4.1.5 Monitoring the impact of offshore windfarms on the marine environment: An obligate multidisciplinary and integrated programme

In 2004 the Belgian government assigned a zone for wind energy in the Belgian part of the North Sea. Since then two companies, C-Power, Belwind ad Northwind, were granted a permit to build and exploit a wind farm on the Thorntonbank, the Bligh Bank and the Lodewijkbank, respectively. The first wind turbines are up and running since 2009. A fourth company, Norther, finalised the environmental permit procedure in 2012. The permit includes the obligation to assess the impact of the project on the marine environment. As such, the monitoring programme covers physical, biological and socio-economical aspects of the marine environment.

The Management Unit of the North Sea Mathematical Model (MUMM) coordinates the monitoring and cooperates with different institutions that have expertise in a specific domain: Research Institute for Nature and Forest (INBO; birds), Institute for Agricultural and Fisheries Research (ILVO; soft sediment epibenthos and fish), Ghent University's Marine Biology Section (soft sediment macrobenthos), Ghent University's Renard Centre of Marine Geology (underwater noise) and MUMM (sea mammals, hard substrate biofouling and fish, radar detection of seabirds, underwater noise, hydrodynamics and seascape).

In general, two parallel and complementary aspects can be distinguished within the monitoring programme. The baseline monitoring, generally following a Before/After-Control/Impact or BACI design, aims at the detection and quantification of the combined effect. The targeted monitoring aims at unraveling and hence understanding the underlying causes of a selected set of priority effects, such as bird collisions and altered (commercial) fish (re)productivity.

The multidisciplinary and integrative approach will lead to scientifically sound advices for possible mitigating measures for existing, but also future offshore wind mill farms in both Belgian waters and abroad.

4.1.6 Monitoring the effects of the Belgian windmill parks on the epibenthic and demersal fish fauna of soft bottom sediments

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The monitoring strategy conducted by the Institute for Agricultural and Fisheries Research (ILVO) consists of a baseline monitoring and a targeted monitoring. For the baseline monitoring, a BACI strategy is applied to monitor the parameters density, biomass, diversity and length-frequency. For the targeted monitoring, several cause-effect relationships are investigated to answer following questions; are there changes in fishing activities in the vicinity of the windmill parks (VMS data), are there changes in feeding guild structure (stomach analyses of several fish species), are windmills used as spawning and nursery area (fish larvae) and is there an effect of underwater noise on juvenile fish and fish larvae?

The results of 2010 indicate a lower number and slightly larger individuals of swimming crab (*Liocarcinus holsatus*) and brown shrimp (*Crangon crangon*) and higher autumn densities of whiting (*Merlangius merlangus*) inside the Thornton windmill park compared to the reference area. VMS data show an increase in fishing intensity between the Thorntonbank and the Bank Zonder Naam (Lodewijkbank) since the construction of the windmills. The absence of the smallest size classes of sole (*Solea solea*)

in this area might be an indication of an increased indirect fishing mortality (such as discards) or changes in local benthic community.

The preliminary results of 2011 show larger individuals of plaice (*Pleuronectes platessa*) inside the Bligh Bank windmill park. No such large individuals were found outside the park. Several individuals of turbot (*Psetta maxima*) and brill (*Scophthalmus rhombus*) were present in the windmill park and were not found outside the park. There were also higher densities of green sea urchin (*Psammechinus miliaris*) in the gullies of the Bligh Bank windmill park compared to gullies in the reference area. The absence of fishing activities in the windmill park and the presence of a heterogeneous habitat around the windmills can explain these results and indicate that windmill parks could function as a refugium for epibenthos and demersal fish.

Challenges for future research are the further testing of the refugium hypothesis, the experimental tests concerning underwater noise, the acquisition of VMS data on foreign vessels and vessels smaller than 15m and the communication and collaboration with the sector.

4.1.7 Determing the effects of Offshore Wind Farms on marine benthic organisms throughfield scale experiments

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There are different phases in the life of an Offshore Wind Farm (OWF) that need to be considered in terms of how they interact with the coastal ecosystem. Furthermore there are different time and spatial scales that OWF impacts will occur over. To move towards determining the impacts we set up a framework of associated stressors and their effect on coastal organisms which is an important step before going on to determine whether actual impacts may occur. In light of this framework, we have developed studies focussing first on assessing the effects on species individuals at an appropriate scale and, subsequently looking at the effect across multiple individuals which could then be used to assess effects at the level of the population, thereby providing evidence for an impact (either positive or negative). To obtain ecologically relevant results at a scale appropriate for OWFs, we have taken the experimental approach, incorporating a treatment and control, into the coastal environment using large underwater netted structures (mesocosms) to provide a more realistic setting. To date, our studies have used the mesocosm approach to increase understanding of two relatively unknown effectors on fish: underwater pile-driving noise (Construction Phase) and Electromagnetic Fields (EMF), associated with the production of the electricity by OWFs (Operational Phase). The approach presented here clearly demonstrates that specific effects of OWFs on fish (and potentially other marine benthic organisms) can be determined at a scale that is relevant both ecologically and to the industry. Furthermore, it provides an important step in assessing what effectors need to be considered in terms of their possible impacts, thereby moving the research