Chapter 12. Recommendations for a future monitoring of wind farms in Belgium's marine waters

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Photo Jan Haelters / RBINS

12.1. Introduction

The future monitoring will continue to aim at the hypothesized impacts in the concession areas. As well as some changes within the technicalities and scientific designs of this monitoring (see Executive Summary), suggestions for fine-tuning the focus of the monitoring programme have been formulated in the different chapters. These recommendations are further complemented with suggestions drafted during several research-partner meetings early in 2009.

Given their importance for the future of the monitoring programme, this chapter provides an overview of these recommendations, with a view to implementing them in 2009 and/or the following years of monitoring.

12.2. Recommendations as taken from the monitoring results

Underwater noise

Future underwater noise monitoring activities will focus on pile driving and on those activities of which the noise characteristics are less well known and/or are expected to cause a significant increase in noise levels. Examples are the dumping of scour protection and cable laying.

Hard substrate epifauna and fish

1. Species richness, species-specific densities and biomass will be measured wherever possible.
2. Given their possibly high nursery capacities for invertebrates, as well as (commercial) vertebrates, special attention should be given to the habitat engineering effects of species, such as *Lanice conchilega*, *Sabellaria spinulosa*, *Tubularia* spp., *Electra* spp. and the alien *Crassostrea gigas*. ROV videoing is considered useful here.
3. Within and between sites replicated sampling is recommended in order to increase the reliability of the measurements.
4. The future monitoring of the hard substrate fauna will also include density and diversity, feeding behaviour and physiological condition of fish in the direct vicinity of the wind turbines.

Soft substrate macrobenthos

To evaluation the possible edge effects of the colonized hard substrates on the surrounding soft sediments, samples should be taken starting close to the wind turbines and at small spatial intervals away from them (i.e. small-scale study).

Soft substrate epibenthos and fish

No immediate fine-tuning of the monitoring focus required.

Seabirds

Since monitoring should also focus on displacement through avoidance behaviour, as well as migration flux and collision risk, seabird radar research will be implemented in the monitoring programme. The Automated Radar System will first be tested and calibrated onshore.

Marine mammals

1. Passive acoustic devices (i.e. Porpoise Detectors or PoDs) will be applied for the detection of harbour porpoises. PoD deployment is foreseen from the beginning of 2009 onwards.
2. More aerial surveys will be conducted to allow for the development of density surface models, revealing information on spatial and temporal variability. This is needed for the assessment of possible effects of the construction and operation of offshore wind farms.
3. Although less abundant than the harbour porpoise, attention will also be paid to the white-beaked dolphin, which is a very regular visitor to Belgian waters.

Seascape

To investigate the impact of the wind farms on the seascape a two-step approach will be used: a landscape imagery part will aim at simulating the seascape impact and is to be used in a sociological landscape part. The pictures will be used to evaluate the people's opinion on the seascape impact of offshore wind farms. The inquiry will be held among people regularly who are staying at the coast side.

12.3. Integrative monitoring

12.3.1. Integrating monitoring programmes

As both monitoring programmes (i.e. C-Power and Belwind) are strongly intertwined, most conclusions from the monitoring apply to both areas. This should be considered an advantage, rather than a disadvantage, as from a macro-environmental perspective these sites can be considered highly similar and hence (most probably) representative for the Belgian offshore water ecosystem. Both sites might thus be considered replicates, increasing the reliability and generality of any observed impact. The MUMM strategy therefore includes the integration of the monitoring exercises for the C-Power, Belwind and possible future concessions in the Belgian part of the North Sea.

12.3.2. Cause-effect relationships

While the first aim of this report was to provide an overview of (1) what has been done so far, (2) what the major conclusions regarding impact detection are at this point and (3) what would be the major lessons learned for future monitoring, this part of the monitoring only represents a first step within the monitoring programme. Whereas the current (baseline) monitoring design aims at an objective *a posteriori* evaluation of existing and possible resultant impacts of marine wind farms in Belgian waters, it is incapable to disentangle the processes behind an eventual impact. Since however knowledge of these processes help understanding the cause-effect relationships, an upgrade of the monitoring programme from a level of *a posteriori* phenomenon observation to a level of process understanding is needed. The capability to link environmental changes to an underlying cause-effect rationale (i.e. targeted monitoring) is not only a pre-requisite for effective regulatory application, but – as it provides baseline knowledge to comprehend impact processes – also permits (1) current and future impact mitigation, (2) better prediction of future impacts, as well as (3) moving away from site-specific observations to more generic knowledge.

Consequently, it is advised to feed the information taken from the baseline monitoring into the investigation of a selected set of hypothesized cause-effect relationships. Selection should here be based on the knowledge from and prioritization within the baseline monitoring and the Environmental Impact Study. Within the monitoring programme, it will hence be important to find an adequate effort and budgetary balance between baseline and targeted monitoring.

The process of selecting the priority cause-effect relationships for future monitoring in ongoing. Hereto, a close interaction between MUMM and its research-partners is ascertained so as to assure a relevant selection with a direct added value to the marine wind energy sector.

12.3.3. Evaluation of the overall impact based on environmental indicators

After the quantification of the differential impacts of the construction and exploitation of marine wind farms, as presented in this report, a next and most legitimate request would be to compare the overall impact of this anthropogenic activity with that of other activities (e.g. marine aggregate extraction). Such comparison would allow us to evaluate and/or scale the overall severeness of any anthropogenic activity. However, this exercise is not as simple as it might seem. Here below, we therefore introduce the background of the subject and formulate MUMM's intentions for future action.

To fully comprehend the impact of an anthropogenic activity on the marine ecosystem, impact evaluation should be framed within the Driver-Pressure-State-Impact-Response (DPSIR) model, of which especially the pressure, state and impact are relevant here. In this case, the pressure, being the overall pressure of the construction and exploitation of marine wind farms on the marine ecosystem, eventually combined with the exclusion of bottom trawling fisheries, is clearly delineated. The environmental state as a result of the pressure, however, cannot be covered by only one (or a limited number of) characters, given the multi-faceted and hence multivariate nature of the environmental state. Marine wind farms, for instance, are known or at least expected (1) to cause local changes in hydrodynamic conditions (with consequent alterations within the sediment grain size composition), (2) to cause visual disturbance due to the presence of above-water structures, (3) to add new hard substrate habitat to a formerly and naturally soft substrate marine environment or (4) to cause vibrations due to the construction and exploitation, adding to the natural background levels of underwater noise. In their turn, each of these altered environmental states influences the ecosystem, which is the environmental impact we would finally like to evaluate. Again this impact on the ecosystem is multi-faceted and hence multivariate by nature. Local changes in sediment grain size composition, for instance, will – or at least might – cause community shifts within the benthos, as exemplified by an altered community structure (e.g. diversity, density or biomass) or functioning (e.g. remineralization processes and predator-prey interactions). Each of these measures or response variables can be quantified, which is exactly the aim of this monitoring programme, i.e. to unravel and quantify the ecosystem impacts due to the construction and exploitation of marine wind farms. Ecosystem impact can now be defined as the deviation of each of the response variables[1] from its condition prior to the impact or relative to the reference area(s).

From this reasoning it is clear that the evaluation of the overall impact is not as straightforward as we would like it to be. As e.g. (1) the impacts themselves are multivariate, (2) some of the impacts might be positive, other negative, (3) some might be severe, other more moderate or (4) some only cover one ecosystem component (e.g. benthos), other cover several ecosystem components (e.g. altered bentho-pelagic coupling), an overall judgment on whether the overall impact is positive or negative, not to speak about how positive or negative the impact is, remains difficult.

Here, environmental indicators offer a solution. These indicators generally combine several assets of the ecosystem into an integrative measure of ecosystem quality. As such, they are considered quantitative proxies for ecosystem quality. This combination of assets is generally based on known or presumed cause-effect relationships and are hence (presumed to be) generically applicable. Several indicators have already been developed and testing and intercalibration exercises were performed mainly as a consequence of the European Water Framework Directive (WFD). They will further be developed within the European Marine Strategy Framework Directive (MSFD). The indicators used in coastal waters for WFD purposes can be grouped in three types: (1) the multi-metric indicators based on the AMBI principle (e.g. m-AMBI [Spain], IQI [UK]); (2) the multi-metric indicator Benthic Quality Index (BQI, Sweden), using an objective way to define sensitivity-tolerance of species ($ES50_{0.05}$); and (3) the multi-level Benthic Ecosystem Quality Index (BEQI) evaluating different aspects of the benthic habitat/ecosystem without predefined sensitive-tolerance classes for species. Given its suitability to evaluate the effects of multiple pressure types, the BEQI was adopted to evaluate the environmental status (ES) of benthic ecosystems in Belgium and the Netherlands.

As such, an array of well-challenged and intercalibrated indicators exists and will be used in the future to present an integrative view on the ecosystem quality change (*prior* versus *post hoc* or impact versus reference site) as a result of the construction and exploitation of marine wind farms. From this array it was advised to select not only one, but a suite of suitable indicators (Royal Commission on Environmental Pollution, 1998). The selection of this suite should be based on indicator performance, as quantified in the various WFD intercalibration exercises, and the availability of response variables from the monitoring programme. As an alternative to the latter, the monitoring programme could be

[1] The true size of the multivariate impact space is dependent on both the number of response variables considered and their cause-effect connectivity. Several variables are interconnected (e.g. a change in hydrodynamical regime will cause changes in the sediment's grain size distribution or a change in benthic community structure will cause changes within the food availability to benthos-eating fish) and should hence be considered dependent. The true size of the multivariate impact space and hence the number of relevant response variables is limited to only independent response variables.

partly redirected towards those response variables, relevant for the selected indicators. The use of such environmental indicator approach will hence not cause a proliferation of the monitoring effort or cost.

If the ecosystem quality change – based on environmental indicators – could be calculated for several anthropogenic activities, then a comparison of the change between the different activities would allow us to scale the activities along an impact severity gradient. As such, the MUMM intention is to integrate the results of other, existing monitoring initiatives (e.g. aggregate extraction, dredging and dredge sludge disposal) with those from the marine wind farm monitoring initiative. This exercise would significantly contribute to an objective evaluation of the impact of the construction and exploitation of marine wind farms. The exercise will further allow to scale the magnitude of the overall impact, relative to the ES categories, as defined in the WFD and to be defined in the MSFD. Here, an impact should only considered unacceptable if it causes a significant degradation within the GES categories perspective (e.g. from good ES to bad ES).

In conclusion, integrative monitoring is and will be narrowly intertwined with the ongoing monitoring programme. Herein, three priority items can be discerned:

Detailed observations of the Before-After/Control-Impact (BACI) changes of a selected set of response variables within each of the (main) ecosystem components (i.e. benthos, fish, seabirds and marine mammals) provide the knowledge necessary for impact detection and quantification (i.e. baseline monitoring). This selection should be based on the list of expected impacts as taken from the environmental impact study (EIS).

The information taken from the baseline monitoring should be exploited for a selected set of hypothesized cause-effect relationships in order to improve possible mitigation and prediction of (future) impacts. Selection should here be based on the knowledge from the baseline monitoring results and the EIS. The capability to link environmental changes to an underlying cause-effect rationale is not only a pre-requisite for effective regulatory application (Rees et al., 2006), but also provides the baseline knowledge to comprehend impact processes and, therefore, to permit current and future impact mitigation, as well as better prediction of future impacts.

A last priority item should cover the evaluation of the severeness of impact by (1) comparing the overall impact with those of other pressures and (2) scaling its magnitude according to the ES categories, using a suite of multimetric environmental indicators.

These items will be covered simultaneously as the information taken from both first priority items is directly fed into the third priority item.

12.4. References

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