Non technical summary

Norther nv

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Non technical summary

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1 AIM AND PROPOSED ACTIVITY

Norther NV has taken the initiative to build an offshore wind farm in the North Sea (the ‘North Sea Power wind farm’), to be located at 20 to 30 km from the cost, within a zone southeast from the Thorntonbank, alongside the border with the Netherlands. The wind farm will generate a yearly output of approx. 800 GWh to 1,500 GWh, corresponding to the average yearly consumption of ca. 230,000 to 430,000 households. Before construction can begin, a license must be applied for. To assist with the decision-making process concerning the license application, the procedure for an environmental impact report together with an environmental impact assessment will be followed.

In order for the environmental interests to be taken fully into account in the license granting, an environmental impact report (EIR) must be drawn up. This EIR will be used to underpin the consents process and must describe the construction, exploitation, dismantling as well as the cable installation of the North Sea Power wind farm.

The initiator can currently not state the final choice of turbine or foundation yet. In practice this final choice is only made after an extensive analysis and tender procedure. References, the financial capacity of the various manufacturers, the economic analysis, the proven technology and several other items are very important hereby. The EIR therefore departs from three configuration alternatives that cover the complete range of installation possibilities within the North Sea Power wind farm. In that way the principle of the worst case approach is also taken into account for the methodology and analyses within the EIR. The dimensions and specifications of the eventually chosen turbine and foundation types need to be equivalent or inferior to the described types within this EIR.

In this EIR following configuration alternatives for the planned North Sea Power wind farm will be discussed:

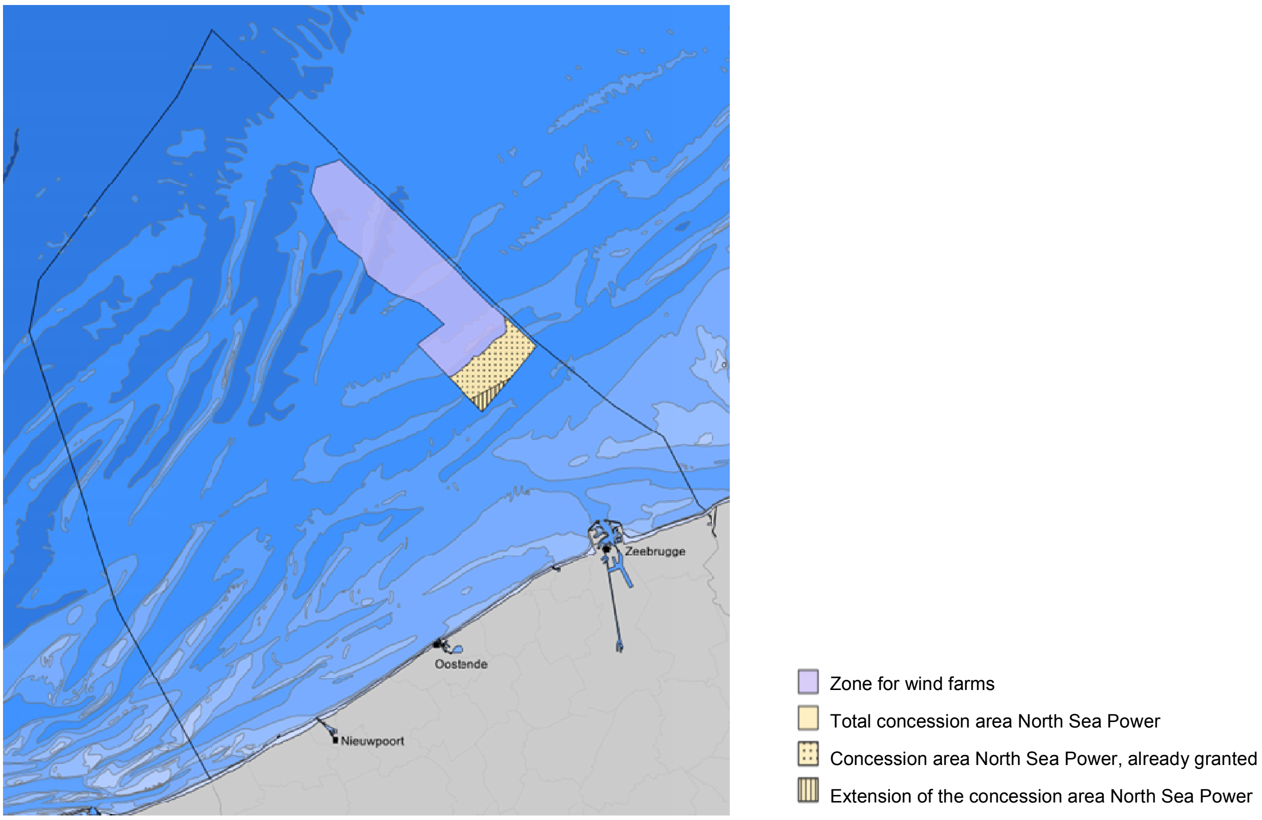
- Configuration 1: 86 wind turbines with rotor diameter approx. 120 m, with an individual capacity between 3 and 4.5 MW, corresponding with a total installed capacity of approx. 320 MW. The Siemens SWT-3.6-120 turbine will be used as a type-example (3.6 MW per turbine → 310 MW total installed capacity);
- Configuration 2: 74 wind turbines with rotor diameter approx. 130 m, with an individual capacity between 5 and 6.5 MW, corresponding with a total installed capacity of approx. 420 MW. The 6M REpower turbine will be used as a type-example (6.15 MW per turbine → 455 MW total installed capacity);
- Configuration 3: 47 wind turbines with rotor diameter approx. 150 m, with an individual capacity between 7 and 10 MW, corresponding with a total installed capacity of approx. 400 MW. The Britannia C-150 turbine from Clipper Windpower will be used as a type-example (10 MW per turbine → 470 MW total installed capacity).

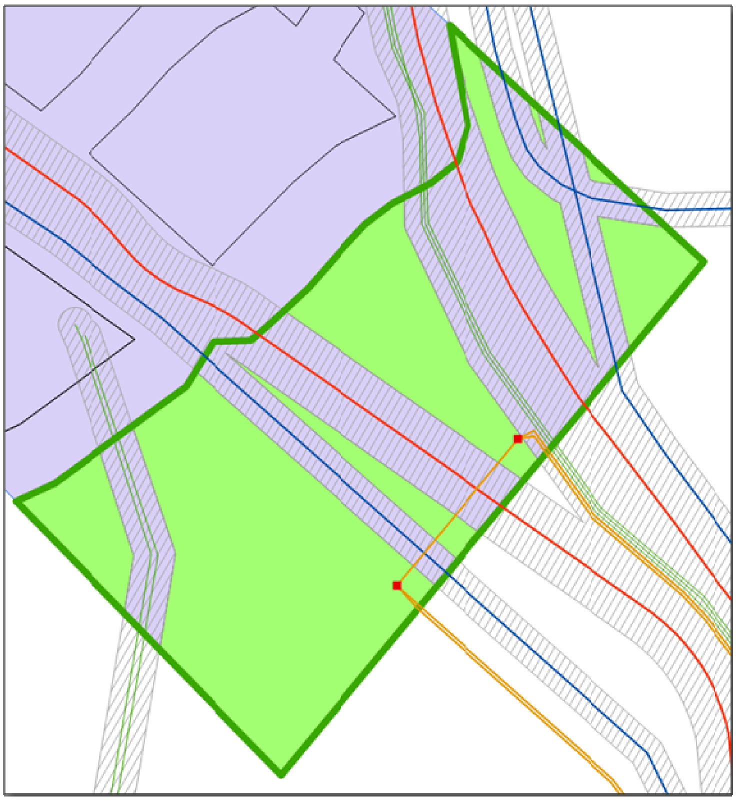
Finally, the cumulative impact of the North Sea Power wind farm together with the three currently licensed wind farm projects in the Belgian North Sea (C-Power, Eldepasco and Belwind) will be discussed.

2 PROJECT DESCRIPTION

The North Sea Power wind farm will be built at 20 to 30 km from the Belgian cost, within a zone southeast from the Thorntonbank, alongside the border with the Netherlands. The northern border of the project area is situated at approx. 1 km from the concession domain of C-Power.

On October 5th 2009 the Federal Public Service Economy, S.M.E.s, Self-employed and Energy granted a concession domain to Norther for the construction and exploitation of a wind farm for the block that is demarcated by the coordinates listed in annex 1 of the Ministerial Decree of 05/10/2009 (an area of approximately 38 km²) with the exception of the safety perimeters of the cables and pipelines situated within the area (see article 1 §1° of the Ministerial Decree of 05/10/2009). Norther will apply for a modification of the concession area. The modification consists of an extension of the granted concession area (conf. block in annex 1 of the ministerial decree of 05/10/2009 of approx. 38 km²) in southern direction, to a total area of approximately 44 km². Again, taking into account the buffering zones around cables and pipelines laying within this area, the available space for installation of wind turbines amounts to approx. 26 km² (concession area *sensu stricto).* When referring to the concession domain or concession area of the North Sea Power wind farm in this EIR, it is always meant as the complete extended area (44 km²), as this is the most relevant with regard to the environmental effects, unless stated otherwise explicitly.





The individual capacity of the turbines varies between 3 to 10 MW, with a maximum total installed capacity of 470 MW. The generated power will be transported to the coast (Zeebrugge) by an underground cable.

The construction of the North Sea Power wind farm is planned in the period 2014-2016.

In the table below the principal technical features of the future North Sea Power wind farm are described.

Subject	Description
Location	
Site	• Situated at 20 to 30 km from the cost; • Southeast from the Thorntonbank alongside the border with the Netherlands; • The project area is situated at the utmost southeastern part of the demarcated zone for wind farms that is designated by the Royal Decree of May 17th 2004, modified by the Royal Decree of February 3rd 2011; • The northern border of the project area is situated at approx. 1 km from the concession domain of C-Power, in compliance with the buffering zones.
Wind farm area	Approx. 44 km²
Park configuration	• Implantation: three alternative configurations, see Map 1.1.1, Map 1.1.2 and Map 1.1.3; • Depth of the seafloor at the project area: -14 to -30 m TAW ('Tweede Algemene Waterpassing' or second general leveling); • Distances to be respected to the Interconnector gas pipeline and the 'Seapipe' gas pipeline of Statoil (500 m) and telecommunication and electricity cables (250 m), and buffering zone of 1000 m around the concession domain of C-Power.
Wind turbines	
Implantation	Three alternative configurations; see Map 1.1.1, Map 1.1.2 and Map 1.1.3.
Type - Capacity - Rotor diameter	Circa 3 to 10 MW per turbine; several turbines are suitable. The alternative configurations are drawn up with three type-examples: • Configuration 1: wind turbines with rotor diameter approx. 120 m, with an individual capacity between 3 and 4.5 MW, corresponding with a total installed capacity of

	approx. 320 MW. The Siemens SWT-3.6-120 turbine will be used as a type-example (3,6 MW per turbine); • Configuration 2: wind turbines with rotor diameter approx. 130 m, with an individual capacity between 5 and 6.5 MW, corresponding with a total installed capacity of approx. 420 MW. The 6M REpower turbine will be used as a type-example (6.15 MW per turbine); • Configuration 3: wind turbines with rotor diameter approx. 150 m, with an individual capacity between 7 and 10 MW, corresponding with a total installed capacity of approx. 400 MW. The Britannia C-150 turbine from Clipper Windpower will be used as a type-example (10 MW per turbine).
Number of turbines	• Configuration 1: 86 turbines; • Configuration 2: 74 turbines; • Configuration 3: 47 turbines.
Production	Approx. 800 to 1,500 GWh/year
Foundation of the wind turbines	
Either monopile	Thick steel piles are driven into the seabed. The total depth of piling appropriate to achieve a stabile foundation depends on the soil profile. The pile is surrounded with scour protection. This type of foundation is suitable for configuration 1 and 2.
Either jacket	The jacket foundation consists of a framework, composed by steel tubes with four points of support, that is funded by steel piles driven into the seabed. Norther does not intend to apply scour protection around this type of foundation. This type of foundation is suitable for configuration 2 and 3.
Either gravity based foundation	The gravity based foundation consists of a massif block of concrete with a smaller section on top, on which the wind turbine is mounted. The foundation is prefabricated on land and sunk into the seabed that has been leveled out previously from a vessel or pontoon. The foundation is surrounded by scour protection. This type of foundation is suitable for configuration 2 and 3.
Meteo mast	
Number	2 masts (optional)
Position	Dependent on the configuration: see Map 1.1.1, Map 1.1.2 and Map 1.1.3.
Foundation of the offshore high voltage stations (OHVS) and the meteo masts	
Type	• Offshore high voltage stations: monopile or jacket foundation • Meteo masts: monopile foundation
Electrical infrastructure	
Cables within the wind farm site	• The wind turbines are connected in groups of each approx. 30 MW with 33-36 kV (alternating current) cables; • Cable route: see Map 1.1.1, Map 1.1.2 and Map 1.1.3; • Installation depth cables: approx. 1 m into the seabed.
Offshore high voltage stations	• Number: two; • Step-up transformers 33-36 kV → 150 kV or 220 kV.
Cables to shore (export cables)	• Power cables of 150 kV or 220 kV (alternating current); • Cable route: 2 alternative routes (see Map 2.4.1); Route 1 follows the existing route of the Belwind and Eldepasco export cables; Route 2 follows the telecom cable 'Concerto South1'; • The cabling will occur conform the guidelines drawn up by the Directorate-general Maritime transport of the Federal Public Service (FPS) 'Mobility and Transport' and other qualified authorities; • Landing point: Zeebrugge.
Exploitation	
Operation and control of the wind farm	SCADA-system (Supervisory, Control And Data Acquisition) from a control room onshore
Frequency of the planned maintenance	Once a year, unplanned maintenance and reparations excluded.
Logistics – Access to the wind farm	Access by means of maintenance vessels (windcats) or by means of helicopters.

3 ALTERNATIVES

The alternatives are briefly described in Chapter 1 & Chapter 2.

4 IMPACT ASSESSMENT

In this paragraph the most important results of the impact assessment are summarized per discipline.

At this moment, three wind farms (C-Power, Belwind and Eldepasco) are permitted in the Belgian marine waters. Two wind farms are already under construction; C-Power has built 6 turbines (gravity based foundations) at the Thorntonbank and Belwind has constructed 55 turbines (monopiles) at the Bligh Bank. In contrast to preceding environmental impact reports (EIR) for offshore wind farms where the effects of only one individual wind farm (including various configuration alternatives) were assessed, in this EIR the configuration alternatives of Norther will be assessed in combination with the existing situation, further named as 'the basic scenario' (consisting of 6 gravity based foundations of C-Power (shorted: C-Power**) + 55 monopile foundations of Belwind (shorted: Belwind**) + Norther).

Given the difficulties to quantitatively describe certain effects, a semi-quantitative approach has been chosen. The effects are described as a relation between their size, their range (dimension) and their temporarily or permanent character. The described effects are presented as a plus-minus assessment.

The following definitions have been applied:

Symbol	Definition	Description	Assessment environment/ organisms
++	Significant positive effect	Measurable positive effect, large range (BPNS[1]), temporarily or permanent character	Very positive
+	Moderate positive effect	Measurable positive effect, limited range (project area), temporarily or permanent character	Positive
0/+	Small positive effect	Measurable small positive effect, limited range (project area), always temporarily character	Neutral
0	(almost) no effect	Non-measurable effect or not relevant	No
0/-	Small negative effect	Measurable small negative effect, limited range (project area), always temporarily character	Negligible
-	Moderate negative effect	Measurable negative effect, limited range (project area), temporarily or permanent character	Acceptable
--	Significant negative effect	Measurable negative effect, large range (BPNS), temporarily or permanent character	Not acceptable

In the impact assessment distinction has been made between effects during construction, exploitation, dismantling and the laying of cables. Knowledge gabs and possible mitigating (effect reducing) measures

[1] Belgian Part of the North Sea

have also been indicated. Attention has been given to both the negative and possible positive environmental effects.

4.1 SOIL

4.1.1 Reference situation and autonomous development

The concession area of North Sea Power is located at 22-30 km from the Belgian coastline northwest from Zeebrugge. The northeastern border of this area is adjacent to the Dutch territorial waters. The area partly overlaps with three banks: the Thorntonbank at the northwest, the utmost northeastern embranchment of the Goote Bank at the southwest of this area and the Rabsbank in the northeastern part from the Dutch part of the North Sea.

The tidal banks are the largest offshore relief features and seem to be very stable. Sand waves (some meters high) are remarkably smaller but more dynamic than sand banks, and also prominently present at the Belgian part of the North Sea (BPNS). Recent bathymetrical surveys show an average height of dunes of 5 m (Thornton- and Rabsbank).

The tidal banks are situated on top of the tertiary geological layer 'Formation of Maldegem'. The Formation of Maldegem consists of marine sediments, containing mainly rigid clay and clay-containing sand layers. This forms the seabed at places without banks or dunes. Mostly the seabed is covered with coarse sand and gravel. The thickness of the banks within the concession area varies between 0 to 14 m. Mainly sand with an average diameter of 0.25-0.3 mm (fine to moderate sand) occurs at this area.

Because of its close location, its comparable granulometric composition and its situation in the same tidal pattern as the Thorntonbank, a comparable chemical environmental quality of both zones can be expected. On the basis of data available for the Thorntonbank, it can be concluded that for none of the measured heavy metals the limiting values is exceeded.

As a consequence of the climate change, the characteristics of the currents and the morphology of the BPNS will change too. Even within the period of exploitation some changes will already be noticeable. In addition to changes in the general average values of e.g. the sea level, temperature, etc., the number of extreme climate events is expected to increase. There are no other marine activities (wind farms on other banks, sand extraction, transport, dumping of dredging mud…) on the BPNS which in the future could affect the North Sea Power concession zone and the wind farm to be built there.

4.1.2 Impact description and assessment

4.1.2.1 Construction phase

When using a monopile or jacket foundation no sand is removed but the pile is driven into the seabed. The only effect is that the geological layers up to a depth of a few tens of meters in close proximity to the pile will be compacted (compressed).

In the case of the gravity based foundation, per wind turbine approx. 100,000 m³ sand will be excavated, of which about 20,000 m³ will be used again to refill in the foundation pit and to fill the gravity based foundation (net 45.000 m³). The rest is considered as dumping- and dredging losses (the total loss is even bigger). Of this, approximately 25-30 % consists of sand layers, while the remaining 70-75 % mainly consists of tertiary clay and clay-containing sand, probably generally mixed with some gravel (Maas gravel). It is proposed that the sand/clay left over will be:

- Either laid up within the concession area;
- Or commercially exploited: in this case the impact on the morphology will be extremely low (only 45,000 m³ surplus). Moreover, if this commercial use involves that less sand needs to be extracted at other sites, the global impact of all marine activities on the natural morphology of the North Sea will be reduced.

The surplus sand must be stored at a location that ensures that the general morphodynamics of the area are changed as little as possible. The determination of the best location for storage of the surplus sand is not clear-cut, due to insufficient knowledge about the dynamics of the sediment. It seems best to deposit the sand in a location as close as possible to the wind turbines to be installed and to the southwest of the wind turbines, so that the stored sand through the main tidal flows in northeastern direction can be spread across the concession area before being transported further. Using a layer thickness of 2 – 7 m as demanded in BMM (2007) for the Belwind wind farm seems a practical and realistic compromise. The option to store per turbine separately must certainly be considered, in spite of taking up a relatively larger area, as the spread will be faster from smaller piles of sand (morphological point of view), and as the distance between the dredging and discharging areas will be smaller (work-technical point of view).

The impact of the cable installation is negligible (0/-). The risk of causing significant pollution of the soil is extremely low (effect = 0).

4.1.2.2 Exploitation phase

Although there will be a local disturbance of the natural sediment transport around the wind turbines, the general natural processes on the project area will hardly be affected (0/-), for the impact of each construction is very small due to the installation of scour protection, and the wind turbines are very far apart. The same applies for the cables.

It is clear that if foundations without scour protection were to be used, the local erosion would be so significant that the effect would have to be mitigated and could even jeopardize the stability of the entire construction in the long term. Therefore, the initiator will instantly provide scour protection for monopile and gravity based foundations. Based on research Norther currently opts not to provide scour protection in the case of jacket foundations. Scour protection consists of a ring of stones around the foundation. Obviously gravity based foundations, due to their larger dimensions, will require a more voluminous scour protection than pile foundations.

The dimensions of the proposed scour protections (only applicable for the monopile and gravity based foundation type of the North Sea Power wind farm) are sufficient for each foundation type considering the hypothetical dimensions of an erosion pit without protection. The erosion will indeed move to the area between the seabed and the scour protection, in downstream direction (secondary erosion), though it will be greatly reduced. Although the scour protection as such will be locally heterogeneous to the sandy seabed, the installation of a scour protection is environmentally acceptable.

The cables will be laid at a sufficient depth (1 m in the park, 2 m for the export cable(s) and even up to 6 m in the shipping channels) so that the chance of a cable to become exposed is relatively small. At places with tertiary clay the excavation depth shall possibly be reduced to 1 m, depending on the feasibility. Damage to cables due to anchors at shipping channels shall be avoided by means of application of an appropriate excavation depth. Moreover, the cable route will be monitored regularly to prevent any cables from becoming dislodged.

As is the case with the construction phase, there is no reason at all for the exploitation to lead to pollution of the seabed (effect = 0).

4.1.2.3 Dismantling phase

For a monopile (conf 1) or jacket foundation (conf 2 & 3a) no additional effects on the geological structure of the involved soil layers will occur as these foundations shall partly stay into the soil. Removing pile foundations (conf 1, 2 and 3a) also has no effect on the morfodynamics. If the pit that arises from cutting of the piles at a depth of approx. 2 m below the seabed should evolve by local erosion, it is proposed to fill this pit with sand or scour protection material.

For gravity based foundations (conf 3b) everything is removed. Only each pit per turbine remains. For this turbine type also no additional effects will appear compared to the construction and exploitation phase. The pit that arises from removal of the gravity based foundation (conf 3b) can also be filled with sand if the pit should evolve by local erosion (in case the present scour protection stays). If the scour protection is completely removed, the same effect appears at the removed foundation as at the scour protection.

The decision whether to remove the scour protection or not (not applicable for conf 2 and 3a) will be made towards the end of the exploitation period and will be based on the results of the monitoring, the available technology and the gained experience.

The decision whether to remove the cables or not shall be made later on. If the cables are removed, non-significant effects comparable to the effects during the construction phase appear. If the cables stay in situ, no effects occur at all.

4.1.3 Mitigating measures

There should be a good timing between the construction of the foundation and the placement of the rubble (scour protection). This indeed prevents erosion and leads to a minimal use of rubble. Anyhow a good timing between the separate constituent processes is necessary with regard to the storage of sand, as to reduce the various losses as much as possible.

If the cable route must be installed over the top of other cables and/or pipes and the minimum installation depth cannot be realized, extra protection must be installed on top of the cables. This can be done by the same rubble as used for the scour protection at the wind farm.

4.2 WATER

4.2.1 Reference situation and autonomous development

The currents in the North Sea water are mainly caused by the tides (dominating component), but also by winds or potential differences in density. The most extreme situations (strong currents and extreme water levels) arise when gale-force winds coincide with a spring tide.

In the project area the average depth of the water varies between 15 and 32 m. The maximal fluctuation in the depth of the water caused by wave action is about 2.5 m. Maximum wave heights are approx. 12 m. The twice-daily ebb and flood cycle off the Belgian coast causes a fluctuation in water depths that can be in excess of 5 m.

The water speeds are usually between 0.2 and 0.8 m/s. The residual average (surface) water speed is approximately 0.6 m/s. Surface currents are clearly tidal driven whereby the flood stream (from the SW) prevails over the ebb stream which comes from the NE. In the project area the currents flow mainly from the SW and also from the NE - NEE, driven by the tides and prevailing winds.

The average water temperature in the BPNS (Belgian Part of the North Sea) is around 11 °C. There are seasonal variations of 8 or 9 °C in relation to the average temperature. The salinity in the BPNS amounts to 31-35 g/kg.

For the project area it can be assumed that the natural concentrations of heavy metals are relatively low. The main organotin compound is tributyltin (TBT). This is a biocide that is used in the aquatic environment as an antifouling agent. The tributyltin concentration offshore amounts to <1 ng/l. Bunker oil and lubricating oil are the main sources of oil pollution in the North Sea. The oil spills from drilling for offshore oil and gas industries has been greatly reduced over the last 10 years (by more than 80 %). The human influence on the nutrients balance can be detected mainly in the coastal zones and not so much in the sandbank area.

The turbidity or clarity of the seawater is determined by the amount of floating particles in the water (in suspension). Specific information for the concession area has not been found, but it can be assumed that average concentrations will certainly be lower than 10 mg/l.

Climate change can potentially bring about changes in the current characteristics and in the chemical properties of the seawater. Even within the time-span of the exploitation period, some changes can already be noticeable. For example, as a result of global warming a global sea level rise of 0.9 m maximum is expected in the period 1990-2100. In addition to changes in the general average values of e.g. sea level, temperature, etc., an increase in extreme climate events is expected.

Furthermore it is to be expected that the anthropogenic impact on the water quality in the marine environment will drop further. For instance, TBT concentrations, heavy metals, nutrients supply via rivers, etc. should show a positive downward trend in the future. There are no other marine activities (wind farms on other banks, sand extraction, transport, dumping of dredging mud…) on the BPNS which in the future could affect the North Sea Power concession area and the wind farm to be built there.

4.2.2 Impact description and assessment

4.2.2.1 Construction phase

During the installation phase – of the cables as well as the wind turbines – the hydrodynamics will not be affected, irrespective of which type of configuration alternative is used.

Analogue to heavy metals, the potential impact of the release of organic pollutants from the top layer of sediment during construction is relatively minor (0/-). Since the North Sea has been designated as a 'special area' (according to MARPOL 73/78) for waste since 1991 and for oil since 1999, this activity will not result in the dumping of waste or oil as it is legally forbidden (for ships > 400 ton). Dredging may cause a minor temporary increase in nutrients in the water column. The antifouling paint used on the vessels during the installation phase is TBT-free as since 2003 a world-wide prohibition exists on the use of TBT on ships and since January 1st 2008 all TBT should be removed from the ships. No impact is expected on temperature, dissolved oxygen or salinity.

During the construction of the foundation, the turbidity may locally increase when the piles are driven into the seabed (monopile, jacket), when dredging and discharging (gravity based foundation). Usually the work will be carried out in calm weather conditions (slow current), so it can be assumed that the natural turbidity will be low. This also means that any churned-up sediment will settle relatively quickly and in a small radius around the activities. For each construction method and foundation type, the construction of the foundation shall bring a local and temporary increase in turbidity, but the impact will be negligible in comparison with the turbidity concentrations caused naturally by high winds (0/-).

The impact (increase in turbidity) for both types of cables and construction methods is judged to be temporary and local (0/-).

4.2.2.2 Exploitation phase

A wind farm construction will have no significant impact on the current, nor will the underground cables.

No long-term impact on the quality of the water is expected. The risk of an accidental discharge with an immediate impact on the water quality is judged to be extremely small.

Apart from an insignificant local turbidity in close proximity to the foundation (from disturbing the sand near the seabed) during the exploitation phase, the activity will have no effect whatsoever on the turbidity, irrespective of the configuration alternative. The underground cables won't affect the turbidity.

4.2.2.3 Dismantling phase

Impacts during the dismantling phase (i.e. the removal of the piles and possibly the removal of the scour protection and underground park and export cables) will be similar to those during the installation phase. Moreover, most of the effects will have even less impact than during the installation phase.

4.2.3 Mitigating measures

As part of the global safety and environmental management system, a clear procedure needs to be in place that describes in which way and by whom actions will be taken at the moment a calamity occurs during installation, exploitation or dismantling that can have adverse consequences for the water quality (e.g. oil spill).

4.3 CLIMATOLOGICAL FACTORS AND ATMOSPHERE

4.3.1 Reference situation and autonomous development

Belgium has a temperate sea climate, with cool summers and mild winters. The conditions at sea are similar, but there is a more constant wind climate and higher wind speeds. The prevailing wind direction near the Belgian coast is (W)SW. The wind speed increases with the height above sea level. At an altitude of 100 meters above sea level, the wind speed averages between 8.5 and 10 m/s.

With regard to the global climate, for this project the greenhouse effect and global warming are especially relevant. The increase in atmospheric concentrations of CO_2, CH_4 and N_2O is by far the most important cause of global warming. In order to reduce the emission of greenhouse gases, a switch to environmental-friendly energy, such as solar energy, biomass energy, wind energy, etc. is essential.

As regards the air quality, the relevant parameters are CO, NO_x, SO_2 and PM_{10} (dust). The air quality off the Belgian coast more than meets the quality objectives for these parameters. CO_2 is, as stated earlier, of particular importance with respect to the greenhouse effect.

For the autonomous development it can be stated that:

- there will be no emission as a consequence of the use of materials, the construction and dismantling of the wind farm and therefore there will be no temporary impact on the local air quality;
- the avoided emissions as a result of the electricity production by the wind farm will be realised ;
- without extreme measures the atmospheric CO_2 concentrations will increase further.

4.3.2 Impact description and assessment

4.3.2.1 Construction phase

During the installation of the wind farm, the global climate and the local wind climate won’t encounter relevant effects.

Considering the air quality during the construction phase, not just the actual construction of the wind farm is to be taken into account but also the winning of the raw materials needed to produce the various components of the wind turbines. This phase also involves the production and pre-assembly components, the transport to the offshore building site and the actual construction of the wind farm. The energy consumption and related emissions will be greatest during the period of winning the raw materials up to and including the production of the turbine components.

The additional emissions resulting from the complete construction of the turbines and wind farm will have a negligible negative impact (0/-) on the local air quality.

4.3.2.2 Exploitation phase

During the exploitation phase there will be some energy consumption for inspection and maintenance of the wind farm. However, the most important effects during the exploitation phase are the emissions avoided on land as a consequence of the fact that the estimated net electricity production prognosis of the wind farm namely 800 to 1,450 GWh/year doesn't have to be generated by traditional (partly nuclear or not) production.

The emissions prevented annually, calculated on the basis of the emission factors for traditional production, amount to 3.7 % (800 GWh) to 6.95 % (1,500 GWh) of the emissions by traditional production in Belgium for all pollutants. The annually avoided emissions, calculated on the basis of the emission factors for traditional production and nuclear production, amount to 2.02 to 3.78 % of the emissions by traditional production in Belgium for all pollutants.

If the electricity production of the wind farm should effectively lead to an equivalent reduction of the electricity production on land by means of traditional thermal production, it would have a significant positive effect (++) on the air quality on land in general and the greenhouse effect and acid deposition in particular. In reality the project shall probably only lead to the slowing down of the increasing emissions that contribute to the greenhouse effect.

The wind farm will only contribute to a very limited degree towards the reduction of greenhouse gas emissions on a global scale, but it will make a measurable contribution (+) as far as Belgium is concerned. The Kyoto target for Belgium is a reduction in greenhouse gas emissions of up to 130.5 million tones CO_2 equivalent (National Climate Plan 2002-2012). The actual avoided emissions, calculated on the basis of the emission factors for traditional production, amount to 0.44 to 0.82 % of this ceiling, which is significant.

As part of the NEC-guidelines (2001/81/EG), reduction targets for SO_2 and NO_x were also set. Towards 2010 emission ceilings were imposed on Belgium for SO_2 and NO_x of 99,000 and 176,000 tonnes/year respectively. The actual avoided emissions, calculated on the basis of the emission factors for traditional production, amount to 0.58 to 1.08 % of the emission ceiling for SO_2 and 0.33 to 0.62 % of the emission ceiling for NO_x, which is also significant. In the thematic strategy for air pollution of the European Commission, a review of the NEC-guidelines is provided. This review doesn't imply an adjustment of the emission ceilings of 2010, though does hold the imposition of emission ceilings for 2020. The review of the NEC-guidelines has not been finished yet.

The impact of the wind farm on the local wind climate will be restricted to some very local effects in the wind farm area. The wind climate (wind speed, turbulence…) will be influenced by the wind farm up to more than 3 km from the last wind turbines.

The negative effect of the heat emission of the buried cables on the local temperature climate will be restricted to a small surrounding area in the seabed (no more than a few meters) (0/-).

4.3.2.3 Dismantling phase

During the dismantling of the wind farm, the global climate and the local wind climate won't encounter relevant effects.

The dismantling phase has a positive influence on the energy consumption in the lifecycle of a wind turbine because approx. 80 % of the turbine material can be reused. The winning of new raw materials and related emissions will therefore be reduced.

The impact on the air quality as a result of emissions by the vessels used for the dismantling is, just as in the construction phase, local (around the wind turbines), limited in time and insignificant compared with the total emissions of the shipping traffic in the Channel, so that the negative impact on the air quality is small (0/-).

4.3.3 Mitigating measures

Globally wind turbines will account for a significant reduction in emissions compared with the emissions of traditional power stations on land, which has an extremely positive effect on the air quality and on the reduction of greenhouse gas emissions. Moreover, the negative impact of the project on the air quality during the construction and dismantling phase is limited, so that no need for mitigating measures or compensations arises.

4.4 NOISE & VIBRATIONS

4.4.1 Reference situation and autonomous development

For the purpose of the reference situation the existing noise climate at 4 locations is discussed, i.e. above water, underwater, at the shoreline and in the nearest housing area.

The natural underwater background noise level lies between 90 and 100 dB (re 1 μPa) at frequencies ranging from 100 Hz to a few kHz. Natural noises are the main contributors. Passing ships however can temporarily increase the sound pressure level (110-120 dB (re 1 μPa)) in the same frequency range.

Above water the background noise level (LA95) is estimated to be 35 + 5 dB(A).

According to data found in literature, it seems that near the shore the background noise level lies between 50 and 65 dB(A) at 25 m from the shoreline. This sound pressure level depends on the wind direction and wind speed.

In the nearest housing area the background noise level lies between 30 and 40 dB(A).

As far as noise is concerned, no significant change is to be expected in the autonomous development of the area from a global point of view. The underwater noise will hardly evolve because no appreciable increase in shipping traffic is expected in the project area. Only the construction and the exploitation of the wind farms of C-Power (Thorntonbank), Belwind (Bligh Bank) and Eldepasco (Bank With No Name) will effect a change compared with the current situation.

4.4.2 Impact description and assessment

4.4.2.1 Construction phase

Underwater

As a consequence of the piling (monopile and jacket foundations) the noise level of the surroundings will temporarily increase. Literature shows that an average sound level of 250 dBp-p (re 1 μPa @ 1 m) is present during piling. As a consequence, sound levels higher than the background noise level of 105 dB (re 1 μPa) will still be detectable at a distance of 20 km from the piling activities.

Above water

During construction, the piling activities shall also cause the main sound load above water. Literature indicates that a hydraulic piling hammer with coat has a sound capacity of approx. 101 dB(A). As a consequence the calculated specific sound (calculated by the transference model IMMI 2010) at 420 m amounts 35 dB(A) (the determined background noise level at the project area).

Due to the activities during the Construction phase (piling, shipping…) a temporary increase in sound level shall arise, above water as well as underwater. The impact of this temporary altered sound climate on the present fauna is discussed in chapter 4.6 ‘Assessment of the effects on fauna’.

4.4.2.2 Exploitation phase

Underwater

When assessing the underwater sound level it must be noted that there is a knowledge gab with regard to the noise immission and emission of the used wind turbines (3 MW to 10 MW).

The specific sound of a wind turbine predominantly consists of frequencies lower than 1 kHz and a sound pressure level between <90 and 115 dBLeq re 1 μPa at a distance of 1 m.

Calculations show that at a distance of 500 m (safety zone) from the wind turbine the specific sound of the wind turbine underwater probably shall be masked by the background noise. When under water the maximum background sound is 195 dB (re 1 μPa) (for example due to seismic activity), the wind turbines will only be clearly detectable up to 50 m. As a result of this conclusion it is assumed that for all underwater fauna there is a masking effect of the detection of sound that is similar to the masking effect occurring in the hearing of most land animals. At higher wind speeds the specific sound of the wind turbine shall increase, but at the same time the background sound level will increase too by wave action and water movement. Finally, it can be assumed that the impact of the sound of the wind turbine underwater will at worst be restricted to the area between the wind turbines and will not go past the 500 m safety zone. It is important to point out that when a small ship passes by, noise levels are detected of more than 10 dB higher than the maximum background sound levels referred to earlier. However this rise in the noise level is temporary.

Above water

In a moderately aggravating situation sound travels three-dimensionally, and at a distance of 0.5 – 0.8 km and a distance of 0.7 – 1.4 km reaches a sound level of 45 and 40 dB(A) respectively. Above water the wind turbines can be heard at a distance of up to 5 km. Above water, just as underwater, the specific sound of the wind turbines will increase along with the wind speed, but at the same time the background noise level will rise too.

In general it can be said that nearest to the wind farm where shipping is allowed (500 m safety zone around the wind farm) the wind turbines can be heard with a sound level of around 50 dB(A). 50 dB(A) can be compared with the noise of light traffic at 30 m, rain, a fridge, or ambient sounds in the woods.

The sound of the wind farm calculated in a moderately aggravating situation (when sound travels three-dimensionally) on the shoreline and in the nearest housing area will be lower than the measured background noise and therefore undetectable.

4.4.2.3 Dismantling phase

As a result of the activities during the dismantling phase the sound levels will temporarily increase, above water as well as underwater. However no significant negative effects are anticipated.

4.4.3 Mitigating measures

Considering the potential significant negative effects on mammals due to the piling activities, mitigating measures need to be provided to protect these mammals. The mitigating measures with regard to piling activities are discussed within the chapter ‘Mammals’.

As the number of observers at sea who would frequently notice the wind turbines is indeed very limited, it does not seem useful to propose mitigating measures for the sound in the air either.

4.5 FAUNA, FLORA & BIODIVERSITY

The discipline Fauna and Flora deals with four different groups of organisms, namely the benthos (macro- and epibenthos), the fish, the birds (avifauna) and the sea mammals. Besides distinction is made between organisms living on soft substrates and those living on hard substrates.

4.5.1 Reference situation and autonomous development

4.5.1.1 Soft substrate benthos and fish

Marine organisms that live in or on the seabed, or benthos, are an important part of the food chain (dominant prey for demersal fish) and the ecosystem. They contribute to the biodiversity and the productivity of the sea. In this study we focus exclusively on the epibenthos (> 1 mm; on the seabed) and the macrobenthos (> 1 mm; in the seabed). Due to its limited mobility the presence of macrobenthos is an important indicator for the ‘health’ of marine systems. As regards the fish we focus only on fish living on or near the seabed (demersal fish) as they are the ones that will probably be affected most by the planned activities. As regards the epifauna and fish communities, distinction is made between those occurring at the mobile soft substrates and those living on hard substrates (foundations, turbines, scour protection).

The description of the reference situation and effects on benthos and fish of the soft substrates in the study area is initially based on studies carried out as part of the C-Power project for the reference situation at the Thorntonbank (De Maersschalck *et al.*, 2006) and the monitoring results from year 1 (Reubens *et al.*, 2009b; Vandendriessche *et al.*, 2009) and year 2 (Coates & Vincx, 2010; Derweduwen *et al.*, 2010), considering the proximity of this sand bank (approx. 1 km). This is followed by a consultation of other recent studies (including monitoring reports) that gathered data of various research projects to produce a description of the benthic communities in the Belgian part of the North Sea.

Along the onshore-offshore gradient of the Belgian Part of the North Sea (BPNS) five clearly defined **macrobenthos** communities can be found, named after the most dominant species in the community. In between, another 6 transition-communities are identified. These are characterized by typical species, diversity and density and each are observed within a specific and well-defined environment.

The project area shows a gradual transition from the *N. cirrosa* community to the *O. limacina-G. lapidum* community (Van Hoey *et al.*, 2004; Degraer *et al.*, 2009b). This transition community is characterized by low biodiversity and density, typical of well-sorted mobile sands. Mobile polychaeta (e.g. *Nephtys cirrosa, Ophelia limacina, Spiophanes bombyx*) and crustacea (e.g. *Bathyporeia guilliamsoniana* and *Urothoe brevicornis*) are typical species in this community (Van Hoey *et al.*, 2004). According to the biological valuation map the project area is classified as an area of moderate to high biological and ecological value (macrobenthos) (Derous *et al.*, 2007).

Degraer *et al.* (2009b) however show that the project area is potentially suitable for formation of *Lanice conchilega* aggregations (with a density > 500 individuals/m²) and richer in gravel. Several studies demonstrate that this communities contain a rich fauna and flora with high biodiversity of infauna as well as epifauna underneath stones (Degraer *et al.*, 2009b). These rich communities can only evolve if this habitat isn't subject to natural and/or anthropogenic disturbance (e.g. burial under sand in case of non-mobile substrates (Van Lancker *et al.*, 2007b) or bottom-churning fishing techniques). Thereby the biotope, created by *Lanice conchilega* aggregations, forms a hotspot of biodiversity within the mobile soft substrates of the Belgian part of the North Sea (Rabaut *et al.*, 2007).

Neither on the basis of the biological value and densities (habitat type 1110 – sand banks), nor on the basis of the special distribution of *Lanice conchilega* and the gravel beds (habitat type 1170) the Thorntonbank and Goote Bank are nevertheless both not selected as a potential Habitat Directive Area with special ecological value (Degraer *et al.*, 2009b).

All analyses regarding species composition, density, biomass, diversity and length frequency of the **epibenthos** indicate a clear difference between the sand bank stations and the gully stations, with higher (up to six times higher) densities recorded in the gullies. Samples from the gullies however showed a lager mutual variation than the sand bank samples. The demonstrated seasonal, interannual and spatial variation was mostly due to varying proportions of some common epibenthic species as brown shrimp (*Crangon crangon*), two brittle star species (Ophiura spp.), hermit crab (*Pagurus bernhardus*), flying crab (*Liocarcinus* *holsatus*), lesser bobtail squid (*Sepiola atlantica*) and squid (*Loligo vulgaris* and *Todaropsis eblanae*). The gullies are thus in general richer (density and diversity) than the tops of the sand banks with regard to the epibenthos, though the project area stays of less ecological value in comparison with the richer coastal areas.

The same argumentation counts for the **demersale visfauna** (gullies richer than banks, mainly in spring). Important fish species in spring are sprat *Sprattus sprattus* and herring *Clupea harengus* (Clupeiformes), as well as reticulated dragonet *Callionymus reticulatusl.* In autumn, the main species are horse mackerel *Trachurus trachurus*, lesser weever *Echiichtys vipera*, dragonets and sand goby *Pomatoschistus minutus* for the Perciformes and solenette *Buglossidium luteum* and dab *Limanda limanda* for the Pleuronectiformes.

Probably the project area is less important for commercial exploitation of shrimp and fish than other closer coastal areas. Uncertainty remains concerning the importance of the project area as a spawing area, potentially for sprat and herring, and to a lesser degree for e.g. dab and solenette.

As regards the autonomous development it can be said that the benthic communities and the demersal fish fauna would not really change if no wind farm were built and exploited. Long-term trends and recent monitoring results don't show any change in dominant species, just a general increase in density and diversity. On the other hand, activities such as fishing and aggregate extraction, mariculture, as well as climate change are more likely to have an impact on the underwater fauna.

4.5.1.2 Hard substrate epifauna and fish

In the project area of Norther no hard substrates currently occur. Indeed C-Power already installed six turbines, that are relevant for the description of the reference situation and impact assessment of the North Sea Power wind farm (as well the basic scenario as the cumulative scenario) considering their proximity.

Therefore it is opted to mention this new state already here so the reader can already clearly picture this group of organisms.

The description of the reference situation for the **epifauna** is based on the results of Kerckhof *et al.* (2009; 2010). Several parts of a wind farm are suitable as a substrate for the growth of epifauna: parts of the turbines, the foundations and the sour protection.

The colonization process of the first 6 wind turbines in the Belgian marine waters occurred fast and intense. After approximately 3½ months the submersed part of the foundation appeared to be already covered with a close biofouling of epibionts and also the intertidal zone was almost completely colonized (Kerckhof *et al.*, 2009). A clear depth zonation (3 zones) could be observed, with an intertidal-splash zone, a transitional zone with *Jassa* and barnacles, and an extensive subtidal zone (species-richest) with e.g. the bryozoan *Electra pilosa* (forming a dense, uniform turf) and several small mobile species as crabs, small shrimps, polychaetes, amphipods and sea anemones. A total of 75 taxa (mostly species) was identified, including 13 spp. exclusively in the intertidal. 42 species have not been encountered yet in earlier research. Besides the earlier observed vertical zonation (depth zonation), also a strong seasonal influence could be determined within the structure of the biofouling community. In comparison with the results of 2008 (Kerckhof *et al.*, 2009) a more fine scale zonation in the intertidal became apparent: by summer 2009 a conspicuous mussel belt was established in the transitional barnacle-*Jassa* zone and a clear zone of the intertidal barnacle (Se*mibalanus* *balanoides*) became apparent in the splash zone. Larger algae were rare. For a number of species it remains unclear whether the observed changes in relative abundance reflect either a recurring seasonal cycle or a more gradual successional change, although a combination of both is more likely.

A species richness of 75 is high in comparison with other hard substrates in the BPNS, certainly because of the short colonization period of the foundations. Despite differences in substratum type this preliminary results indicate that the overall structure of the marine biofouling community encountered at the wind turbine foundation on the Thorntonbank site is similar to that encountered on the foundations of other offshore wind farms in Germany, Denmark and The Netherlands and on other hard structures in the North Sea (Kerckhof *et al.*, 2010). Moreover four non-indigenous species were found: the slipper limpet *Crepidula fornicata*, the New Zealand barnacle *E. modestus*, the giant barnacle *M. coccopoma* and the giant midge *T. japonicas* (Kerckhof *et al.*, 2009; 2010). All four species, already known from the area, are opportunists and early colonizers after disturbance, taking advantage of man-made structures and disturbed conditions to settle.

First results for the **fish communities** of hard substrates in Belgium were collected by Reubens *et al.* (2010). This study provides the first insights in the use of offshore wind turbines from the wind farm at the Torntonbank (Belgian part of the North Sea) by several fish species, with a focus on the present fish community on the one hand, and the trophic relationship between pouting (*Trisopterus luscus*) and the artificial reefs on the other. At total of seven different fish species were caught, of which four species regularly: cod (*Gadus morhua*), pouting (*Trisopterus luscus*), mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*). The visual surveys, carried out between July and October 2009, revealed a population size of at least 29,000 individuals of pouting (representing a biomass of 3.5 * 10^3 kg), in the vicinity of a single wind turbine. Densities varied between 7 and 74 specimens/m² with an average density of 18±21 individuals/m² on the scour protection. A large variation in densities was detected both between observers and over time. Line fishing was conducted throughout 2009 to investigate food selectivity. A large variation in prey species was present within the diet of pouting. The hard substrate species, *Jassa herdmani* and *Pisidia longicornis* appeared to be of prime importance as prey species. These species occur in very high densities as epifauna on the foundations of the wind turbines (Reubens *et al.*, 2010).

As regards the autonomous development it can be said that the amount of hard substrates as a potential habitat for epifauna and fish shall increase in the future as a consequence of the number of (new) permitted wind farms and the possibilities created for the production of bivalves in mariculture (KB 07/10/2005). Furthermore wrecks also create an ideal habitat for hard substrate epifauna and fish communities, though at this point no increase in the number of wrecks is expected (‘salvage policy’).

4.5.1.3 Avifauna

Results of recent seabird countings (2005-2009) indicate that the part of the BPNS at the Goot Bank – Thorntonbank is of great ornithological importance. A high variety of species occur in high densities, as Northern gannets, Lesser Black-backed Gull, Kittiwake, Razorbills and Guillemots (Vanermen & Stienen, 2009). These species are considered as widespread and common species in the BPNS, with the project area of the wind farm as a zone of no particular importance. Nevertheless these species are considered as suitable monitoring species because of their general occurrence (Vanermen *et al.*, 2010). Moreover the

Thorntonbank, laying in the immediate vicinity of the project area, is also of importance for some less common and European protected seabirds such as Little gull, Sandwich tern and Common tern. These three species are namely Annex I species of the European Birds Directive. The Thorntonbank is less important for the Great skua, Red-throated diver, Great crested grebe, Northern Fulmar, Common Scoter and Herring gull.

4.5.1.4 Mammals

All sea mammals are protected species, where Belgium has taken the responsibility to protect and preserve them as much as possible from negative impacts. Whales and seals are species of the European Habitat Directive (Annex II and IV), which means that they may not be disturbed during wintering, reproduction and migration (article 12). In the framework of ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas) Belgium has also accepted to strive for the avoidance of significant disturbance, especially acoustic disturbance (Di Marcantonio *et al.*, 2007).

Until 2003 sea mammals were only sporadically observed during seabird counting in the BPNS. Since spring 2003, sea mammals are however increasingly found in the Belgian and Dutch part of the North Sea, whereby Harbour porpoises and White-beaked dolphins are the main species. Probably this is not an actual increase in numbers, but a shift of the foraging areas of sea mammals from more northerly areas, although other reasons cannot be excluded (Courtens *et al*., 2006; Depestele *et al.*, 2008; Haelters & Camphuysen, 2009).

Due to the mobility of sea mammals, the large area in which populations occur and the unpredictable nature of their occurrence, it is currently very difficult to determine migration corridors or areas that are more or less important for sea mammals (Di Marcantonio *et al.*, 2007; Degraer *et al.*, 2009b).

Four sea mammal species are considered as indigenous in Belgium; the Common seal, Grey seal, Harbour porpoise and Bottlenose dolphin (Haelters, 2009; 2010). As the Harbour porpoise occurs in much larger numbers than the other sea mammal species in the BPNS, as several of these species (especially seals) are used to stay nearby the cost, and as the Harbour porpoise turns out to be very sensitive to disturbance, the focus for the impact assessment is set on the Harbour porpoise.

During migration a large part of the Harbour porpoise population of the North Sea uses the Belgian part of the North Sea. Therefore the Belgian part of the North Sea is considered as seasonal important for the Harbour porpoise within Europe, namely at late winter and early spring (Haelters, 2009; Haelters & Camphuysen, 2009; Degraer *et al.*, 2010b).

4.5.2 Impact description and assessment

4.5.2.1 Soft substrate benthos and fish

Construction phase

Most important impacts for soft substrate benthos and fish during the construction phase are: disturbance/destruction of habitat (loss of biotope), loss of organisms, disturbance by sedimentation and turbidity and disturbance by noise and vibrations as a consequence of piling activities. With the exception of the destruction of the biotope and organisms, the other effects will be temporary.

By the installation of foundations and scour protection of the wind turbines, the meteo masts and the OHVS, part of the original soft biotope (sand/clay with some gravel beds) will be taken up by new structures (direct loss of biotope). This habitat loss greatly depends on the number of structures, the foundation type and the dimensions of the scour protection. For the monopile and jacket foundation the direct biotope loss per turbine is respectively 594 m² and 16 m², and for the gravity based foundation 4,000 m² (50 m x 80 m). In case static scour protection is chosen for the monopiles, a preceding leveling of the seabed has to be executed for 15 monopiles, at the zones with large sand waves. For these cases the direct loss of biotope is also estimated at 4,000 m² per turbine (50 m x 80 m). Depending on the foundation type, the total direct loss of sandy biotope for the entire wind farm (including meteo mast, OHVS) varies between 0.08 ha (conf 3a (jacket)) and 20 ha (conf 3b (gravity)) or respectively 0.002 % - 0.47 % of the concession area.

For the monopiles with static scour protection (conf 1) or gravity based foundations (conf 3b) a considerable area shall also be disturbed by the storage (permanent or not) of the dredged sand for the foundations (indirect biotope loss), next to the direct habitat loss per turbine (1,530 m³/MP versus 58,500 m³/GBF). Depending on the storage scenario, 337 ha (storage 1 m) or 86 ha (storage 5 m) will be disturbed in the worst case situation (conf 3b), or respectively 7.95 % (storage 1 m) and 2.04 % (storage 5 m) of the concession area.

A clear scaling-up (between the 5 x (configuration 1 (MP)) and the 100 x (configuration 2 and 3a (JF)) of the total habitat loss (direct and indirect) appears at the choice for the gravity based foundation in relation to the monopile (MP) or jacket foundation (JF). The big difference is mainly due to the (nearly) absence indirect habitat loss for storage of sand/clay when choosing a monopile or jacket foundation. In case a storage scenario of 5 m of the dredged sand (gravity) is chosen, a reduction of habitat loss of approximately 75 %. The total disturbance of habitat (scour protection + storage) in the storage scenario of 5 m (most probable) for the gravity based foundation (conf 3b) for the concession area *sensu stricto* (2.5 %) stay relatively small in comparison with the wind concession zone (< 0.5 %) and certainly in comparison with the entire BPNS (< 0.05 %). In addition the project area isn't characterized by special natural values, so it can be concluded that the habitat loss for benthic organisms for the different configuration alternatives of the North Sea Power wind farm shall have a limited (0/-; conf 1, 2 and 3a) to moderate (conf 3b – storage scenario 5 m) negative impact on the marine ecosystem and shall therefore always lie within the acceptable standards. Considering the limited increase of habitat loss/disturbance due to the turbines already installed and analogue with preceding argumentation, it can be concluded for the basic scenario that the effect shall be limited (0/-; conf 1, 2, 3a) to moderate (-; conf 3b) negative.

The installation of the wind turbine structures and the scour protection (if relevant) will result locally in a loss of creatures that is directly proportional to the habitat loss. Nearly all macrobenthos is found in the top 10 cm of the sediment. Part of the epibenthos and some demersal fish will also be damaged or die. This is a direct and irreversible effect. In case of a monopile (conf 1) or jacket foundation (conf 2 and 3a), the negative impact is negligible (0/-). In case of a gravity based foundation (conf 3b), the loss of organisms will increase significantly for the concessions (moderate negative effect (-)) compared to the other two foundation types, but the influence of the mortality is expected to have only a small negative (0/-) impact on the biomass or functioning of the local ecosystem (BPNS). The first monitoring results of C-Power (6 GBF) seem to confirm this. Recolonization of the replaced sand (storage) will moreover probably occur within a year. Further, it is true that the potential closure of an area to certain activities (such as trawler fishing) will have a positive effect (+) on the benthos as well as fish stocks (refugium effect).

During the construction phase the entire concession area will be disturbed. This disturbance will predominantly arise from the production of noise and vibrations, churning up of the seabed and the ensuing change in turbidity. The increase in turbidity may lead to a blockage of the filter mechanisms of marine organisms with potentially fatal consequences, but it can also increase the availability of prey for the fish. Despite the degree of disturbance (sedimentation) due to the construction of the wind farm (for gravity based foundations) is comparable with the sand extraction activities carried out in the North Sea, the disturbance caused by the installation of the offshore wind farm is local and temporary. Furthermore, the communities present there have already adapted to the by nature extremely dynamic system, so that the negative influence by sedimentation is expected to be moderate (-) (analogue to the described environmental impact for sand extraction) for the gravity based foundation (conf 3b). In case of monopile (conf 1) or jacket foundation (conf 2 and 3a), the negative influence is expected to be minor (0/-), as the quantities of storage and replacement of sand are significantly lower. For the basic scenario (including conf 3b) the impact is also assessed as moderate negative (-), as C-Power currently only counts 6 additional gravity based foundations (additional disturbance by the 55 monopiles of Belwind is in this case less relevant).

An important disturbance during the construction phase is de production of noise and vibrations due to piling activities (monopile/ jacket foundation), the cable laying activities and the increase of shipping traffic. Most of the noise disruption is expected to occur during piling (conf 1, 2 and 3a). This disturbance may lead to significant effects (damaged hearing, bleeding, mortality, behavioral changes) on certain fish. Besides the potential effects on adult fish populations, fish larvae can also experience impacts by piling. According to Prins *et al.* (2008; 2009) it can be stated that mortality occurs within a radius of 1 km from the sound source (worst case scenario based on a hydrodynamic model with data of larvae transport of herring, dab and sole). There is however still a great deal of uncertainty about the scope of the impact and species-specific data are not available. Despite this uncertainty it is clear that the effect of piling shall increase with the number of turbines to be installed and with increasing diameter of the pile. On the basis of available literature the impact of piling o, fish communities is judged to be significantly negative (--) (configuration alternative 1 (86 MP) and configuration alternative 2 (74 JF)) to moderately negative (-) (configuration alternative 3a (47 JF)).

Nevertheless the piling activities don't take very long, the project that uses monopile or jacket foundations shall only be acceptable on condition that some mitigation measures and a monitoring program are applied, to reduce significant negative effects as much as possible. The impact of noise for a gravity based foundation (configuration alternative 3b (47 GBF)) is almost nil compared to the other two foundation types. In this case only the noise of dredging vessels is of importance, which is assesses as much lower than piling noise. Further experimental research to the disturbance by piling activities is nevertheless desirable.

Exploitation phase

During exploitation the potential effects on soft substrate benthos and demersal fish are limited to changes in the hydro-physico-chemical conditions (water quality, hydrodynamic changes) of the project area and the noise disturbance by the turbines in exploitation and by the planned transports to the wind farm (inspection, etc.).

Underwater noise probably affects fish and mammals most (see further). Sound plays a role in the detecting and catching of prey, communication, chasing away enemies, etc. The emissions of noise and vibrations in the marine water column can lead to a change in behavior or a reduction in habitat size. The extent of the impact or damage and acclimatization depends also on how sensitive to noise the species of fish involved are. Quantifying the impact therefore requires species-specific data and these are not available for the area in question. Calculations in the chapter Noise show that within the safety zone (500 m) the underwater noise will probably be completely masked by the ambient background sounds, irrespective of the Norther configuration alternative. Most fish species shall therefore not be disrupted. The findings of a wind farm in Denmark and those of ship wrecks in the North Sea do not directly indicate that noise and vibrations cause a negative impact on the fish community during exploitation. Some studies (e.g. around the wind farm 'Egmond aan Zee') even indicate that the wind farm attracts certain fish species. Further research is advisable.

In spite of the fact that it is not straightforward to make a quantitative estimate of the impact, it can be assumed that the effects of noise and vibrations during the exploitation phase are of minor consequence and that technological improvements will possibly lead to lessening the impact even more. No negative impact (0) on benthos is expected for all considered configuration alternatives. The impact on fish is assessed as being minor (0/-).

For all different configuration alternatives of the North Sea Power wind farm and the basic scenario's no impact is expected on the soft substrate benthos and fish due to other kinds of disturbance during the exploitation.

Dismantling phase

Grosso modo comparable operations will be executed during the dismantling phase as during construction, but the intensity of the impacts will be much lower. The noise disturbance will for example be limited to the noise produced by the involved ships and the dismantling activities (cutting of turbines; removal of gravity based foundation). The significant noise disturbance due to piling (monopile/ jacket) during construction will not be present here. Also the loss of habitat and organisms will be limited to the areas actually disturbed during dismantling (so no indirect loss due to storage (gravity based foundation)). The effects will vary from (almost) no effect (0) to a small negative effect (0/-), depending on the configuration alternative (number of turbines, foundation type).

Cabling

The most important impacts due to cabling on benthos and demersale fish are habitat disturbance, increased turbidity, the appearance of electromagnetic fields and the potential heating.

Next to the wind farm cabling (between 62 and 71 km, depending on the configuration alternative), two alternative cable routes are presented by Norther. The export cable with landing at Zeebrugge has a length of approx. 24.1 km from OHVS 1 (western) and 24.6 km from OHVS2 (eastern). In addition the distance between both OHVS's amounts to 2.8 km. Assuming that the entire working zone can be considered as disturbed surface, a zone of < 0.1 km² (wind farm cabling, trench of approx. 1 m) and approx. 0.25 km² (export cable, trench of approx. 5 m) shall be disturbed, irrespective of the configuration alternative. As this disturbance can be considered as limited compared to the entire BPNS and the works will only be temporary, the impact of habitat disturbance by cabling is assessed as negligible (0/-).

The increased turbidity that shall occur because of the preparation works and the laying of the cables of the North Sea Power wind farm is of a much smaller dimension than the one described during the construction phase and is considered as almost non-existent (0).

At last the transmission of electricity via sub-sea cables will generate electric and magnetic fields, that also will be detectable outside of the cables. These electromagnetic fields depend on the type and capacity of the cable (33-36 kV wind farm cables versus 150 kV à 220 kV export cable). Electromagnetic fields can affect certain sensitive species, in particular their orientation, migration and hunting behavior and their general occurrence close to cables, but the size of the impact and the cause-effect relation cannot be accurately assessed on the strength of the available knowledge (certainly for the 220 kV cable). More is known about the impact on rays and sharks that are likely to be affected most, but these are not commonly seen in the project area. On the basis of this fact, the local nature of this effect and the fact that burying the cables at a depth of 1 m (wind farm cables) à ≥ 2 m (export cable) will have a mitigating effect (reduction directly proportional to the depth squared), we can assume for now that the impact will be almost non-existent (0; benthos) to small negative (0/-, fish).

The buried cables will radiate a certain amount of heat. Because the cables are laid at depth, this will generate a minor and very local warming of the seabed surface. The effect is judged as non-existent (0; epibenthos and fish) to negligible (0/-; macrobenthos).

4.5.2.2 Hard substrate epifauna and fish

Construction phase

The presence of turbines, foundations, scour protection and meteo masts as artificial hard substrate will give rise to a new habitat in an area that mainly contains sandy sediments. The introduction of hard substrate – the so-called reef effect – is considered as the most important effect on the original marine environment of the installation of the wind farm. It will lead to greater heterogeneity of the habitat, and the creation of a new community typical of hard substrates. It will also increase the abundance and the biomass of certain species. Which species of fauna and flora and in what numbers they will populate the artificial structures depends on the complexity and the height of the structure, the incidence of light, the water depth and the kind of materials used. The first monitoring results of C-Power (Kerckhof *et al.*, 2009; 2010) indicate that this colonization process occurred fast and intense. Already after approximately 3½ months the intertidal and subtidal part of the foundation appeared to be covered with a close biofouling of epibionts and a clear depth zonation could be observed. The typical species of the first stage of an ecological succession (the so-called r-strategists) are found. Moreover a high diversity is observed compared to other artificial substrates in the surroundings. It is expected that this initial community shall be overgrown rapidly and shall give rise to changes in the zonation pattern and new communities. Most likely a mussel zone will arise and also tubeworms and oysters will settle. Depending on one's point of view this effect can be regarded as positive (e.g. increased biomass and diversity, attraction for fish) or negative (e.g. disturbance of natural habitat, new 'harmful' species).

The magnitude of the impact – irrespective of whether it is judged to be positive or negative – is at this moment in time difficult to estimate for the offshore wind farms at the North Sea. The total hard substrate area very much depends on the type of foundation (with or without scour protection) and the number of turbines. It is clear that the area of hard substrate introduced shall be considerably larger in case of a gravity based foundation (conf 3b) compared to a monopile (conf 1) or jacket foundation (conf 2 and 3a), and in case of configuration 1 (lager number of turbines). The area that effectively becomes available for colonization by organisms is – regardless of the type of foundation – relatively small as the foundations as well as a large part of the erosion protection are buried in the seabed and therefore completely covered by the original soft substrate. So it may be expected that, in spite of the significant changes in relation to the original situation, the impact can be regarded as being acceptable (0/+ or 0/-) for all different configuration alternatives of the North Sea Power wind farm and the defined basic scenarios (Norther + 6 GBF C-Power + 55 MP Belwind), considering that the area covered by these artificial structures as well as the available area for the development of a new community is relatively small in proportion to the Belgian part of the North Sea (≤ 0.01 %).

Exploitation phase

During the exploitation phase the potential effects on the hard substrate epifauna and fish communities will be restricted to changes in hydro-physico-chemical condition of the project area and to potential noise disturbance of the spinning wind turbines, as discussed for soft substrate fauna.

Dismantling phase

The dismantling of the wind farm should lead to the almost complete removal of hard substrates. Again it can be questioned if this has to be evaluated as positive or negative, as the original condition of the sandy substrate is obtained on the one hand, even though this will lead to the a loss of biodiversity and other potential functions that have been performed by the artificial substrate during the exploitation (e.g. nursery room, stepping-stone, attraction for certain species). The effect can however not be assessed yet as currently only initial results are available with regard to the effect of the introduction of hard substrates in a predominantly sandy environment.

Cabling

The most important impacts due to cabling on hard substrate epibenthos and demersale fish are habitat disturbance, increased turbidity, the appearance of electromagnetic fields and the potential heating. These will be similar to those discussed for the soft substrate epibenthos and fish communities.

4.5.2.3 Avifauna

Construction phase

During the construction phase no significant negative effects are expected on the present avifauna. The most important effects are disturbance by sedimentation, barrier effects and noise disturbance. These effects are assessed as small negative (0/-) because of their temporary nature and their limited dimensions.

Exploitation phase

During the exploitation phase wind turbines can cause problems for birds in two ways. Firstly they can collide with parts of the turbines (mainly the rotor blades) which may kill or injure them (collision aspect). Secondly the birds may be disturbed by turbines (disturbance aspect), either as a direct impact in the form of loss of habitat for breeding, foraging or resting by direct seizure of space or restriction of flyways of the birds, or as indirect impact by disturbance by the physical presence, the movement and the noise of the turbines (Stienen *et al.*, 2002).

With regard of the collision aspect, the impact is determined by the amount of birds that pass (flux) and the flying height. These aspects might be influenced by the weather conditions. On the basis of the first monitoring results (Vanermen & Stienen, 2009) it can be expected that especially large gulls (Great black-backed gull, Lesser black-backed gull and Herring gull) (chance of 1/500) have a lager chance for collision because of their size and flying height. Other species as the Great skua and the Northern gannet are also vulnerable to a collision due to their large dimensions and low manoeuvrability. Razorbills and Guillemots never fly at rotor height. On the basis of the current monitoring results limited differences are expected between the collision risk of the various types of turbines. Though it can be expected that the chance of collision shall increase with increasing number of turbines present.

With regard to the Annex I bird species the collision risk for the Common tern and the Sandwich tern is assessed as limited. Based on the low vulnerability to disturbance and the fact that Little gulls fly relatively low above the water surface, it is expected that the future implantation of offshore wind farms within the migratory route of this species won't have an important impact.

As a result of the noise production of the spinning wind turbines no significant negative impact is expected with regard to the present birds.

Dismantling phase

In general the effects of the dismantling phase can be expected to be similar to those of the construction phase. Therefore these effects are assessed as slightly negative.

Cabling

Both cable route alternatives cross the Birds Directive area 3 (Zeebrugge). The managed marine reserve 'Baai van Heist' and the Habitat Directive area 'Vlakte van de Raan' (notified at the European level) are not crossed.

The installation of the cables can result in a temporary disturbance of the Birds Directive area. This disturbance will result from the presence of cable laying vessels on the one hand, and the actual laying of the cables on the other. The laying of the cables shall cause a temporary rumpling of the sediment at the zone where the cable is being dug. As these effects are temporary and local, no significant impact is expected with regard to the Birds Directive area and the bird species linked to this area. During the landing works of the C-Power export cable in Ostend no large disturbance was found (Di Marcantonio *et al.*, 2009).

The presence of the cables during the exploitation phase will probably have no direct impact on the avifauna.

4.5.2.4 Sea mammals

Construction phase

During the construction of the wind farm the main impact on sea mammals is disturbance. Disturbance occurs due to increasing turbidity of the water, underwater movements, the presence of vessels (busy shipping traffic) and machines, noise and other activity on the seabed. Considering the limited amount of additional transports compared to the existing shipping traffic in the Belgian part of the North Sea (mainly at the shipping routes) and considering the non permanent influence, no additional negative impact in the form of disturbance is expected due to the general construction works (Stienen *et al.*, 2002; Di Marcantonio *et al*, 2009).

Ramming of monopiles however is considered to have a significant negative (--) impact on sea mammals close to the piling locations. Determining factors for the occurrence of effects on sea mammals due to piling activities are the sound pressure level of the source (that is strongly dependent on the diameter and length of the pile and therefore also the type of foundation), the water depth and the characteristics of the soil on the spot (determining for the propagation of the noise), the duration of the piling activities and the period in which these activities take place. Piling jacket foundations is also assessed as significantly negative, despite that it is expected that the piling of the thinner piles of the jacket foundation shall produce a lower sound pressure level, because a longer piling period is foreseen. Disturbance can chase away harbour porpoise and other sea mammals out of areas that are most suited for feeding. Considering the seasonal high density of harbour porpoise in Belgian waters, and the large distances whereupon disturbance can appear, behavioral changes can be expected for hundreds to thousands of animals. Although the effects of pile-driving only last for a while, the project that uses monopiles or jacket foundations shall only be acceptable if some mitigating measures and a monitoring program are provided, in order to minimize the risk of damaging the hearing and other significant negative effects on sea mammals.

In contrast to monopile and jacket foundations, gravity based foundations do not need the ramming of piles, by which no ‘impulsive’ sounds with a high sound level are produced. The potential consequences for sea mammals during the construction phase shall be less negative when installing gravity based foundations compared to the monopile and jacket type of foundations, because of the lack of piling activities.

Exploitation phase

During the exploitation phase it is expected that the effects on sea mammals (vibrations, noise, disturbance by maintenance works, changes in feeding sources) will be limited (0/-). However, as possible effects can be chronically during a longer period, monitoring of the effects is advised.

Dismantling phase

In a worst case scenario it can be expected that the effects during dismantling will be comparable with the effects during construction: disturbance will occur of the sea mammals. However, as during dismantling no piling and dredging will occur and as the hard structures (scour protection, parts of piles) will remain in place, the disturbance shall be lower than during construction. The effects of the dismantling phase on sea mammals are therefore expected to be slightly negative (0/-).

Cabling

The installation of the cables can have a disturbance impact on sea mammals. This effect however is temporary, limited in size and therefore judged to be only slightly negative. After installation of the cable the surroundings will restore. During the exploitation phase the cables that connect the wind farm with the coast shall generate an artificial electromagnetic field, that potentially could interfere with the orientation mechanisms of sea mammals. The knowledge about the impact of electromagnetic fields on sea mammals is currently limited or non-existent (in case of the 220 kV cable). However the chance is limited that sea mammals shall be exposed to these electromagnetic fields. Therefore it is not plausible that the electromagnetic fields generated by the cables shall affect sea mammals (0).

4.5.3 Mitigating measures

Benthos and fish

During the discussion of the effects a number of knowledge gaps were identified: species-specific influence of noise and vibrations, the effect of electromagnetic fields and heat generation. Apart from that, some ambiguity still remains about the importance of the project area as spawning ground and about the impact of the introduction of hard substrate in the naturally sandy biotope. In view of this lack of knowledge it is difficult to specify detailed mitigating measures. The emphasis is therefore on an adequate monitoring program (consistent with other wind energy initiatives) that tries to fill in these knowledge gaps.

Avifauna

On the basis of the current knowledge about the impact on avifauna due to the construction and exploitation of the North Sea Power wind farm, no mitigating measures and compensations are proposed.

Though monitoring is advised, that potentially can lead to mitigating measures in a further stage. On the basis of experience and/or monitoring as part of the construction and/or exploitation of other wind farms within the Belgian part of the North Sea (e.g. Belwind, C-Power, Eldepasco) mitigating measures can also be proposed by the competent authorities.

Sea mammals

In spite of the temporary nature of the pile-driving, the project that uses monopiles or jacket foundations shall only be acceptable if some mitigating measures and a monitoring program are provided. The use of acoustic deterrents and of a 'ramp-up' procedure in which the power during pile-driving is slowly increased, are potential mitigating measures. The efficacy of plenty of mitigating measures is however questioned (Boon *et al.*, 2010). Research into this efficacy is therefore advisable.

4.6 SEA SIGHT & CULTURAL HERITAGE

4.6.1 Reference situation and autonomous development

The sea and the beach are regarded by the population as an asset. In Belgium the coast is an important tourist attraction, for day trippers as well as holiday makers. In contrast to the sea view, the coastal view in the inland direction is characterized by a range of high-rise buildings. Movement in the landscape by freighters, fishing boats, pleasure boats, surfers, etc. are part of the landscape experience of people on the dikes. Especially near the seaports there is a continuous coming and going of ships. A development that shall change the seascape in the future is the (further) construction of the currently permitted wind farms (C-Power, Belwind and Eldepasco).

Along the coast there are a great many heritage sites, either protected or not protected. The most important ones are a number of dune areas and polders, piers, lighthouses, a fort of Napoleon etc. At sea the cultural heritage consists mainly of wrecked ships. There are no shipwrecks at the North Sea Power concession area. Though several wrecks are situated along both alternative cable routes of the export cable.

4.6.2 Impact description and assessment

4.6.2.1 Construction phase

During the construction of the wind turbines there will be a temporary visual change of the seascape due to the transport of materials by several vessels and due to the presence of platforms and installation vessel at the offshore construction site. The onshore landscape could also be altered temporary, when it is opted to execute the pre- assembly of the turbines and other parts of the wind farm at a construction site in a nearby harbour. The perception of these activities can be assessed as negative (disturbance) or positive (touristic attraction). Because of the temporary nature of the works the impact of the construction of the North Sea Power wind farm on the sea sight is assessed as negligible (0/-).

The construction of the wind farm will not have any direct or indirect effect on the cultural and landscape heritage along the Knokke-Ostend coast. As there are no ship wrecks situated at the North Sea Power concession area, also no impact (0) is expected on the maritime cultural heritage due to the construction of the wind farm.

4.6.2.2 Exploitation phase

At optimal atmospheric conditions the North Sea Power wind farm (or at least part of it) shall be visible from the shoreline of several coastal cities. A wind farm is rather in contrast with the existing seascape and doesn't fit with the existing characteristics of the seascape. The verticality of a wind farm works downscaling. So the presence of the North Sea Power wind farm will affect the perception of the seascape. From recent survey research (summer 2009) it can't clearly be derived that this influence on the sea sight is largely experienced as negative. A well-considered choice of wind turbine lay-out and pattern and orientation of the wind farm are factors that can affect the perception and acceptance of the wind farm at sea in a positive way. The impact of the construction of the North Sea Power wind farm on the sea sight is assessed as small (0/-) (configuration 1 and 2) to moderately (-) (configuration 3) negative on the basis of realistic surroundings and the fact that optimal atmospheric conditions in respect of visibility rarely occur. Informing the general public in advance can have a positive effect on the acceptance of the project and is considered as a surplus value.

Beaconing and lighting is always performed in accordance to the IALA and ICAO Guidelines and in accordance to potential additional guidelines of the competent authorities.

The exploitation of the wind farm won't have any direct or indirect impact on the (maritime) cultural heritage.

4.6.2.3 Dismantling phase

The impact on the sea sight and the cultural heritage during the dismantling of the wind farm shall be similar to those of the construction phase. As stated before, this impact is assessed as negligible (0/-) to non-existent (0).

4.6.2.4 Cabling

The laying of the export cable(s) of the wind farm to the coast can have an impact on the maritime cultural heritage, as several (known) ship wrecks are present along both alternative cable routes. From the point of view of the maritime archaeological heritage there is no preference for a specific route as wrecks are situated along both routes. If the avoidance of these ships wrecks is strived for maximally, the impact on the maritime cultural heritage is reduced to a minimum (0).

The offshore laying of the cables has no direct or indirect impact on the cultural heritage along the coastline Knokke-Ostend.

4.6.3 Mitigating measures

Informing the general public in advance can have a positive effect on the acceptance of the influencing of the seascape by the planned project.

In order to prevent damage to ship wrecks, it is appropriate to perform a side scan sonar (or a similar survey) along the chosen cable route in advance of the laying of the export cables, or at least make use of the already available data from surveys executed within the scope of the laying of other export cables.

4.7 MAN

4.7.1 Reference situation and autonomous development

The Belgian marine waters are an intensively used area. The seabed is also strewn with shipwrecks and certain areas are protected areas of natural value (Ramsar, Natura 2000, Birds and Habitat Directive areas, etc.).

The concession area is completely situated within the zone reserved for the development of wind energy (Royal Decree 17/05/2004, altered by Royal Decree 03/02/2011). With this Royal Decree the legislator intended to give a clear concrete filling-in to their policy goals with regard to the development of green energy and intended to indicate that this activity has precedence over other activities that could take place in this area. Next to other wind energy initiatives, the area reserved for wind farms or the surroundings is used for sand- and gravel extraction, fishery, cables and pipelines, military activities, shipping and other recreational activities. The intended cable route with landing at Zeebrugge crosses the shipping route 'Scheur' and the Birds Directive area 3 (Zeebrugge) .

In the non-technical summary we will only describe those activities that are actually taking place within the concession area. As there are no interactions with other activities in the near vicinity or further away in the BPNS, these activities are not discussed here. In the main document of this EIR, the activities in the vicinity are briefly mentioned however. In general it was concluded that the construction and exploitation of the North Sea Power wind farm will have no negative impacts (0), irrespective of the chosen configuration alternative.

Fishery

The most important species supplied are shrimps and demersale fish species, mainly sole, ray and flounder (Tessens & Velghe, 2010; Dienst Marien Milieu, 2009; Vanderperren & Polet, 2009). The catch for codfish, dab and whiting is less important. The intensity of the fishery (namely trawling) is carried out predominantly in the gullies between the sandbanks. Shrimp fishers on the other hand will look for their catch on the sand banks, mostly nearer the coast.

On an international and national scale the fishing sector is faced with socio-economic problems by 1) a steady decline of the existing biomass in the higher trophic levels in the North Atlantic since 1950 and 2) increased fishing intensity during the 1950-1975 period. Researchers have found that the current fish exploitation cannot carry on and that due to the existing trends the higher trophic level of fish in the North Atlantic will disappear completely in the next few decennia (Christensen *et al*., 2002). This is also evident from the fact that the stocks of nearly all species are specified as being 'outside safe biological limits'.

This trend is also seen in the Belgian fishery. An increase in supply was only seen between 1950 and 1955, after which a steady decrease in supply and fleet size was noted. The amount of vessels remained quite constant between 1980 and 1990, though began to decrease from 1993. The economic situation in the Flemish sea fishing industry is a source of great concern for the people involved, due to a yearly decline in profitability. A sharp decline in profit is determined due to a steep rise of the costs (mainly due to rising gas oil prices) in relation to the turnover.

Developments in the European Fisheries policy lead us to believe that further quota restrictions and accompanying measures (such as technical measures and restricting the days at sea) will mean that the trends described above will only grow stronger in the short and medium term.

Military activities

The North Sea Power concession area doesn't overlap with any military exercising zone. The two other concession areas that are part of the basic scenario, namely Belwind and C-Power, though do overlap with a military zone where artillery exercises with floating targets are held. These exercises can take place either by day or at night, during the whole year (indeed only after announcement of the artillery exercises). During this activities vessels are asked to avoid the area. In preceding EIR's it was already noted that the government has agreed that within the confines of the area reserved for wind farms (in accordance with concession RD) no military exercises will be held once the concession is granted (in which the department Defense also gives advice).

Cables and pipelines

The North Sea Power concession area is crossed by 2 gas pipelines, 3 telecommunication cables and electricity cables of other wind farms. One of these gas pipelines is the 'Interconnector' (235 km), exploited by Interconnector UK Limited, that transports approximately 25.5 billion m^3/year from Zeebrugge to Bacton (UK). The second gas pipeline the 'Seapipe' (814 km) connects Zeebrugge with the offshore oil platform Sleipner Rise (Norway) and is exploited by Gasco. Next to gas pipelines a lot of telecommunication cables are situated within the BPNS. Three telecom cables that are currently in use cross the North Sea Power concession area, by which the prescribed safety distances (250 m) are always respected.

At present Elia prepares a permit for the construction of an Electricity cable (HVDC interconnector between UK and Belgium), from Richborough (UK) to Zeebrugge. This electricity cable should be in use by 2016. The laying of this electricity cable has no direct consequences for the North Sea Power concession area, but can potentially conflict at the landing point at Zeebrugge (western side), where the export cables of Belwind, Eldepasco and Norther shall also land. Currently the EIR for this electricity cable is being prepared, so public data aren't yet available.

4.7.2 Impact description and assessment

Fishery

One of the studies consulted for this description of the impact on fishing was the one carried out by Mackinson *et al.* (2006) on the views of the fishing community about the potential socio-economic impact of offshore wind farms on their sector.

The potential loss of access to traditional fishing grounds is generally seen as the most important negative effect of the development of wind farm projects at sea. The installation of the North Sea Power wind farm (including the safety zone of 250 m) would lead to an additional loss of fishing grounds of 1.5 % for the

BPNS. When also taking the concession areas of C-Power en Belwind into account (the basic scenario), the potential loss corresponds to approx. 3 % of the BPNS.

The impact as a result of the North Sea Power wind turbine project as described is therefore small (0/-) and is furthermore far less relevant than the loss of income caused by the fluctuating fuel prices and the restrictions imposed by the European Fisheries policies. Moreover, a recent scientific study shows that the closure of small areas to trawler fishing could have a significant positive effect (++) on the fishing in nearby areas (bigger catches).

Apart from the spatial loss, the fishing community has concerns about the short and long term effects during the construction phase and exploitation phase. During the construction phase pile-driving (when choosing monopile or jacket foundations) is seen as the main cause for changes in fish behavior, while constructing a gravity based foundation and the cable laying will temporary disturb the sediment. The main impacts expected during the exploitation phase are the changes in fish behavior as a result of the electromagnetic radiation generated by the cables and the introduction of hard substrates (Mackinson *et al.*, 2006). For a description of these effects and the knowledge gaps on this subject, see chapter 'Fauna and Flora'.

The electricity cable to the coast has no impact on fishery, irrespective of the chosen configuration alternative. This export cable is laid deep enough to prevent deterioration of the cables by fishery vessels.

Besides these negative effects on fishery, the development of the North Sea Power wind farm can also offer opportunities, namely the creation of nursery areas and protected nature zones. Moreover the closure of the area for fishery shall inevitably lead up to the fact that disturbance of the soil and organisms by trawling activities will stay away (Dayton *et al.*, 2002; Frid *et al.*, 2002; Lindeboom 2002).

At last there is the positive impact of a closed area on the fishing yield in the surroundings. Scientific research (Roberts *et al.*, 2001) showed that small marine reserves (10-25 km²) can also have a significant positive impact on the fishery in the surroundings (e.g. increasing catches). Although the suitability of these data in the particular case of the BPNS still has to be proven, considerable consensus exists within the scientific world concerning the 'superabundance and breeding' effect of marine protected areas, that shall be even more intense within a network of marine reserves.

Military activities

Because of the regular communication with the competent services of the Marine, the infrequency of the military activities and the recent adaptations of military areas, no effects of the planned North Sea Power wind farm project or the basic scenario are anticipated.

Cables and pipelines

The lay-out of the North Sea Power wind farm takes the required safety zone around pipelines (minimal 500 m) and telecommunication cables (minimal 250 m) into account. Moreover the owner shall be consulted for any construction works within a distance of 500 to 1000 m besides both sides of the axis of the pipeline. With regard to the works that need to be executed and the potential crossings of pipelines and cables, Norther shall conclude a proximity agreement with each owner/licensee in accordance to the regulations of the Royal Decree of 12/03/2002 (art. 15, 8°).

So it can be assumed that no impact shall arise on the existing cables and pipelines due to the implantation and exploitation of the North Sea Power wind farm (export cable included).

Other activities

No conflict with all the other human activities on and in the Belgian marine waters is expected to arise during the construction and exploitation of the wind farm. These activities occur far enough from the wind farm and its cabling or the activities are separated in time.

The only possible conflict from an environmental point of view between the wind farm project and the protected areas mentioned is the fact that the proposed cable route to Zeebrugge runs through the Birds Directive area 3. On the strength of the impact description in chapter 'Fauna and Flora' and the conclusions of the assessment within the context of the Royal Decree 14/10/2005, the effects are temporary and local (0/-) and therefore no significant effects are anticipated for the protected nature areas.

4.7.3 Mitigating measures

No mitigating measures or compensations are proposed for the development of the North Sea Power wind farm with regard to other marine users.

4.8 SAFETY

The reference situation and the effects on radar, shipping communication and navigation systems, and relevant mitigating measures are established in a monograph by Prof. Catrysse (2011). The most important conclusions can be found here.

The description of the reference situation and the description and assessment of the effects on the shipping industry and oil spoilage is given in § 5.8 of the Non-technical summary ('Cumulative effects' – 'Safety').

4.8.1 Reference situation and autonomous development

4.8.1.1 Installations

Currently there are no installations present at the North Sea Power concession area yet.

4.8.1.2 Radar and shipping communication

Along the Belgian and the southern part of the Dutch coast a series of coastal radars has been installed, the so-called Scheldt Chain of Radars (or SRK). The purpose of these radars is to help the authorities in organising the shipping traffic in the southern part of the BPNS, the Scheldt estuary and the southern Dutch marine coastal waters.

The North Sea Power wind farm is located in a zone known as 'Westpit'. This zone is situated off the Zeebrugge coast, close to the Dutch border and approx. 21 km from the radar installation of Zeebrugge, at the south-southeast of the Thorntonbank. Data supplied by, amongst others, SRK show that there is important shipping traffic at the so-called 'West-rond' route. The SRK harbour radar of Zeebrugge is able to follow this traffic, although the zone 'Westpit' it is not situated within the 'official' SRK surveillance domain. The main shipping route from the Channel to Rotterdam lies much more northerly than the Bligh Bank, and is outside the range of the SRK radar stations (Catrysse, 2011).

4.8.2 Impact description and assessment

4.8.2.1 Installations

The wind turbines of the North Sea Power wind farm are subjected to various classification systems. In order to belong to a certain classification the turbines themselves and their components are tested (rotor blades, nacelle, electrics, mast and foundation). The wind turbines have a type certification in accordance with IEC 61400 or equivalent.

For safety reasons it is important to establish what the chances are of objects or activities in the vicinity of the turbines being hit by, for instance, a broken-off rotor blade. The maximum throwing distance during an overrev-situation (2 times nominal number of revolutions) for a 3 MW wind turbine turns out to be around 400 m. For a 6 MW and 10 MW wind turbine the throwing distance is assumed to be about the same. In principle this risk will be covered by the safety zone of 500 m for ships around the wind farm.

Provisions for the protection of the environment are included as standard for the wind turbine and the offshore high voltage stations (OHVS). The amount of oils in the turbine is approx. 1000 liters per turbine (gear box, hydraulic system). Probably the transformers within the turbines shall be the dry type of transformers, not the oil-cooled type. The transformers of the OHVS though will be the oil-cooled type (1 or 2). Moreover both OHVS contain a storage tank (double hull) containing diesel fuel (approx. 30 m^3). Leakage of fluids (oil, grease, etc.) from the installation is prevented or minimized by the fitting of various collection systems (basins, brims) as well as the way in which the components of the installations are constructed. Assuming that these collection systems function properly and are well designed (certified), there will be no negative impact on the environment. This will not be the case if a wind turbine should collapse as a result of extreme climate conditions (extremely small chance; considering the existing classification and certification systems) or as a result of a collision by ships (see § 5.8 of the Non-technical summary).

As there are usually no people in, or in the immediate vicinity of the wind farm, there are no risks or consequences for man. It must be noted once more that occupational hazards (that do exist) are not considered.

4.8.2.2 Radar and shipping communication

According to Catrysse (2011) the dominant factor for large wind turbines is the mast with regard to mariphone systems. Large reflecting objects can also have an effect (e.g. dead areas, multiple reflections, etc.). The effects should however be seen in relation to the position of both the radio/radar system as well as the configuration of the wind farm. Taking into account the location of North Sea Power wind farm in relation to the coastal stations, the potential effect of receiver saturation could only affect the ships radar (Catrysse, 2011). The installation of the wind turbines in the North Sea Power wind farm within the 'Westpit' zone will not interfere with the radar tracking by SRK. Firstly, the installation lies outside the range of most radar posts.

Secondly, the situation will not change for the shipping traffic passing in front of this implantation at the zone 'Westpit'. In the area behind the North Sea Power wind farm, in particular behind the Thorntonbank and the Bank with No Name, shadow zones and an area of reduced visibility will arise, affecting radar tracking as well as other mariphone systems. But this area is almost out of range anyway.

Some effects shall be emphasized by the realization and implantation of other offshore wind farms, of which some are currently already in progress (see description and assessment of the cumulative effects in § 5.8 of the Non-technical summary). It has to be noted that the type of wind turbines does not influence these situations, although bigger types lead to a more open structure of the wind farm.

The influence of potential multiple reflections affecting the ships radar is noticeable within a zone of approx. 1 km from the wind farm. Still it is clear that these potential multiple reflections will not necessarily lead to dangerous situations and could give a false radar image only inside or in the near vicinity of the wind farm. There will never be a false echo resulting in a false image between the ship and the first object near the ship.

As far as the mariphone VHF (very high frequency) communication is concerned there are some reservations but only for the communication on the far 'Westrond-North' route and far-away routes. But here too, it must be made perfectly clear that there will be no changes compared to the current situation for the area between the coastline and the North Sea Power wind farm. Here too the real restriction is the actual range of the radio installations.

Catrysse (2011) also shows that the impact on following systems will be rather minimal or non-existent:

- RDF (Radio Direction Finder) systems
- DGPS system
- AIS (Automatic Information System)

According to Catrysse (2011) it can be assumed that the realization and installation of the North Sea Power wind farm will almost have no impact (effect = 0) on the surveillance of and communication with the shipping traffic as it is now at the big shipping routes.

4.8.3 Mitigating measures

Adequate sensors and regular inspections could be foreseen on the places where leakages can lead to significant spill quantities of oil or grease to minimize the environmental risk. In this way the operator can detect rapidly the leak and intervene.

In case of a spill caused by an incident or accident and threatening the environment, the harmful substances must be removed as soon as possible and processed according to current regulations.

5 CUMULATIVE EFFECTS

5.1 INTRODUCTION

The potential impact of a combination of several wind farms can, in connection with other human activities at sea, lead to an accumulation of effects. We could be talking about a relatively simple adding-up of all the effects of the various individual activities, but it could also be the case that certain effects intensify each other or indeed partly or completely cancel each other out. Alternatively it could also be possible that the individual effects must in fact be added up, but do not lead to significant problems for life in and on the sea and the habitats involved, until a hitherto unknown threshold value is crossed, after which significant problems may suddenly materialize after all. In that case we are dealing with a non-linear response.

In this chapter we will explore the potential cumulative effects due to the North Sea Power wind farm and the 3 currently permitted wind farms in the Belgian part of the North Sea (Eldepasco + Belwind + C-Power):

- C-Power NV has the required permits (concession domain, environmental permit and cable permit) to build a wind farm in the marine waters under Belgian jurisdiction in the Thornton Bank area and to exploit it for the duration of 20 years. In April 2004 C-Power began with the necessary soil testing. In 2008 the first 6 wind turbines have been constructed at sea, that are currently already operational. The granted concession at the Thorntonbank (Ministerial Decree 27/06/2003 and 03/02/2010) is divided into two areas: one on the western side of the telecom cable Concerto South1 and the Interconnector gas pipeline (sector A) with 30 turbines and one on the eastern side (sector B) with 24 turbines. A total area of 19.9 km² is taken up, for a total installed output of up to 325 MW.
- Eldepasco has obtained a concession domain (Ministerial Decree 15/05/2006, extended by Ministerial Decree 24/03/2010) for the construction and the exploitation of a wind farm of 72 turbines (approx. 14.3 km²) on the Bank With no Name located at approx. 38 km from the Belgian coast, with a total installed capacity of 216 MW; the individual capacity of the wind turbines amounts to 3 MW. The environmental permit has been granted at November 2009.
- Belwind has the required permits for a large-scale wind turbine project (363 MW) on the Bligh Bank. A concession domain for an area of 35.4 km² has been obtained (Ministerial Decree 05/06/2007). The wind farm will consist of 110 turbines of 3 MW, of which 55 turbines are currently installed.
- On October 5th 2009 the Federal Public Service Economy, S.M.E.s, Self-employed and Energy granted a concession domain to Norther for the construction and exploitation of a wind farm (for an area of approximately 38 km²). Norther will apply for a modification of the concession area. The modification consists of an extension of the granted concession area in southern direction, to a total area of approximately 44 km². When referring to the concession domain or concession area of the North Sea Power wind farm in this EIR, it is always meant as the complete extended area (44 km²). The wind farm shall be built at 20 to 30 km from the coast, within a zone southeast from the Thorntonbank, alongside the border with the Netherlands. The northern border of the project area is situated at approx. 1 km from the concession domain of C-Power. This EIR will be used to underpin the consents process and must describe the construction, exploitation, dismantling as well as the cable installation of the North Sea Power wind farm.
- At last there are two new initiatives that have received a concession domain for the construction and exploitation of a wind farm in the Belgian marine waters recently: Seastar (Ministerial Decree 24/03/2010) and Rentel (Ministerial Decree 04/06/2010). These projects fall outside of the scope of this EIR as their permit procedure hasn't been started yet.

Norther plans the construction of the North Sea Power wind farm in the period 2014-2016. Taking into account the current duration of the works and the submitted planning of other wind farms, there is a actual chance that there will be an overlap of the construction phase of the North Sea Power wind farm with the construction of one or more wind farms already permitted.

Only those effects that have a non-negligible (positive or negative) impact on a certain discipline will be discussed. It is assumed that if a certain impact on the environment is totally negligible for each individual wind farm, the cumulative effect will be negligible too. An exception to this rule is possible if the impact of each wind farm individual approximates to a certain threshold value, so that the cumulative impact is situated within another class of effects (moderate to significant).

5.2 SOIL

If the gravity based type of foundation is chosen for the North Sea Power wind farm, a total of 3.6 million m³ of sand shall be stored for all four wind farms due to the required excavation. For the other wind farms the current decisions concerning the foundation types have been taken as a basic assumption: Belwind and Eldepasco (monopile); C-Power (combination of gravity based and jacket foundation). This storage will be done in stages over time: the construction of each wind farm will take 2 years; the construction period for each wind farm will differ. To compare, last years a yearly volume of 1.9 million m³ of sand and gravel extraction for commercial purpose has been executed at the BPNS, spread over a few locations, as well as approx. 16 million m³ of sand that has been dredged out and dumped at the provided dumping sites. The cumulative effect will be smaller than the sum of the individual effects.

The impact on the morphodynamics of the BPNS caused by the installation of the cables is negligible. The impact will be reduced if the cables are laid together (adjacent cable routes) instead of each of the four projects using different routes.

Local erosion as a result of the constructions is prevented at the four wind farms by the installation of scour protection a priori (except for the jacket foundation of the North Sea Power wind farm). When monopiles are chosen it can be concluded that the scour protection in all cases will be perfectly adequate. When gravity based foundations are chosen there is some uncertainty due to a lack of scientific studies and practical experience and therefore initiators are taking even larger safety ranges for the dimensions of scour protection. The cumulative effect will certainly be smaller than the sum of the individual effects. If local erosion should occur after all, it will be straightforward to negate the effect by making repairs and installing additional scour protection.

If the scour protection is removed it will leave a pit around every foundation. The space and time needed for the natural restoration of these foundation pits is, based on the information available to date, difficult to estimate. The cumulative effect will not be greater than the sum of the individual effects.

5.3 WATER

The construction of the foundation will cause, for each construction method and type of foundation but more so for the gravity based foundation, a local and temporary increase in turbidity, which will have a negligible effect (0/-) compared with the turbidity concentrations created naturally by strong winds. The cumulative effect is merely the sum of the individual effects.

The impact of the cable installation within each wind farm and the installation of the export cable will be temporary and local. The impact (zone) would be reduced if the cables were to be installed together and at the same time (shared routes) instead of each of the projects using different routes or laying the cables along the same route but at a different time.

5.4 CLIMATOLOGICAL FACTORS AND ATMOSPHERE

An important effect during the exploitation phase is the prevented emissions on land as a result of the fact that the net electricity production of the wind farms does not need to be generated by traditional production (combined with nuclear production or not).

The prevented emissions of each wind farm on its own already make a considerable contribution to the targets set for Belgium for the reduction of SO_2, NO_x and CO_2. The cumulative contribution will obviously be even greater and is equivalent to the sum of the individual contributions (significant positive effect), namely 3 % for SO_2, 1.8 % for NO_x and 2.4 % for CO_2.

5.5 NOISE & VIBRATIONS

The noise of ramming of foundation piles can propagate up to relatively large distances with only limited attenuation. Though because the piling activities produce an impulse sound (non-continuous) and because the piling activities only occur temporary, the cumulative effect shall not be larger than the sum of the individual affects for each wind farm. The chance that pile-driving sounds from the different wind farms will be heard simultaneously is extremely small.

During the exploitation the underwater noise of the wind turbines is restricted to the area between the turbines and will not go beyond the safety border of 500 m around the wind farms, consequently the cumulative effect is equivalent to the sum of the individual effects.

Only between the Belwind and the North Sea Power wind farm at the C-Power and Eldepasco wind farm will the cumulative effect of the 4 wind farms together cause the noise level above water to be slightly higher (> S). As the effect of the individual wind farms is expected to be small, there will be only a limited effect of the noise above water coming from the 4 wind farms.

5.6 FAUNA, FLORA & BIODIVERSITY

For the majority of the effects on benthos and fish (loss of biotope, disturbance, loss of organisms, introduction of hard substrate, noise) the cumulative effect is the sum of the individual effects per wind farm. Also, these are often directly proportional to the space occupied. The total area of the four wind farms together (inclusive the safety zones) is relatively small compared with the BPNS (4.6 %). As most of the effects will only occur on a small part of the concession domains (gravity > monopile/multipod/jacket) it can be concluded that the effects will be acceptable. There is still a great deal of uncertainty about the magnitude of the cumulative effect of underwater noise disturbance and electromagnetic radiation from the cabling. More research is advisable.

With regard to the avifauna it can be expected that the presence of a great amount of wind farms in a relatively small area can cause a slight increase in mortality of sea birds on the population level. Although probably a relatively small amount of collision victims will occur, this can have a significant impact on the long term for the populations of certain species (Drewitt & Langston, 2006). Moreover the presence of the wind farms can involve a loss of habitat for some seabird species that are vulnerable to disturbance. This is especially the case during the winter period, when large amounts of sea birds concentrate at the BPNS before they migrate to their breeding areas. The presence of the wind farms can also involve a reduction of the foraging area for certain species that are vulnerable to disturbance, or a barrier effect that shall especially be of importance for migrating birds. However these cumulative effects can’t be assessed properly on the basis of the current data. Further research is necessary.

With regard to sea mammals it is expected that most cumulative effects (disturbance, noise, physical presence of the wind farms, changes in food availability…) will be the sum of the individual effects. Though several knowledge gaps are present.

5.7 MAN

Within the chapter ‘Man’ it was already indicated that the potential loss of access to traditional fishing grounds is generally seen as the most important negative impact of the development of wind farm projects at sea. As more wind farms are realized, the loss of fishing ground increases proportionally. If it is assumed that approx. 85 % of the BPNS can be fished (Ecolas, 2003), this would amount to an additional loss for the traditional fishery of approx. 5 % due to the 4 wind farms when taking the safety zone of 500 m around the concession areas into account. In relation to the fished area of the North Sea (approx. 171,500 km² (Grontmij, 2006b)) approximately 0.1 % is lost. Besides, the closure of a large unbroken area (the area reserved for wind energy projects) can lead to an increase of the shipping time of fishery vessels.

A clear distribution pattern of the fishery grounds and spawning areas of the fish is not available for the Belgian marine areas. Currently a BELSPO study is being executed (LEKOFISH) that aims to gain an insight into these traditional fishing grounds on the basis of local fishery knowledge. Based on the general data of available studies it is assumed that the Thorntonbank, Bligh Bank and Bank with No Name are less important for the Belgian fishery. On the basis of these data the cumulative impact (limited dimensions, permanent nature) of the loss of traditional fishing grounds by the wind farms is assessed as moderately negative and therefore evaluated as acceptable. Besides it can be noted that the Belgian fishery is already pressurized heavily by the European Fisheries policy (quota restrictions and accompanying measures such as technical measures and restrictions of the days at sea) and the described cumulative impact of the wind farms can be put into perspective in comparison with this.

Next to the spatial loss some cumulative short and long term effects on fish during the construction phase are important for fishery. Potential cumulative effects are caused by piling (monopile and jacket foundation) and the arise of electromagnetic fields (cables). At this moment the impact of these effects is very uncertain. Until further notice this effect is assessed as significantly negative (piling noise during construction) to slightly negative (electromagnetic fields), though further research is desirable. Provided that mitigating measures are used, both effects are assessed as acceptable.

On the other hand, the closure of the delimited area for wind farms can have a positive impact on the fish populations for fishery (trawling) and shipping. Moreover the introduction of hard substrates can result in an increase of fish. Currently these last aspects are included in the monitoringsprogramma of the permitted wind farms, though no results are yet known until now.

As the construction of the North Sea Power wind farm will proceed according to the statutory guidelines, no negative cumulative effects are anticipated for the various users of the North Sea.

5.8 SEA SIGHT & CULTURAL HERITAGE

The construction periods of the various wind farms can partly overlap, by which the disruption of the sea sight during the construction (by the constant transport of materials by several vessels and due to the construction activities at sea) will decrease in duration, although the intensity of disturbance will be higher. Those wind farms that are situated nearest to the cost (North Sea Power and C-Power) are most important with regard to the cumulative impact of the presence of several wind farms on the sea sight, as these wind farms determine the seascape from the cost. The combination of several wind farms will cause a certain 'condensing' of the zone within the visual field, by which it will become more and more difficult to distinguish the separate wind farms with increasing number of turbines within the zone for wind farms. This more uniform view can be experienced as more positive in comparison to the view on all wind farms separately, though the opposite effect is also possible, by which a larger amount of turbines is experienced as more 'crowded'. Because the diverse wind farms are built in phases, a slow habituation to the chances seascape can potentially occur, by which the impact will be assessed as minimal after finalization of the complete four wind farm projects. Concentration of the diverse wind farms within one legally delimited zone decreases the size of the impact zone as much as possible, and besides a higher energy production can be obtained with only a slight increase in visual disturbance. At last a comparative assessment of the impact needs to made within the wider energy framework, taking the negative impact of classic energy production (e.g. nuclear waste issue of nuclear plants) into account. The cumulative effect is therefore assessed as acceptable.

The cumulative impact on the cultural heritage is negligible.

5.9 SAFETY

The reference situation, effects for and by shipping and the relevant mitigating measures are defined in a monograph of MARIN (2011). The most important conclusions are repeated in following paragraphs. Besides the consequences of accidental oil spoilage is assessed in this chapter on the basis of preceding studies. The cumulative effects on radar, shipping communication and navigation systems, and relevant mitigating measures are established in a monograph by Prof. Catrysse (2011). The most important conclusions are repeated shortly in § 5.9.3 of the Non-technical summary.

With regard to the discipline 'Safety', the two new wind farms (Rentel and Seastar) that have obtained a concession domain are also taken into account, next to the already permitted wind farms. The impact assessment of the shipping safety starts from two scenarios (scenario 1. the four granted farms; 2. the four granted farms + Rentel and Seastar), by which two configuration alternatives of the North Sea Power wind farm (configuration 1 & 2) are considered each time. The third configuration of Norther (47 wind turbines of 10 MW) is not taken into consideration because this configuration will cause a notable lower risk compared to configuration 2, because the number of turbines (most determining risk factor) is much smaller than for configuration 2. A higher risk per turbine is however expected due to the lager dimensions, though this remains limited.

5.9.1 Shipping safety: reference situation and autonomous development

The Belgian Part of the North Sea (BPNS) is an intensely used marine area. The study of MARIN (2011) shows that the shipping traffic in the concession area is well assembled by the AIS receiving station in Westkapelle. The most important shipping lane is west-east orientated in the direction of the Scheldt (Zeebrugge).

Preceding literature (Ecolas NV, 2003; Le Roy *et al.*, 2006; DNV, 2008) shows that the estimate of shipping accidents in the Belgian territorial waters is a very difficult calculation. The numbers vary enormously (from several accidents per year to less than 0.0005/year), depending on the considered area, the shipping type and the type of accident (grounding/ drifting; with ship/ offshore obstacle). An insight in the actual chance of an accident on the BPNS is therefore difficult to estimate. Furthermore especially RoRo (Rol on/Roll off) ships, cargo ships and to a lesser degree also container ships seem to be involved with accidents between 2 vessels (DNV, 2008).

Analogue to this, large variation turns out to exist with regard to estimates of the number of accidents that actually lead to environmental contamination. In the RAMA-study (Le Roy *et al.*, 2006) it is noted that the chance of an accident resulting in spoilage of dangerous substances (environmental contamination) is estimated at once every 3 year. This number is considered rather as an overestimation because of diverse reasons (e.g. characteristics of the model in combination with the sand bank system). MARIN (2011) calculated that chance at once every 31 years. In Ecolas NV (2003) it is noted that MUMM considers 3 incidents with environmental contamination every 100 years, or once every approx. 30 years, as acceptable.

Therefore prudence is in order when interpreting the figures, taking into account the mentioned uncertainties. Since there is no unambiguous conclusion about the accident risk in the southern North Sea, a comparison with the additional risk due to the North Sea Power project will be difficult to interpret.

5.9.2 Shipping safety: description and assessment of the cumulative impact

The area of the wind farm, once completely built, will be a 'forbidden' area for all shipping traffic (except reparation/maintenance vessels). It is therefore possible that ships shall have to follow a different route than before the construction of the wind farm. Compared to the current situation by which the wind farms Belwind, Eldepasco and C-Power are supposed to be present, the presence of the North Sea Power wind farm won't alter the traffic around the wind farms.

The wind turbines at the southern side of the North Sea Power wind farm have a relatively high chance for collision compared to the other turbines. These turbines are situated nearest to the route from and to Maas West that passes by the wind farm. Differences in collision/drifting chance are mainly determined by the configuration; the choice of foundation has a clear impact, but the number of turbines is most determining. Unless the use of jacket foundations, the variants with 6.15 MW turbines though have a lower collision chance per generated unit of energy. The presence or otherwise of the wind farms Rentel and Seastar has nearly no impact on the North Sea Power wind farm.

The chance of collision for the North Sea Power wind farm by route bound vessels is estimated at once every 12 years (conf. 1; MP) to once every 11 years (conf. 2; JF), but is relatively high compared to the nearby wind farms, excepted for the Belwind wind farm that is characterized by similar collision chances. The total collision and drifting chance of the North Sea Power wind farm varies from 32.4 % to 38.7 % of the total collision and drifting chance of all wind farms in the scenarios.

The chance of personal injury when colliding or drifting is extremely small. The criteria for the external risk are therefore largely met, with regard to the individual as well as the group risk.

If no wind farms would be present at the BPNS, the total spill risk is estimated at once every 31 years. An average of 6.1 m³ bunker oil and 164.2 m³ of tanker oil would be spilled. The spill frequency of bunker and tanker oil due to collision with a turbine of the North Sea Power wind farm in the cumulative variant NSP_sc2_conf1 (= 4 permitted wind farms + Rentel + Seastar + Norther conf. 1) is approx. 8.3 % of the spill frequency at the Belgian North Sea without wind farms. For the other variants this figure is lower. Depending on the considered cumulative variant, the share of the North Sea Power wind farm amounts to 15 % to 20 % of the total spill due to the other wind farms (an average of 20 m³/year).

The modeled oil spoilage is a 'worst case' approach. Because the percentage of double-walled tankers increases, the chance of oil spilled as a result from collision with a turbine shall decrease.

On the basis of extrapolations of existing modeling studies (Kleissen, 2003; Boot, 2003) it appears that the oil slick coming from a collision with the North Sea Power wind farm (at approx. 20 km from the coast) would reach the Belgian coast in 11 hours (at wind friction of 3 %). The time of arrival is mainly driven by wind. For the same amount of spill by spring tide a bigger length of the beach will be daubed with oil. With higher wind friction (5 % wind friction) the oil particles shall wash ashore after approx. 7 hours. The time for intervention is thus relatively short.

Especially avifauna, and possibly sea mammals too, will experience the most important short-term effects of oil spoilage. The impact of a spill on the bird population depends on the present species, their density and vulnerability on the one hand, and the contaminated surface on the other. For the worst case scenario (wind speed 17 m/s; impact area of 47 km² of coast), the model expects a number of 300 to 400 dead birds (Ecolas NV, 2003). The number of victims rises to 669 with wind speeds of 10 m/s and to 1,117 with wind speeds of 7 m/s (Di Marcantonio *et al.*, 2009). The modeled losses of beach birds remain negligible. Next to the direct victims that are caused by the calamity, negative impact on the population can also occur (long-term impact). It is however not always easy to distinguish the impact of a calamity from natural fluctuations in the population.

For above-mentioned conclusions it has to be taken into account that such effects strongly depend on geographical, physiological, chemical and weather conditions by which the oil contamination can be influenced.

5.9.3 Radar & shipping communication: description and assessment of the cumulative impact

It is stated that the realization and implantation of the diverse offshore wind farms won't have a notable impact on the surveillance of or communication with shipping traffic as it currently occurs and situated within the official working area of SKR. The surveillance of far away shipping traffic and of the future shipping traffic from and away from the concerning wind farms can be approved by installing an additional radar station and a supporting relay station for the marifone communication. The necessity and potential position of this additional station has to be examine by the competent authorities.

6 MONITORING

Monitoring is performed to be able to detect potential changes in the ecosystem due to the implantation of the wind farm. As currently several wind farms become (potentially) active within the legally delimited area for wind farms, a tuning between the diverse monitoring programs is advised.

In the various thematic chapters of this EIR, monitoring measures were proposed. These proposals were predominantly based on the EIR drawn up for the wind farm of C-Power, Eldepasco and Belwind (Ecolas NV, 2003 and 2004; ARCADIS Belgium, 2007 and 2008) and the environmental impact assessments (EIA) by the authorities for the same projects (MUMM, 2004 and MUMM, 2006a; Di Marcantonio *et al.*, 2007 and 2009).

7 CONCLUSIONS

Norther NV has taken the initiative to build an offshore wind farm (**the 'North Sea Power wind farm'**), to be located at 20 to 30 km from the cost, within a zone southeast from the Thorntonbank, alongside the border with the Netherlands. The wind farm will generate a yearly output of approx. 800 GWh to 1,500 GWh, corresponding to the average yearly consumption of ca. 230,000 to 430,000 households. The completion of this wind farm will help to achieve the objective of the authorities regarding renewable energy (13 % by 2020).

To assist with the decision-making process concerning the license application, the procedure for an environmental impact report together with an environmental impact assessment will be followed. This EIR will be used to underpin the consents process and describes the construction, exploitation, dismantling as well as the cable installation. Throughout the chapters the effects of wind turbines within the range of 3 MW to 10 MW are discussed, and three different foundation alternatives (monopile; jacket; gravity based foundation) are studied. In consultation with the competent authorities some alternatives (configuration + foundation type) have therefore been restrained for the North Sea Power wind farm, that are further discussed through the diverse chapters. Next to the study of the North Sea Power wind farm separately, the existing situation has also been discussed, by which 6 turbines of C-Power and 55 turbines of Belwind already have been installed (defined as the 'basic scenario').

The number of turbines depends on the chosen alternative: configuration 1 (86 MP * 3 – 4.5 MW); configuration 2 (74 JF * 6.15 MW); configuration 3 (40 JF/GBF * 10 MW). Then the power will be transported to Zeebrugge via underground cables (for the route at sea the cables are buried into the seabed). The necessary controls regarding security and operation of the wind farm will be put in place, as well as illumination, marking and signposting for the air and shipping traffic. It will take 2 years to build the farm, that shall be exploited for 20 years minimum.

In general the effects are similar for the North Sea Power wind farm and the basic scenario. If relevant, clear distinction has been made between these scenarios within the diverse disciplines.

During **the installation phase** there will be temporary disturbance in the vicinity of the project site as a result of the activities. With gravity based foundations (conf 3b) a considerable amount of surplus sand will have to be laid up in the concession area. As a result of the activities (ship movements, piling, use of cranes…) the sound level will temporarily increase underwater and above the water. Due to the scour protection and the turbines limited loss of sandy substrate as a habitat will occur. There will be a temporary disturbance of benthic habitat by the storage of dredged sand and a limited and temporary disturbance of the benthic fauna and fish. There is some uncertainty about the size of the impact caused by noise and vibrations on the marine life. The creation of hard substrates will lead to a higher and changed biodiversity. Species sensitive to disturbance and sea mammals will probably temporary leave the area. No effects are anticipated for other users of the BPNS.

During **the exploitation phase** there will be also some effects. Potential erosion in the area around each turbine will be prevented by the installation and monitoring of scour protection when using a monopile or gravity based foundation. Study by Norther showed that this is less relevant in case of a jacket foundation. The risk of water and soil pollution is negligible. During the exploitation of this wind farm up to 6 % emissions of green house gasses will be prevented in comparison with traditional power stations (significant positive effect). At optimal atmospheric conditions the North Sea Power wind farm will be visible from the shoreline of several coastal cities. This will be most explicit for the bigger turbines (configuration 3). Due to the functioning of the turbines increased underwater noise is expected nearby the turbines. Increased sound levels will also be present above water, and will be detectable up to 5 km. For the majority of fauna species there will be (almost) no impact. During the exploitation phase the wind farm may cause hindrance (small to moderate negative effect) to bird species that are sensitive to disturbance and collisions. Further radar research is though desired in order to be able to confirm these temporary estimations. The presence and behavior of sea mammals could be altered by the vibrations, noise, maintenance activities and change in food sources during the exploitation phase. The impact on sea mammals during the exploitation phase is judged to be slightly negative. A positive effect (increased catches) is expected on traditional fishing at the traditional fishing grounds in the vicinity, by the closure of the wind farm zone for trawling.

The effects during **the dismantling phase** will be similar to those during the installation phase, though the intensity of occurrence will be much lower. The effects depend on whether the foundation (or part of it) and the scour protection are removed. The choice whether or not to remove the scour protection and the foundation is best made at the end of the exploitation and based on the available experience, technology and monitoring results.

The main effect of **the cable installation** is the local disturbance of the seabed and the animal life in it. The impact will be limited to the immediate vicinity of the cable route and disappear after a time (small negative impact). Not much is known about the influence of electromagnetic radiation and the local warming of the seabed (due to the heat formation of the electric cables) on fish, benthic organisms and sea mammals during the exploitation of the wind farm but it will be restricted to the near vicinity.

It can be concluded that the effects during construction, exploitation and dismantling will be all in the range of acceptable for both the North Sea Power wind farm and the basic scenario and that in no case it is a matter of significant negative effects (in relation to the BPNS).

In view of the position and distance of the installation in relation to neighboring countries some limited negative **border crossing effects** can be expected concerning the Netherlands. Of all the disciplines that were considered, only the disciplines noise, sea view and safety are relevant with regard to these border crossing effects. As a result of the large distance to the Dutch coast, the effects will be acceptable.

For **the cumulative effects** (effects of the four wind farms combined) only those effects are discussed that are non-negligible for a single wind farm. For these non-negligible effects, the cumulative effect will usually be equal or smaller than the sum of the individual effects. If the gravity based foundation is chosen for the North Sea Power wind farm (other wind farms chose for monopile and/or jacket), a total of 3.6 million m^3 of sand will be stored for the 4 wind farms in the respective concession areas due to the necessary excavation. The cumulative effect of the laying up of sand will be smaller than the sum of the effects, due to phasing of the activities. The prevented emissions of each wind farm on its own already means a considerable contribution to the targets set for Belgium for the reduction of SO_2, NO_x and CO_2. The cumulative contribution will obviously be even greater and is equivalent to the sum of the individual contributions. During the exploitation, the underwater noise of the wind turbines is limited to the safety zone; the cumulative effect is therefore equal to the sum of the individual effects. For the majority of the effects on benthos and fish, the cumulative effect is the sum of the separate effects per wind farm, often directly proportional to the space occupied, which in reality is relatively small in relation to the BPNS. For birds and sea mammals the cumulative effect is the sum of the separate effects too. Only as regards the loss of habitat for resting and foraging birds by the impact of each wind farm, there is a cumulative effect that is greater than the sum of the effects per wind farm. Here the cumulative effect on the disturbance of Razorbills, Guillemots and Gannets is judged to be moderately negative. No negative cumulative effects worth mentioning are anticipated for the various users of the North Sea. The chance of collision for the North Sea Power wind farm is estimated at once every 12 years (conf. 1; MP) to once every 11 years (conf. 2; JF) irrespective of the considered scenario, and is relatively high compared to the nearby wind farms, excepted for the Belwind wind farm that is characterized by similar collision chances. The total collision and drifting chance of the North Sea Power wind farm varies from 32.4 % to 38.7 % of the total collision and drifting chance of all wind farms in the scenarios. The wind turbines at the southern side of the North Sea Power wind farm have a relatively high chance for collision compared to the other turbines (situated nearest to the route from and to Maas West). This is a negative impact, though because of the recent adjustment in the legally wind concession zone (Royal Decree 17/05/2004, adjusted by 03/02/2011), made up in dialogue with Shipping security and other competent authorities, just because of the Westpit shipping route and the safety of vessels, it can be assumed that already enough margin has been incorporated and the current results can be assessed as a calculated ‘acceptable’ risk. In principle no significant negative impact is expected on the surveillance of or communication with shipping traffic due to the presence and exploitation of the wind farms.