REPORT

Gap analysis ecological monitoring Dogger Bank

Power Hub islands and Windfarms

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1 Introduction

Recently, Ecofys and Royal HaskoningDHV (RHDHV) have presented the need for building before 2045 large capacities of offshore wind farms (more than 180 GW) in order to fulfil the objectives of the Paris Agreement. Because of its relative low water depths, one of the options is to develop a large number of windfarms and one or more artificial 'power hub islands' on the Dogger Bank in the North Sea. The construction, operation and decommissioning of windfarms and power hub islands will have impacts on the ecosystem.

TenneT wants an insight in the available information on possible impacts and a gap-analysis of the studies that need to be executed to assess the possible impacts on the ecosystem in relation to the proposed infrastructural initiatives on the Dogger Bank.

Development of wind farms consists of the construction of foundations, interarray cables, small collection platforms and the laying of high capacity cables to HVDC stations. Construction of a power hub island includes a revetment to resist waves, a breakwater and a quay wall or berthing structures in a port. Such a power hub island will probably contain:

- A large number HVDC stations
- Cable connections from the wind farms and interconnectors
- Facilities for air connectivity (airstrip or helideck)
- Operation and Maintenance base for wind farm operators
- Power to Gas production facilities
- Storage facilities of P2G, transport facilities of P2G
- An installation yard for new wind farms
- Housing facilities including utilities (water, power, communication, etc) and recreational facilities.

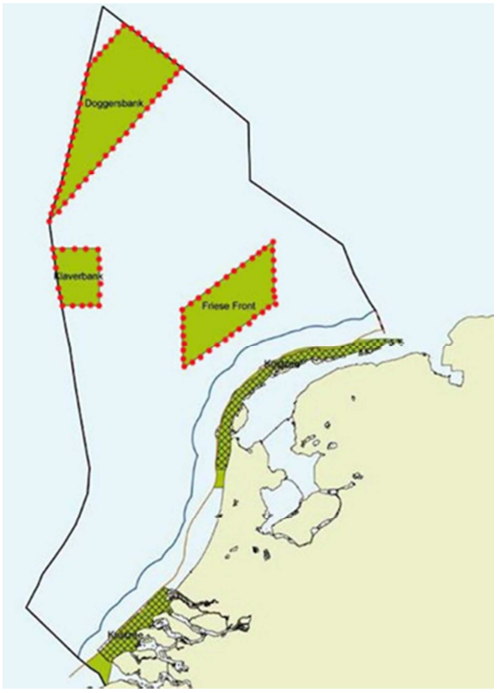
In this report the ecological significance of the Dogger Bank is explained in chapter 2 and the possible impact of power hub islands and windfarms in chapter 3. In chapter 4 the knowledge gaps and the existing monitoring is described. Recommendations on location specific monitoring for the Dogger Bank can be found in chapter 5.

2 Dogger Bank

2.1 Location

The Dogger Bank is located in a relatively shallow area of the North Sea. It rises from 40 meter deep water to a depth of about 13 meter under the seawater level. The Dogger Bank was formed by glacial processes and submerged through sea-level rise. A large part of the southern area of the bank is covered by water seldom deeper than 20 m. The bank is non-vegetated and comprises mainly of moderately mobile, clean sandy sediments. The bank is almost 300 km long and is located in British, Danish, German and Dutch parts of the Exclusive Economic Zones (EEZ). In this report it is assumed that the power hub island would be located in the Dutch part of the Dogger Bank.

Figuur 2-1 Dogger Bank in the North Sea



Figuur 2-2 Habitat Directive sites in the Dutch EEZ

2.2 Ecological significance of Dutch part of Dogger Bank

The Dogger Bank is designated as a Habitat Directive site or SAC in the UK (site area 12.331 km^2), Germany (site area 1.624 km^2) and the Netherlands (site area 4,715 km²). In 2016 the Dutch part of the Dogger Bank was designated as a Habitat Directive site. This marine site lies at the northern tip of the Dutch Exclusive Economic Zone. It consists of '*sandbanks which are slightly covered by sea water all the time, subtype Dogger Bank*' (habitatype H1110C). This habitat type is also protected in the British and German part of the Dogger Bank. Protected Habitat Directive species are harbour porpoise (Netherlands and Germany), grey seal (Netherlands) and harbour seal (Netherlands and Germany).

The water depth in the Dutch part of the Dogger Bank varies between 24 m and 40 m. Since this area is far from the coastal areas, no fresh river water mixes with the salt water. This is an important difference from most water-covered sandbanks closer to the coast. As there is little suspended material in the water column, light can penetrate right down to the seabed. This enables photosynthesis at the sea bottom and makes it possible for numerous organisms to thrive. This provides also the quite unique ecological situation of the Dogger Bank in the North Sea.

The Dogger Bank is an important spawning site for herring, plaice and smelt. For seabirds and marine mammals, the sand eel and smelt are important food sources here. This site is home to numerous fish species that are nowadays rare, live long and have slow reproduction. One of these is the thornback ray.

3 Possible impacts

The possible impacts of power hub islands and wind farms are partly similar, but also have differences. In the following paragraphs the impacts are described separately.

3.1 Possible impacts of power hub islands

In the construction phase and operational phase of power hub islands a number of effects on the marine life can be distinguished. The most important impacts are listed in table 3.1.

Table 3.1 Possible impacts of power hub islands

Habitat/species	Construction phase	Operational phase
Water column	Turbidity of the water column, primary production may decrease, impact on the food chain	-
Sandbanks	Disturbance, loss and change of habitat	Loss and change of habitat
Marine mammals	Avoidance of areas with underwater noise	Possible attraction to islands due to high food abundance
Seabirds	Disturbance by vessels (avoidance distance 2 km)	Possible attraction to islands due to high food abundance, nesting and resting areas
Fish	Disturbance, change and loss of habitat Negative impact on fish eggs and larvae	Increased food availability leads locally to higher biomass and larger fish
Benthos	Disturbance, loss and change of habitat of soft substrate species	Higher biodiversity and a higher biomass of hard substrate species, stepping stone for invasive species

3.2 Possible impacts of windfarms

In the construction phase and operational phase of windfarms a number of effects on the marine life can be distinguished. The most important impacts are listed in table 3.2.

Table 3.2 Possible impacts of windfarms

Habitat/species	Construction phase	Operational phase
Marine mammals	Avoidance of areas with underwater noise due to piling	Possible attraction to windfarms due to high food abundance (see fish)
Seabirds	Disturbance by vessels (avoidance distance 2 km)	Collision risk, avoidance of windfarms, new habitat
Fish	Disturbance, change and loss of habitat Negative impact on fish eggs and larvae	Decreased fishing and vessel activity leads locally to higher biomass and larger fish
Benthos	Disturbance, loss and change of habitat of soft substrate species	Higher biodiversity and a higher biomass of hard substrate species, stepping stone for invasive species
Sandbanks	Disturbance, loss and change of habitat	Loss and change of habitat

4 Existing monitoring

A lot of aspects are being monitored in The North Sea. In this chapter we mention the most important programs that are relevant for this gap analysis.

4.1 Regular monitoring

The Dutch Continental Shelf is being monitored regularly in the monitoring programme called MWTL (Monitoring Waterstaatkundige Toestand des Lands). Marine mammals and birds, fish and benthos are measured through a standard grid, also on the Dogger Bank. The density of the grid is very low, therefore the number of samples and tracks on the Dogger Bank is limited.

The monitoring programs and grid are visible on the monitoringagenda of 'Informatiehuis Marien' (http://www.informatiehuismarien.nl/producten/monitoringsagenda/).

4.2 Monitoring power hub islands

Important for this gap-analysis is to mention that building power hub islands is a new phenomenon at the North Sea; no monitoring plans have been elaborated for this. However, studies were executed to assess the impacts of Flyland (airport island at sea) and Maasvlakte 2 (expansion of the port of Rotterdam). Information on the monitoring in relation to these projects is used for this report.

Flyland
At the end of 1999 the Dutch Cabinet decided on limited growth of Schiphol Airport at the current location in the short and medium term. To determine whether an airport island would be an alternative for the current Schiphol location in the long term, the cabinet decided to commission further investigation into the feasibility of this by means of a research programme extending over several years. The programme was named Flyland. At the end of 2002 it emerged that, as a result of various global developments in aviation, a possible alternative for Schiphol would only become relevant at a much later date than had been envisaged in 1999. This understanding resulted in the freezing of Flyland. To assess the impacts on such an island the research program 'Marine Ecology and Morphology' was executed. Benthos, fish, birds and sea mammals were investigated, as well as sediment transport and turbidity of the water column.

Maasvlakte 2
Maasvlakte 2 is the expansion of the port of Rotterdam. A new European location for port activities and industry is being created immediately to the west of the present port and industrial area. When the construction of Maasvlakte 2 began in 2008, the sea there was 17 meters deep. Maasvlakte 2 existed on no map, except for the design drawings. Maasvlakte 2 encompasses 1,000 hectares of industrial ground, located directly on deep water.

A monitoring and evaluation program (MEP) for sand extraction and a MEP for land reclamation have been drafted. The main purpose of the MEP Sand extraction was to assess the impact on the benthos. On 300 locations benthos was monitored before sand extraction (baseline monitoring). During extraction and afterwards the monitoring was repeated every two years.

The main purpose of the MEP Land reclamation was to check if the impacts of land reclamation were adequately compensated by the mitigating measures (assignment of protected area, dune restoration). The ecological marine monitoring is aimed at benthos, coastal birds and seabirds.

4.3 Knowledge gaps power hub islands

The following knowledge gaps related to power hub islands were identified in the report Quick scan ecology artificial island IJmuiden ver (RHDHV, 2017):

- What is the cumulative impact with other activities
- Impact of a slib plume on the primary production during construction
- Impact of light on birds: how much light will there be on the island, what is the impact on birds and will migration routes be affected?
- Role of an island as hub for invasive species: what species will colonise the island and will they be invasive?
- Role as breeding and resting area for birds: what bird species will be attracted by the island and what will be the side effect?

4.4 Monitoring windfarms

To fill the knowledge gaps and to monitor the current effects in operational windfarms monitoring programs on various offshore windfarms have been and are being executed. Examples of offshore windfarms with monitoring programs are:

- Netherlands: Egmond aan Zee Offshore Wind Farm (OWEZ) and Prinses Amalia Wind Farm.
- Denmark: Horns Rev and Horns Rev 2.
- Belgium: Bligh Bank, Thornton Bank.
- United Kingdom: North Hoyle, Greater Gabbard`.
- Germany: FINO, MINOS.

Recently Environmental Impact Assessments and Appropriate Assessments have been drafted for two wind farms in the Dutch part of the North Sea: Borssele I and Borssele II. These assessments include up-to-date insights in the knowledge gaps and the monitoring needs for new windfarms for both the construction phase and the operational phase.

Relevant for the purpose of this memo are the monitoring plans for the proposed UK windfarms on the Dogger Bank and the generic Dutch Offshore Wind Ecological Program (WOZEP). These are described in more detail in the paragraphs 4.4.1 and 4.4.2

4.4.1 Monitoring UK windfarm project on Dogger Bank

The UK part of the Dogger Bank has been identified as a potential site for four UK windfarms. Royal HaskoningDHV has made the Environmental Impact Assessments and a monitoring plans for these projects Dogger Bank Creyke Beck area will be the first stage of development of the Dogger Bank Zone, and will comprise two windfarms (Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B). A monitoring plan is drafted for this wind farm development. The plan is meant to give more insight in potential effects on the Dogger Bank. The monitoring will mostly take place in both pre-construction and operation phase. The planning of the monitoring depends on the final go for these windfarms, at the moment it is not clear when this will be. This means that no monitoring results are available at this moment.

Potential effects wind farms Dogger Bank	Monitoring proposed
Displacement of Razorbill (Alca torda); Guillemot (Uria aalge); and Gannet (Morus bassanus) Collision of Gannet; and Kittiwake (Rissa tridactyla)	Appropriate surveys of existing ornithological activity inside the area
Effects on habitat (benthos)	Appropriate surveys to determine the location and reasonable extent of any benthic habitats of conservation, ecological

	and/or economic importance
	Appropriate surveys to determine change in size and form of the disposal mounds (deposition of drill arising's)
Effects on sand eel population	Appropriate surveys of sand eel
Disturbance effects on harbour porpoise	Appropriate surveys of existing marine mammal activity inside the area
Increased noise levels	Measurements of noise generated by the installation of one pile from each of the first four structures with piled foundations
Loss or restricted access to traditional fishing grounds	*Monitoring the effects on vessels that target the inshore crab and lobster fishery.*
Effects on the levels of marine traffic across the project	*Vessel traffic monitoring by Automatic Identification System*
Effects on the archaeological resource	*Appropriate high resolution bathymetry surveys and side-scan surveys of the area*
Changes in seabed topography, including scour processes	*Appropriate high resolution bathymetric and side-scan surveys of the area*
Effects on sediment transport	*Survey programmes and methodologies for the purposes of monitoring to be submitted*

4.4.2 Monitoring Program WOZEP

WOZEP stands for Dutch Offshore Wind Ecological Programme .The Dutch government has drafted an overall monitoring and research program for the period **2017-2021**. The purpose is to study knowledge gaps in relation to the impact of offshore wind farms on the ecosystem of the North Sea.

Potential effects of wind farms	Monitoring proposed
Birds: displacement from habitat	Identify top 10 vulnerable species and draft ecological profiles Develop Individual Based Models (IBM) for top 5 vulnerable species Develop of re-use (improved)data-fed population models Establish relevant changes in food availability for seabirds (benthos, fish) Investigate habituation of seabirds to presence of wind farms
Birds: collision risk	Continuation/evaluation of WT-Bird system in OWEZ (existing windfarm) Integrated monitoring of collision risk, species-specific fluxes and avoidance behaviour in OWEZ and Borssele wind farms Onshore study on effectiveness of mitigation during migration Study of changes in flight behaviour as a consequence of wind turbines Identify top 10 species with highest collision impact on population Modelling population dynamics on top 10 species
Bats	Telemetry onshore Bat detector research Thermal imaging offshore Population survey Analysis of existing population data
Marine mammals	Desk study sensitivity of seals to piling sound compared to harbour porpoise Desk study to investigate other effectible species Tagging harbour porpoise in the North Sea Investigate impact of underwater sound on vital rates of harbour porpoise Presence of marine mammals in windfarms (before, during and after piling) Develop Individual Based Models (IBM) for harbour and grey seal

	Distribution and behaviour of marine mammals in North Sea Determine maximum permissible impact on harbour porpoise population Investigate effects of other stressors on marine mammals Investigate effects of other foundations on marine mammals
Fish	Lab and field studies on effects of Electro Magnetic Fields to fish behaviour Validation of modelled EMF's Modelling cumulative effects of EMF's on fish populations Determine effects of exclusion of bottom trawlers on fish populations Modelling wake effect on primary producers
Benthos	Long term monitoring of soft sediment benthos Long term monitoring of hard sediment benthos Inventory of biogenic structures

4.5 Knowledge gaps windfarms

From the above described inventory, the knowledge gaps for windfarms we have identified are:

- What is the seasonal and spatial distribution of seabirds;
- Timing and spatial magnitude of migration of migratory birds;
- How do diving birds use underwater hearing in their search for prey and orientation, hence what are the effects of underwater noise on diving birds?
- Abundance of bats at sea and their behaviour in windfarms;
- Quantification of the amount of disturbed marine mammals;
- Translation of sound effects on vital rates (health, survival and reproduction success) of marine mammals;
- Impact of Electromagnetic fields (EMF's) on the behaviour and distribution of fish.

4.6 Other aspects

There are other aspects that might be important or interesting to study, these are:

- Windfarms as stepping stones for invasive species (negative notion)
- A coherent network and Building with Nature. (positive notion)

4.6.1 Stepping stones or coherent network

When offshore installations are placed at the boundaries of larval distribution potential, they may function as stepping stones to increase the spread of certain species. This stepping stone effect has been suggested in many recent publications including the warning for expansion of native and non-native species previously unable to colonise offshore areas. This depends strongly on the currents in the area. The report also states that the intertidal zone does not naturally belong to most part of the offshore North Sea and that the available substrate in the intertidal zone should be minimized. It is still not clear yet whether the stepping stone issue is a problem on the longer term or not (Coolen, 2017).

Researchers at the Environmental Research Institute and the Scottish Association for Marine Science are currently investigating ways in which to monitor and reduce the impact offshore infrastructures will have on facilitating the invasion of non-native species. So far, this work has included the completion of a baseline survey for the presence and distribution of fouling non-native species within the Pentland Firth and Orkney marine energy park and the assessment of the detection abilities of different monitoring methods. Future work will investigate how device material, habitat orientation and season affect non-native species composition. The results of this research will inform best practices for future monitoring programmes and suggest control measures which aim to reduce the introduction and spread of non-native species.

This is the negative side of stepping stones, there could, however, with the same mechanism, also be a positive side: the wind farms and the power hub islands could also work as a coherent network for species that are native and have a positive impact on the dispersal. There is currently no information on if and how this coherent network works.

4.6.2 Building with Nature

Optimizing the scour protection of offshore wind farms or the way an island is being build can be used to enhance its ecological functioning. This means that habitat suitability for species (or communities) occurring naturally in the Dutch North Sea will be increased. This could be interesting to mitigate possible negative impacts of windfarms and artificial islands or maybe to add some positive effects.

5 Location specific monitoring needs

The monitoring plans mentioned in chapter 4 will provide valuable information that can be used to determine the impacts and to formulate mitigating measures but is, however, only addressed to current windfarm development. The Dogger Bank is a Natura 2000 area now, which means that collection of specific ecological information on location will be necessary for some species and/or habitats. In the following paragraphs the extra monitoring is described that is needed to assess the impact of for power hub islands and windfarms on the Dogger Bank.

5.1 Monitoring needs power hub islands

1. Impact of a sediment plume

The turbidity of the water column will increase due to sand dredging and sand nourishment. The rate of increase depends on the silt fraction of the sand that is being used. An increase in turbidity will affect the primary production and could cause smothering of the benthos. Birds and fish that hunt on sight may avoid the area because of the increased turbidity. To know more about the impact of this on different species and the food chain, the rate of the sediment plume and the decrease in primary production needs to be modelled.

2. Disturbance by light

Sea mammals and birds will be disturbed during the construction and operational phase by the presence and noise of ships and helicopters, the presence of human activity and light. The area will be avoided by most animals. In some cases birds can be attracted to light, which can cause disturbance of migration routes. More information is needed on the use of light on the islands and the migration routes in the surrounding area. We recommend *to start with a literature study* on this topic, because quite a lot is known about the impact of light on birds. After the literature study, a better estimate of the necessary research or monitoring can be made, and it can be assessed if more research is needed.

3. Role of an island as breeding and resting area for birds

Birds may use the island as a resting or breeding area (e.g. gulls and terns). There won't be predators like foxes and food is close by. On the other hand, weather conditions may be more severe and there will be human presence and accompanying disturbance. And, there will be wind turbines at a certain distance around the island; so there is a risk for collision of birds. Further research is needed to learn more about the positive and negative impacts. We recommend *to start with a literature study and*/or expert meeting on this topic. After the literature study a better estimate of the necessary research or monitoring can be made, if it is and it can be assessed if more research is needed

4. Role of an island as hub for invasive species

Recently it was stated that structures in the North Sea (like platforms) can function as a stepping stone for invasive species via pelagic larvae. This depends strongly on the currents in the area. The report also states that the intertidal zone does not naturally belong to most part of the offshore North Sea and that the available substrate in the intertidal zone should be minimized. It is still not clear yet whether the stepping stone issue is a problem on the longer term or not. Further research is needed.
We suggest to organize a workshop with experts and NGO's to determine a list of possible invasive species that may/will use the islands as a hub and for which species. And, with that knowledge determine what the negative or positive impacts will be and decide whether monitoring or research is needed.

5. Building with Nature

The results of the workshop on invasive species can be used to determine how negative impacts can be mitigated or positive impacts can be stimulated by using the right material for the revetment of the power

hub islands. Recommendations to include Building with Nature in the design of the island can be based on the workshop under 4 and on existing expertise.

5.2 Monitoring needs windfarms

1. Seasonal and spatial distribution of seabirds

The vulnerability of seabirds differs from species to species. In WOZEP the most vulnerable species will be identified. Individual Based Models for these species will be developed and collected data will be fed to population models. To establish possible impacts on birds on the Dutch part of the Dogger Bank it is vital to know which birds are present in which time of the year. The following species are expected to be present and need to be monitored monthly for at least 2 years: arctic skua, atlantic puffin, black-legged kittiwake, common guillemot, great black-backed gull, great skua, lesser black-backed gull, little auk, northern fulmar, northern gannet and razorbill (Appropriate Assessment Teesside A & B, 2014).

2. Timing and spatial magnitude of migration of migratory birds

The Appropriate Assessment Teesside A & B concludes that there is no adverse effect on the integrity of designated SPA migratory bird populations as a result of the potential barrier posed by Dogger Bank Teesside A & B alone or in combination with other projects. This is based on generic insights on the total numbers of migratory birds that cross the North Sea. Nevertheless specific knowledge of the timing and magnitude of the migration over the plan area is essential for determination of the most cost-effective mitigating measures. There has been and still is being done a lot of monitoring on bird migration in the North Sea. Possibly data from other studies can be used. A more detailed overview of the results of these studies is necessary to get a complete picture of the monitoring need, if any.

3. Abundance of bats at sea and their behaviour in windfarms

Different species of bats haven been seen to migrate on the North Sea and to possibly forage in offshore windfarms. It is known that bats can suffer injuries from collisions with wind turbines, leading to mortality. Although no attention is given to bats in EIA and Appropriate Assessment of Teesside A & B, the Dutch legislation oblige developers to assess the impacts of their project on the population of bats. Therefore monitoring of bats migrating over the plan area is recommended. If mitigating measures include temporary closedown of the turbines in case migrating bats are passing, monitoring bats in the operation phase is also recommended.

4. Stepping stones for invasive species or coherent network

Since there are a lot of opinions on this topic, it is advised to organize a workshop with experts and NGO's to determine a list of possible invasive species that may/will use wind turbines as stepping stones and for which species a windfarm will act as a coherent network. And then to determine what the negative or positive impact will be and decide whether monitoring or research is needed.

5. Building with Nature

The results of the workshop on stepping stones can be used to determine how negative impacts can be mitigated or positive impacts can be stimulated by using the right material for the scour protection.

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