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

25–28 March 2014

Tallinn, Estonia



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International Council for
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Executive summary

The 2014 annual meeting of the Working Group on Marine Benthic and Renewable Energy developments was attended by 19 experts, representing nine countries (Belgium, Estonia, France, Germany, Ireland, Poland, Sweden, United Kingdom, Netherlands) and was held in Tallinn, Estonia during March. The meeting was co-chaired by Jennifer Dannheim (Alfred Wegener Institute, Germany) and Andrew B. Gill (Cranfield University, United Kingdom). As in the previous year, the terms of references were summarised in three thematic sub-groups: (A) The 'knowledge group' (ToR A, E) will evaluate and review existing knowledge on the effects of offshore renewable constructions and related topics (e.g. artificial reefs). (B) The 'monitoring group' (ToR B, F) will review and evaluate sampling techniques the scientific efficiency of ongoing monitoring programmes of offshore renewable construction projects by identifying knowledge gaps and simplifying future standardised research. (C) The 'metadata database group' (ToR C, D) will develop a database of metadata that will help to cross-foster research and target monitoring, as well as future modelling approaches.

Two main themes were the focus of activity during the meeting, namely the knowledge and monitoring themes, which address the TORs A, B, E and F. Significant progress on both these topics was made particularly in relation to formulating publications. The monitoring group is looking to submit a paper early in 2015 and have a plan of activities between sessions to meet this time schedule. The knowledge group has a task list and is on target to have a draft paper for discussion by the next WGMBRED meeting in 2015. For the metadata database theme, a decision was made to link with the existing Tethys Annex IV database via a dedicated webpage for WGMBRED hosted on the Tethys database. The links and WG member sign up will take place intersessionally.

In addition to the three main themes and the TORs the WG discussed the importance of scale issues and cumulative impacts, in general and in relation to current knowledge on effects of offshore renewable devices on the benthic ecosystems and monitoring strategies. These two topics are considered very important in the topic area at the moment hence the need for the WG to ensure that it keeps its activities relevant to current knowledge.

Several talks and posters at international conferences were presented with a number of WGMBRED members contributing to them. A viewpoint article has also been submitted to the journal *Hydrobiologia* for a special issue on wind farms and environment.

The WG is functioning extremely well with high active participation across northern Europe. Members from other ICES member countries would be encouraged. The WG is on course to meet its TORs which will be of key importance for ICES if there is any need to advise on marine renewable energy developments in relation to the benthic ecosystem.

1 Administrative details

Working Group name

Marine Benthic and Renewable Energy Developments (WGMBRED)

Year of Appointment

2013

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

2nd year

Chair(s)

Jennifer Dannheim, Germany

Andrew B. Gill, UK

Meeting venue

Tallinn, Estonia

Meeting dates

25–28 March 2014

2 Terms of Reference a) – f)

- a) Critically evaluate current knowledge of the effects of offshore wind farms and other renewable energy constructions on benthic organisms (i.e. marine invertebrates, demersal fish and macroalgae) in the North Atlantic;
- b) Review and develop guidelines for sampling techniques on renewable energy construction monitoring techniques by providing an overview of existing guidelines, in order to standardize and simplify future research and monitoring;
- c) Develop a meta-database for cross fostering research to target monitoring and future potential modelling approaches;
- d) Populating and keeping the meta-database updated;
- e) Review existing knowledge from related topics (e.g. artificial reefs) and how these are applicable to cause–effect relationships in the benthic associated with renewable energy constructions;
- f) Evaluate scientific efficiency of ongoing monitoring programmes by identifying knowledge gaps and overlap in research.

3 Summary of Work plan

Year 1 ToR – A, C, D, E

Year 2 ToR – A, B, D, E

Year 3 ToR – A, B, D, F

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.

- Two main themes were identified during the meeting, knowledge and monitoring, which address the TORs A, B, E and F.
- Significant progress on both these topics was made particularly in relation to formulating publications
- The importance of scale issues and cumulative impacts was discussed, in general and in relation to current knowledge on effects of offshore renewable devices on the benthal and monitoring strategies.
- Several talks and posters at international conferences that WGMBRED members contributed to.
- Viewpoint article submitted to Hydrobiologia special issue on wind farms and environment.

Knowledge: ToRs A and E

Current activity:

- Matrix/literature review on related topics of hypothesis that are part of the specific cause-effect relationships of effects of offshore energy constructions on the benthal.

Expected output:

- Assessment of sensitivity, certainty and consistency of cause-effect-relationships;
- Analysis of knowledge gaps via literature review in order to identify and prioritise the known unknowns.

Expected output (year 3):

- Review paper;
- Feasible and readable paper, relevant to managers, policy makers, developers and academics;
- Highlighting knowledge gaps and prioritisation (cf. known unknowns).

Monitoring: ToRs B and F

Current activity:

- Manuscript outline laid out ready for discussion during the meeting. Currently the MS has been through a few stages which were edited by different partners leading to the version addressed during the workshop.

Expected output (year2):

- Review paper;
- Aimed at audience of scientists who are involved in translating fundamental and applied science for those involved in decision and policy making;
- Focus on addressing questions on why the benthos is important, scale aspects and the relevance to monitoring, defining suitable objectives and approaches to determine relevant changes to the benthic ecosystem.

The Metadatabase: ToRs C and D

Current status:

- A link has been established to the already existing global database (Tethys, Annex IV, US DoE) that will bring together projects, experiments, research and scientists that relate to the effects of marine renewables on the benthos.
- Consideration of a webpage portal entry for WGMBRED with a link to ICES. However, so far no metadata from members of the WGMBRED were stored in the database.

Expected output (year3):

- Dedicated webpage link within Tethys with all members of WGMBRED signed up and with expertise details visible;
- Set of relevant reports, metadata and publication notices that expose the work of the WGMBRED to the outside world as they come to experts on the topic;
- Link through to ICES website and WGMBRED outputs.

5 Progress report on ToRs and workplan

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

At the start of the inaugural meeting, Andrew B. Gill (co-chair) and Jennifer Dannheim (co-chair) welcomed the 19 participants representing nine countries and thanked Georg Martin and Liis Rostin (Estonian Marine Institute, University of Tartu) for hosting the meeting.

Jennifer Dannheim introduced the expectation for this meeting, aimed at an update of the state-of-the-art knowledge, evaluating monitoring efficiency and knowledge gaps, identification of burning issues and opportunities for collaboration. All this was to be facilitated by the structured agenda, but leaving room for open conversations and discussions. Three axes are tackled through six multi-annual ToRs (2013–2015), being the knowledge base, the monitoring issues and (meta-) database on marine renewable energy (MRE) benthos monitoring:

- a) The 'knowledge group' (referring to ToR A and E) will evaluate and review existing knowledge on the effects of offshore renewable constructions and related topics (e.g. artificial reefs) which might provide information on effects comparable to those of offshore renewables.
- b) 'monitoring group' (referring to ToR B and F) will review, evaluate and develop sampling techniques and scientific efficiency of ongoing monitoring programmes of offshore renewable construction projects by identifying knowledge gaps and simplify future standardised research.
- c) 'metadatabase group' (referring to ToR C and D) will develop a database of metadata that will help to improve cross fostering research and target monitoring, as well as future modelling approaches.

The outcome of these ToRs will eventually lead to a report to ICES (2015) and several inter-term peer-reviewed publications. During the last year WGMBRED's work has been introduced at two conferences (Germany, Belgium) and has submitted a viewpoint paper on MRE monitoring:

- Several talks and poster on the StUKplus conference - five years of ecological research at Alpha Ventus - challenges, results and perspectives, Berlin, Germany, 30–31 October 2013;
- Several talks and poster on the WinMon.BE conference, Environmental impact of offshore wind farms "Learning from the past to optimise future monitoring programmes", Brussels, Belgium, 26–28 November 2013;
- Viewpoint review article "Environmental impact assessment of offshore renewable energy installations: A call for hypothesis-based and collaborative monitoring programmes and research" (working title), submitted to a special issue of *Hydrobiologia* from the WinMon.BE conference.

During this year's meeting we aimed to continue building along the three axes and planned for future work.

WGMBRED has close links to several other ICES WGs, among those WGMRE, chaired by Finlay Bennett (Scotland, 2014–2016), has close links to WGMBRED. While WGMBRED is focused on the scientific challenges of MRE monitoring for the benthic ecosystem, WGMRE has a wider remit and is focused on the policy aspects of MRE

siting, consenting, licensing and monitoring. Andrew B. Gill (co-chair) will represent WGMBRED at WGMRE's first meeting (San Sebastian, Spain, 31/03–04/04).

WGMBRED's current position is that it is focused on offshore renewable energy devices (e.g. wind farms, tidal and wave energy installations) but acknowledges that there are other MRE devices. WGMBRED does not currently have the in-house expertise to deal with these. If future scientific questions would show up, WGMBRED will aim at finding the appropriate expertise.

Introductory presentation by the Estonian Wind Power Association by Tuuliki Kasonen

Offshore wind farms (OWF) are currently not present in Estonia, but plans are available to construct OWFs mainly in front of the coast of Hiiumaa and Saaremaa. The National Renewable Energy Plan for example foresees 250 MW of offshore renewables by 2020 (onshore: 400 MW). Estonia has its policies in place to start constructing. The national spatial plan "Estonia 2030+" (enacted August 2012) includes two pilot maritime spatial planning projects, one of which being the waters around the island of Hiiumaa and Liivi bay. The planned Hiiumaa wind farm (Nelja Energia; planned capacity: 700 MW) and the Liivi Lahe OWF (Eesti Energia; planned capacity: 600 MW) for example are now closely investigated, including a (pre-) environmental impact assessment. Estonia is presently investigating whether or not other-than-maintenance or –research shipping should be allowed in OWFs. The siting of OWFs goes hand in hand with the delineation of SPAs under the Habitats Directive, in which HA1170 (*in casu* geogenic reefs) are considered highly important. Estonia has chosen to install gravity-based foundations (GBF). These foundations will add hard substrate to the ecosystem, significantly enhancing the (artificial) reef effect in Estonian waters. The fisheries sector however has doubts about the transferability of positive effects on fish as observed in other OWF. Continued dialogue is needed here.

5.2 National updates

Ireland: Francis O'Beirn provided an update on the Irish ORE developments and monitoring programmes. The Sustainable Energy Authority of Ireland (SEAI-www.seai.ie) is responsible for the development of marine renewables in Ireland. In addition to funding prototype development, the SEAI has also taken responsibility along with other state agencies (incl. The Marine Institute) to identify and apply for renewable test sites along the Irish coast. Currently there is one site licenced and operational for 1/4-scale devices in Galway Bay. In addition, an application is in train for a full-scale device test site (County Mayo) which would encompass two locations – at 3km offshore in 30m water depth and at 10km in 100m water depth. An EIA has been produced; however, further cetacean baseline information has had to be gathered. In addition, planning and scoping is currently underway for the development of a site of the Coast of County Clare which would be a small scale array site for approximately 20 devices generating 10 MW. To facilitate these developments other agencies have prioritised research and survey activities in these areas, e.g. The Marine Institute and the Geological Survey of Ireland under the INFOMAR program to carry out acoustic survey of the seabed in these areas (www.informar.ie).

Contact: Francis O' Beirn, Marine Institute, Rinville, Oranmore, Galway

Germany: Jennifer Dannheim reported on the German status of ORE development and monitoring. In October 2013 the StUKplus conference took place in Berlin. Results of the standard monitoring evaluation were presented, based on five years of

ecological research at Alpha Ventus. Besides the basic monitoring that is implicit for offshore wind farm environmental assessments, no further research projects on the effects of offshore wind farms on benthic invertebrates and demersal fish are carried out or financed in the near future.

Contact: Jennifer Dannheim, Alfred Wegener Institute, Bremerhaven

United Kingdom – Emma Sheehan reported on Wave hub, a test site for Marine Renewable Energy located 10 miles north of SW UK. Wave hub was connected to the grid in 2010 and the first device to be tested at Wave hub will be deployed in Summer 2014. Annual benthic monitoring surveys were done by Plymouth University Marine Institute of the Wave hub site and the associated cable route. Funding is required to repeat the annual survey of the Wave Hub site for device developers to use for impact assessment. Funding is also needed to repeat the impact study of the cable route to inform on recovery of the cable and to use as a baseline for future comparison with the potential impact of EMF when the cable becomes live.

Contact: Emma Sheehan, Plymouth University

United Kingdom: Andrew Gill gave an update on activities that he and Cranfield Univ were particularly involved in. He had hoped to report that the field site in western Scotland would be up and running with a wave device (provided by a small Scottish company) and a set of research studies ongoing. However significant problems with the Crown Estate lease meant that it was not possible to allow the project to deploy a wave device at the present time. Other options are now being considered to see how research projects can be moved forward. On a more positive note Andrew reported on a new flagship EU project named MaRVEN – Marine Renewable Energy Vibration, EMF and Noise that was awarded to a consortium of nine organisations across seven countries. The project is 18 months long and will critically review the noise, vibration and EMF aspects of marine renewable energy devices (across the technologies – wind, wave and tidal) taking particular note of gaps in knowledge. These gaps will be filled by a field measurement campaign. The data collection covers important aspects of relevance to the benthic ecosystem, such as particle motion component of noise, vibration within sediments and EMF emissions.

Contact: Andrew Gill, Cranfield University, Cranfield, UK

United Kingdom/Scotland: In September 2012, the University of Exeter, Cornwall campus, hosted a workshop on environmental impact of tidal energy devices. Following this workshop, a manuscript titled “Towards resolving fundamental issues in environmental impact assessment of marine renewable energy installations” has now been submitted to the Journal of Applied Ecology. The conference of “Environmental Interactions of Marine Renewables” (EIMR 2014) will run in Stornoway, UK at the end of April 2014. Many of the topics and presentations will be of relevance to our WG. The outputs of a project (“A review of the potential impacts of wave and tidal energy development on Scotland’s marine environment”) for the Scottish Government is now available online. This consists of 1) a written report (www.scotland.gov.uk/Resource/0039/00391880.pdf) and 2) an online tool giving preliminary assessments of likely impacts associated with deployment of 10 MW arrays of wave or tidal energy devices in Scotland. The tool allows you to choose any realistic combination of device technology, mooring method and species (including benthos) or habitat. The tool is available at www.scotland.gov.uk/Topics/marine/Licensing/marine/tool. The information system is in the process of being updated which should be available later in the year.

Contact: Angus Jackson, Cornwall College Newquay, Cornwall Plymouth University

Scotland: Mike Robertson (Marine Scotland Science), on behalf of Finlay Bennet chair of Working Group on Marine Renewable Energy (WGMRE), delivered a short presentation describing the ToRs to be applied to the inaugural meeting of the WGMRE. These topics were discussed in plenary by all members of the WGMRED.

Mike also briefly described the current status of marine renewable developments, wind, wave and tidal, in Scottish waters. Many sites have now been identified and leased while biological and environmental survey work is either ongoing or has also been compelled. Government (ministerial) approval to develop has been granted for two sites in the Moray Firth and has been applied for at major sites off the Firth of Forth.

In addition, Mike demonstrated seabed survey work carried out by MSS over the last few years in support of offshore renewables and the Scottish Marine Protected Area (MPA) project. Details of further survey work planned for 2014 were also presented.

Contact: Mike Robertson, Marine Scotland Science, Aberdeen

Poland: European Climate Plan, launched in 2008, imposes upon each member state a target contribution figure for the production of electricity from renewable energy sources that should be achieved by 2020. The goal for Poland was set at 15%. Construction of offshore wind farms maybe necessary to achieve current goal and other goals that are going to be set with future European Climate Plans. In total 95 sites were chosen in three regions proposed for wind farms construction: Oder Bank, Słupsk Bank and Middle Bank. Chosen sites total area comes to 2219.23 square kilometers. Natural hard bottom is rare in the southern part of the Baltic Sea. Therefore, artificial structures such as offshore wind farms may create favourable conditions for new benthic communities to appear in this region. The aim of this research was to characterize both short-term and long-term benthic communities associated with artificial hard bottom in the Southern Baltic Sea. In order to do that species composition as well as the abundance, biomass and percent coverage were examined at various sites. An inactive World War II torpedo testing facility in the Gulf of Gdansk served as a site for sampling long-term communities while short-term communities were sampled using settlement panels and PVC cylinders. Panels were deployed at the torpedo testing facility for 5 months. PVC cylinders were deployed for 3 months in the Polish Exclusive Economic Zone. Twenty two faunal taxa, including 9 crustacean taxa, were identified during the research. *Mytilus edulis* and *Amphibalanus improvisus* were the most abundant invertebrates at sampled surfaces. Five non-indigenous species were detected. For the first time adult individuals of *Mytilopsis leucophaeta* were detected in Polish Marine Areas indicating, that it is possible for this non-indigenous species to reproduce in this region. There are no offshore wind farms in the Polish marine sea areas yet but four regions (sandy, mixed sediments) have been selected for future investments (~2018). Large-scale studies on soft-bottom benthos were carried out in the past but current Polish monitoring stations are not situated near the planned wind farms. Natural hard-substrate is uncommon and thus hardly ever investigated, e.g. by monitoring. Succession studies of fouling communities on artificial substratum were done in the Gulf of Gdańsk. In 2012 short term studies on the colonization of artificial substratum were carried out in the southern part of the Baltic Sea.

Contact: Radosław Brzana & Urszula Janas, Institute of Oceanography, Gdansk University, Gdynia

Sweden: Swedish off shore wind farms currently amount to 81 turbines and a total capacity of 180 MW. The largest one is still the Lillgrund wind farm in Öresund, with was connected in 2007 and has a capacity of 110 MW. Another 2 450 MW have permission but are not (yet) constructed, and 5 000 MW is undergoing consenting process. A number of studies have recently been published on the environmental effects of off shore renewables. Summaries of the following papers were presented:

Bergström L, Kautsky L, Malm T, Rosenberg R, Wahlberg M, Åstrand Capetillo N, Wilhelmsson D. et al (2014). Effects of offshore wind farms on marine wildlife – a generalised impact assessment. *Environmental Research Letters* 9 034012

Wilhelmsson D & Langhamer O (2014). The Influence of Fisheries Exclusion and Addition of Hard Substrata on Fish and Crustaceans. In: Shields M. A. & Payne. *Marine Renewable Energy Technology and Environmental Interactions*. Springer. 176 pp

Hammar L, Wikström A and Molander S (2014) Assessing ecological risks of offshore wind power on Kattegat cod. *Renew. Energy* 66 414–24

Bergström L, Sundqvist F., Bergström U (2013) Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community *Mar. Ecol. Prog. Ser.* 485: 199–210 Current experimental research is focussing on the effects of underwater sound of offshore wind farm development on fish larvae and juveniles and on behavioural aspects of marine mammals. Field monitoring is currently limited to a monitoring programs at Amalia Wind Farm.

Contact: Lena Bergström, Swedish University of Agricultural Sciences, Öregrund; Dan Wilhelmsson, Swedish Secretariat for Environmental Earth System Science (SSEESS), Royal Swedish Academy of Science, Stockholm

Estonia: Georg Martin and Liis Rostin gave an overview on offshore projects to investigate the effect on benthos, i.e. experimental studies in Estonian coastal waters. In Estonia, wind energy is one of the most credible alternatives to solve the problems which have been associated with the depletion of fossil fuels and their negative impact on the environment and thus pressure on the suitable marine habitats is likely to increase in the near future. Effects of construction and exploitation of offshore wind parks on benthic communities are difficult to predict. Our study was designed to study some aspects of possible effects of construction of offshore wind farms on benthic communities and habitats. Experiment of effect of eutrophication and other environmental factors on colonisation patterns of new hard substrate was set up in May and June 2012 and ended in spring 2013. We placed on the seabed 2 transects in three different areas with different levels of eutrophication in Gulf of Riga – Kõiguste, Sõmeri and Orajõe. We put on the seabed natural rustic granite stones at five depths to assess fouling communities. Sampling is completed, but data analyses have not been done at the moment. The aim of the experiment is to assess the effect of eutrophication and other environmental factors on the colonization pattern of new substrate and structure of pioneer community. New substrate colonisation experiments utilising the base of wind measurement construction was set up July 2013 on the location near the Kihnu Island. In August 2010, wind measurement construction was installed in the Gulf of Riga by Eesti Energia. Wind measurements were carried out in the area proposed for development of offshore wind farm. Part of the construction, which was above the water, was removed in the end of the same year. The foundation was left behind. Due to the knowledge of exact timing of the installation of the construction it is a good opportunity to evaluate colonization process and utilise this knowledge for future EEA of proposed wind farm. Artificial substrate was installed using the structure of the base of the wind measurement station. The aim of the experiment is to evaluate the impact of installation of new hard substrate in soft bottom habitat. Our

main hypothesis is that newly introduced hard substrate will increase habitat diversity and will add to the species diversity and overall biomass. What is unknown is how the depth and other environmental variables will affect this process.

Contact: Liis Rostin & Georg Martin, Estonian Marine Institute, University of Tartu.

France: No offshore wind farms have yet been constructed along the French coast. Six areas were determined in April 2012 and the first four farms are planned to be operational in 2018 and the remaining two were determined in April 2014 for operation in the period 2020–2022. After that, environmental impact assessment should be started. During the same period, we assisted a French organization for the Marine Renewable Energy Development mainly in terms of ecological and socio-economic impacts. The Basse-Normandie region has edited a Directory of Marine Renewable Energy research skill to favour the contacts between the industry and the research. Three sites are specifically concerned with the Normandy region in the eastern part of the English Channel. In this part of the Channel, we benefit from historical (1960s–1970s) data obtained by Holme and Cabioch teams and recent information obtained during an European INTERREG CHARM project (2006–2011), on the sediment composition, macro-benthos structure and functioning. These databases should be an important resource for the estimation of reference conditions and the assessment of real impacts of wind farms in such megatidal environments where coarse sand, gravels and pebbles dominate. For the Courseulles sur mer (50 km², 75 machines) and Fécamp (65 km², 83 machines) wind farms developments under a consortium led by EDF the preliminary studies of the biological components began in 2007 and the main survey will begin in 2016.

For the Zone of the Tréport project under a consortium led by GDF, it is necessary to increase the level of knowledge on the structure and functioning of the marine ecosystem. The PhD project of Jean-Philippe PEZY will begin in September 2014 for three years on the consequences of the anthropological activities on the secondary producers and the trophic networks of the eastern part of the English Channel. During his PhD thesis, Jean-Philippe has two main objectives: 1) acquisition of new data on the biological compartments (zooplankton, hyperbenthos, benthos and demersal fishes) within four cruises in April and September–October 2015/2016 and 2) Ecopath flux modelling on the wind farm site in comparison with the global functioning of the eastern part of the English Channel.

Moreover, the M2C laboratory will be concerned in the future with the development of marine turbine farms mainly on the experimental site in the Raz Blanchard are (north-west of the Hague Cap in the North of the Cotentin). There is a zone with strong tidal currents (> 10 knots during spring tide), at 30–60 m depth and on hard bottom with pebbles, gravels and coarse sand enclaves.

So, it is important for us to benefit from the European expertise of other countries where the development of MRE has occurred over a number of years. Contact: Jean-Claude Dauvin, Université de Caen Basse-Normandie. UMR CNRS 6143 Morphodynamique continentale et côtière.

The Netherlands: The research and monitoring program regarding the ecological effects of offshore wind farms for the last year has been a straightforward continuation of the former year. The experimental research is focussing on the effects of underwater sound of offshore wind farm development on fish larvae and juveniles and on behavioural aspects of marine mammals. Field monitoring is currently limited to a monitoring programs at Amalia Wind Farm. The monitoring program for this wind

farm is strongly comparable to the one carried out for the Offshore Wind Farm Egmond aan Zee (OWEZ).

Contact: Arjen Boon, Deltares Research Institute

Belgium: Six years of Belgian research on the environmental impact of offshore wind farms, was compiled in a concluding report and presented by Belgian scientists at an international scientific symposium (26, 27 and 28 November 2013), organised by the Royal Belgian Institute of Natural Sciences, Operational Directorate Natural Environment. The research executed by ILVO takes part of this monitoring project and focusses on the wind farm effects on epibenthos and demersal fish of soft substrates and on the effects of pile driving on fish larvae and eggs.

For the baseline monitoring, epibenthos and fish were investigated within a BACI design. Samples were taken before and after wind farm construction, in impact and control areas. Several significant results were observed within the BACI design and within a certain year, for several parameters. At the Thorntonbank for example, the length of dab was significantly lower at the sand bank top in autumn 2012 as a result of the wind farm presence. Similarly at the Bligh Bank, significant results were noted: possible edge effects for sole density in spring 2012 and wind farm effects for ophiuroids in 2009.

One of the targeted monitoring topics is the investigation of any changes in fisheries activities in the vicinity of the wind farms. Vessel Monitoring System data indicated three zones with an increase and one zone with a decrease in fisheries activity in areas surrounding the wind farms. This might be a redistribution effect or it may indicate a local change in availability of commercially interesting fish species. Results on the presence of demersal fish in the vicinity of the wind farms showed no major differences concerning species of commercial interest. So, the observed changes are likely due to a redistribution process. Data on recreational fisheries (from ship based survey observations) indicated a concentration of angler activity around the Gravity Based Foundations in 2008/2009. The year after, that concentration was mostly gone. Two hypotheses are suggested: there was less fish than expected or the wind farms were too far for day trips. Extra research is needed to see what happens with recreational fishing effort.

Another targeted monitoring topic is the investigation of the feeding guild structure of several fish species by stomach analysis. Data from a small-scale pilot study at the Thorntonbank in 2010 showed little differences in the diet of dab originating from inside and outside the wind farm. The most abundant hard substrate species present on the turbines could not be found in the stomachs of dab. This may be linked with the small sampling size, the sampling distance or the prey preferences of dab.

The effects of pile driving noise on sea bass have mainly been studied in the lab. The first field experiments close to the pile driving activity were performed in 2013. The experiment was performed on board of a piling vessel exposing young European sea bass to a complete piling event as close as 45 m from the pile driving activity. The young sea bass did not die immediately or during the following two weeks after exposure. No abnormalities were found in the skeleton. The stress level of the fish was assessed by measuring the oxygen consumption during exposure. A depressed respiration during exposure indicates a certain level of stress. The growth and condition of the fish was monitored over one month and was not affected by this rather short-term exposure. This suggests that pile driving has no long-term impact on the fitness of sea bass.

To answer the research question 'Are wind farms functioning as spawning and nursery areas?' data still have to be analysed.

Contact: Jozefien Derweduwen, Institute for Agricultural and Fisheries research (ILVO), Animal Sciences, Aquatic Environment and Quality, Bio-environmental Research, Ankerstraat 1, 8400 Oostend, Belgium.

5.3 Scale issues

Tom Wilding gave a brief introduction to the aspect of scales in relation to assessing interactions between benthos and offshore renewables: scales are different from local, single device testing to commercial deployment, this will have important consequences to how the benthos responds and also how we determine the level of change and ultimately whether there are any impacts. The scale of change is already happening for offshore wind as plans for much larger developments and more developments in adjacent areas of the sea are in place with construction already occurring (e.g. southern North Sea). The cumulative effects on the benthos are much related to the scale aspect.

TW suggested that it is relatively straightforward to consider scales of meters. Near-field effects are going to occur and we have the knowledge with which to determine the changes. People tend to draw impact halos around devices. But who cares about changes at this scale? What about further afield? Devices are usually part of an array, London Array is 100 km², but an effect at 50m distance, is small compared to total footprint. We need to think from single devices to arrays to superstructures: clusters of OWF. Reckon on 100–500 wind farms. What happens at this scale? We also need to consider linked questions such as what about invasive species at this scale, important for distribution.

We should also consider other human activities (i.e. MREDs as part of coastal modification): shipping, aquaculture, fishing: scale-based connectivity and gradients are visible here, as are temporal scale aspects such as seasonal, annual and long-term variability. National boundaries do not make things easier. All these things are part of the EIA. But there is no consistent guidance on scale related and cumulative effects, and there are no 'significant thresholds identified'. Decision makers use the term 'reasonable foreseeable future' however this is impossible to define. We need identification of relevant receptors, however there is currently no consideration for benthos except for designated features such as *Sabellaria* reefs.

Critical Q: what does society want from seas and oceans, why is benthos is important?

Some receptors are protected (e.g. *Sabellaria*, *Lophelia*, *Modiolus*): but we need to understand what scale these receptors operate at.

In relation to benthos: important questions are raised, such as 'can we define a population, reproductive dispersal strategy, rarity, critical mass, baselines'.

Environmental positives – negatives: connectivity, habitat restorations/constructions etc. what is weighed and how?

Biodiversity, biogeochemical cycling, food production is key to why we should care about benthos. How we are going to 'sell' this? Scales relate to system functioning (production). It was agreed that this was important and Steven Degraer highlighted that a new PhD student is researching the changes in food web structure and the relationships with organic matter input.

Scale is relevant for both ecosystem structure and functioning. Also for 'populations' the functional aspect is of importance. We also need to include human activities in general and all marine developments. Structure and function go hand in hand. Various approaches exist, researchers agree (more or less), but the message needs to come from us researchers to explain to policy makers and managers. So we need a strategy to make these steps relevant and scale plays a crucial role here.

MREDs are not placed randomly so more local scale effects may need to be considered on a site by site basis. However, the scale of the deployment footprint in relation to the benthic habitats within the jurisdiction of the country making the decision to deploy is relevant. For example, in Poland 7% of their sea is fit for OWF, which is quite a large area. The question then arises, should Poland be more focussed in looking for cumulative and synergistic effects than areas of sea where deployments are much more dispersed?

Basically we ecologists lack knowledge to understand relevant scales, but the society lacks even more. Choosing the right receptor is important in telling the story, e.g. cod/demersal or even flatfish ecology would likely tell a much better story to policy makers than some benthic polychaete. Hence, Cod or gadoids in general, could be used as receptors for studying food function of benthos. This could then be combined with fisheries and climate impact. It is here that the scale issue combines with cumulative effects and with natural variability.

The aim of this section was to get the WG participants to bring to the front of their minds the most relevant aspects that we as benthic ecologists need to consider when looking at the moving forward the science of interactions between the benthos and MREDs.

5.4 Cumulative impacts (CE): developing a framework to assess CE associated with offshore renewable energy developments

Silvana Birchenough (Cefas, UK) presented and supported the discussion on this topic. Cumulative effects (CE) from single or multiple activities have moved to the top of the priorities for Marine Spatial Planning (MSP). CE by definition is considered as the combined impacts of a single activity or multiple activities. The individual impacts from a single development may not be significant on their own but when combined with other impacts, those effects could become significant. For example the combined effects of wind farms, climate change and loss of biodiversity can be considered as CE.

One of the main challenges facing offshore wind farm developers, regulators and environmental practitioners is how to best assess the CE or impacts of major offshore developments. At present there are several methods which offer the possibility of predicting cumulative effects, on biological receptors in response to cumulative effects of multiple interacting human activities. UK has developed a conceptual framework based on the DPSIR approach for documenting cumulative effects for UK offshore wind farms. This framework was then used to describe the main steps necessary for assessing cumulative impacts within the context of MSP (for example issues related to activities, scales and considering different levels of effects).

This work presents an initial assessment on the utility of various GIS modelling approaches to investigate cumulative impacts on marine biota and seeks to develop a consensus when developing CEA methodologies. Additionally some of the outputs from regional climate models (e.g. UKCP09) as well as data layers of current and fu-

ture human activities have been considered to identify regions where multiple pressures are likely to interact to impact marine organisms in the future. Other countries (e.g. Belgium, Germany and the Netherlands) are facing similar challenges when assessing CEA and trans-boundary exchanges on suitable methodologies for assessing CEA will help managers and regulators to integrate and harmonise knowledge from current and future OWF developments.

In plenary, the group discussed the importance of transparent and continuous communication between different lobby groups in the context of CEA. Such complex issues require collaboration between groups with dissenting interests over short and long term.

5.5 Knowledge group (ToR A and E)

The knowledge group continued the work of the last two years, i.e. developing a set of hypothesis-driven pathways based on the schematic presentations of cause-effect-relationships (see ICES 2012) to provide a list of prioritised hypotheses (ToR A) and to evaluate knowledge available from related topics (e.g. artificial reefs) that can contribute to the issue of effects of renewable energy constructions (ToR E). The expected output will be a review paper (three years) entitled 'Benthic effects of offshore renewables: prioritising the known unknowns'. This publication will be relevant to managers, policy makers and developers of offshore renewables.

Jennifer Dannheim gave an overview on the work done at the last meeting (ICES 2013) and the intersessional work. Three conceptual presentation of cause-effect-relationship of offshore renewables on the benthos were finalised between the expert group meetings 2013 and 2014 of WGMRED. These refer to three societally relevant issues, i.e. the benthal being (1) a 'biogeochemical reactor', (2) a source of biodiversity, (i.e. the compositional aspect of biodiversity as e.g. number of species, community composition) and (3) a source of food resources for higher trophic levels. Biodiversity was defined in its broadest sense, etc. The schemes come along with brief text descriptors describing the processes of the cause-effect-relationships between components (see ICES 2013).

During the meeting, the group started to develop a matrix as a base for scientifically justification of the hypothesis and thus to identify knowledge gaps and prioritise the known unknowns. First, the hypotheses were classified in order to structure the manifold hypothesis, i.e. biogeochemical reactor 19, biodiversity 29 and food resources 15 hypothesis. Four overarching pressure groups in accordance with Bergström *et al.* (2014) were defined: (1) mechanical sea-floor disturbance, (2) artificial reef, (3) additional energy (sound, other energy) and (4) fishery cessation & displacement. The categories will be used to group and structure the cause-effect-relationships and to discuss the relationships in a thematic context. A large literature review feeding into the matrix will be carried out intersessionally. Therefore, for each hypothesis responsible authors were defined during the meeting which will steer the review process within small subgroups throughout the year (see Annex 2 for time schedule).

As a second step, a sensitivity assessment of importance, confidence/certainty (i.e. amount of knowledge available) and consistency (i.e. appliance to all biotopes/habitats/areas) will be done on each hypothesis. Here, also the concept of Bergström *et al.* (2014) will be used as a base (see table 1).

Table 1. Criteria for assessing the probability of impact on marine life from pressures associated with offshore wind farms. The evaluation was made separately for each pressure (acoustic disturbance during construction, sediment dispersal during construction, habitat gain, fisheries exclusion, acoustic disturbance during operation, and electromagnetic fields). Spatial extent was defined as the expected dispersal of the pressure from its source, temporal extent as its expected duration. Sensitivity was assessed in relation separately for each ecosystem component (marine mammals, fish, and benthic species) and geographical area (Skagerrak–Kattegat, Baltic Proper, and Bothnian Sea). The level of certainty was assessed based on the level of documentation in peer-reviewed literature.

Score	Spatial extent	Temporal extent	Sensitivity	Certainty
1 (low)	<100 m	During construction	Minor or no effects on the abundance and distribution of local species	Limited or no empirical documentation
2 (moderate)	<1000 m	Throughout operational phase	Effects on the abundance and distribution of local species, no effects on food web	Documentation available, but results of different studies may be contradictory
3 (high)	>1000 m	Permanent	Effects on the abundance and distribution of local species, effects on food web	Documentation available, relatively high agreement among studies

As there might be differences in the response of the benthic system to the effects of offshore renewable developments, the consistency of the hypothesis will be evaluated for different habitats (soft – hard substrate) and different biological components (demersal fish, invertebrates and phytobenthos including benthic algae and microphytobenthos). For the sensitivity assessment it is of particular importance to consider different spatial and temporal scales of the effect size caused by renewable energy developments. The sensitivity analysis will finally help to prioritize the knowledge gaps in research.

The sensitivity analysis will also be carried out intersessionally after the literature review. The analysis will be led by the same responsible authors (see Annex 2 for time schedule). All information will be structured in a draft manuscript, coordinated by Jennifer Dannheim, Steven Degraer and Angus Jackson, and circulated between the group experts before the next WGMBRED meeting.

Literature cited:

- Bergström, L., L. Kautsky, T. Malm, R. Rosenberg, M. Wahlberg, N. A. Capetillo and D. Wilhelmsson. 2014. Effects of offshore wind farms on marine wildlife—a generalized impact assessment. *Environmental Research Letters* 9(3). 12 pp.
- ICES. 2013. Report of the Working Group on Marine Benthos and Renewable Energy Developments (WGMBRED), 19–22 March 2013, Caen, France. ICES CM 2013/SSGEF:17. 23 pp.
- 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.

5.6 Monitoring group (ToR B and F)

The progress made by the monitoring subgroup since the last workshop was briefly presented by Andrew Gill. He then went on to highlight the plan of action for the sub-group during the Tallinn workshop.

At the last meeting the sub-group drafted an outline of topics to be considered in a paper. Francis O’Beirn, Tom Wilding and Andrew Gill had worked on a skeleton of the paper intersessionally and had a suggested draft outline with bullet point sections that would need to be discussed. So the sub-group’s aim at the present workshop was to look at the draft paper with fresh eyes and then work on sections to have new draft paper with clear section contents and people assigned to all sections by end of the workshop. This was important to ensure that the intersessional work is not too onerous on particular individuals and that the paper can be drawn up relatively easily ready for submission.

All members of the WG were reminded that we needed to complete the Table B template so that we have the detail required for the main table in the paper.

The overall aim of the paper was to be monitoring concepts and principles.

Within the paper the tone we wanted to set was to first think of the monitoring philosophy: why should we bother and then identify pros/cons of current monitoring. This slightly provocative angle was necessary to make an informed judgement on whether what is currently undertaken is 'Fit for purpose'. We also wanted to consider if relevant indicators could be determined and if so how they could be applied effectively.

At the previous workshop we introduced the idea of scenarios for concepts of scale to detect 'acceptable' level of scale. This was agreed as a good way to proceed.

Aspects that need to be included in the paper:

- Introduction to current monitoring, problems, solutions and way forward. What needs to be monitored and how best to achieve those needs.
- Is current approach fit for purpose (what is its purpose?). Reviewing existing guidelines for monitoring marine renewables.
- Defining the problem as important: For whom do we write this paper? Why do we write this paper?
- Identify scale issues and significance testing of changes to the benthos.
- Consideration of fundamental questions: baseline knowledge, what do we need in relation to robust and useful monitoring.
- We want to make the point of understanding changes and subsequent impacts, but legislation/policymaking is too rigid.

We considered whether we had missed anything by jumping too soon into renewables as there is a more general problem with benthic monitoring. We decided that the focus should be on the specific problems with renewable energy. We did however identify the need to link to the approach from the MSFD (ecosystem approach) and also the risk-based approach (EIA approach). There was also the need to include some consideration of other stressors as the cumulative and synergistic effects could be very important in terms of the benthos.

The group also considered integrating positive effects into impacts to give some balance (e.g. improving fish stock for instance). In EIAs, focus is on the 'negative' impacts, which is imposed by legislation. Changes that are deemed important or 'acceptable' should be considered into the three important ecosystem services previously identified by the WGMBRED: food production, diversity and biogeochemical cycling.

A general conclusion was that there would be too many things in the paper if we tried to include modelling. Some reference can be made to how the outputs can be of utility to modelling though.

Overall recommendations: knowledge gaps and scales need to be highlighted.

We discussed the journal to submit to: Journal of Applied Ecology was identified as a good option. We might try and apply for funding (potentially via ICES) to enable the paper to be open access. We need a plan B, if JAE won't accept it. We will look for suggestions from the sub-group.

The sub-group ended their discussion with a time table of actions and specific names attached to the sections and sub-sections, with leads identified who would liaise with those named intersessionally. The plan is to have a paper ready to submit by Christmas 2014. Only those who contributed to the writing are to be included amongst the paper authors.

5.7 Metadatabase group (ToR C and D)

AG introduced the ToRs C & D. This was then followed by specific consideration of:

- Metadatabase
- Tethys database discussion

The goal of the metadatabase (ToR C) is about monitoring methodology: what do we do and how do we do it. It is connecting to ToR B: develop guidelines for sampling techniques, best practice development and to ToR F: evaluate scientific efficiency of ongoing monitoring.

It was expressed that our focus should be on fostering and guiding the methodological development for assessing benthic ecological research related to marine renewables. In Bremerhaven it was decided that an information system was needed that was able to link people to be able to foster cooperation between research(ers).

It has felt like WGMBRED had been going in circles in relation to the metadatabase so it was important that we consolidated our position and made a commitment to move forward. We identified that we want to consolidate our knowledge on monitoring and research, we need a platform where such knowledge can be presented, including guidance on how to set up monitoring. There already exist other databases that may enable us to meet the ToRs without having to develop a new database ourselves, with the obvious implications for time and effort to undertake the development and implementation. The Tethys database, which is led by the Pacific Northwest National Laboratory in the USA, has been identified as a suitable portal that we could potentially link to. AG introduced the Tethys website and a paper that explains its background, development, purpose and utility. AG also highlighted that the Tethys leaders would welcome a link to the WGMBRED and suggested we have a webpage section for ourselves that we could add material and links to. We just all need to add our details by signing up (this is free and provides good exposure on a worldwide basis).

In the ICES BEWG a table has been developed (and a website is planned to be set up: BELTSnet), and this could be connected to Tethys and extended with specifics on monitoring and research on the benthic ecological effects of offshore marine renewables.

The decision was to have a good look at Tethys, and decide whether this is a useable platform.

The ICES BEWG table was considered as a good basis if we then add extra keywords or columns for the monitoring and research for marine renewables. We could then upload to Tethys.

After further discussions on the last day of the workshop it was agreed to take the action highlighted above and link to Tethys. AG will take this forward with ALL others signing up.

5.8 Opportunities for collaboration and funding

Since the WKEOMB meeting in 2012 (ICES 2012) collaboration opportunities and cross-fostering research is an important and continuous topic on the agenda of WGMBRED. Jennifer Dannheim and Andrew B. Gill gave a summary on possible funding opportunities which were discussed in a plenary session by the group. The funding and collaboration perspectives ranged from workshops to tackle specific scientific questions in manuscript writing (e.g. joint data analysis on wind farm effects on benthos) to research projects at the EU level. The following possibilities for funding were introduced:

ICES science fund has the aim to strengthen collaboration and support innovation (www.ices.dk/community/icessciencefund/Pages/default.aspx). Thus this fund supports innovative projects developed in collaboration with academic and government institutions from ICES member countries. Financed are all initiatives that add specific value by science activities that contribute to the new ICES Strategic Plan aims. This includes joint data analysis and writing of synthesis papers.

The **COST fund** supports networking activities such as meetings (e.g. travel, subsistence, local organiser support), conferences, workshops, short-term scientific exchanges, training schools, publications and dissemination activities (www.cost.eu). ESSEM supports interdisciplinary research networks on adaptation and mitigation for regional or local authorities and policy makers also in the context of renewable energy production.

The **European Science Foundation (ESF)** has had regular calls for research networking programmes. However, no new call was advertised on the webpage so far (www.esf.org/coordinating-research/research-networking-programmes.html).

It was discussed to apply for a meta-analysis of data on multiple offshore wind sites of those countries which have already finished their first monitoring cycle (e.g. past 5-6 years). Suggestion is a southern North Sea case study, including neighbouring residents.

EU is looking for ideas to develop the **Horizon 2020 - Blue Growth** focus area. Blue Growth aims at a long-term strategy to support sustainable growth in the seas and ocean. The Blue Growth Strategy recognises that the European seas and oceans are central to economy and has a large potential for innovation, economic growth and job creation. The priority domains are: valorising marine life diversity, sustainable harvesting of deep-sea resources, new offshore challenges, ocean observation technologies and the socioeconomic dimension.

INTERREG 5 will be announced in near future. The INTERREG programme is an important tool for European regional development supporting cross-border, transnational and inter-regional cooperation of various entities, institutions and companies on relevant matters. A major aim of INTERREG is to support equal living conditions and development requirements in European regions. Thus it supports sustainable and integrated growth and link economic, environmental and social issues such as in the EU 2020 strategy. The launch of the next call (period 2014–2020) is expected soon.

The **ERA-NET** (European Research Area Network) scheme supports cooperation and coordination of research activities carried out at national or regional level, including member and associated states. It supports network activities of research at a national and regional level and mutual opening of national and regional research programmes.

JPI Oceans follows the concept of joint programming and was initiated to implement the European Research Area (ERA). It aims at solving challenges that cannot be solved at a national level. Thus it funds member states and associated countries to participate in joint initiatives for a common planning, implementing and evaluating national research programmes. Participants should coordinate national activities on a broad scale by pooling resources along a long-term cooperation through synergies and complementarities in common research. JPI Oceans is a platform where applied research questions e.g. monitoring concepts and strategies in OWF research field might be funded.

WGMRED will keep track on the upcoming calls.

Literature cited

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

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 2015 will take place in Oban, Scotland, 21–24 April.

Annex 1: List of participants

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Annex 2: Intersessional work and action points

Deadlines of intersessional work

Date	Topic
Knowledge group	
Literature review	
April 2014	Send hypothesis table to whole group to invite all colleagues from the group to be engaged by Jennifer Dannheim (JD), 2 weeks (beginning of May)
30.08.2014	Literature review of experts (5-15 lines), to be send to JD and Steven Degraer (SD)
15.09.2014	Send to all knowledge group colleagues involved to review the literature review (6 weeks, 31.10.2014), to be send to JD and SD
15.11.2014	Send group-comments on hypothesis to hypothesis-experts
15.12.2014	Harmonisation of the review
Prioritisation/Scoring	
15.11.2014	Individual expert scoring for each hypothesis
31.01.2015	Individual expert scoring, to be send to JD and SD
15.02.2015	Summary of individual scoring system/harmonization
28.02.2015	Select on those hypothesis scoring that have to be discussed at the WGMBRED meeting 2015 (skype)
Before WGMBRED	MS finalizing: Introduction, knowledge (review) JD/SD/Angus Jackson (lead)
Next WGMBRED	consensus of review and scoring, discuss those with no consensus
Monitoring group	
Mid April 2014	Notes on agreed structure of MS from Arjen Boon and Andrew B. Gill (ABG) to be summarized and sent to Tom Wilding (TW)
End April 2014	TW to resection and update the MS highlighting the thread through the paper and allocation of section leads - New draft onto sharepoint (engagement to ABG from all!)
End Aug 2014	Section authors to review literature and bullet point sections in logical order
End Sept 2014	Overview of common thread through draft MS (lead: TW & ABG)
Mid Nov 2014	Drafting of full text for sections and group reviewing
Dec 2014	Final paper circulate before christmas

Actions points

- Metadatabase: ABG, JD will contact Tethys to set up webpage;
- All: fill out Table from Francis O' Beirn on national monitoring strategies (18.04.2014);
- Funding opportunities/Collaboration: Horizon 2020 ABG: MPA's, Kattegat-Story, Invasives/Regime shifts; JD/Cost: Case-study: joint analysis/metaanalysis of e.g. ecological functioning – OWF;
- Funding opportunities: Participants agreed to look out for funding and becoming active if there is an opportunity!
- Look for WG members to take part outside of northern Europe.