- Hydrobiologia special issue (volume 756, issue 1) on Environmental impacts of offshore wind farms – learning from the past to optimise future monitoring programmes (eds: **Steven Degraer, Jennifer Dannheim, Andrew B. Gill, Han Lindeboom, Dan Wilhelmsson**) (publications of WGMBRED experts: **Delphine Coates, Jennifer Dannheim, Steven Degraer, Andrew B. Gill, Ilse De Mesel, Francis Kerkhof, Jozefien Derweduwen**)
- Conference on International Offshore and Polar Engineering, Anchorage, Alaska, USA, 2013, Publication in Proceedings of the Twenty-third (2013) International Offshore and Polar Engineering Benthic Interactions with Renewable Energy Installations in a Temperate Ecosystem, **Emma V Sheehan**
- Workshop leader – **Thomas A. Wilding**. 2nd International Conference on the Environmental Interactions of Marine Renewables (EIMR - II). Theme: Interactions with devices (oral contributions: **Thomas A. Wilding, Andrew B Gill, Silvana Birchenough**)
- Grand Challenges in Ecosystems and the Environment (GCEE) NERC Impact Workshop on 24th November, 2014 at Imperial College London. Prof./Dr. Steven Degraer presented on the theme of "New approaches to monitoring in offshore wind farms". **Andrew B Gill** presented an overview of WGMBRED and Silvana Birchenough presented ICES BEWG and marine renewables energy
- Keynote speaker on the Conference on Wind energy and Wildlife impacts, Berlin, Germany, 2015 (**Andrew B. Gill**) and oral presentation (**Jennifer Dannheim**)
- **Jennifer Dannheim** presented the overview of work from WGMBRED at the ICES BEWG meeting in Calvi Stareso (4-8th may 2015).

The outcome and recommendations of the three years' work of WGMBRED will enable to focus on specific processes in the benthal research that deserves urgent investigation but which, at the same time, are important for marine ecosystem goods and services in the context of marine spatial planning strategies in future ecosystem-based management approaches. Further it will contribute to optimise future monitoring, i.e. by evaluating already ongoing monitoring programmes in those countries that already have MRE in coastal waters, but also by giving advice on proper and efficient monitoring strategies for countries where renewable energy developments are still formulated on paper only.

Literature cited

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.

5.2 National summaries: ongoing activities and research

Belgium

Belgium has allocated a 238 km² zone of the Belgian part of the North Sea to offshore renewable energy production, for example offshore wind farms. Prior to construction, a developer needs obtaining a domain concession and an environmental permit. The latter includes a number of terms and conditions to minimise or mitigate the environmental

impact of the wind farm project. This also imposes a monitoring programme to assess the potential impacts on the marine environment.

The environmental monitoring programme targets physical (hydro-geomorphology and underwater noise), biological (epifouling community on the hard substratum, macro and epibenthos of the soft substratum, fish, seabirds and marine mammals), as well as socio-economic (seascape perception and offshore renewables appreciation) aspects of the marine environment. The Operational Directorate Natural Environment (OD Nature) of the Royal Belgian Institute of Natural Sciences (RBINS) coordinates the monitoring programme. To cover all necessary scientific expertise OD Nature collaborates with several institutes: the Research Institute for Nature and Forest (INBO), the Institute for Agricultural and Fisheries Research (ILVO - Bio-Environmental research group), Ghent University (Marine Biology Research Group and INTEC), International Marine and Dredging Consultants (IMDC) and Grontmij Belgium NV.

The Belgian offshore wind farm environmental monitoring programme started in 2005 with the t_{-1} data collection at C-Power wind farm on the Thorntonbank, where the first windmills were installed in 2008. The monitoring programme is running continuously since 2008 (i.e. t_0) and now (July 2015) covers three wind farms (i.e. C-Power, Belwind and Northwind). The environmental monitoring programme led to a variety of scientific findings that have been published in yearly reports (Degraer and Brabant, 2009; Degraer *et al.*, 2010, 2011, 2012) and summarized for the period 2005-2013 in Degraer *et al.* (2013). The next yearly scientific report is due in 2016.

Below is an overview of the part of the monitoring programme tackled by ILVO is given as an example of the scientific information that is gained by the monitoring programme.

Published references coming from these activities:

Degraer, S. & R. Brabant (eds.) (2009). Offshore wind farms in the Belgian part of the North Sea. State of the art after two years of environmental monitoring. Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models, Marine Ecosystem Management Unit. 287 pp. + annexes.

Degraer, S., R. Brabant & B. Rumes (eds.) (2010). Offshore wind farms in the Belgian part of the North Sea. Early environmental impact assessment and spatio-temporal variability. Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models, Marine Ecosystem Management Unit. 212 pp. + annexes.

Degraer, S., R. Brabant & B. Rumes (eds.) (2011). Offshore wind farms in the Belgian part of the North Sea. Selected findings from the baseline and targeted monitoring. Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models, Marine Ecosystem Management Unit. 157 pp. + annex.

Degraer, S., R. Brabant & B. Rumes (Eds.) (2012). Offshore wind farms in the Belgian part of the North Sea: Heading for an understanding of environmental impacts. Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models, Marine Ecosystem Management Unit. 155 pp. + annexes.
Degraer, S., R. Brabant & B. Rumes (Eds.) (2013). Environmental impacts of offshore wind farms in the Belgian pert of the North Sea: Learning from the past to optimise future monitoring programmes. Royal Belgian Institute of Natural Sciences, Operational Directorate Natural Environment, Marine Ecology and Management Section. 239 pp.

Contact: Steven Degraer, Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature), Marine Ecology and Management (MARECO), Brussels, Belgium

Six years of Belgian research on the environmental impact of offshore wind farms, was compiled in the report http://odnature.naturalsciences.be/downloads/winmonbe2013/winmonbe_report.pdf 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 the Institute for Agricultural and Fisheries Research (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 effect of wind farm underwater sound on fish.

For the baseline monitoring, epibenthos and fish of soft substrates 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.

Within the targeted monitoring, several topics were investigated, i.e. changes in feeding behaviour of commercially important demersal fish species, wind farms as spawning and nursery areas for commercially and ecologically important species, changes in commercial and recreational fisheries in and in the vicinity of the wind farms, the needs in order to optimally sample pelagic fish in the wind farms and the effect of wind farm underwater sound on fish. This latter topic is part of the Phd of Elisabeth Debusschere who acknowledges an IWT predoctoral grant.

A number of papers and MSc theses on these topics have been published:

- Vandendriessche, S., Derweduwen, J., & Hostens, K. (2014). Equivocal effects of offshore wind farms in Belgium on soft substrate epibenthos and fish assemblages. Hydrobiologia, 1-17.
- Debusschere, E., De Coensel, B., Bajek, A., Botteldooren, D., Hostens, K., Vanaverbeke, J., Vandendriessche, S., Van Ginderdeuren, K., Vincx, M., and Degraer, S. (2014). In situ mortality experiments with juvenile sea bass (Dicentrarchus labrax) in relation to impulsive sound levels caused by pile driving of windmill foundations. PLoS ONE 9(10): e109280. doi:10.1371/journal.pone.0109280.
- De Backer, A., Van Hoey, G., Coates, D., Vanaverbeke, J., & Hostens, K. (2014). Similar diversity-disturbance responses to different physical impacts: Three cases of small-scale biodiversity increase in the Belgian part of the North Sea. Marine pollution bulletin, 84(1), 251-262.
- da Costa, A.M.R. (2014) Do offshore wind farms influence the occurrence of ichthyoplankton and squid larvae? Master Thesis. Marine Biology Research Group, Ghent University, Ghent.
- Vercauteren, M. (2014) Behavioural responses of European sea bass juveniles to pile-driving sound. Master Thesis. Marine Biology Research Group, Ghent University, Ghent.

- Persoon, K. (2015) Who is the recreational fisherman and what does he catch? An overview of recreational fisheries at sea in Belgium. Master Thesis. Marine Biology Research Group, Ghent University, Ghent.

Belgian offshore wind farms currently consist of 181 wind turbines with a total capacity of 706.2 MW. From May 2016 onwards, additional wind farms will be built and the basic and targeted monitoring will be continued. The basic monitoring however, has been optimised for all investigated ecosystem components (macrobenthos, epibenthos, fish, mammals, birds, bats).

Contact:

Jozefien Derweduwen, Institute for Agricultural and Fisheries research (ILVO), Animal Sciences, Aquatic Environment and Quality, Bioenvironmental Research, Oostend, Belgium and Elisabeth Debusschere, University of Ghent, Belgium

Estonia

Estonia has jurisdiction over 36 500 km² of sea area in the NE Baltic Sea. 11300 km² belongs to Exclusive Economic Zone (EEZ). At the moment there is no major offshore wind parks currently in operation in the northern part of the Baltic Sea. In Estonian waters have 3 offshore wind farm development projects – Hiiumaa, Kihnu and Neugrund. Environment Impact Assessment (EIA) programmes have been conducted in all of these areas. Two projects are located in the areas of pilot Marine Spatial Planning regions (done currently at county level).

Overview of Estonian offshore wind farms in development phase:

Wind farm name	Neugrund	Hiiumaa	Kihnu
Sea name	Gulf of Finland	Baltic Sea	Gulf of Riga
Developer	OÜ Neugrund	Hiiumaa Offshore Tuulepark OÜ	Eesti Energia AS
Development status	consent application submitted	consent authorised	consent application submitted
Number of turbines	27–29	146–212	160
Capacity	ca. 180 MW	594–730 MW	600 MW
Foundation	not decided	not decided	not decided
Area	13 km²	155 km²	100 km²
Water depth	3–20 m	8–38 m	17–24 m
Depth range stated by Developer	5–15 m	10–30 m	17–18 m
Distance from shore (computed from wind farm center)	9,5 km	15 km	12 km

There is no official monitoring strategy or procedure established In Estonia concerning monitoring the effects of offshore installations including wind farms. Standard EIA procedures apply to the offshore windfarm projects before the actual project establishment phase. Usual licensing conditions include monitoring during construction and post construction monitoring. The aim of post construction monitoring is to establish and quanti-