to their institutional affiliation, country of operation, field of interest, operational role (e.g., academic or regulatory) etc.

Expected output:

- Network linkages and attributes of WGMBRED members and other groups within ICES and beyond
- Collated list

Expected output (year 2):

- Network map

ToR D: Indicator

Current activity:

- Proof of Concept for a scale and indicator development using three different case studies: the Baltic Sea, the Irish and western British coasts and the North Sea

Expected output:

- Specified indicators for specific cause-effect-relationships caused by renewable energy devices on the benthos on ecologically relevant scales

Expected output (year 3):

- Review paper

5 Progress report on ToRs and workplan

5.1 Current work status of the expert group on marine benthal and renewable energy developments

At the start of the inaugural meeting, Andrew B. Gill (co-chair) and Jennifer Dannheim (co-chair) welcomed the 22 participants representing seven countries and thanked Arjen Boon (Deltares) and Joop W.P. Colen (IMARES) for hosting the meeting.

Jennifer Dannheim summarised the work of WGMBRED of the last multi-annual cycle, introduced new challenges for the WGMBRED group as the marine renewable energy sector is rapidly growing. Further, she gave an outlook on the expectation for this meeting concerning scale issues, knowledge improvement, the impact of the expert group's science and the identification of indicators. All this was to be facilitated by the structured agenda, but leaving room for open conversations and discussions. The topics during the meetings are to be tackled by the four multi-annual ToRs (2016–2018):

a) 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;

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

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

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

The group discussed the new challenges by new devices. The discussion circled around different energy devices such as tidal-stream, wave and floating energy devices and potential upcoming constructions for storing energy which are currently under discussion. The group agreed that only already implemented devices will be tackled by the expert group, but no prospective imaginary constructions for energy storage. Further, the group discussed the multi-use of offshore wind farms, e.g. maximize cooperative use such as aquaculture, mussel farms etc., and the potential cumulative effects on the benthic system. Several projects are dealing with this multi-use of offshore wind farms (e.g. Mermaid, projects at SAMS). The group is aware of ongoing initiatives and will discuss these if they become relevant within the specific topics of the groups ToRs.

Andrew Gill summarised the research priorities (and sub priorities) of the ICES Science plan to which the WGMBRED makes a significant contribution. There are:

- 1.1: Climate change processes and predictions of impacts

- 1.3: The role of coastal zone habitat in population dynamics of exploited species

- 2.3: Influence of development of renewable energy resources (e.g. wind, hydropower, tidal and waves) on marine habitat and biota

- 2.4: Population and community level impacts of contaminants, eutrophication, and habitat changes in the coastal zone

This was followed by a summary of the intersessional activities relating to the WG:

- knowledge paper progressing towards final draft
- monitoring paper was submitted but rejected by the Journal of Applied Ecology, a new version of the paper taking into account the user reviewers comments is to be drawn up and submitted to another journal
- keynote presentation to USA Dept of Energy by Andrew
- Tethys webinars (by Andrew, and also Finlay Bennett, Chair of WGMRE)

Finally, the group discussed the agenda that had been drafted prior to the Delft meeting.

5.2   National updates

Germany

The offshore wind farm industry is continuously increasing. Currently, 11 wind farms are operational with 694 turbines. Another 25 wind farms were authorised already comprising another 1440 turbines. Current plans are for a minimum of 36 wind farms with 2134 turbines in total to be installed in the German Exclusive Economic Zone (EEZ). However, there are still applications for further 76 wind farms (6706 turbines) which leads to a maximum of 112 wind farms with 8840 turbines potentially build in the German EEZ (OSPAR citation).

The Alfred Wegener Institute (AWI) has built up an information system on benthic invertebrates from environmental impact assessments (EIA) and research projects.

This information system has been established in close cooperation with the approval authority, the Federal Maritime and Hydrographic Office (BSH). The system serves as an important tool for a high-resolution and large-scale analysis of occurrence and spatial distribution on endangered (red-list) species and biodiversity, biological traits and benthic community. Thus the information system serves to estimate species or group specific "natural corridors of variation" to discriminate anthropogenic effects from natural background variability. As an example, the spatial distribution of red-list species and their most important traits, which might make them more sensitive to anthropogenic impacts, were presented. Further, species rareness and species categorisation into red-list categories were evaluated using the relative abundance model of Preston (1948). The preliminary results showed that not all red-list species are rare and not all rare species were red-list species.

Further, the new project ANKER that will start in 2016 was introduced to the group. This project has the aim of cost reduction approaches and increase in efficiency of monitoring data surveys of offshore projects by using the information system introduced above. This aim will be achieved by establishing a long-term open data service in order to provide stakeholders, such as authorities and scientific institutions, with scientific advice. Study outcomes from analysis based on the information will be made public via the internet (GeoSeaPortal, Marine.Data.Infrastructure Germany, MDI-DE).

Contact: Jennifer Dannheim, Alfred Wegener Institute, Bremerhaven

Germany

Offshore windfarms as lobster habitats. From 2013 till 2015 a lobster settlement project (located at AWI) took place inside the offshore wind farm Riffgat. The main aim of the project is to answer the question if operating offshore wind farms might be used to establish new stocks of the European lobster (*Homarus gammarus*). A successful settlement could support the population of this species which is endangered on a local scale. The wind farm is located inside the southern German Bight approximately eight nautical miles north-westerly of the island Borkum. In 2014 a total of 2400 one-year-old lobsters from the hatchery of the Hummerstation Helgoland had been released at four scour protections of natural rock surrounding the monopiles of the wind turbines. Each lobster was marked to enable identification after release. A baseline study and the first monitoring, one year after the lobster release, were performed systematically by scientific diving and pot fishery on the scour protections. Preliminary results show that operating offshore wind turbines can be inhabited by lobsters. After the first monitoring year, the lobster abundances at the settlement scour protections achieved up to 4.5 times more lobsters per square metre than at the typical natural lobster site at Helgoland. At present long-term monitoring, including the spatial distribution of the lobsters and the additional release of one-year-lobsters is in its planning stage.

Different reef effects of different turbine foundations?

To contribute to the question how the presence of wind turbine foundations might alter the mobile demersal megafauna of the North Sea, the communities at the common types of offshore wind power foundations "jackets" and "tripods" without scour protection and "monopiles with scour protections" have been compared. In the second year after construction it became obvious, that monopiles with scour protections are inhabited by more reef species, such as the edible crab (*Cancer pagurus*) and goldsinny wrasse (*Ctenolabrus rupestris*). However, the typical sand bottom inhabiting gobies (Gobiidae) are nearly excluded by the scour protections. Furthermore, there are first indications for an increased production of *C. pagurus* at the foundations. To improve these predictions long-term monitoring focusing on the development of reef fauna beyond the first years of succession is in its planning stage.

What is coming next?

There are a few natural reef sites (rocky substrate) inside the German Bight. So far it is unknown to what extent the new reef fauna at foundations will be a quantitative or qualitative addition to the established biocoenosis at natural reefs. Therefore, as a further step of the project, the mobile faunal communities at the wind power foundation will be compared with those of the few natural reef sites inside the German Bight.

Contact: Roland Krone, Krone-Projekte, Unternehmen für Meereskunde, Umweltwissenschaften & Technik, Bremerhaven; R. K. and Isabel Schmalenbach, Alfred Wegener Institute, Helgoland

Poland

Marine renewable energy developments in Poland

At the time of writing the report, there are no offshore wind farms in Poland. Initial plans for development of offshore wind farms in the country's marine areas assumed that the capacity of installed wind power is going to be at least 0.5 GW in year 2020 and may reach 6 GW until year 2025. Currently due to ongoing delay in the pre-construction process it is obvious, that these goals will not be achieved and the commissioning of the first wind parks in Polish EEZ has been scheduled for years 2020 and 2023. These two wind parks form only a small part in the plans for offshore wind farms development in Poland. In total 23 sites has been chosen and approved for wind farms construction in three regions: Oder Bank, Słupsk Bank and Middle Bank. Total area of chosen sites comes to 1880 square kilometers.

Previous and ongoing research

Natural hard bottom is very rare in the southern part of the Baltic Sea. Therefore, artificial structures such as offshore wind farms should be concerned as a significant interference in the local marine environment. Large-scale studies on soft sediment benthos were carried out in the past but current Polish monitoring sites are situated far away from the areas planned for wind farms construction. As there are no offshore wind farms in Polish EEZ yet, any research in the area is limited to other artificial hard substrates such as shipwrecks and inactive offshore structures left after the World War II. Experimental hard substrates such as settlement plates are also used during the studies. In year 2012 a pilot study on benthic fauna associated with the artificial hard substrata was carried out in the southern part of the Baltic Sea. Both long-term and short term communities were investigated. The study is described in detail in Brzana R. & Janas U. article "Artificial hard substrate as a habitat for hard bottom benthic assemblages in the southern part of the Baltic Sea – a preliminary study" published in 2016 in volume 45, issue 1 of *Hydrobiological and Oceanological Studies* (pages 121-130).

Ongoing studies focus further on fouling communities and their ecological functioning in comparison to assemblages associated with natural hard bottom. In the future macrobenthic assemblages associated with sandy bottom in the vicinity of the artificial structures will also be investigated. We are planning to investigate an enrichment of soft sediment macrobenthos around offshore manmade structures in the Gulf of Gdańsk, southern Baltic Sea. The research is going to be conducted in similar manner as described by Coates *et al.* (2013) in "Environmental impacts of offshore wind farms in the Belgian part of the North Sea: Learning from the past to optimise future monitoring programmes". Samples are going to be collected around 70-year old foundations of an offshore World War II watchtower, which will allow us to study fully-developed benthic communities. We also plan to collect the samples several times a year in order to describe seasonal changes of the process of organic enrichment.

Contact: Radek Brzana & Urszula Janas, Institute of Oceanography, University of Gdańsk, Gdynia

France

Modelling impacts of offshore wind farms on trophic web: Le Tréport and the Courseulles-sur-mer cases studies. The French government is planning the construction of three offshore wind farms in Normandy. These offshore wind farms will integrate into an ecosystem already subject to a growing number of anthropogenic disturbances such as transportation, fishing, sediment deposit, and sediment extraction. The possible effects of this cumulative stressors on ecosystem functioning are still unknown, but they could impact their resilience, making them susceptible to changes from one stable state to another.

Understanding the behaviour of these marine coastal complex systems is essential in order to anticipate potential state changes, and to implement conservation actions in a sustainable manner. Currently, there are no global and integrated studies on the effects of construction and exploitation of offshore wind farms. Moreover, approaches are generally focused on the conservation of some species or groups of species. Here, we develop a holistic and integrated view of ecosystem impacts through the use of trophic webs modelling tools. Trophic models describe the interaction between biological compartments at different trophic levels and are based on the quantification of flow of energy and matter in ecosystems. They allow the application of numerical methods for the characterization of emergent properties of the ecosystem, also called Ecological Network Analysis (ENA). These indices have been proposed as ecosystem health indicators as they have been demonstrated to be sensitive to different impacts on marine ecosystems. Based on this background, two three year PhDs will focus on an ecosystem approach on the impacts of the Le Tréport and Courseulles-sur-Mer offshore wind farms through the food web. Within these PhD projects, we present in detail the strategy for analysing the potential environmental impacts of the construction of the Courseulles-sur-Mer offshore wind farm (Bay of Seine), such as the reef effect through the use of the Ecopath with Ecosim software. Similar Ecopath simulations will be made in the future on the Le Tréport offshore wind farm site. Moreover, the Ecopath model of the Le Tréport offshore wind farm will be compared with the global functioning of the eastern part of the English Channel for the same habitat.

Results will contribute to a better knowledge of the impacts of the offshore wind farms on ecosystems. They also allow us to define recommendations for environmental managers and industry in terms of monitoring the effects of Marine Renewable Energy, not only locally, but also on other sites, national and European levels. Finally, this approach could contribute to a better social acceptability of Marine Renewable Energy projects allowing a holistic vision of all pressures on ecosystems.

Contact: Jean-Claude Dauvin, Jean-Philippe Pezy & Aurore Raoux, UNICAEN

United Kingdom

Much of the focus of the research in the UK has been on offshore wind farm expansion for a third round of development, particularly in English waters. In the wider UK there have been activities in relation to wave and tidal power. The wave sector has been struggling with two companies recently going into administration. However smaller and more specific wave power generation initiatives have fared better in relation to powering is-

land communities and aquaculture facilities. Tidal stream and barrage developments have been given planning permission in Scotland and Wales, respectively.

From a research perspective, Cranfield University has been working on understanding the interaction between marine renewable energy developments and the marine environment and receptors.

The MaRVEN-project: A review and field study of the environmental impacts of noise, vibrations and EM emissions from marine renewables finished September 2015 and the–: final report is now out. The highlights from the research that are relevant to WGMBRD are that:

- Scale of habitat change and cumulative effects are high priority effects
- The review undertaken included findings of noise impacts on benthos.

  Research priorities are particle motion effects on benthos during construction and also operation at an offshore wind farm & wave device sites.

  A further study priority is to understand the electromagnetic fields (EMFs) that were measured during the MaRVEN project and whether they influence benthic species.

Other projects that are currently underway are:

- BOEM MAGNETIse – EMF effects from HVDC cable on migratory fisheries species, e.g. lobsters and skates which are mobile benthic fauna. A field study using state of the art 3D acoustic tags in the USA (Long Island Sound) is being undertaken in collaboration with the University of Rhode Island and the Swedish Defence Agency (FOI).
- Zoe Hutchison summarised the outcome of her PhD research recently completed at SAMS (Scotland) understanding MRED and the influence of sediment on benthic fauna, in particular bivalve molluscs. Her research has recently been published in peer review journals.
- Edward Willsteed is NERC Case Award with CEFAS PhD student in his 2nd year at Cranfield whose research topic is MRED CEA with the research exploring how scale (spatial and temporal) and perspective (what is being assessed) influence CEA. Research to date has investigated the strengths and weaknesses of different CEA approaches, and has critically evaluated MRED CEAs in UK waters relative to the needs of marine managers seeking to implement the ecosystem approach. The next steps will to analyse if a receptor-led (rather than driver-led) CEA offers insights into setting appropriate CEA boundaries and monitoring for cumulative change.
- Paul Causon is a new PhD student at Cranfield with the Renewable Energy Marine Structures (REMS) doctoral training programme researching fluctuations in inertia and hydrographic loading on wind turbine foundations due to variability in marine growth.

Contact: Andrew Gill, Zoe Hutchison, Ed Willsteed, Paul Causon, Cranfield University, Cranfield, UK

United Kingdom

Identifying risk and opportunities resulting from multiple activities under a changing climate: A case study in the South and East Marine Plan Areas, UK.

The UK Marine Policy Statement requires that the use of the marine area is adequately planned and regulated. This implies that marine plans need to take into account the potential effects of climate change. In addition, marine plans must contain information about overarching climate change policies and should consider appropriate climate change mitigation and adaptation measures. It is acknowledged that seas around the UK have been highlighted as a "hot spot" of marine climate change, having warmed by more than 1ºC over the past 40 years. This rate of increase is more rapid than almost anywhere else on Earth. The combined changes in storminess and ocean acidity have prompted considerable interest among scientists as well as concern among policy makers and industry. It is clear that aquatic organisms and industries are sensitive to climate change; however, the level of knowledge concerning marine climate change impacts is still limited when compared with terrestrial systems. This work aimed to support marine planning, producing appropriate temporal and spatial scales assessments for the East Inshore and Offshore Marine Plan Areas. Our analysis has considered which sectors will be likely to be at risk or to benefit from the effects of climate change, as well as documenting what the impact may be. This assessment has addressed where conflicts between sectors may arise as a result of changing use patterns in response to the impact of climate change. The overall work provides specific recommendations at potential climate change effects across sectors for the East Inshore and Offshore Marine Plan Areas and South Inshore and Offshore Marine Plan Areas with targeted climate adaptation and mitigation advice. We believe, this work has wider applications for several marine areas, particularly on the context of the EU MSFD, where there is a need to understand 'prevailing conditions' to ensure that marine systems are used in a sustainable manner.

Key words: Marine Spatial Planning, climate change, risks, opportunities, human activities.

Contact: Silvana Birchenough, Centre for Environment, Fisheries and Aquaculture Science (Cefas)

United Kingdom

CEFOW H2020 – Clean Energy From Ocean Waves

The CEFOW project has been put on hold for up to 10 weeks, so that investigations can be made to find the best possible technical solution for subsea cabling.

Contact: Emma Sheehan, Plymouth University

Belgium

At present, 2.5 wind farms operate in Belgian waters, representing about 700 MW of renewable energy. The second half of the third wind farm will be constructed in 2016, after which another five wind farms will be constructed in 2017/2018 (or beyond). In total, these wind farms will represent ~ 2000 MW of offshore renewable energy.

The basic monitoring programme was revisited at the end of 2014, aiming at streamlining the monitoring across ecosystem components. When streamlining a differentiation between the benthic and the pelagic environment was made. The benthic environment is represented by the soft sediment sedimentary conditions, the (macro)infauna, epifauna and demersal fish, as well as the artificial hard substrate (macro)epifauna and fish. The hyperbenthos, pelagic fish, marine mammals, birds and bats, together with underwater sound feature the pelagic realm. Within each realm the monitoring programme is now streamlined in terms of e.g. timing of sampling (as to increase compatibility of the data) and target monitoring questions (e.g. effects of distance to wind turbine, foundation type and distance to the shore. A detailed report on the new Belgian basic monitoring programme will be published in this year's WinMon.BE report (Degraer *et al.*, in prep.) and is implemented since 2015.

Recently, targeted monitoring activities were lowered given the temporarily reduced financial means for Belgian offshore wind farms. This notwithstanding, externally financed research focused on (1) the impact of impulsive underwater sound on larval and juvenile fish (Debusschere, 2016), funded by the Agency for Innovation by Science and Technology, (2) the spatial upscaling of offshore wind farm impacts onto ecosystem functioning (i.e. food webs and biogeochemistry; project FaCE-It), financed by the Belgian Science Policy, and (3) the stepping stone potential of offshore wind farms in the southern North Sea (project UNDINE; see also below), financed by INSITE. The Belgian targeted monitoring also established links with the project TROPHIK (University of Caen), modelling ecosystem impacts of offshore wind farms and other human activities using Ecopath, Ecosim and Ecospace modelling.

Literature: Debusschere, E. (2016). On the effects of high intensity impulsive sound on young European sea bass Dicentrachus labrax, with special attention to pile driving during offshore wind farm construction. PhD thesis, Ghent University. 200 pp.

Contact: Steven Degraer, RBINS

Belgium

A new sampling strategy for monitoring the macrobenthos inside offshore wind farms has been adopted. A distinction is made between close (50m from turbine) and far (300–500 m from turbine) samples. In addition, there are impact and control samples. The combination of close-far and impact-control allows us to investigate both the wind farm and the turbine effect.

In relation to fish (of interest as they feed on macrobenthos) is the existence of an acoustic telemetry network in the Belgian part of the North Sea and the Westernscheldt estuary (http://www.lifewatch.be/en/fish-acoustic-receiver-network). This network allows flexible and cost-efficient spatio-temporal tracking of migratory fish species. It can provide detailed observations of animal movements and behaviour in relation to the aquatic environment and it significantly improves our understanding of ecosystem functioning and dynamics.

Contact: Jan Reubens, University Ghent

Scotland

The Maygen development continues, with the objective of generating 398MW from off-shore tidal stream energy by 2020. Grid connections are established and the project is on course to be the first commercial tidal generation of power in the UK. Offshore wind-power developments continue, for example Beatrice Offshore Windfarm is consented and will consist of 84 x 7 MW turbines. Total cost ~£2B, about £3-5M was spent on pre-deployment survey. Main (benthic) issues identified were in relation to cod and herring spawning.

Scotland has introduced the 'SpORRAN' network to bring together, and co-ordinate research into Marine renewables and their impacts: Tom Wilding (SAMS) and Andrew Gill (Cranfield Univ) sit on the benthic sub-group which is chaired by Mike Robertson (MSS).

Contact: Tom Wilding, Scottish Marine Institute

The Netherlands

Current state of offshore wind farms in the Netherlands: The third Dutch OWF Luchter-duin (off the coast of North-Holland province) has been finished, No. 4 GEMINI (ca. 80 km north of Groningen province) is about to be finished. These are windfarms from the second round of licensing. Other licenses for the second round consenting have not yet led to construction plans, mostly due to lack of financing. The third consenting round has started, with licenses being awarded for a large consenting area in the southwest of the Netherlands, Borssele, bordering the Belgian border.

Projects we have taken part in:

MERMAID: Innovative Multi-purpose offshore platforms: planning, design & operation. Studied the development of concepts for and the socio-economic and environmental effects of multi-purpose offshore wind platforms. Finished 2016.

Workshop on Cumulative Effect Assessments: Joint Governmental Offshore Renewables Group focusing on developing ambition level and framework for assessing the cumulative effects of offshore windfarms on the environment; focus on birds and mammals.

Short study on potential effect artificial reefs on biodiversity North Sea, including off-shore wind farms.

Cooperation with Joop Coolen, IMARES on study to the connectivity of offshore hard structures through relating mussel genetics to hydrodynamics in the North Sea.

Contact: Arjen Boon, Deltares Research Institute

The Netherlands

RECON: Reef effects of structures in the North Sea: Islands or connections?

The aim of this study is to investigate and model the species distribution and inter-connectivity of reef communities on artificial offshore structures in the North Sea, using different techniques.

First, the study provides community data from taxonomic species inventories. Second, a cost efficient method for inventory of communities is developed using state-of-the-art DNA metabarcoding. Third, the genetic population structures of the mussel *Mytilus edulis* and crustacean *Jassa herdmani*, abundant invertebrates with different dispersal strategies, are analysed. Ultimately, the data from this study and other available data are used to model the distribution of species on offshore structures and their inter-connectedness.

Main questions:

1) What is the species composition of marine growth on offshore structures?

2) To what extent is this composition explained by abiotic factors (e.g. depth, temperature, location, platforms age, marine growth cleaning frequency) and biotic factors (e.g. food availability, proximity to marine growth on other off-shore structures, distance to coastal populations)?

3) To what extent are the communities on the structures isolated from or con-nected to each other and how is this explained by the factors noted earlier?

Methods

In addition to analysing existing footage collected with remotely operated vehicles, we carry out fieldwork in a highly cost efficient manner, using fully equipped mobilized diving-vessels already present at offshore installations for regular inspection and maintenance work.

Biodiversity and multifunctional use of old production platforms and new offshore wind farms

The aim of this study is to study the effect of hard substrates on biodiversity.

Offshore structures in the Dutch North Sea provide a habitat for a range of species such as anemones, soft corals, edible crabs and many others that are not found elsewhere on the predominantly sandy seafloor. Up to date, very little is known about the species community that is associated with hard substrates in our sea. Parameters such as species richness, biomass and role in the food web remain to be elucidated. In the past, large oyster beds, peat banks as well as stones and rocks originating from glaciers covered large parts of our seafloor. Most of these have now disappeared. In recent decades how-ever, new hard substrates have been introduced. Would these platforms, wind farms and shipwrecks enrich the North Sea biodiversity in a similar way?

The aim of this study is to fill that gap in our knowledge: to study the effect of hard substrates on biodiversity. We want to investigate the role of hard substrates as stepping stones for certain species, and the potential of hard substrates for marine production such as aquaculture of mussels. An important part of the study will focus on the question whether decommissioned platforms can be deployed as artificial reefs to increase biodiversity (rigs-to-reefs).

Results will be made public in a dissertation, peer-reviewed articles, as well as through social media and other dissemination platforms.

Recent publications/presentations:

Coolen, Joop W P Bos, Oscar G Glorius, Sander Lengkeek, Wouter Cuperus, Joël Van Der Weide, Babeth Agüera, Antonio (2015) Reefs, sand and reef-like sand: A comparison of the benthic biodiversity of habitats in the Dutch Borkum Reef Grounds ; Journal of Sea Research

van der Stap, T.; Coolen, J.W.P.; Lindeboom, H.J. (2016) Marine Fouling Assemblages on Offshore Gas Platforms in the Southern North Sea: Effects of Depth and Distance from Shore on Biodiversity; PLoS ONE

Coolen, J.WP., Lengkeek, W., Lewis, G., Bos, O.G., van Walraven, L., van Dongen (2015) First record of Caryophyllia smithii in the central southern North Sea: artificial reefs affect range extensions of sessile benthic species; Marine Biodiversity Records

JWP Coolen, H Lindeboom, J Cuperus, B van der Weide, T van der Stap (2015) Benthic communities on old gas platforms as predictors for new offshore wind farms; Conference on Wind Energy and Wildlife Impacts 2015

Contact: Joop Coolen, IMARES

International Project UNDINE

As one of the first projects with an international scope, the UNDINE project will focus on potential offshore wind farm projects across borders covering the whole southern North Sea, i.e. Belgium, Dutch, British and German waters. UNDINE will evaluate (i) the ecological impact of man-made structures on trophic functioning and (ii) potential changes in connectivity by man-made structures using dispersion models validated by genetic population structure. Trophic functioning and connectivity are considered key issues as man-made structures start proliferating in the marine environment. They necessitate the extrapolation of artificial hard substrate effects from local to regional scales, all of which will be tackled by UNDINE. This research will synthesize and integrate state of the art knowledge to understand ecosystem structure and functioning. This will be useful for a sustainable management of North Sea ecosystems, especially in relation to hard substrate habitats. Additionally, UNDINE will identify knowledge gaps and provide scientific recommendations for future research priorities.

UNDINE will use offshore wind farms and data from other man-made structures in order to understand the ecological impact of man-made structures. Particularly, the high amount of high-quality data from offshore wind farms monitoring programmes will be of use here. UNDINE's approach of combining different datasets will ensure its outcomes to be transferable to a more generic man-made structure effect context.

UNDINE is funded by the INSITE initiative and is a joint project of the Royal Belgian Institute of Natural Sciences (RBINS), Centre for Environment, Fisheries & Aquaculture Science (Cefas), IMARES Wageningen UR and the Alfred Wegener Institute (AWI).

Contact: Jennifer Dannheim, Alfred Wegener Institute, Bremerhaven

5.3 Wrap up of monitoring and knowledge publications of the 1st multiannual cycle – state of the art

A morning session was held to discuss the Monitoring Group's review paper titled 'Turning off the DRIP ('Data-rich, information-poor') – rationalising benthic-related assessments around marine renewable energy developments' with particular focus on the issue of scale. Designating appropriate scales for monitoring programmes is a challenge particularly when assessing change at lower trophic levels where population boundaries are often poorly defined/understood or highly variable and where species are migratory and/or exhibit considerable ontogenetic changes in habitat utilisation (i.e. have a planktonic stage). What constitutes an appropriate scale to which inference should be made will, in part, be determined by the relevant regulatory framework: these may include locally agreed scales e.g. bays or inlets to regional-sea scale multinational agreements (e.g. EU MSFD). From an ecosystem perspective geopolitical boundaries may be useful (e.g. MSFD Baltic and Celtic Sea sub-regions) but only where they coincide with eco/hydrologically defined boundaries that are relevant to the distribution of the species under investigation. The scale issue was discussed in relation to structure colonisation, non-indigenous species, biodiversity and fisheries exclusion.

The monitoring paper (Wilding et al) was submitted to the Journal of Applied Ecology but rejected after review. Two referees commented, one was positive, another negative,. Discussion followed about further development of the paper and approach for submitting elsewhere:

- Focus should be on threshold development and issues with null hypothesis significance testing (NHST);
- Thresholds are, conceptually, relatively easy to specify in relation to birds and mammals (e.g. prevent 'local' extinction), but less so for benthos;
- Threshold issue: two schools of thought in the outside world: one wanting to use the pre-industrial baseline, and the other wanting to use the 1980s baseline. Currently there are no thresholds;
- Suggestion is to use concept from 'novel ecosystems' approach in restoration ecology. They use trajectories;
- OSPAR has an overview of the different types of thresholds, see figure below.
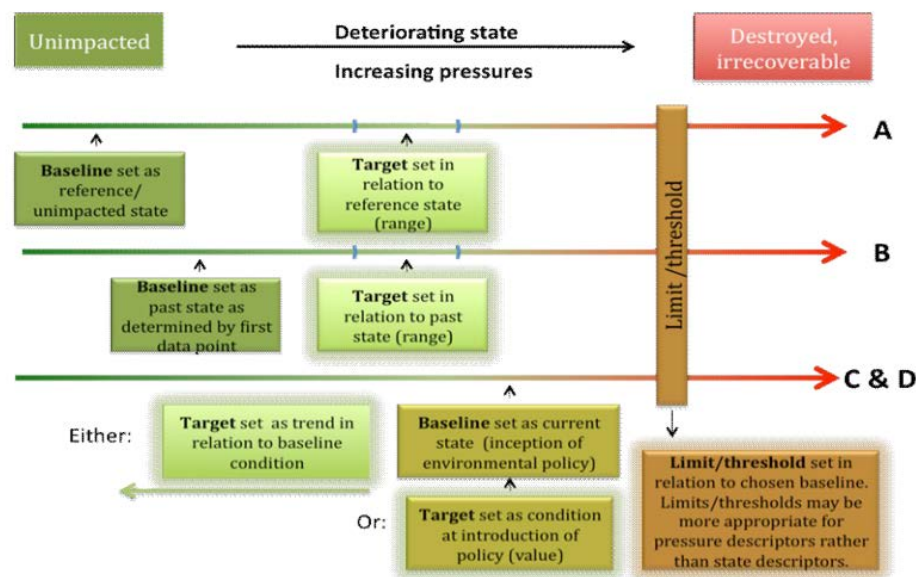
The conceptual relationship between reference and baseline conditions, targets and limits. Environmental status can be considered as a gradation from unimpacted conditions to destroyed or an irrecoverable state (top of figure). Assessment systems variously set reference, baseline, target or limit points (or ranges) along this gradient to assist in status assessment and for monitoring progress against time and actions. Here four different approaches are shown (A, B, C, D). From: OSPAR (2011). OSPAR's MSFD advice manual on biodiversity. Approaches to determining Good Environmental Status, setting of environmental targets and selecting indicators for Marine Strategy Framework Directive descriptors 1, 2, 4 and 6. Draft 1, BDC 11/4/3-E.

- Benthic metric selection needs to be updated; there is more space to do that in the new version of the paper.

- There was a lot of discussion about target setting and objectives for MSFD Good Environmental Status but it was recognised that the main regulation for individual wind farms relates to the Birds and Habitats Directives (in Europe).

- Some discussion about the figures in the paper; Tom Wilding (lead author) included a new figure on truth inflation vs Type II errors, which is very illuminating.

- Flow of the paper needs to be improved.

- Figure with phases needs to be adapted, and in case of lack of threshold, monitoring and data need to be placed in context of knowledge development, so it is not drippy. The same applies for the NO from 'Feasible monitoring'; needs to be reconsidered to reconnect.

- Further discussion was had about the need to ensure that monitoring data are made publically available and is of a quality that helps parameterise ecosystem models.

These comments were agreed upon and a new version of the paper was planned to be put together after the Delft workshop, with particular parts allocated to different WG members. Tom Wilding will continue to co-ordinate and lead in publication preparation.

The Knowledge group reviewed the progress made on the manuscript since the last meeting. Having conducted a substantial literature review involving many participants, Jennifer Dannheim, Angus Jackson and Steven Degraer prepared a manuscript. The first three chapters were linked to the three Societally Important Issues (SII's); the biogeo-chemical reactor, food resources and biodiversity, highlighting the importance of ben-thos. The second part of the manuscript summarises the identification and prioritization of knowledge gaps by assessing potential impact sizes of MRED on benthos. The general outline of the manuscript was presented together with analysis of the results from the scoring for prioritisation of knowledge gaps. Figures of the manuscript prepared in-tersessionally were reviewed by the expertise of WGMBRED members. The remaining tasks to bring the manuscript to full draft for submission to Renewable and Sustainable Energy Reviews were identified and split between co-authors of the manuscript. After finishing all outstanding tasks the complete manuscript will be circulated by the key writers to the broader group.

5.4   ToR A: Scale issues

ToR A – Critically assess relevant temporal and spatial scales in relation to the effects of MREDs on the benthic ecosystem and evaluate the consequences in relation to environ-mental policy and decision-making

Topic: what are relevant scales for the benthos and how to link them to policies and legis-lation?
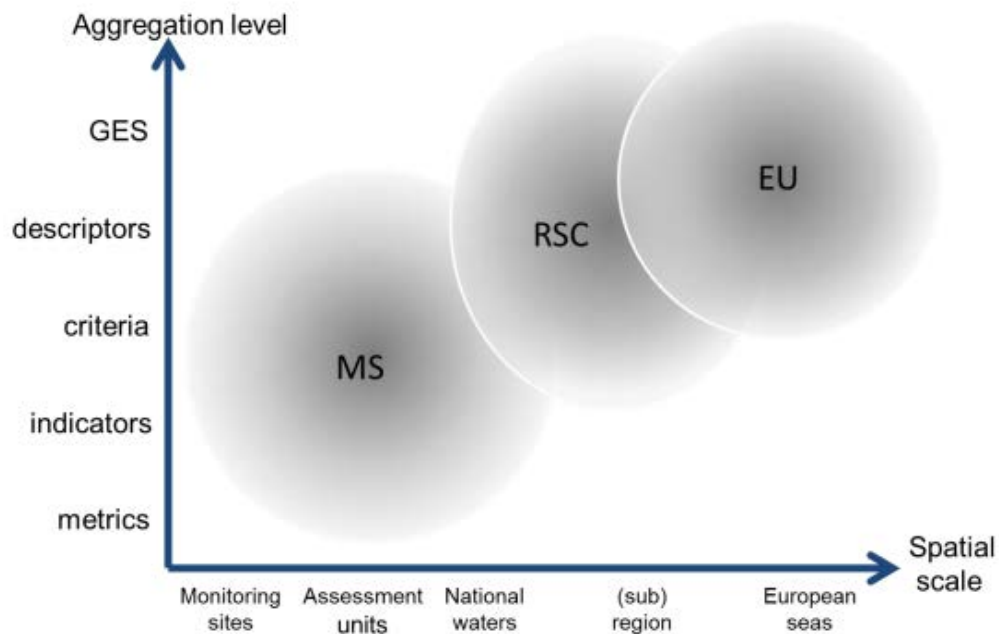
The diagram above shows differences in information needs and associated spatial scales and aggrega-tion levels (From: Prins *et al.* (2014) Coherent geographic scales and aggregation rules for environmen-tal status assessment within the Marine Strategy Framework Directive - Towards a Guidance document, Deltares report 1207879-000).

The diagram is useful when considering scale as it highlights:

- Issues: classify/organize; criteria for relevance needed; boundaries between natural scales and influences artificial substrates; connectivity would be specifically relevant for benthic environment.
- Biogeochemical processes would also play a role at larger spatial scales.
- Temporal and spatial scales are linked to disturbance and recovery processes.
- Critical distances are important in connectivity issues, linked to hydrographical scales.
- Other important processes that are affected by spatial scale: biomass redistribution and aggregation.

As a WG, our task is to scale up from small-scale effects (in space and time) and determine if this becomes relevant for policy and management, mostly by thought experiments, but validation would be needed (perhaps through modelling): from concept to practice, using concrete examples, working towards ecosystem services and tackle spatial issues and indicator issue first for the three ecosystem effect groups: biodiversity, biogeochemical reactor and food resources.

These aspects were agreed as important for the WG to keep in mind for the rest of the workshop discussions on ToR A focussing on scale to move us forward in the second, three year term of WGMBRED.

5.5   ToR B: Knowledge improvement

ToR B: Review progress on filling knowledge gaps relating to the benthic ecosystem including differentiation among MRE technologies using e.g. reports of national activities

During the last multi-annual cycle, WGMBRED has worked on the identification of knowledge gaps for understanding of the various effects of marine energy developments on the marine benthos as well as on the whole ecosystem. WGMBRED developed a set of hypothesis-driven pathways based on the schematic presentations of cause–effect-relationships to subsequently provide a list of prioritized hypotheses and evaluated what and how much knowledge on related topics (e.g. artificial reefs) contribute to the issue of effects of renewable energy constructions (WGMBRED, ICES 2015). Jennifer Dannheim gave an overview on the outcomes of the last multi-annual cycle. However, the effects of marine energy developments on the benthos were mainly related to offshore wind farms in the past. Thus WGMBRED will carry out a review progress on filling knowledge gaps relating to the benthic ecosystem including differentiation among other MRE technologies other devices such as tidal stream and wave energy devices, as well as floating wind farm devices using e.g. reports of national activities. The expert group has good knowledge on the number, scale and effects of these devices and how these can be linked to the developed causal network. Based on the hypothesis developed during the last three years (WGMBRED, ICES 2015), the group carried out a preliminary scoring the cause-effect-relationships by a system of 1 to 3 (1= lowest to 3 = highest relevance) following the scheme of the WKEOMB meeting (WKEOMB, ICES 2012).

This scoring is meant to be preliminary which will serve for a further, more detailed evaluation of the effect magnitude of the devices on benthos in the following year. The group split into three groups to score the three devices: tidal stream, wave and floating wind farm devices. The group focused on the device differentiation with particular em-

phasis on noise, electromagnetic fields (EMF) and non-endemic invasive species (NIS) colonisation. Energy emissions in the form of noise and EMFs were identified as an important under-research topic in the context of MRE devices. The risk of NIS colonisation was considered, as this impact was expected to be large for the floating devices, in combination with shipping and transportation, as NIS are dependent on clear water and hard substrates. The outcomes of the preliminary evaluation of the different devices are summarised in Table 1.

The expert group will carry out a literature review and collect available information on the three energy devices intersessionally which will serve to ground truth the preliminary scoring and to identify knowledge gaps by the expert group.

Literature

ICES. 2012. Report of the Workshop on Effects of Offshore Windfarms on Marine Benthos - Facilitating a closer international collaboration throughout the North Atlantic Region (WKEOMB), 27–30 March 2012, Bremerhaven, Germany. ICES CM 2012/SSGEF:13. 57 pp.

ICES. 2015. Report of the Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED), 21–25 April 2015, Oban, Scotland, United Kingdom. ICES CM 2015/SSGEPI:17. 49 pp.

Table 1. Preliminary prioritisation scoring of cause-effect-relationships in the benthal affected by construction/operation of wave energy, tidal and floating wind farm devices in relation to major societally important issues (biological resources, biogeochemical reactor, biodiversity). Scoring = 1 lowest to 3 highest relevance, ER = ecological relevance within each issue/topic ('+++'highest to '+'lowest priority), L = effects only on local scale.

Overarching topics	Hypothesis	Wave energy devices		Tidal devices				Floating wind farm devices	
		floating	fixed	anchored	piled/drilled	gravity based	remarks	floating	remarks
Artificial reef effect	Altered food availability to filter-feeders	1,2	2	1	2	3		1	on biodiversity
Artificial reef effect	Colonisation by non-indigenous species through transport on shipping, ballast water, translocated equipment	3	3	3	2	2	position in water column and likelihood of device movement will heavily influence	3+	likely high owing to movement to/from port on biodiversity
Artificial reef effect	Modified currents/ hydrodynamic conditions will determine settlement success and species occurences in the surrounding natural substrates.	1	3	2	3			1	on biodiversity
Artificial reef effect	Three-dimensional artificial structures which extend through the entire water column will affect local hydrodynamic conditions such as tidal and wind induced currents.	1 (L)	3	n/a	3	n/a			Maybe a lesser interaction depending on clearance from seabed
Artificial reef effect	Suspension-feeding fouling organisms extract plankton and suspended matter from the water column and thereby decreasing turbidity.	1,2	2	1	1	1	very strong current may reduce influence		extremely low level effect given water volume

Overarching topics	Hypothesis	Wave energy devices		Tidal devices				Floating wind farm devices	
		floating	fixed	anchored	piled/drilled	gravity based	remarks	floating	remarks
Artificial reef effect	The addition of artificial hard structures will change the morphology and the complexity of benthic habitats. Alters types and amount of habitat	1	3	1	2	3	dependent on device - some add/lose habitat and have different spatial coverage	1 (L)	partitioned effect with anchors similar to aquaculture cage moorings, on biodiversity and biogeochemical reactions
Artificial reef effect	Organisms from higher trophic levels (e.g. fish) are attracted/aggregated to/at the physical artificial structures for shelter.	1	3	2	2	2	attraction to artificial reef but also hydrodynamics & food		
Artificial reef effect	Organisms from higher trophic levels forage on the assemblages on the artificial structures and in the surrounding natural habitats.	1	3	2	2	2		1 (L)	on food web ressources
Artificial reef effect	Hard-substrate fauna will profit from opportunities in natural habitats and vice versa	1	3	1	3	3	anchored devices could have extensive buoys associated with them >20	2	going to/from port on biodiversity

Overarching topics	Hypothesis	Wave energy devices		Tidal devices				Floating wind farm devices	
		floating	fixed	anchored	piled/drilled	gravity based	remarks	floating	remarks
Artificial reef effect	A specific hard bottom assemblage (fouling and mobile megafauna) consisting of primary and secondary producers will colonise the new and complex artificial habitat.	2	3	1	3	3		2	on biogeochemical reactions, biodiversity and food resources
Artificial reef effect	Export of organic matter released by the fouling and megafauna community on the artificial structure provides food for benthic communities in the nearby natural substrate.	2	3	1	3	3		2	on biogeochemical reactions and food resources
Artificial reef effect	Fouling organisms themselves, such as mussels, increase structural complexity of the artificial habitat, thereby providing settlement space for other benthic organisms.	1	3	2	3	3		3	effects on biodiversity and food resources
Artificial reef effect	Altered rates of sedimentation (influences benthic anoxia, anaerobiosis and presence of H2S). Released organic material from the accumulated fouling community on the artificial structure become deposited in the nearby sediments. Bacteria decomposition is accompanied by oxygen depletion and release of toxic H2S in the structures surrounding.	1	1-2	1	1	1	less important at the site but more important downstream/upstream	1	effects on biodiversity and biogeochemical reactions

Overarching topics	Hypothesis	Wave energy devices		Tidal devices				Floating wind farm devices	
		floating	fixed	anchored	piled/drilled	gravity based	remarks	floating	remarks
Artificial reef effect	Deposition of particles from fouling assemblages such as shell debris alters granulometry of nearby sediments.	2	3	1	1	1	see above	1	effects on biodiversity and biogeochemical reactions
Artificial reef effect	Changes in the current conditions/altered hydrodynamics resuspend fine inorganic and organic sediment fractions in the water column and cause scour effects .	1	3	1	3	3	scour may be considered differently for anchored device		
Artificial reef effect	Anaerobic and/or toxic (H2S) conditions in the surrounding sediment of the structure cause organisms mortality in adjacent natural habitats.	0	1-2	1	1	1	v. tidal/high flow		
Artificial reef effect	Changes in benthic anoxia affects mortality/colonisation of natural habitats	0	1-2	1	1	1			
Artificial reef effect	Changes in water flow can lead to turbulences that cause resuspension of fine sediment fractions. The export of fine sediments will cause scour and select for coarse sediment in the surrounding of the artificial structures.	1 (L)	3	1	1	1	site/context specific		
Introduction of energy effects	Vibration and noise might induce avoidance behaviour and reduce fitness of sensitive organisms, thereby potentially changing population	3	3	1	1	1	construction only/site specific	1 (L)	effects on food web resources

Overarching topics	Hypothesis	Wave energy devices		Tidal devices					Floating wind farm devices	
		floating	fixed	anchored	piled/drilled	gravity based	remarks		floating	remarks
	structure and distribution patterns									
Introduction of energy effects	Shipping noise: Construction activities, operation of devices and shipping (e.g. for maintenance purposes) cause vibration and noise of various frequencies and intensities that might affect performance and behaviour of sound-sensitive organisms.	3	3	1	2	2			1	construction period mainly effects on biodiversity and food resources
Introduction of energy effects	Construction noise: Construction activities, operation of devices and shipping (e.g. for maintenance purposes) cause vibration and noise of various frequencies and intensities that might affect performance and behaviour of sound-sensitive organisms.	2	3	1	3	2			2	effects on biodiversity and food resources
Introduction of energy effects	Operational noise: Construction activities, operation of devices and shipping (e.g. for maintenance purposes) cause vibration and noise of various frequencies and intensities that might affect performance and behaviour of sound-sensitive organisms.	3	3	1	1	1			1	effects on biodiversity and food resources

Overarching topics	Hypothesis	Wave energy devices		Tidal devices				Floating wind farm devices	
		floating	fixed	anchored	piled/drilled	gravity based	remarks	floating	remarks
Introduction of energy effects	Electromagnetic fields might affect the migratory behaviour of sensitive species thereby potentially changing population structure and distribution patterns.	3	3	1	1	1	unknown/specific	1	
Introduction of energy effects	Conduction of electricity through high-voltage cables induce electromagnetic fields.	3	3	3	3	3		1	with more turbines and cables in water column likely to be higher score, effects on food resources
Introduction of energy effects	Direct mortality or reduction in fitness through damage caused by sound waves of the natural substrates. Changes in distribution: introduced noise will cause distribution changes in natural and artificial hard-substrate fauna	2	3	1	3	1	pile/driving specific	1	effects on biodiversity
Mechanical sea-floor disturbance	Turbidity caused by suspended matter reduces light penetration into the water column thereby reducing the primary production of photosynthetically active phytoplankton.	1,2	2	1	1	1		1	anchor chain drag, effects on biogeochemical reactions
Mechanical sea-floor disturbance	Change in sediments cause changes in diversity	1	3	2	2	2	spatialy and temporaly variable	1	anchor chain drag, effects on biodiversity
Mechanical sea-floor	Direct mortality, reduction in fitness or altered function through removal,	1	3	2	2	2	spatialy and temporaly variable		

Overarching topics	Hypothesis	Wave energy devices		Tidal devices				Floating wind farm devices	
		floating	fixed	anchored	piled/drilled	gravity based	remarks	floating	remarks
disturbance	abrasion, smothering, or increased sedimentation.								
Mechanical sea-floor disturbance	Benthic species are sensitive to sediment conditions and thus community structure and function will change in response to the altered habitat.	1	3	2	2	2			
Mechanical sea-floor disturbance	Sediment disturbance such as dredging and cable laying during the construction phase will resuspend formerly deposited organic matter from the sediment.	2	3	2	2	2	further afield	1	only if cables are buried, effects on biogeochemical reactions
Mechanical sea-floor disturbance	Disturbance of the sea floor by dredging, disposal of extracted sediment and cable laying will change the granulometry of local sediments and thus benthic habitats.	2	3	2	2	2	cable laying further afield but localised to the cable	1	Only if cables are buried, effects on biogeochemical reactions and biodiversity

5.6   ToR C: Network

ToR C: Analysis of network and interactions amongst WGMBRED and other relevant groups including regulators, stakeholders, policy makers and scientists, in order to evaluate the impact of MBRED science.

The broad purpose of this term of reference is to generate a database of connectivity among scientists working on interactions of MRED with benthic ecosystems. The ultimate goal is to coordinate efforts among MRED scientists, to avoid redundancy of effort and to generate a wider international interest in the subject area with a view to informing and provide science-based evidence to policy makers and regulators.

An initial goal and output of this work package is to identify the linkages among members of WGMBRED with other groups within ICES and beyond. Another output is the identification of linkages with other groups outside of ICES community and establish the strength of these links with a view to identifying network gaps. To carry out this task it is proposed to conduct Network Analysis. Network analysis allows linkages to be identified among individuals or groups based upon a defined set of criteria or attributes. The attributes can range from a singular to multiple criteria and can include broad categories such as, country and institutional affiliation to more detailed features such as specific research topics, e.g. reproductive biology of bivalve molluscs. The analysis also allows strengths among groups to be established.

An overview of Network Analysis was presented by Tom Wilding (Scotland) whereby a preliminary output of connectivity between WGMBRED members. The initial analysis highlighted some interesting outputs between WGMBRED and other ICES experts groups. Of particular interest was there was no 'formal' link between WGMBRED and WG Marine Renewable Energy. Some linkages were identified between WGMRED and the Benthos Ecology WG. These results are only considered preliminary and are subject to data review for completeness and validation. What is critical is the type and quantity of data that is used for analysis as well as how these data are collected? In order to gather relevant information, it is proposed to design a survey which would allow critical pathways among members and groups to be identified on the basis of a range of attributes. A number of standard attributes have already been proposed whereby the members are categorised according to their institutional affiliation and country of operation. Others include field of interest, operational role (e.g., academic or regulatory). In order to expand the categories in the dataset, discussion centred on the applicability of the existing categories (attributes) and their applicability with regard to data generation and if others (i.e. attributes) can be included in the analysis.

A number of new attributes were discussed and a number of recommendations were proposed for the creation of new ones and to modify/expand existing ones.

1) For categorisation of members (operational role) existing categories include, e.g. Academia, regulator, etc. It was proposed that the following be added to this list: NGO, Private individual, Consultancy, Scientific Advisor

   It was further agreed that the Scientific Advisor be subcategorised into the bodies for which advice is created, e.g., regulators, industry, policy generators and that the extent of advice be quantified (either by absolute numbers or frequency of contact weekly, monthly etc.

2) It was agreed that a new category be created (Working Group Affiliation) in order to identify the membership of individuals with working groups within ICES or national or international bodies, e.g. OSPAR.

3) For the attribute Field of Interest, it was agreed that multiple research areas be selectable by survey participants, in order to capture, as much as possible, the cross-disciplinary nature of the research conducted by members of various groups.

4) A new category was created (Outreach) that identifies the primary communication mechanism used to disseminate information or data, e.g., media outlets, primary literature, 'grey' literature.

These tasks would be undertaken intersessionally by the group and led by Tom Wilding (SAMS, Oban, Scotland). In addition, a small subgroup, comprising members from each participating country in WGMBRED, would provide iterative feedback on the survey as it is developed. The purpose is to develop the survey so that it is fit-for-purpose for wider circulation and data generation. The members of the sub-group are: Tom Wilding (Scotland) – Lead, Arjen Boon (Netherlands), Silvana Birchenough (England), Liis Rostin (Estonia), Francis O'Beirn (Ireland), Urszula Janas (Poland), Steven Degraer (Belgium), Aurore Raoux (France) and Jennifer Dannheim (Germany).

It was agreed that WG members should be on the lookout for potential funding source(s) in order to assist with this work.

Upon completion of the testing phase the survey would be circulated to the wider group for completion and circulation to the wider research and regulatory community with an interest in MREDs. The progress of the survey development and initial results will be discussed at WGMBRED 2017.

5.7   ToR D: Indicators

ToR D: Identifying and operationalising relevant indicators in relation to assessing ecosystem functioning and change in relation to MBRED at scales related to ToR A.

An overview of indicators was provided by Jennifer Dannheim in order to introduce the topic. In brief, indicators can be split into three groups; classical indicators, regulatoral structural indicators and functional indicators. Some examples of these and their uses were presented. The group participated in an extensive discussion regarding the information that was to be gained by the application of indicators which is inherent in the identification of suitable indicators. It was acknowledged that ICES 2010 had already provided a thorough review of indicators and their application and OSPAR also provided recommendations. WGMBRED decided to screen this literature to avoid duplication of work. It was suggested that ecological indicators could be used to help define the ecological and societally important issues (SII) that were identified by the knowledge group (WGMBRED, see ICES 2015), but was cautioned that we should not attempt to establish true ecosystem services since this was not the expertise in the group.

Discussions included the application of indicators to determine when a functional ecosystem was established over a temporal scale. This brought into question what would be defined as a functional ecosystem and the need for a sensible and useful end point in an analysis. A meta-analysis was suggested where the different indicators in use in different MRED developments were identified. These could then be applied to a case study and critique of the information gained and changes in community and function were established. The endpoint would be an assessment of what was missing and where to focus for improvement of the process. A slightly different approach was to assess what was in use and what information was gained, which would lead to advice regarding what is most appropriate and why, which could then be demonstrated in a case study. The conclusion of the discussion was that the trajectory of the exercise would likely

change as we progressed and that the suggested routes were not necessarily isolated from each other.

As a first start to tackle the indicator ToR, the group split into three groups covering different geographical region of interest in the development of marine renewable energy. The regions provided case studies for the application of indicators relating to the Societally Important Issues (SII's, ICES 2015) whilst incorporating cumulative effects, connectivity and scale. The three SII's are the biogeochemical reactor, food resources and biodiversity.

The three regions chosen were the Baltic Sea, the area of western British coasts and Ireland which chose a development in the Irish Sea and the North Sea. Each group worked to the following outline:

Process Proof of Concept Scale & Indicator development

1) Choose relevant site;

2) Start with pressure classifications (Bergström *et al.* 2014): Artificial reef effect, Fisheries exclusion, introduction of energy and sound, Mechanical sea floor disturbance;

3) Link those to each of the three SII;

4) critical path analysis: looking at cause-effect relations and the parameters best describing the cause-effect relations in space and time; look at pathways choose relevant process in the pathway to be discussed (include connectivity, scale);

5) Leading to proof of concept for indicator selection and scale issues.

Each group developed a concept of scale and indicator developments for the three case studies and the outcomes were discussed between experts of WGMBRED. Below the three case studies are characterised.

Case Study: Baltic Sea

Background: The Baltic Sea has an impoverished brackish fauna which is sensitive to invasive species. Invasive species are represented already in Baltic soft and hard substrate. There is little diversity so stability is maintained with few species. Spreading of species is restricted as salinity gradient/reduction inhibits reproduction in certain regions and currents are only wind driven, i.e. no larger currents which connects the Baltic Sea areas over larger distances.

1) Choose relevant site

    a. Focus area: southern Baltic

    b. Most likely OWF projects: Middle Baltic II, Baltica 3 and Middle Baltic III.

2) Pressure classification (Artificial reef effect, Fisheries exclusion, Introduction of energy and sound, Mechanical sea floor disturbance)

    a. Reef effect: potential local enrichment of sediment with organic matter may lead to changes in benthic fauna and anoxic sediments. Changes in local hydrodynamics.

    b. Fishery exclusion: cod present in area but fishing activities prevented by stony environment so fishery exclusion would be a less important pressure

  c. Energy and sound: turbine foundations most likely monopole. Effects of piling on benthos largely unknown.

3) Choose relevant processes to be discussed (include connectivity, scale)

  a. Hard substrate is rare in this region. Some isolated stony reefs, in shallow (approx. 8-15 m) and pristine areas far from shore. Impoverished fauna is sensitive to invasive species. Invasive species are present on soft and hard substrate. Hard substrate could lead to inflation of invasive species

  b. Baltic fauna is an impoverished brackish fauna. Little diversity to maintain stability with few species (8 dominant species in area), any effects on species assemblages by introduction of invasive species might severely affect the benthic communities

  c. Restrictions on the spread of species (such as common shore crab, *Carcinus maenus*): salinity gradient/reduction inhibits reproduction in certain regions; mostly wind driven spread means possible lack of connectivity due to reduced ability for fauna to drift long distances between wind farms

  d. Biomass increase due to artificial reef effect. This may lead to oxygen depletion. As the system is lacking of strong currents, biomass might not be transported far from wind farms.

4) Link to each three Societally Important Issues (SII)

  a. Biogeochemical reef effect: local enrichment of sediment with organic matter. May lead to changes in benthic fauna. Changes in local hydrodynamics

  b. Biodiversity: introduction of invasive species and potential anoxic sediment conditions will affect biodiversity

5) Critical path analyses: looking at cause-effect relations and the parameters best describing the cause-effect relations in space and time

  a. Pathway for biogeochemical changes: B-O-P-Q1

    i. B: "A specific hard bottom assemblage consisting of fouling organisms (fauna and flora) and associated mobile megafauna will colonise the new and complex artificial habitat."

    ii. O: "Released organic material from the accumulated fouling community on the artificial structure become deposited in the nearby sediments. Bacteria decomposition is accompanied by oxygen depletion and release of toxic H2S in the structures surrounding."

    iii. P: "Anaerobic and/or toxic (H2S) conditions in the surrounding sediment of the structure cause organisms mortality in adjacent natural habitats."

    iv. Q1: "Important functions of the benthos such as bioturbation and decomposition may change due to the altered benthic assemblage structure. This may substantially affect biogeochemi-

cal processes crucial to the functioning of the local marine eco-system."

    b. Effects may lead to eutrophication/ cyanobacteria blooms

    c. Organic matter may be transported from shallow to deep, anoxic areas. As carbon flux to anoxic zone is faster than from anoxic zone deep areas may act as carbon sink.

    d. Hypothesis O would be the critical part of the above pathway. This could lead to a cascading effect through the system, either through space and time or through the food web

6) Proof of concept for indicator selection and scale issues

    a. Possible indicator measure might be organic matter concentration in sediment. Increased organic matter may increase the redox layer in the sediment. Local scale.

    b. Increase in organic matter could lead to increase in deposit feeders and reduction of suspension feeder, causing a 'wormification' increase in fine sediment and change in porosity of seabed. Index of Dauvin *et al.* (2016) on polychaete/amphipod ratio might be used.

Case study: western British and Irish coasts

Background: The offshore windfarms created new hard bottom substratum which favour the suspension feeder species such as the blue mussel *Mytilus edulis*. High biomasses generate faeces and organic matter around the structure and favour deposit feeder as a result of the increase of organic matter. Some benthic indices developed in the Water Framework Directive (WFD) could be used to assess the impact of windfarm on soft-bottom communities. Three categories of indices have been developed. The indices based on species classification in ecological groups: AMBI (AZTI Marine Biotic Index) and M-AMBI, BO2A (Benthic Opportunistic Annelida Amphipods index) BPOFA (Benthic Polychaete Opportunistic Families Amphipods). Index based on trophic groups. ITI (Infaunal Trophic Index) and indices based on diversity: H' (the Shannon Index with log2), BQI and its variation for the North Sea and Baltic environments.

1) Choose relevant site

    a. Walney Extension, Irish Sea

    b. 87 monopile turbines

    c. Directly adjacent to existing wind farm

    d. 149 km² footprint

    e. 21-50 m depth

    f. 19 km from shore (nearest edge, 29 km from centre)

    g. 2 export cables, array cable 173 km length

    h. 25 year life for the project (need to determine what does this include?)

Further information needed:

    a. Current human activity?

        i. At the site but spatially – other MPAs, OWF, fishery activity, aggregate extraction, aquaculture, salmon migration, adjacent designations (e.g. close to the river lune & others, RAMSAR area)

b. Hydrography

   i. 121 N/m² (find map/direction/more information)

c. Bathymetry & sediment type/substratum

   i. Shallow muds, muddy area, shelf rock/biogenic reef (information from EMODnet)

d. Seawater parameters (temperature, salinity, thermocline as stratification)

e. Consideration of the scale that the data was collected at

f. EUNIS habitat also available but less detailed

2) Pressure classification (Artificial reef effect, Fisheries exclusion, Electrical cables, Mechanical sea floor disturbance)

   a. Pressure groups relevant: artificial reef effect, Introduction of energy and sound , mechanical sea floor disturbance

3) Choose relevant processes to be discussed (include connectivity, scale) and

4) Link to each three Societally Important Issues (SII) and

5) Critical path analyses: looking at cause-effect relations and the parameters best describing the cause-effect relations in space and time were investigated together

   a. Cause-effect-relationships of interest for biodiversity hypothesis p: "A specific hard bottom assemblage (fouling and mobile megafauna) consisting of primary and secondary producers will colonise the new and complex artificial habitat." in relation to hypothesis e: "The addition of artificial hard structures will change the morphology and the complexity of benthic habitats. Alters types of habitat."

      i. If natural seabed and no other influence, natural colonisation would come from the rocky shore line and surrounding habitat/larval provision paths (hydrodynamics are important, e.g. prevailing and residual currents

      ii. Sandy muddy environment – 1 turbine = sig. change at small scale, so what scale is important – 87 turbines, 150 km² -> assumption of similar colonisation at each monopile (e.g. 8 km² acc. to S. Birchenough)

      iii. significant physical and ecological change at a scale smaller than the planned wind farm (abiotic hypothesis e)

      iv. Interested in the spatial scale at which the change in biodiversity becomes significant (1 monopile, scaling up to multiple monopiles)

      v. Indicator – community analysis incorporating, must detect biodiversity in sandy sediment and hard structure, Shannon diversity index, can use abundance and biomass to look at primary production (feeds directly into other hypotheses identified)

   b. Cause-effect-relationships of interest for food resources, hypothesis K1: "Construction noise: Construction activities, operation of devices and

shipping (e.g. for maintenance purposes) cause vibration and noise of various frequencies and intensities that might affect performance and behaviour of sound-sensitive organisms."

      i. Potentially need to consider different life stages – lobsters/seismic effects publication, effect may be influenced by sex of organism (crabs, electromagnetic fields, sex)

    c. Cause-effect-relationships of interest for biogeochemical reactor, hypothesis L: "Sediment disturbance such as dredging and cable laying during the construction phase will resuspend formerly deposited organic matter from the sediment."

      i. Indicator: polychaete/amphipod ratio of Dauvin *et al.* (2016)

Case study: North Sea

1) Choose relevant site

    a. Belgian part of the North Sea, coastal

2) Pressure classification (Artificial reef effect, Fisheries exclusion, Introduction of energy and sound, Mechanical sea floor disturbance)

3) Choose relevant processes to be discussed (include connectivity, scale)

    a. Fouling-colonisation-interaction (3D structure) within the fouling community

    b. Community development in substrate around the foundations

    c. Noise during construction

    d. Food availability (attraction-production)

4) Link to each three Societally Important Issues (SII)

    a. Biodiversity, biogeochemical reactor and food resources

5) Critical path analyses: looking at cause-effect relations and the parameters best describing the cause-effect relations in space and time

    a. Hypothesis 1: attraction – production

      i. Illustrative species: Cod (best studied species) - Dab (*Limanda limanda*) - lobster – pouting (real hard substrate species, commercial value in France)

      ii. Selection of Dab: recent finding show they are taking advantage of the available food in the windfarm, as shown by stomach content analysis – effect clearer now than several years ago – total density of Dab did not increase in the windfarm

      iii. Time scale: time lag between food availability and fish feeding on it

      iv. Spatial scale: from individual perspective – local, population level – effect will expand to larger scale

    b. Hypothesis 2: Fouling – colonisation (including NIS) – connectivity

      i. Illustrative species: mussels – *Patella sp.* –biogenic 3D structures – number of species

    ii. Impact on food resources and biodiversity : more species and invasion risk

    iii. Putting increasing number of species in perspective: you add (±) 100 species locally, but the same species occur on all turbines in the southern North Sea, so all windfarms together add 100 species to the Southern North Sea (Impact on biodiversity)

    iv. Risk of invasions: strengthening the strategic position of NIS , cause effect relationships on

        1. spatial scale: defined by distribution of larvae and ability to develop a viable population

        2. time scale: rate of dispersal, time it requires to develop a viable population

6) Proof of concept for indicator selection and scale issues

    a. it is a key to have an intelligent contribution to the scale discussion

    b. the model species have indicator potential, you can identify specific parameters that you should measure

    c. selected case study is useful for proof of concept, but the focus and work carried out has to be very specific

The outcomes of the three case studies were discussed in plenary. It was general agreed that the exercise demonstrated well the use of the SII's as a structure and identifying the potential indicators of important changes. The expert group agreed that exercises should remain very focused on the aims and that there is a need to collect information available (literature) to support of the case studies in preparation for the next meeting. It was suggested that the groups would collect background data intersessionally in support of the case studies which will be briefly presented to the expert group at the next WGMBRED meeting. Further, an introduction on critical path way analysis will be given by Arjen Boon during the next annual meeting in relation to ToR D.

Literature:

ICES. 2015. Report of the Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED), 21–25 April 2015, Oban, Scotland, United Kingdom. ICES CM 2015/SSGEPI:17. 49 pp.

Dauvin JC, Andrade H, de-la-Ossa-Carretero JA, Del-Pilar-Ruso Y, Riera R. 2016. Polychaete/amphipod ratios: An approach to validating simple, Ecological Indicators 63. 89-99.

5.8 Opportunities for collaboration and funding

Participants agreed that they would upload funding calls of interest to the SharePoint.

6   Revisions to the work plan and justification

There is no revision of the work plan necessary.

7   Next meetings

The group agreed that the meeting in 2017 will take place on 6–10 March 2017 in Gdynia, Poland. The meeting in 2018 will be held in Galway, Ireland.

Annex 1: List of participants

Name	Address	Phone/Fax	Email
Mohammed Alsebai	Ghent University Krijgslaan 281/S8, 9000 Gent, Belgium	Tel: +32-(0)9-264 85 24	mohammed.alsebai@UGent.be
Silvana Birchenough	Cefas Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, UK	Tel:+44(0) 1502 527786 Mobile: +44 (0) 7827661379	silvana.birchenough@cefas.co.uk skype:silvana.birchenough
Arjen Boon	Deltares Research Institute Unit of Coastal and Marine Science P.O. Box 177 2600 MH Delft The Netherlands	Fax: + 31 88 3358582 Mobile: + 31 6 51635449	arjen.boon@deltares.nl skype: arjenrboon
Paul Causon	School of Energy, Environment and Agrifood, Offshore Renewable Energy Engineering Centre, Cranfield University Cranfield Bedfordshire MK43 0AL, UK	+44(0)7870194676	p.causon@cranfield.ac.uk
Joop W. P. Coolen	Aquatic Ecology and Water Quality Management group Wageningen UR IMARES Offshore Energy Group Ankerpark 27, 1781 AG Den Helder the Netherlands	Tel: +31 (0)317486984 Mobile: +31 (0)613005630	Joop.coolen@wur.nl Skype: joop.coolen
Radosław Brzana	Instytut Oceanografii Uniwersytet Gdański al. Marszałka Piłsudskiego 46 81 - 378 Gdynia		radek.barbus@gmail.com
Jennifer Dannheim (co-Chair)	Alfred Wegener Institute for Polar and Marine Research P.O. Box 120161 27570 Bremerhaven Germany	Phone: +49 471 4831 1734 Fax: +49 471 4831 1425	Jennifer.Dannheim@awi.de
Jean-Claude Dauvin	UNICAEN, Université de Caen Normandie. UMR CNRS 6143 Morphodynamique continentale et côtière 24 rue des Tilleuls F-14000 Caen	Phone: +33 2 31 56 57 22 Fax: +33 2 31 56 57 57	jean-claude.dauvin@unicaen.fr
Steven Degraer	RBINS-OD Nature Gulledelle 100 B-1200 Brussels Belgium	Phone: +32 2 773 2103	steven.degraer@naturalsciences.be skype: sdegraer

Ilse de Mesel	RBINS-OD Nature 3e en 23e linieregimentsplein B-8400 Oostende Belgium	Phone: +32 59 24 20 51	Ilse.demesel@naturalsciences.be skype: ilsedemesel
Jozefien Derweduwen	Institute for Agricultural and Fisheries Research (ILVO) Ankerstraat 1 B-8400 Oostende Belgium	Phone: +32 59 56 98 18	jozefien.derweduwen@ilvo.vlaanderen.be
Andrew B. Gill (co-Chair)	Environmental Science & Technology Department Cranfield University Cranfield Bedfordshire MK43 0AL UK	+44 1234 750111 x2711	a.b.gill@cranfield.ac.uk
Zoe Hutchison	School of Energy, Environment and Agrifood, Offshore Renewable Energy Engineering Centre, Cranfield University Cranfield Bedfordshire MK43 0AL, UK	+44 (0) 1234 750111 ext 4706	zoe.l.hutchison@cranfield.ac.uk
Urszula Janas	**Instytut Oceanografii** Uniwersytet Gdański al. Marszałka Piłsudskiego 46 81 - 378 Gdynia	Phone: +48585236867	oceuj@univ.gda.pl
Roland Krone	Krone- Projekte, Meereskunde Technik Umweltwissenschaften Germany Hummertation Helgoland Alfred Wegener Institute for Polar and Marine Research D-27498 Helgoland	Phone: +4947195481249	r.krone@krone-projekte.de
Francis O'Beirn	Marine Institute, Rinville, Oranmore, Galway, IRELAND	Ph: +353-91-387250	fobeirn@marine.ie
Jean-Philippe Pezy	UNICAEN, Université de Caen Normandie. UMR CNRS 6143 Morphodynamique continentale et côtière 24 rue des Tilleuls F-14000 Caen	+33231565708	jean-philippe.pezy@unicaen.fr

Aurore Raoux	UNICAEN, UMR-CNRS-BOREA, Biologie des OrganismesMarins et Écosystèmes Aquatiques IBFA – Université de Caen Normandie Esplanade de la Paix CS 14032 14032 CAEN Cedex 5	+33649663864	raoux.aurore@unicaen.fr
Jan Reubens	UGent-MARBIOL Universiteit Gent Faculteit Wetenschappen Vakgroep Biologie Campus De Sterre, s8 Krijgslaan 281 9000 Gent Belgium	+32-(0)9-264 85 17	jan.reubens@ugent.be
Emma Sheehan	Plymouth University Marine Institute Marine Building Drake Circus Plymouth, PL4 8AA UK	0044 1752 584699	emma.sheehan@plymouth.ac.uk
Tom Wilding	SAMS, Scottish Marine Institute Dunbeg Nr Oban Argyll, Scotland,PA37 1QA UK,	+44(0)1631 559214	Tom.wilding@sams.ac.uk
Edward Willsteed	School of Energy, Environment and Agrifood, Building 53, Cranfield University, Cranfield, Bedfordshire, MK43 0AL	+44(0)7917 0600072	e.a.willsteed@cranfield.ac.uk Skype: ed.willsteed

Annex 2: Recommendations

RECOMMENDATION	ADDRESSED TO
None	

Annex 3: Intersessional work and action points

Intersessional work

- Network analysis: survey monkey questionnaire to be developed (see chapter 5.6);
- Screening for appropriate indicators.

Actions points

- ABG literature on SharePoint for other devices for knowledge ground truthing, literature review for report (see chapter 5.5);
- TW will send an email to the ICES Communications on a video clip of the work from WGMBRED;
- SB will scan for calls to fund international projects in the WGMBRED context, everybody will drop calls at the SharePoint, ABG will set up a SharePoint folder for funding opportunities;
- AB will prepare an introduction on critical path way analysis in the context of finding appropriate indicators (ToR D) for the next WGMBRED meeting.