NON-TECHNICAL SUMMARY

1 AIM AND PROPOSED ACTIVITY

Belwind has taken the initiative to build an offshore wind farm in the North Sea, to be located on the Bligh Bank. The completion of this wind farm will help to achieve the objective of the authorities as regards renewable energy (6 % by 2010). Before construction can begin, a licence must be applied for. To assist with the decision-making process concerning the licence 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 licence 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.

In this EIR the environmental impact of the basic version (a wind farm with a total of 66 turbines generating 5 MW each) will be discussed throughout the chapters and compared, where relevant, with the alternative scenario of a wind farm with 110 turbines of 3 MW each.

In a separate chapter the cumulative impact of three current wind farm projects in the Belgian North Sea will be discussed.

2 PROJECT DESCRIPTION

The aim of the project is to construct, maintain and exploit an offshore wind farm generating around 330 MW on the Bligh Bank off the Belgian coast. This capacity could supply approx. 340,000 households with electricity.

The lay-out plans for the wind farm investigated in the EIA are based on either the base variant where 66 turbines of 5 MW will be installed or the alternative where 110 turbines of 3 MW. At the moment of realisation, a choice will be made within the range of 3 to 5 MW. These variants are hence on the under and upper limit of this power range. This is also true for the technical characteristics of the wind turbines and the other parts of the wind farm. Generally it can be stated that the effects of a wind farm with a power per wind turbine within the 3-5 MW range will be not more harmful than the effects of a wind farm for turbines of either 3 MW or 5 MW. The offshore wind farm will be equipped with either 3-bladed or 2-bladed wind turbines.

The power will be transported to either Ostend or Zeebrugge via 2 underground cables. The necessary controls regarding security and operation of the wind farm will be put in place, as well as illumination, marking and signposting. It will take 2 years to build the farm and its life expectancy will be 20 years minimum.

For the turbine installation of the basic 5MW version and the alternative 3MW version, see Figure 2.1.1 and Figure 2.1.2.

In the table below the principal technical features of the future wind farm on the Bligh Bank are described.

Table1.1.1: Synthesis technical features wind farm Belwind nv

Subject	*Description*
Location	
Site	BLIGH BANK; outside the 12 mile zone
Wind farm area	35,4 km²
Depth of water	minimum 15 m, maximum approx. 37 m
Foundation wind turbines	
Either monopile or jacket construction	Thick steel piles are driven approx. 30m into the seabed.
or gravity foundation	The foundation made of reinforced concrete is prefabricated on land and sunk into the seabed that has been levelled out previously from a vessel or pontoon.
For all types of foundation	Erosion protection is always installed around the foundation.
Wind turbines	
Capacity prognosis	3 or 5 MW per turbine; 330 MW for the entire wind farm
Number of turbines	110 or 66
Hub height	70 or 90 metres (with regard to HAT)
Rotor diameter	90 or 126 metres
Estimated production capacity	1,129,600 or 1,282,400 MWh/year
Electrical infrastructure	
Cables within the wind farm site	Power cables 33 kV Cable length : approx. 63.5 or 50.3 km Installation depth cables : approx. 1m in seabed
Transformer station	transformers 33/150 kV
Cables to shore	2 power cables 150 kV Cable length off-shore: 2 x approx. 50 km (option Zeebrugge) or approx. 55 km (option Ostend) between power stations and shore Cable route : see diagrams Installation depth cables : approx. 1m in seabed;
Estimated transport loss	Approx. 3 % (from wind turbines to shore)
Exploitation	
Remote control wind farm	Controlled from the shore, location to be decided
Frequency planned maintenance	Once a year;
Logistics – access to wind farm	From BELWIND. Logistical on-shore base (location to be decided). Transport to wind farm by boat

3 ALTERNATIVES

TO LOCATION OF THE WIND FARM

There are no alternative locations. The licence application is for a unique zone in which the wind farm is to be situated.

TO CAPACITY AND CONFIGURATION OF THE WIND FARM

Based on the morphologic characteristics of the Bligh Bank and based on the prevailing wind dynamics a number of alternatives were considered, taking into account the following criteria:

- Maximum energy production;
- Economic considerations;
- State of technology;
- Safety.

This resulted in two clear alternatives as regards capacity and configuration:

- A basic version with a configuration of 66 turbines of 5 MW;
- An alternative version with a configuration of 110 turbines of 3 MW.

With these alternatives, the under and upper limit of the power range that will be selected, is given. If the wind turbine power changes, also the number of turbines and the lay-out of the park changes, as indicated above.

TO FOUNDATION TYPE OF WIND TURBINE

Various types of foundations are considered and will be viable options for both alternatives as regards capacity and configuration. The type of foundation naturally depends on the location (seabed, water depth), load on the wind turbine and movement of the water (waves, currents). For offshore locations in the North Sea various foundation types can be considered: monopile, jacket construction and gravity foundation.

Taking into account the data concerning the seabed characteristics that are currently available, monopile foundations are considered to be the best existing technology for the planned location. Thorough on-site surveys of the seabed, including test drilling, will influence the final decision.

TO CABLE ROUTE BETWEEN WIND FARM AND LAND

For the wind farm 2 cable routes are planned for each of the alternatives outlined above as regards capacity and configuration. The landfall points will either be:

- Landfall in Ostend: approx. 55 km; or
- Landfall in Zeebrugge: approx. 50 km.

According to the exploratory study conducted by ELIA, both the substation Oostende-Slijkens and the one in Zeebrugge are viable options for connecting the wind farm to the grid. Both routes will be the same up to a certain point where they split up, to Ostend and to Zeebrugge respectively. Here it becomes evident (see Figure 1.2.2) that:

- For the option “landfall in Ostend”: the special protection area SBZ-2 (Ostend) will be crossed;

- For the option “landfall in Zeebrugge”: the special protection area SBZ-3 (Zeebrugge) will be crossed, whereas the marine nature reserve “Bay of Heist” and the special conservation area “Vlakte van de Raan” (SBZ-H) will not be crossed.

4 IMPACT ASSESSMENT

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

4.1 SOIL

4.1.1 Reference situation and autonomous development

The concession area is in the Bligh Bank area. The Bligh Bank is situated outside the 12 mile zone; the edge of the wind farm is at a distance of approximately 42 km from the shore. The east side of the concession area borders on the Dutch territorial waters (see Figure 1.2.1). The Bligh Bank is situated 10 km more northerly than the Bank zonder Naam. Bathymetrically the area investigated has a depth of between 15 and 37 m.

The Bligh Bank lies at an angle of approx. 40° to the coastline. The Bligh Bank is the most linear bank of the Hinderbanken group and measures around 23 km by 1.5 km (based on the 20m isobath) while the bank rarely extends beyond the 10m isobath (Deleu, 2001). The bank is situated in a SSW-NNE direction; the NNE-end is rounded while the SSW-end is more elongated. The bank is mostly asymmetrical with the steep side facing east. There are some large dunes, which bend in towards the bank’s ridge line.

There is an anti-clockwise sediment circulation around the Bligh Bank. There is no obvious dominance of the tidal flow as regards the outgoing tide and vice versa, hence there is no migration of the Bank in a specific direction.

The tertiary substrate of the western part of the BPNS (Belgian Part of the North Sea) is the Formatie van Kortrijk (Y1), while the eastern part is situated on the younger outcropping members of the Formaties van Tielt (Y2), Aalter (L), Maldegem (M) and Zelzate (P). The Bligh Bank runs through the entire tertiary sequence mentioned, over a distance of approx. 15 km from its furthest south-western point to the eastern edge of the BPNS. The thickness of the quaternary layer reaches a height of 20 m on the highest part of the Bligh Bank. In the gullies at the foot of the bank the thickness decreases to less than 2.5 m.

The sand on the Bligh Bank has an average grain size of between 300-350 µm. To the NW of the bank a slightly coarser sand grain is found, up to 0.5 mm (Deleu, 2001). The silt or clay content is negligible (< 0.2 %). There is a shingle fraction of < 5 %. In the gully between the Bank zonder Naam and the Bligh Bank as well as between the Bligh Bank and the Oosthinder there is a wide strip of sand with high shingle content (fraction > 2 mm). In general, shingle is mainly found in the gullies.

The chemical quality of the soil on the Bligh Bank is expected to be good; e.g. as far as heavy metals and tributyltin (TBT) is concerned.

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 Bligh Bank and the wind farm to be built there.

4.1.2 Impact description and assessment

CONSTRUCTION PHASE

When using a monopile foundation or jacket construction no sand is removed but the pile is simply sunk into the ground. The only effect is that the geological layers up to a depth of around 15 and 40 m (monopile) and 20-30 m (jacket construction) in close proximity to the pile will be compacted (compressed).

Per wind turbine approx. 38,400 m³ (3MW turbine) or 57,940 m³ (5MW turbine) sand will be excavated, of which 4 or 6 % respectively will be used again to fill in the gravity foundation. It is proposed that the sand left over will be laid up within the concession area (total storage of approx. 4,000,000 m³ of sand for the wind farm with 3MW turbines and 3,600,000 m³ of sand for the wind farm with 5MW turbines).

The surplus sand – only relevant for gravity foundations – must be stored in a location that ensures the general morphodynamics of the area is changed as little as possible. To determine 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 near as possible to the wind turbines to be installed and to the south-west of the wind turbines. From a morphological viewpoint the option to store per turbine separately must certainly be considered – in spite of taking up a relatively larger area.

The impact of the cable installation is negligible. The risk of causing significant pollution of the soil is extremely low.

EXPLOITATION PHASE

Although there will be a disturbance of the natural sediment transport around the wind turbines (see further on), the general natural processes on the Bligh Bank will hardly be affected. Due to the installation of erosion protection the impact of each construction is too small and the wind turbines are too far apart. The same applies for the cables.

It is clear that if foundations without erosion 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 always provide erosion protection for each type of foundation. Erosion protection consists of a ring of stones around the foundation. Obviously gravity foundations, due to their larger dimensions, will require bigger erosion protections than pile foundations. The dimensions of the proposed erosion protections are sufficient for the monopile or jacket construction considering the hypothetical dimensions of an erosion pit without protection; as regards the gravity foundation there is some uncertainty due to a lack of scientific knowledge. The erosion will in fact move to the area between the seabed and the erosion protection, in downstream direction (secondary erosion) but it will be greatly reduced. Although the erosion protection as such will be locally heterogeneous to the sandy seabed, the installation of an erosion protection is environmentally acceptable.

The cables will be laid at a sufficient depth (minimum 1 m, even 4 m in the shipping channels) so that the chance of a cable to become exposed is relatively small. Moreover, the cable route will be monitored annually to prevent any cables from becoming dislodged.

As is the case with the preparation phase, there is no reason at all for the exploitation to lead to pollution of the seabed.

There is little difference between the impact of the basic version (5MW) and the alternative version (3MW).

DISMANTLING PHASE

The potential impact during the dismantling phase will be of the same nature and size as the potential impact during the construction phase.

The decision whether to remove the erosion protection and the cables will be made towards the end of the exploitation and will be based on the results of the monitoring. If it should be decided to remove the foundations and erosion protection, it will be investigated whether it is necessary to correct the soil profile. With regard to the cables, it is noticed that in general cables that will not be used in the future, are abandoned.

4.1.3 Mitigating measures

If the cable route must be installed over the top of other cables and/or pipes and the minimum installation depth cannot be realised, extra protection must be installed. This can be done with the same quarry stone that is used for the erosion protection on the turbine park.

4.2 WATER

4.2.1 Reference situation and autonomous development

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

The depth of the water varies between 15 and 37 m, so within the project area there are quite considerable fluctuations in water depths. There are substantial waves, 3 to 6 m high, corresponding with wave periods between 0.4 and 2.2 s (RIKZ, 2007). 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 0.25 and 0.95 m/s. The residual average (surface) water speed is approximately 0.55 – 0.57 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, driven by the tides and prevailing winds, flow mainly from the SSW and also from the NNE.

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 mg/kg.

For the Bligh Bank it can be assumed that the natural concentrations of heavy metals are relatively low. The main organotin compound is tributyltin (TBT). It is a biocide that is used in the aquatic environment as an antifoulant. 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 Bligh Bank has not been found, but it can be assumed that average concentrations will certainly be lower than 10 mg/l.

The climate change will 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 will 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 climatic 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 concentrates, 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 Bligh Bank and the wind farm to be built there.

4.2.2 Impact description and assessment

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 foundation 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. Since the North Sea has been designated 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. Dredging may cause a minor temporary increase in nutrients in the water column. The antifoulant paint used on the vessels during the installation phase is TBT-free. 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 sunk (monopile, jacket construction), when dredging and when the sand is put back (gravity 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. The construction of the foundation will, for each construction method and type of foundation, 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.

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

There is not much difference between the impact of the basic version (5MW) and the alternative version (3MW). The alternative version will cause more turbidity due to the larger number of turbines.

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 type of foundation. The underground cables will not affect the turbidity either.

There is little difference between the impact of the basic version (5MW) and the alternative version (3MW).

DISMANTLING PHASE

Impacts during the dismantling phase (i.e. the removal of the piles and possibly the removal of the erosion protection and underground 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 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 disaster occurs during installation, exploitation or dismantling that has 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 metres above sea level the wind speed averages between 8.5 and 10 m/s.

As regards 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 it is essential we switch to environmental-friendly energy, such as solar energy, biomass energy, wind energy, ...

As regards the air quality the relevant parameters are CO, NO_x SO_2 and PM10 (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 emissions 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 prevented emissions as a result of the electricity production by the wind farm will be realised;
- The atmospheric CO2 concentrations will increase further;
- The Intergovernmental Panel on Climate Change expects a warming of 0.2 °C per decennium over the next 2 decennia, a value in accordance with the warming observed at the moment. The forecast for the average global warming towards 2100 strongly depends on the emission scenarios consulted. Compared with the period from 1980 to 1999 the warming is expected to be in the region of 1.8 to 4.0 °C.

4.3.2 Impact description and assessment

4.3.2.1 Construction phase

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 of the components, the pre-assembly of the wind turbines and parts in a nearby port (in this case Zeebrugge or Ostend), transport to the Bligh Bank 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 impact on the air quality will be greatest for the alternative version, but will remain limited in both cases.

The emissions resulting from the shipping traffic will have very little impact on the local air quality near the Channel.

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 effect during the exploitation phase are the emissions prevented on land as a consequence of the fact that the estimated net electricity production prognosis of the wind farm (983 (3 MW) – 1,120 (5 MW) GWh/year) does not 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 3.5 to 4 % of the emissions by traditional production in Belgium for all pollutants. The emissions prevented annually, calculated on the basis of the emission factors for traditional production in combination with nuclear production, amount to 2.1 to 2.4 % of the emissions by traditional production in Belgium for all pollutants.

Towards 2010 emission ceilings will be imposed on Belgium for SO_2 and NO_x of 99,000 and 176,000 tonnes/year respectively (2001/81/EG). The prevented emissions, calculated on the basis of the emission factors for traditional production, amount to 1.04 to 1.19 % of the emission ceiling for SO_2 and 0.55 to 0.62 % of the emission ceiling for NO_x, which is significant. The Kyoto target for Belgium is a reduction in greenhouse gas emissions of up to 130.5 million tonnes CO_2 equivalent by 2010. The prevented emissions, calculated on the basis of the emission factors for traditional production, amount to 0.56 to 0.64 % of this ceiling, which is significant.

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.

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. Any effects that this reduction in greenhouse gas emissions may have, e.g. on the sea level and on the temperature of the earth, will be too small to assess correctly. Effects on the prevention of extreme situations (gales, severe winters, hot summers, ...) are even more difficult to assess, but will be just as small.

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 speed will be influenced by the wind farm up to approx. 3 km from the last wind turbines.

The 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 metres).

4.3.2.3 Dismantling phase

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 used again. 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 emissions in total of the shipping traffic in the Channel, so that a significant impact on the air quality is not a concern.

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. The yearly avoided emissions, calculated on the basis of the emission factors for traditional power stations, amount to 3.5 % (3 MW) to 4 % (5 MW) of the emissions for traditional power stations in Belgium, for all pollutants. Moreover, the impact of the project on the air quality during the construction and dismantling phase and on the wind climate and sediment around the cables during the exploitation phase is limited, so that no need for mitigating measures or compensations arises.

4.4 NOISE AND VIBRATIONS

4.4.1 Reference situation and autonomous development

For the purpose of the reference situation the existing noise climate in 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 1µPa) 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 there are not expected to be any significant changes in the autonomous development of the area from a global viewpoint. The underwater noise will hardly evolve because no appreciable increase in shipping traffic is expected in the shallow coastal waters above this sandbank. Only the construction and the exploitation of the wind turbine parks of C-Power (Thornton Bank) and Eldepasco (Bank zonder Naam) will effect a change compared with the current situation.

4.4.2 Impact description and assessment

4.4.2.1 Construction phase

As a consequence of the activities during the construction phase (piling, shipping...) the noise level will temporarily increase, above water as well as underwater. However no significant effects are anticipated.

4.4.2.2 Exploitation phase

<u>Underwater</u>

When assessing the underwater sound level it must be noted that there is a considerable lack of knowledge about the noise immission and emission of the wind turbines used (110 wind turbines of 3 MW or 66 wind turbines of 5 MW).

The specific noise 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 will probably be masked by the background noise. It is therefore unlikely that any marine fauna will be affected at this distance. When the underwater background noise level is at 195 dB (re 1µPa), the wind turbines will only be heard clearly at a distance of less than 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 will increase, but at the same time the background noise 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 noise levels referred to earlier. However this rise in the noise level is temporary.

<u>Above water</u>

In a moderately aggravating situation sound travels three-dimensionally, and at a distance of 0.6- 0.9 km and at a distance of 1.2 – 1.8 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 8 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 30m, 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 effects are anticipated.

4.4.3 Mitigating measures

In view of the lack of knowledge about the impact of the underwater sound of the wind turbines used in this project (110 wind turbines of 3 MW or 66 wind turbines of 5 MW) it does not seem useful to propose mitigating measures to diminish the underwater sound level. It is however proposed that the underwater sound levels should be monitored. If from these observations it should appear that a large impact is taking place underwater, mitigating measures should still be implemented.

As the number of observers at sea who would frequently notice the wind turbines is very limited indeed, it does not seem useful to propose mitigating measures for the sound in the air either. For the Bligh bank wind mill farm, modern offshore wind turbines will be used, with design and production always striving towards reduction of noise.

4.5 FAUNA, FLORA & BIODIVERSITY

4.5.1 Reference situation and autonomous development

4.5.1.1 Invertebrates and fish

The description of the invertebrates and the fish in the study area is initially based on the recent study about the reference situation on the Thornton Bank (The Maersschalck *et al.*, 2006), situated at approx. 15 km from the Bligh Bank. This was followed by a consultation of other recent studies that gathered data of various research projects to arrive at a description of the benthic communities in the Belgian part of the North Sea.

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.

There are two macrobenthic communities to be found on the Bligh Bank: the *Nephtys cirrosa* community and the *Ophelia limacina-Glycera lapidum* community (Van Hoey *et al.*, 2004; Degraer *et al.*, 2006).

The *Nephtys cirrosa* community is the most widespread community in the Belgian part of the North Sea and occurs in rather fine-grained sediments. The community is characterized by a low biodiversity and density, typical for well-sorted mobile sands. Mobile polychaeta (e.g. *Nephtys cirrosa*) and crustacea (e.g. *Bathyporeia guilliamsoniana* and *Urothoe brevicornis*) are typical species in this community (Van Hoey *et al.*, 2004). The dominant species are similar to the ones found on the Thornton Bank. On the Thornton Bank they were found in the following abundances: *Nephtys cirrosa* (between 0 and 160 ind/m²), *Bathyporeia guilliamsoniana* (between 0 and 160 ind/m²), *Urothoe brevicornis* (between 0 and 450 ind/m²) and *Spiophanes bombyx* (between 0 and 140 ind/m²; in the border zone) (The Maersschalck *et al.*, 2006). In terms of biomass this means *Nephtys cirrosa* (between 0 and 1800 mg AFDW/m²), *Bathyporeia guilliamsoniana* (between 0 and 100 mg AFDW/m²) and *Urothoe brevicornis* (between 0 and 100 mg AFDW/m²) (The Maersschalck *et al.*, 2006). In most of the locations the abundances, as well as the diversity, biomass and productivity, will be higher in autumn than in spring. The dominant species (*Bathyporeia guilliamsoniana, Nephtys cirrosa, Spiophanes bombyx* and *Urothoe brevicornis*) were already detected in the 1976-1986 and 1994-2001 periods (The Maersschalck *et al.*, 2006). However it is worth mentioning that over time the density of these species has slightly increased.

The *Ophelia limacina-Glycera lapidum* community is found in coarse-grained sediments, mainly further away from the shore. This community is characterized by very low densities and a very low diversity. *Nephtys cirrosa*, *Ophelia limacina* and *Glycera lapidum* are typical species in this community (Van Hoey *et al.*, 2004).

As the Bligh Bank in general is characterized by a lower biological value, the density and biomass figures of the dominant species recorded here may be slightly lower than on the Thornton Bank. The biological valuation map (Derous *et al.*, 2007) confirms these findings and classifies the Bligh Bank as an area of moderate to low biological and ecological value.

There are no specific data available about the epibenthos on the Bligh Bank. The patterns can be expected to be similar to the ones on the Thornton Bank (The Maersschalck *et al*., 2006). In total 38 epibenthic species have been recorded on the Thornton Bank. The total density in most areas was on average 4 times higher in the spring of 2005 (43 ind/1000m²) than in the autumn of 2005 (10 ind/1000m²). Generally a few more species will be found in deeper stations (periphery/gullies) than in the more shallow stations (The Maersschalck *et al*., 2006). The stations on top of the sandbanks are also characterized by a much lower density and biomass (on average 4-5x) than the deeper locations (The Maersschalck *et al*., 2006). The same dominant species are found on the bank and in the gully. In view of its offshore location (± 15 km seaward of the Thornton Bank) the densities and biomass values will be slightly lower than on the Thornton Bank and certainly much lower than in the rich coastal areas.

The Maersschalck et al. (2006) shows corresponding patterns on the Oostdyck, Bligh Bank and Thornton Bank with reference to the demersal fish. The results as regards the reference situation of the demersal fish on the Thornton Bank (The Maersschalck *et al.*, 2006) can therefore be applied to the Bligh Bank and are summarized as follows. In total 40 demersal species of fish were recorded in 2005, of which 32 species in the spring and 29 in the autumn. In the spring the dominant species in terms of density in all areas were: sprat *Sprattus sprattus* and herring *Clupea harengus* (Clupeiformes), as well as reticulated dragonet *Callionymus reticulatus* and to a lesser degree the common dragonet *Callionymus lyra* (Perciformes), and dab *Limanda limanda* and solenette *Buglossidium luteum* (Pleuronectiformes). In the autumn the main species were horse mackerel *Trachurus trachurus*, lesser weever *Echiichtys vipera*, both dragonets and sand goby *Pomatoschistus minutus* for the Perciformes and solenette *Buglossidium luteum* and dab *Limanda limanda* for the Pleuronectiformes. In the spring the fish are mainly representatives of the Clupeiformes (>80 %). In the autumn however there were hardly any Clupeiformes at all.

There is a discernible difference between the top and the periphery of the bank. Generally speaking the average density is approx. 75-80 % lower on the top than in the gullies. The average density on the bank is comparable in spring and autumn (24-38 ind/1000m²), but the diversity is higher in the autumn (16-18 species) than in the spring (11-12 species). On the top as well as in the gullies the Perciformes dominate (resp. 75-85 % and 50-85 %), with a percentage of Pleuronectiformes between 10 and 35 %.

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 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,..., and climate change too, are more likely to have an impact on the underwater fauna.

4.5.1.2 Birds

The range of species on the Bligh Bank is not quite the same as in other parts of the BPNS. Coastal species are less prominent; species that are found further out at sea such as Gannets, Kittiwakes, Guillemots and Razorbills form a large part of the range of species on the Bligh Bank. The Bligh Bank is not regarded as being an area of importance for any rare seabird.

During the summer period many Lesser black-backed gulls are seen on the Bligh Bank, as well as some Gannets. During the winter period there is a variety of species: mainly Guillemots, Kittiwakes and Razorbills, but also (to a lesser extent) Great black-backed gulls, Herring gulls, Common gulls, Great skua, Gannets, Northern fulmars and Divers. In spring the Bligh Bank is often visited by Herring gulls, Kittiwakes and Guillemots. Lesser black-backed gulls, Northern fulmars and Gannets have also been spotted during this period, but only sporadically. During the autumn Gannets are dominant on the Bligh Bank; Razorbills and Kittiwakes are frequently seen too. Also found in the Bligh Bank area in the autumn are Northern fulmars and Lesser black-backed gulls, but only in small numbers.

In addition to the typical seabird species a large number of non-seabirds also appear over the BPNS. Many of these species such as Cormorants, Wigeons and Mallards are in fact coastal birds. The offshore Bligh Bank is therefore not an area of importance for these non-seabirds. Songbirds use the Belgian sea areas as migrating routes. Only Common starlings, Chaffinches, Skylarks, Redwings and Meadow pipits have been spotted in significant numbers from ships in the North Sea. The migration is most concentrated along the shore; further out at sea the migration is more spread out.

For the autonomous development it may be stated that if no wind farm were installed on the Bligh Bank the ornithological value of the site would remain virtually unchanged. With the exception of (semi)-natural fluctuations in the number of seabirds (e.g. by changes in food availability, or a shift in wintering areas) there are no indications that major changes are occurring in the target area at this moment. Changes in the seabird population as a result of global warming will not be measurable in the short term and therefore not interfere with future monitoring of seabirds in the target area (Stienen *et al.*, 2002).

4.5.1.3 Sea mammals

Since the spring of 2003 sea mammals are increasingly found in the BPNS, whereby the Harbour porpoise and White-beaked dolphin are the main species. This is a general trend, possibly a result from the rapidly *deteriorating food conditions in the more northe*rly areas where these species are found, although other reasons cannot be excluded (Courtens et al., 2006).

Four sea mammal species, the Common seal, Grey seal, Harbour porpoise and Bottlenose dolphin, have a resident population in the North Sea: they use this area as a breeding ground and to find food. White-beaked dolphins, Atlantic white-sided dolphins and Minke whales stay regularly in large numbers in a wide area of the North Sea to feed (ICES, 2001). Based on the number of beachings on the Belgian coast and sightings in the BPNS, four species of sea mammals can be considered to appear regularly or quite regularly in the Belgian marine waters: Harbour porpoises, White-beaked dolphins, Common seals and Grey seals.

Certain areas of the BPNS are more important for sea mammals than others. The zone between Ostend and the anchorage ground, the surroundings of the Thornton Bank and the Goote Bank and the deep zone to the north of the Hinder Banks seem to be important to Harbour porpoises and White-beaked dolphins (Courtens *et al.*, 2006). In the eastern part of the BPNS sea mammals seem to be few and far between. This also applies to the Bligh Bank, where up to now at 1 observation point Harbour porpoises were spotted, namely at the most southern point of the Bligh Bank. There seem to be no other sea mammals at all.

Of the four more common sea mammal species the Harbour porpoise is the most prevalent in the Belgian marine areas. They are present all year round in the Belgian sea areas, but are more often seen in the spring (January to May). However an analysis of a large number of research data (Reid *et al.*, 2003) shows that Harbour porpoises are less prevalent in the Belgian marine waters than in the central and northern parts of the North Sea. The presence of Harbour porpoises and the numbers in Belgian marine areas are fairly unpredictable. Based on the counts of the INBO-database (Research Institute for Nature and Forest of the Flemish Community) it is not possible to give an estimate of the size of the Harbour porpoise population in the BPNS. In comparison with the total population size in the southern North Sea, Stienen *et al.* (2003) finds that the population in the BPNS is of little significance on an international level.

From the MUMM database (not published, Management Unit of the North Sea Mathematical Models) it appears that each year some groups of White-beaked dolphins are seen at sea. The analysis of a large number of data shows that the White-beaked dolphin is relatively rare in the southern North Sea compared to the central and northern parts of the North Sea (Reid *et al.*, 2003). Stienen *et al.* (2003) states that, compared with the overall size of the North Sea population, the species is not very significant for the BPNS.

From the MUMM sea mammal database it appears that Common seals and Grey seals are regularly reported in the BPNS. Common seals are mainly seen in autumn and during the winter months (August - February) and not so often in spring. The largest concentrations of Common seals on our coast are found on the West coast (near the Flemish Banks). The place with Common seal colonies nearest to the Bligh Bank is the Delta area with around 165 animals maximum (MUMM, 2004). The number of Grey seals in the southern North Sea is lower than the number of Common seals and negligible in proportion to the overall North Sea population.

As regards the autonomous development it can be said that if no wind farm were installed on the Bligh Bank the value of the site for marine mammals would effectively stay the same. With the exception of (semi)natural fluctuations in the number of sea mammals (e.g. by changes in food availability, or a shift in wintering areas) there are no indications that major changes are occurring in the area at this moment. Changes in the sea mammal population as a result of global warming will not be measurable in the short term and will therefore not interfere with future monitoring of sea mammals in the area (Stienen *et al.*, 2002).

4.5.2 Impact description and assessment

4.5.2.1 Invertebrates and fish

CONSTRUCTION PHASE

Potential impacts during the construction phase are: destruction of habitat (loss of biotope), loss of organisms, disturbance (sedimentation, noise and vibrations, release of materials embedded in the sediment, oil). With the exception of the destruction of the biotope and organisms, the other effects will be temporary.

The installation of the wind turbines and the transformer platform with the erosion protection will take up part of the biotope of the benthic organisms. This loss of biotope depends very much on the type of foundation. In the case of gravity foundation a considerable area is going to be disturbed by the storage of the sand dredged for the foundations. For the monopile around 0.06 km² will be affected, while for the gravity foundation it increases to ca. 1.5 km² with storage of 5 m thick layers or around 4.5 km² with storage of 1 m thick layers. This effect will manifest itself immediately and is irreversible during the exploitation phase of the park. Since the affected area is small in proportion to the entire BPNS (max. ± 0.1%), the biotope loss for benthic organisms is considered to be a negative effect of minor significance.

The installation of the foundations and the erosion protection will result locally in a loss of creatures that is directly proportional to the loss of biotope. 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. It concerns a direct and irreversible effect, but the influence of the mortality is not expected to have a major negative impact on the biomass or functioning of the local ecosystem. Moreover, 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. Compared to the sand extraction activities carried out in the North Sea, the disturbance (sedimentation) caused by the installation of the offshore wind turbine park is minor, 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 minor, even when the activities are protracted, irrespective of the type of foundation.

Most of the disruption will occur during piling when a monopile foundation is chosen. This disturbance may lead to significant effects (damaged hearing, bleeding, mortality, behavioural changes) on certain fish. Due to the larger number of turbines in the 3 MW scenario the impact of the noise will be more significant here. There is however still a great deal of uncertainty about the scope of the impact and species-specific data are not available. Based on recent monitoring studies in Horns Rev and Nysted, the impact is judged to be slightly negative. Further investigation is needed.

In contrast with the type of foundation and the configuration (number of turbines), the choice of output (3 MW versus 5 MW) of the turbines will not influence the effects during the construction phase.

EXPLOITATION PHASE

The most important effects resulting from the exploitation of the wind farm can be summarized as follows: introduction of hard substrate, noise and vibrations and other forms of disturbance .

The introduction of hard substrate in sea areas that almost exclusively contain sandy sediments is probably the most important effect 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. Depending on one’s point of view this effect can be regarded as positive (e.g. increased biomass and diversity) or negative (e.g. disturbance of natural habitat, new “harmful” species).

The total hard substrate area very much depends on the type of foundation and the number of turbines (3 MW or 5 MW version). For the entire wind farm the volume of hard substrate that may be colonized by organisms (say: 20 m from the turbine) will vary between 86,707 m² (monopile 5 MW) and 228,907 m² (gravity foundation 5 MW) or a maximum contribution of 0.65 % of the concession zone (35.4 km²).

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 farm in the North Sea. What is clear is that the area of hard substrate introduced is going to be considerably larger when gravity foundation is used than with a monopile foundation. The choice of the basic version (5 MW) or the alternative version (3 MW) is less important. 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, 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 (= 0.1 %).

Underwater noise probably affects fish and mammals most. 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 behaviour or a reduction in habitat size. The extent of the impact or damage and acclimatization depends also on how sensitive the species of fish involved is to noise. 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 probable be completely masked by the ambient background sounds. The findings of the wind farm in Denmark (Horns Rev) do not directly indicate that noise and vibrations cause a negative impact on the fish community. Since the opening of the wind farm some new species of fish have even settled in the area, but more research is definitely needed.

In spite of the fact that it is not straightforward to make a quantative 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 lead to lessen the impact even more.

No impacts are expected on the water quality or as a result of hydrodynamic changes. Only the shadow-effect of the rotating turbine blades on fish is not sufficiently known.

No significant difference in the impact on invertebrates and fish is expected if a 5 MW turbine is opted for (instead of a 3 MW one).

DISMANTLING PHASE

The effects during the dismantling phase will depend on the way in which the wind farm is dismantled. Belwind is committed to return the site as near as is necessary to its original state if required for reasons of use, exploitation or ecological parameters.

In general the effects of the dismantling phase can expected to be more or less identical to those of the construction phase.

CABLING

The impacts caused by the cabling are not affected by the type of foundation, output of the wind turbine or configuration (66 versus 110 turbines).

Along the entire cable route a general disturbance (churning up of the seabed and sediment and altered turbidity) will occur, but is judged to be insignificant.

The transmission of electricity via sub-sea cables will generate electric and magnetic fields. These electromagnetic fields depend on the type of cable (33kV versus 150 kV). Electromagnetic fields can affect certain sensitive species, but the size of the impact and the cause-effect relation cannot be accurately assessed on the strength of the available knowledge. More is known about the impact on rays and sharks (cartilaginous fish) that are likely to be affected most, but these are not commonly seen in the project area. On the basis of this fact and the fact that burying the cables at a depth of 1 m minimum will have a mitigating effect (reduction directly proportional to the depth squared), we can assume for now that the impact will be very small. Further research is needed to rectify this deficiency in knowledge.

The buried cables will radiate a certain amount of heat. Fully loaded electricity cables will heat up to approx. 60 degrees. Because the cables are laid at depth, this will generate a minor and very local warming of the seabed surface (max. 3 degrees). The effect is judged to be neutral.

4.5.2.2 Birds

The effects of a wind farm on birds are extremely variable and depend on numerous factors. Therefore the impacts of every wind farm will be different and must be assessed individually. Conducting a study of the local situation is essential in order to be able to assess the effects in the area.

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), in the shape of loss of habitat, restriction of flyways, disturbance by the physical presence of the turbines.

CONSTRUCTION PHASE

During the construction phase a significant disturbance of the marine avifauna can occur as a result of the activities. Species sensitive to disturbances (such as the Red-throated diver, Common scoter, Great crested grebe, Guillemots, Razorbills) may consequently temporarily avoid the area; other species (e.g. gulls) could possibly benefit from the activities by food becoming available temporarily (churning up of the seabed, increased shipping movements).

Of the species that are sensitive to disturbance only the non-coastal Guillemots and Razorbills are found in the Bligh Bank area. If the current planning for the construction of the wind farm is adhered to (i.e. construction spread over 2 years, probably period March - September) only the Guillemots are likely to experience significant disturbance, as this species is found in the Bligh Bank area in the spring (March – May). During the summer (June – August) no species that are sensitive to disturbance are found in the Bligh Bank area.

However, the impact during the construction phase is temporary and only affects a small area (0.99 % of the BPNS). For all versions the impact is therefore judged to be slightly negative.

EXPLOITATION PHASE

Migratory birds and local bird movements

During spring and autumn Herring gulls and Gannets are found in high densities in the Bligh Bank area. Exactly which bird species will be disturbed by the wind turbines during the migrating periods and which ones could collide with the wind turbines is difficult to predict. The Bligh Bank is probably situated on the migration route of some offshore species, but observations carried out by Vanermen *et al.* (2006) show that the stream of migrating birds is most intense along the coast; further out at sea it is more spread out.

On the basis of the sensitivity score (Vanermen et al., 2006) the disturbance effect on the seabirds found in increased numbers in the Bligh Bank area during the migrating periods will probably be minimal. On the basis of the collision vulnerability score (Vanermen *et al.*, 2006) and the densities on the Bligh Bank during the migrating periods in spring and autumn, it can be expected that Gannets in particular will be among the victims of collisions. However, the chance that Gannets will fly within reach of the rotor blades (> 25 m) is small: just 4 % fly at the height of the wind turbines (Vanermen *et al.*, 2006), so that it may be expected that the actual number of victims among the Gannets will be small.

The planned 3 MW turbines on the Bligh Bank will, while the amount of MW stays the same, probably bring a higher collision risk for the birds than the 5 MW turbines.

For songbirds the wind mill farm could create a problem during conditions of strong migration above the North Sea. Weather conditions suddenly turning bad (mist or rain) could create a quick interruption of the migration causing large numbers of songbirds to come down in the area of the wind mill farm. During the so-called ‘fall-conditions’ large numbers of songbirds can hence fall victim to the wind turbines. This effect cannot be properly assessed as yet; further research concerning these ‘fall-conditions’ is needed.

The impact on local bird movements will most likely be marginal, but unfortunately no reliable information about this is available.

The overall impact of the wind farm, for both versions, on migratory birds in the Bligh Bank area is judged to be slightly negative.

Resting , foraging seabirds

During the rest of the year Guillemots and Kittiwakes (winter period) and Lesser black-backed gull (summer period) are dominant in the Bligh Bank area. Which species among the resting and foraging seabirds will actually be disturbed by the working wind turbines and which will be colliding with the wind turbines is difficult to predict. It may be assumed that it will be the Guillemots who will be disturbed most, as they are sensitive to disturbance. Based on the collision vulnerability score (Vanermen *et al.*, 2006) it is expected that Kittiwakes are most likely to collide with the wind turbines. In a study by Vanermen *et al.* (2006) on estimated flight heights of seabirds, only 4 % of the Kittiwakes were observed within reach of the rotor blades (> 25 m). Of the Lesser black-backed gulls on the other hand, 12 % flew at the height of the rotor blades. This last species, through a combination of their large size, low manoeuvrability and flying height, will be most vulnerable to a collision. Based on these research findings it can be expected that it will predominantly be Lesser black-backed gulls that will collide with the wind turbines.

The area no longer available to the resting and foraging seabirds is small (0.99 % of BPNS).

The planned 3 MW turbines on the Bligh Bank will, while the amount of MW stays the same, probably bring a higher collision risk for the birds than the 5 MW turbines.

For the various versions the overall impact of the wind farm on resting and foraging seabirds in the Bligh Bank area is estimated to be slightly negative.

DISMANTLING PHASE

In general the effects of the dismantling phase can be expected to be similar to those of the construction phase.

CABLING

The installation of the cables can result in a temporary disturbance of the avifauna by a change in food availability or altered turbidity in the water column. Disturbance of the sediment will cause increased turbidity which can affect fish with filter mechanisms and reduce the visibility for the birds feeding on fish. The Common scoter and Red-throated diver species are the most sensitive to disturbance. As they are fish-eating birds, they can also be most affected by an increase in turbidity caused by the installation of the cables. Because these effects are only temporary and of limited magnitude, the impact on avifauna as a result of the cable installation is estimated to be slightly negative.

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

4.5.2.3 Sea mammals

CONSTRUCTION PHASE

It can be assumed that the seismic surveys carried out prior to the construction phase of the wind farm can have a temporary, significant negative effect on sea mammals that find themselves in the close proximity to the sound source. This can lead to a (temporary) loss of hearing and in some cases could even be lethal.

During the construction of the wind farm some disturbance for sea mammals can occur as a result of the activities being carried out, such as increasing turbidity of the water, underwater movements, noise and other activity on the seabed. The construction activities generating an increase in the underwater sound level and vibrations, in particular the ramming of monopiles with hydraulic hammers, are the activities that are largely responsible for a negative impact on sea mammals. Pile-driving noise can be heard by sea mammals from a large distance (ca. > 80 km) and can, in close proximity to the sound source (ca. 1.8 km for Harbour porpoises, ca. 400 m for seals) damage the hearing of sea mammals and change their behaviour up to a certain distance (ca. > 20 km) from the construction site. It is expected that sea mammals will temporarily leave the construction site and the surrounding area. After the construction phase is over the sea mammals will probably return to the wind farm.

Although the effects of seismic surveys and pile-driving only last for a while, it is imperative to provide temporary deterrent mechanisms in order to minimize the risk of damaging the hearing of the sea mammals. If this mitigating measure is taken into account, the effect of seismic surveys and pile-driving on sea mammals is judged to be slightly negative.

The construction of wind farms can also affect the food sources for sea mammals (e.g. dwindling fish populations). The areas may become less attractive for the sea mammals and they may leave. The decline of the food sources is likely to be temporary and will recover again when the construction of the wind farm is finished. It is also expected that the sea mammals will return to the area as soon as the food sources have returned to normal.

In view of the short duration and limited spatial spread (0.99 % of BPNS) of the activities, the mobility of sea mammals and the current number of sea mammals seen in the BPNS area, the effects of the work during the construction phase will be limited and not permanent. The impact during the construction phase is judged to be slightly negative.

EXPLOITATION PHASE

Working wind turbines will produce noise and vibrations that will probably have an impact on sea mammals and be heard by them. The effects of the noise and vibrations of the 3 and the 5 MW wind turbines can in this moment in time not be estimated because there is a lack of research data, but no great disturbance impact is anticipated. Acclimatization may occur. . Monitoring programs for other wind mill farms (e.g. OW-Egmond aan Zee and OW-Q7 in the Netherlands) are expected to deliver relevant data.

The physical presence of the wind turbines (e.g. reflection in the sun, shadows of the rotating rotor blades) may have an impact on certain sea mammals and cause them to use the area less or abandon it completely. But sea mammals could also be attracted to the area: to use it as a resting place or as a defence against predators. The effect of the physical presence of the wind turbines on sea mammals is judged to be negligible. Over time the sea mammals could get used to them.

It is expected that the annual preventive maintenance activities will have a disturbing effect on sea mammals. This effect is judged to be only slightly negative because of its temporary nature and the relatively small area of the BPNS that will be affected. Moreover, the sea mammals are expected to develop some tolerance to the maintenance activities on the wind farm as they get used to them.

When the foundations and erosion protection have been installed a new, artificial, hard substrate may be created, which can attract more epifauna and epiflora and consequently prey fish too. During the exploitation phase there could therefore be an increase in the number of sea mammals in or around the wind farm, due to the availability of more food around the foundations or other food sources becoming available, but possibly also because of reduced fishing activity in the area. It is expected that more sea mammals will be attracted around a gravity foundation than a monopile or jacket construction, because it is likely that a gravity foundation will attract more fish.

The impact on sea mammals during the exploitation phase is judged to be slightly negative.

DISMANTLING PHASE

In general the effects of the dismantling phase can expected to be similar to those of the construction phase.

CABLING

The installation of the cables can have an effect on sea mammals. This effect however is temporary, limited in size and therefore judged to be only slightly negative. During the exploitation phase the magnetic fields, generated by the cables, will probably not have a discernable effect on the sea mammals. Sea mammals are mainly found in the water column, where the effect of magnetic radiation tends to be limited.

The effect of the cabling on sea mammals is judged to be slightly negative.

4.5.3 Mitigating measures

4.5.3.1 Invertebrates and fish

During the discussion of the effects a number of knowledge gaps were identified: species-specific influence of noise & vibrations, the effect of electromagnetic fields and heat generation. Apart from that, some ambiguity still remains 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 programme (consistent with other wind energy initiatives) that tries to fill in these knowledge gaps .

4.5.3.2 Birds

As far as the mitigating measures is concerned, attention must be paid to the configuration of the wind farm, warning systems, phased interruptions and compensation .

Correct positioning of the wind farm (parallel to the prevailing flight direction) and the reservation of corridors for passing birds can dramatically reduce the risk of collisions (Everaert *et al.* , 2002). For a correct configuration, adequate prior knowledge about the migration movements and local bird movements in the area will be required.

If after monitoring it appears that the number of collisions is proving to be significant, there is choice of warning systems to be considered such as red lights on the rotor blade tips, fluorescent rotor blade parts or sound signals (ultrasound), as this may reduce the number of victims. However, decisions about the warning systems must be made in consultation with the relevant authorities.

A mitigating measure during periods with increased bird movements (e.g. migration period) or when there is poor visibility (fog, rain) could possibly involve stopping the wind turbines for certain periods of time. It needs to be investigated whether this mitigating measure is a viable option. This measure is only indicated if monitoring shows that the physical presence of the wind park causes a significant number of collisions during certain periods. By concentrating in the monitoring programme on the local bird movements and the species-specific differences, it will be possible at a later stage to give well-founded advice regarding the period when the turbines should perhaps be stopped.

It is advisable to be acquainted with the reference situation as regards the prominent bird species before construction begins. If investigation of the reference situation shows that the area where the wind farm is to be built is an important resting area for certain seabirds (in particular for Divers, Guillemots, Razorbills), it is essential to ensure that protected areas are reserved or existing areas extended elsewhere in the BPNS.

4.5.3.3 Sea mammals

In spite of the temporary nature of the seismic surveys and the pile-driving, and the limited presence of sea mammals in the vicinity of the project, some mitigating measures are proposed. The use of deterrents such as ‘pingers’ is a condition that must be met for seismic surveys prior to the construction phase and when the monopiles are driven into the seabed during the construction phase. If it should become apparent that, during certain stages of the installation process of the foundations, noise is generated that is comparable with pile-driving noise or that is potentially dangerous for sea mammals, the same condition still applies.

Also, whenever it is a realistic option, the activities will be carried out outside the periods where there is a heightened chance of sea mammals being present, i.e. outside the period of January – May for Harbour porpoises and outside the period of August – February for seals.

4.6 SEA VIEW & 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 ships are part of the landscape experience of people on the dikes. Especially near the seaports there is a continuous coming and going of ships. This movement in the landscape generated by freighters, fishing boats, pleasure boats and surfers, is observed by many people, especially when the weather is sunny and clear.

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 in the Bligh Bank area. On both cable routes (substation Zeebrugge and Ostend) there are some sensitive zones where the wrecks are situated on or close to the cable route.

4.6.2 Impact description and assessment

During the construction of the wind turbines there will be a temporary visual disturbance of the landscape caused by the presence of wind farm components, such as foundations (the parts that protrude above the water), wind turbines and offshore transformer stations, and an increase in shipping movements.

As the number of ships involved in the project is rather small in relation to the average number of ships using the various shipping routes, this effect is judged to be slightly negative. Moreover, the ship movements are regarded by many tourists as an attraction.

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.

In view of the fact that the wind farm will be situated in the sea at least 42 km from the shore, the construction activities or the actual wind turbines will hardly be visible. It is expected that the wind turbines will only be visible in very clear weather. The visual impact of the project is therefore judged to be slightly negative. In addition it can be said that the presence of a wind farm will be experienced by some people as being attractive or restful.

During the construction and exploitation measures to safeguard the safety of shipping, aviation and fishing must be put in place. It is imperative that the specifications (IALA Directive O-117 and O-114; Circulaire Bebakening Hindernissen, 12/06/06) of the proper authorities are adhered to.

As described in the reference situation some wrecks are found on the cable routes (to the substation of Ostend and of Zeebrugge respectively). From a maritime archaeological heritage viewpoint there is no preference for a particular route as there are wrecks on both routes. In any case it is indicated for the route to be adjusted to ensure that no wrecks are affected by the cable installation.

The effects on the sea view and the cultural heritage will be the same during the dismantling phase as during the construction phase. As stated before, this impact is judged to be insignificant.

4.6.3 Mitigating measures

It will be necessary to scan the seabed in order to keep the impact on the wrecks that are present to a minimum. This can be done for the various planned wind farms all at once.

4.7 MAN

4.7.1 Reference situation and autonomous development

In the Belgian marine areas the following users can be identified: shipping, fishing, mariculture, aviation, sand and gravel extraction, dredging and dumping of dredging mud, gas pipelines and telecommunication cables, military use, wind energy projects, oceanic observation stations, tourism and recreation, scientific research. The seabed is also strewn with shipwrecks and certain areas are protected areas of natural value (Ramsar, Natura 2000, Birds and Habitats Directives, special protection zones (SBZ),...).

The concession zone (assigned in the Royal Decree of 17th May 2004) in question is used for fishing and military exercises. In the vicinity are shipping routes, extraction zones, cables and pipelines and the concession areas of Eldepasco (wind energy) and C-Power (wind energy + mariculture). The intended cable routes will cross some existing cables and pipelines, shipping routes and the Special Protection zone SBZ-3 (landfall Zeebrugge) or SBZ-2 (landfall Ostend).

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 Belwind wind farm will have no negative impacts.

4.7.1.1 Fishing

Fishing for flatfish (plaice, sole, flounder) with trawlers is the main fishing activity in the BPNS area and 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 also evident from the fact that the stocks of nearly all species are specified as being “outside safe biological limits” which means that several species will be not be able to reproduce either.

Belgian fishing showed an increase in supply between 1950 and 1955, after which a steady decrease in supply and fleet size (end 2006: 107 vessels) was noted. 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. Especially for the boats in the Large Vessel Sector the figures show a sharp decline in profit (-13.8%) due to a steep rise of the costs in relation to the turnover. This increase in costs can mainly be attributed to a rising gas oil price in 2005. The relative supply (% share) of the various fish species has hardly changed at all. The dwindling supply and rising costs were compensated to some degree by a general rise in the price of fish during the last few years.

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.

4.7.1.2 Military activities

The concession area of Belwind is situated in the military zone where artillery exercises with floating targets are held. As this military zone overlaps the wind concession zone for a large part, marked off in accordance with the Royal Decree (RD) of 17/05/2004, the government has agreed that within the confines of the offshore zone (in accordance with concession RD) no military exercises will be held. However it has been agreed that they can continue temporarily as long as the turbines have not actually been installed. In due course the military exercise zone will be moved a little so that there will no longer be any overlap. (Cathy Plasman - Advisor Cabinet of Minister Landuyt, Ministry of the North Sea)

4.7.2 Impact description and assessment

4.7.2.1 Fishing

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 this wind farm would lead to an additional loss of fishing grounds of 1.3 % for the BPNS. In view of the limited area (49.1 km² incl. safety zone) and the fact that the Bligh Bank is not an important fishing area, this loss is considered to be acceptable. The impact as a result of the wind turbine project as described is therefore not significant 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 is seen as the main cause for changes in fish behaviour, while the cable installation will temporary disturb the sediment. The main impacts expected during the exploitation phase are the changes in fish behaviour as a result of the electromagnetic radiation generated by the cables and the introduction of hard substrates (Mackinson *et al.*, 2006). However there is some uncertainty about the size of this impact and the species-specificity. For a description of these negative effects and the knowledge gaps on this subject, see chapter “Fauna and Flora”.

4.7.2.2 Military activities

Due to the infrequency of the military activities (maximum of 5 exercises per year) in this zone, no significant effects of the planned wind farm project on these military activities is anticipated .

4.7.2.3 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 at a large enough distance from the wind farm and its cabling or the activities are separated in time.

The crossing of existing cables and pipelines will be done in consultation with the operators and in accordance with international safety regulations. Crossing of the shipping routes too will be done by mutual arrangement. It is assumed that the cabling of the wind farm will cause no impact.

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 routes run through the special protection zone SBZ-3 (landfall Zeebrugge) or SBZ-2 (landfall Ostend). 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 and therefore no significant effects are anticipated for the special protection zones.

4.7.3 Mitigating measures

No mitigating measures or compensations are proposed for the development of the wind farm Belwind.

4.8 SAFETY

In the EIR various kinds of safety risks are discussed. The reference situation, effects on and by the shipping industry and relevant mitigating measures are established in a monograph by Marin (May 2007, Appendix 3). The reference situation, effects on radar, shipping communication and navigation systems, and relevant mitigating measures are established in a monograph by Prof. Catrysse (April 2007, Appendix 2). Risks for the workforce (occupational hazards) are not discussed in this EIR.

4.8.1 Reference situation and autonomous development

4.8.1.1 Installations

There are no installations on the Bligh Bank as yet.

4.8.1.2 Shipping traffic

The reference situation for the shipping traffic (see Figure 4.9.3) is based on a combination of data for ships on fixed routes (statistics from the Dutch Coastguard in 2005 - 2006) and ships that are not on fixed routes (average density counted from aircraft in the period 1999 – 2001).

On this figure two areas are outlined. The inner area is drawn over the outermost turbines of the 3 MW-version. The area outside is composed in such a way that no shipping routes run through this area, so that the ships on the centre line will pass the wind turbines at a minimum distance of 1 nm (nautical mile of 1,852 km).

4.8.1.3 Radar and ship communications

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 Bligh Bank is situated off the Zeebrugge coast, close to the Dutch border and 38 km from the radar installation of Zeebrugge. Data supplied by, amongst others, SRK show that there is no important shipping traffic in the immediate vicinity of this sand bank, although the so-called 'West-rond' route is not far away. The SRK harbour radar of Zeebrugge is able to follow this traffic, although it is not within the "official" SRK surveillance domain. The main shipping route from the Channel to Rotterdam lies more northerly than the Bligh Bank, and is outside the range of the SRK radar stations.

4.8.1.4 Oil pollution

As the project area lies in the North Sea it is subject to the regulations that apply to the MARPOL "special zones", Appendix I. The dumping of oil-bearing liquids is prohibited. On the other hand it must be concluded that illegal oil polluters continue to play a large part in the oil pollution in the North Sea (for example, see Ospar Commission, 2000).

Oil pollution as a result of this project could occur in two ways. The first is an incident with a wind turbine or an incident on the transformer platform, resulting in the spilling of oil or oil-bearing lubricants. The second possible cause of oil pollution could be an unexpected leakage of oil-bearing substances from a ship (e.g. in the construction phase; or as a result of an incident or accident involving ships that have no connection with the project).

From a historical analysis (from 1960 – 2003) of accidents involving oil pollution that were a potential danger to the Belgian coast it appears that during the last 40 years approximately 30 such incidents occurred. The main causes are collisions (70%), followed by incidents resulting from a wrong manoeuvre (7%). The volumes spilled vary from 10,000 tonnes to less than 10 tonnes.

The recent requirement for tankers to be double-walled means that the oil spilled as a result from shipping accidents will in future probably be mainly bunker oil.

4.8.1.5 Air traffic

For the sake of completeness, the safety for air traffic is briefly discussed in this EIR too. We also refer to Figure 4.9.10 and Figure 4.9.11, with navigation maps showing the boundaries of air traffic control (between The Netherlands and Belgium). Although the wind farms are situated in Belgium this shows that the air traffic in this area is controlled by Schiphol and not Zaventem. Within the marked CTR

(Control Terminal Region) zones there is an altitude restriction of 150 m, but the wind farms are not situated inside them.

4.8.2 Impact description and assessment

4.8.2.1 Installations

Modern wind turbines are subjected to various classification systems. Before they are given 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 .

The failure rate of wind turbine components is highest for the small nacelle parts: once every 833 years. This represents an extremely low and acceptable risk. It is also 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 distance during an overrev-situation (2 times nominal number of revolutions) for a 3 MW wind turbine turns out to be around 436 m. For a 5 MW wind turbine the throwing distance will 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 transformer platform installations. The amount of oils and grease in the turbine is approx. 174 kg of grease and 1083 litres of oil per turbine; and on the transformer platform there is a storage tank containing diesel fuel for a few weeks (circa 10 m³). Leakage of fluids (oil, grease, etc.) from the installation is prevented or minimized by the fitting of various (double) seals, collection systems (basins, brims) as well as the way in which the components of the installations are constructed. Assuming that these seals and collection systems function properly and are well designed (certified), there will be no 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) or as a result of a collision by ships.

The necessary provisions are in place to minimize the risks for the environment caused by fire, lightning, falling ice and rotor fracture. 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 that occupational hazards (that do exist) are not considered.

4.8.2.2 Shipping

During the construction and the dismantling phase there will be additional shipping traffic between the wharf and the project site. The work traffic during the construction and dismantling of the wind farm will increase risks for a period of two years. The maximum increase in the risk of a collision between two ships is 2.9% for the construction of the 3 MW wind park, this means an increased risk of 0.019 per year. The increase in risk, and therefore risk of damage to the environment, is greatest for the construction of the 3 MW (i.e. 2.9% compared to 2.0 % for 5 MW), but is much smaller than the added risk of damage to the environment of 9.8% per year for the 3 MW wind farm (see paragraph “Consequential damage to the environment”) by a collision with a wind turbine. For the dismantling phase the risks are even lower (about half) than during the construction phase.

During the exploitation phase the indirect effects of the wind farm on the safety of the shipping traffic (number of shipping accidents outside the wind farm, caused by changed shipping routes) is negligible compared with the direct effect. Also only during a period of maximum 2 to 3 days (on average) somebody could be present on a wind turbine, further reducing the human risk. The number of incidents will hardly change, also because incidents caused by the wind farm will partly ‘move’ from the Belgian EEZ (Exclusive Economic Zone) to the Dutch EEZ. In total the number of ships will increase by 0.06% in both EEZ's together due to the presence of the wind farm on the Bligh Bank, which is negligible. A small effect will also be noticeable in the EEZ of the UK.

The direct effect is greater. The risk of a ship colliding with a wind turbine (monopile construction, worst-case scenario) per year has been assessed for both installation versions. The basic version with the 5 MW turbines poses the smaller risk (0.041 or once every 24 years), as this version has fewer turbines. This in contrast to the 3 MW version with a collision once every 14 years.

In more than 25% of the incidents the collision will not damage the wind turbine, because the ship causing it is small. The Roll-on Roll-off ships (type with a tail gate or loading ramp at the rear) are the most likely to cause damage.

Taking the worst case scenario approach (monopile constructions) for floating collisions, which carry the greater risk, means that the estimated risks of oil spills can also be used for the other foundations.

The risk of an oil spill after an incident increases in the EEZ by 5.9% for the 5 MW basic version and by 9.8% for the 3 MW version. These percentages relate to the risk of an oil spill after a collision in the Belgian EEZ. The oil spill risk is based on a worst-case scenario. As the percentage of tankers with double walls is growing, the chance of an oil spill after a collision with a wind turbine will be lower than predicted.

The basic version with the 5 MW turbines is the most favourable. In general it is true that a higher output per wind turbine is more favourable. The risks for and by the shipping traffic calculated for the Bligh Bank are generally lower than the ones calculated for the Dutch wind farms. This will be evident when the Dutch safety studies are published (Marin, 2007).

4.8.2.3 Radar and ship communications

For large wind turbines the mast is the dominant factor for mariphone systems. Large reflecting objects can also have an effect (e.g. dead areas, multiple reflections, etc.). Taking into account the location of the Bligh Bank in relation to the coastal stations, the potential effect of receiver saturation could only affect the ships radar.

The installation of the wind turbines on the Bligh Bank 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 the Bligh Bank. In the area behind the Bligh Bank there will be shadow zones, affecting radar tracking as well as other mariphone systems. But this area is almost out of range anyway. Other effects will depend on the completion of other projects and the potential installation of wind farms (cumulative effects). The type of wind turbines (5 MW of 3 MW) does not influence these situations.

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 (behind the Bligh Bank) and far-away routes. But here too it must be made perfectly clear that for the area in front of the Bligh Bank there will be no changes compared to the current situation. Here too the real restriction is the actual range of the radio installations.

The influence is rather minimal or non-existent on the following systems:

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

In general it can be assumed that the realization and installation of an off-shore wind farm on the Bligh Bank will not have a discernible impact on the surveillance of and communication with the shipping traffic as it is now.

4.8.2.4 Oil spread and ecotoxicological effects

In addition to analysing the risk of an accident, attention was paid to the potential impact of oil pollution. For the purpose of the EIR for the wind farm on the Thornton Bank, WL Delft Hydraulics has carried out mock-ups to simulate the spread of an oil spill in the environment. Here follows a description of the worst-case scenario, whereby all the contributing factors (wind force, wind direction, amount of oil, season, wind friction,...) were selected to maximize the impact on the environment.

After extrapolating the simulation data of WL Delft Hydraulics, it appears that with strong winds the oil slick would reach the Belgian coast in 14 hours. In these circumstances there would be a relatively short time for intervention. With more moderate wind speeds there should be enough time to allow intervention. The presence of a wind farm on the trajectory of an oil slick has positive as well as negative effects. The wind turbines could be used as anchor points for floating barriers, but on the other hand the turbines themselves could be an obstacle for manoeuvres during the combat and break up the oil slick into several smaller ones.

The quantative impact of a discharge of 1.000 tonnes of heavy fuel oil on animal life depends in many ways on the scenario in question and the animal group concerned. The estimated direct impact (death within a few days) on fish and invertebrates is extremely small and will always be less than 0.2 % of the local populations.

Bird losses at sea were estimated at some 340 birds in a scenario with a strong northerly wind. Hereby it must be said that mock-ups only give an approximation of the number of oil victims. Actual accidents on location often prove that in reality these numbers will be higher. There is no positive correlation between the number of bird victims and the amount of spilled oil. The effect is closely linked to the importance of the area as a wintering place for birds. In addition to the victims that will be killed as a result of a disaster, there may also be negative effects for the population (long-term effect). It is however not always easy to separate the actual impact of the disaster from the natural fluctuations in a population. Bird losses as a result of oil being washed ashore on the Belgian coast, based on worst-case scenario mock-ups, are judged to be negligible (i.e. 4 birds). These estimates only apply to the species listed in the vulnerability index; mortality among other species that could be affected is not taken into consideration due to a lack of data. The oil slick could reach the Dutch coast later on. This can not be verified with the current simulation time.

For the qualitative oil pollution impact description it is stated in Lindgren & Lindblom (2004) that avifauna, and possibly sea mammals too, will experience the most important short-term effects. The plankton community will also be affected, but is able to recover very quickly. The impact on pelagic fish is negligible. The benthic fauna will probably not be affected by acute toxic effects, but thick oil layers can cause them to suffocate. It must however be taken into consideration that such effects strongly depend on various factors that could influence the oil pollution. More research is certainly needed to identify the most important animal and plant species affected by oil pollution in the part of the North Sea relevant for this EIR.

On the basis of availability of data in existing literature (or lack of it) it is therefore not possible to make a scientifically sound declaration about the effects on all benthic fauna and sea mammals in this part of the North Sea.

According to the study by Lindgren & Lindblom (2004) solid ecotoxicological data are difficult to find and incomplete. This seems to be the case too for the part of the North Sea relevant to this EIR. In general the lighter types of oil appear to be more toxic than the heavy types. Pelagic organisms will suffer less than benthic organisms because of their sensitivity to exposure. Eggs and larvae are more vulnerable than fully grown specimen (Lindgren & Lindblom, 2004).

4.8.2.5 Air traffic

In principle a total height (height tip of rotor blades) of up to 175 m should be acceptable. All the same a "permit" to erect high structures must be requested from the people responsible at the FIR (Flight Information Region) at Amsterdam-Schiphol, (Johan Catrysse, personal communication).

4.8.3 Mitigating measures

4.8.3.1 Shipping traffic

The following measures for shipping traffic can be proposed :

- The first measure to be implemented is the safety zone of 500 m around the wind farm, where no shipping traffic will be allowed.
- It is important that from the start efforts are made to establish a procedure for the traffic moving to and from the site to minimize the risk of a collision.
- A tailor-made contingency plan must be drawn up for incidents involving a wind turbine and for oil pollution in the vicinity of the wind farm.
- The wind farm must be equipped with navigation lighting and radar reflectors, to maximize the visibility and detection for the shipping traffic.
- Potential surveillance of the shipping traffic around the wind farm, with adequate warning protocols and/or statutory regulations could increase safety.
- The possibility to use the maintenance vessel from the start as a multi-functional ship will offer a number of additional opportunities to increase safety. Potential additional functionalities are: towing function, fire fighting, containment of oil spills, etc.
- Use of AIS (Automatic Identification System) transponders for all ships over 300 GT (approx. 55 m), which will reduce the risk of a ship colliding with a wind turbine (ramming) by 20%. However, this will not change the risk of a drifting collision.
- Use of ‘De Waker’ (from the Netherlands) or another tug. According to information provided by the proper authorities (Belgian Structure Coastguard, Ulrike Vanhessche, personal comm.) it is the plan that eventually a multi-functional ship could be used as a tugboat, to combat and reduce oil pollution, etc.

4.8.3.2 Oil pollution

In order to step up the combat against pollution, the coastguard was founded on 1 May 2003 and is now up and running. Organising operations when oil pollution occurs is their most important task. According to information provided by the proper authorities (Belgian Structure Coastguard, Ulrike Vanhessche, personal comm.) there are currently two ships available to combat and reduce oil pollution:

- DAB (Dienst Afzonderlijk Beheer) Fleet;
- Navy ship (under the authority of the Ministry of Defence).

In the future a multi-functional ship could also be used as a tug, to combat and reduce oil pollution, etc.

Since April 2005 (Ministerial Decree 19/04/2005) the new “Contingency plan North Sea” has come into force. The contingency plan describes the organisation of emergency services and the coordination of operations if disasters or serious accidents occur in the Belgian waters. The plan also gives operational and practical guidance.

In 2006 the scenarios “Operational intervention plans for the fight against pollution at sea and on the beach” were introduced. The scenario “Clean beaches”, introduced in January 2006, suggests a procedure to tackle the pollution on our beaches or seashore by cargo or waste washed ashore. The scenario “Clean sea” (introduced in August 2006) does the same for the pollution of the sea.

Since early 2007 an intervention plan for birds is available from the Province of West Flanders. This is a scenario for the rescue and treatment of birds struck by oil pollution or another extreme situation at sea.

Since the chance that the wind farm will cause oil pollution or any other pollution is very small, and therefore not likely to affect fauna or flora either, no specific mitigating measures will be necessary.

4.9 MONITORING

In the various thematic chapters, monitoring measures were proposed. These proposals were predominantly based on the EIR drawn up for the wind farm on the Thornton Bank (Ecolas, 2003 and Ecolas, 2004) and the environmental impact assessment by the authorities for the same project (MUMM, 2004 and MUMM, 2006a).

If the monitoring carried out at the first wind park located on the BPNS proves to be representative for other wind farms to be installed subsequently, and if this monitoring shows that there are non-significant effects for certain sub- aspects, it will be sensible to adjust the monitoring requirements in order to gather supplementary information only.

In the relevant chapter proposals for monitoring are formulated for the cumulative effects of the three wind farms per theme. If possible the monitoring programmes of the various wind farms must be attuned to each other and synergies should be identified, in consultation between the MUMM and the three initiators. This should ensure that as many gaps as possible are filled and that financial efforts with regard to monitoring will produce a useful result.

5 CUMULATIVE EFFECTS

5.1 INTRODUCTION

The potential impact of a combination of several wind farms can, in connection with other human activities on 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 of the 3 approved or planned wind farms in the Belgian part of the North Sea (Eldepasco + Belwind + C-power).

- C-Power n.v. has the required permits (domain concession and licence/authorization) 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 they began with the necessary soil testing. The concession area for wind energy is situated to the east of control zone 1, sector 1A. The concession on the Thornton Bank is divided into two areas: one on the western side of the telecom cable Concerto South1 and the Interconnector gas pipeline (sector A) with 24 turbines on an area of 5.0 km² and one on the eastern side (sector B) with 36 turbines on an area of 8.8 km². Including the safety zone of 500 m around the wind turbines a total area of 26.4 km² is taken up (Ecolas, 2003) for a total installed output of up to 300 MW (taking into account the safety zones).
- Eldepasco has obtained a domain concession (15/05/2006) for the construction and the exploitation of a wind farm of 36 turbines (total area: 9 km²) on the Bank zonder Naam. An environmental impact report is being drawn up to obtain the licence/authorization.
- Belwind, the Belgian subsidiary of the Dutch renewable energy group Econcern, has applied for a concession for a large-scale wind turbine project (330 MW) on the Bligh Bank. The wind farm will consist of 66 turbines of 5 MW or 110 turbines of 3 MW or alternatives with analogue power range. A domain concession for an area of 35.4 km² has been applied for. The environmental impact report at hand was drawn up as part of the application for the licence/authorization.

Only those effects that have a non-negligible (positive or negative) impact on a certain discipline will be discussed in the next paragraphs. 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 .

5.2 SOIL

For the three wind farms nearly 7 million m³ of sand in total will have to be laid up as a result of the excavation needed if each project chooses gravity foundations for all wind turbines. This will be done in stages over time: the construction will take 2 years; the construction period for each wind farm will differ. 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 extremely small. The impact will be reduced if the cables are laid together (adjacent cable routes) instead of each of the three projects using different routes.

Local erosion as a result of the constructions is prevented at the three wind farms by the installation of erosion protection a priori. When monopiles are chosen it can be concluded that the erosion protection in the three cases will be perfectly adequate. When gravity foundations are chosen there is some uncertainty due to a lack of scientific studies and practical experience. 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 erosion protection.

If the erosion 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 foundation and caisson foundation, a local and temporary increase in turbidity, which will have a negligible effect 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 park and between parks and the mainland 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 CLIMATE & 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 SO2, NOx and CO2. The cumulative contribution will obviously be even greater and is equivalent to the sum of the individual contributions.

5.5 NOISE & VIBRATIONS

When during the construction phase the piles for the foundation are driven into the ground, there will be an impulse sound (non-continuous). These pile-driving activities will be temporary only. Therefore the cumulative effect will not be greater than the sum of the effects per wind farm (the chances that pile-driving sounds from the 3 wind farms will be heard simultaneously are 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 respective wind farms, consequently the cumulative effect is equivalent to the sum of the individual effects.

Only between the Belwind and the C-power wind farm in the Eldepasco wind farm area will the cumulative effect of the 3 wind farms together cause the noise level above water to be slightly higher. As the effect of the individual effects is expected to be extremely small (of the wind farms separately), there will be a limited effect only of the noise above water coming from the 3 wind farms.

5.6 FAUNA & FLORA

For the majority of the effects on benthos and fish (loss of biotope / disturbance, loss of organisms, introduction hard substrate, noise) the cumulative effect is the sum of the individual effects per wind farm. These are often also directly proportional the space occupied. The total area of the three wind farms together is relatively small compared with the BPNS (2.5 %). As most of the effects will only occur on a small part of the domain concessions (gravity/ caisson > monopile/tripod) it can be concluded that on the whole the effects will be acceptable. There is still a great deal of uncertainty about the magnitude of the cumulative effect of noise disturbance and electromagnetic radiation. More research is needed.

Most cumulative effects on birds are the sum of the individual effects per wind farm. The cumulative effect as a result of the loss of habitat for resting and foraging birds will mainly affect species with pronounced avoidance behaviour, such as Razorbills, Guillemots and Gannets. As it may be assumed that the effects will be felt in a radius of approx. ca. 4 km around the wind farm, the entire concession zone demarcated on the BPNS for the construction of wind farms will be avoided by these species. In the first instance this cumulative effect is considered to be significant. In relation to the entire biogeographical population of these species found in the BPNS, the effect is judged to be moderately negative. As far as the cumulative effect as regards collisions is concerned, there is currently a lack of scientific knowledge as there are no zones with different wind mill parks in operation where such a cumulative effect could occur. It is however anticipated that the collision effect will affect the big gulls most (Lesser black-backed gull, Black-backed gulls and Herring gulls).

No negative cumulative effects on sea mammals are anticipated. They are the sum of the individual effects. The cumulative effect as a result of rest disturbance is considered to be a knowledge gap.

5.7 MAN

No negative cumulative effects worth mentioning are anticipated for the various users of the North Sea.

For fishing and mariculture the construction and exploitation of the various wind farms can have indirect positive effects as they will stimulate the fish population (areas closed to trawler fishing, shipping, ...) and consequently the fishing in the area too, or provide opportunities to develop alternative ways of fishing.

5.8 SEA VIEW

The three wind farms are at such a long distance from the coast that they will be hardly visible. The wind turbines nearest to the coast will be visible in extremely clear weather only. These wind turbines will not be prominent enough to spoil the sea view, so no significant negative effect is anticipated. From the shipping route the turbines will be more visible but not affect the view much either.

5.9 SAFETY

There is a very small and acceptable risk of environmental pollution from oil and grease spills if a turbine topples over or if there is a complete structural collapse of the transformer platform.

In general it can be stated that as a result of the presence of the two other wind farms the total risk of shipping for the three wind farms will be more or less the same than the sum of the risk for the individual wind farms.

For the three wind farms, 810 of installed power altogether, a collision or floating collision with a wind turbine on one of the three wind farms is expected to occur once every 8.8 years for the 5 MW basic version, based on worst-case calculations, whereby this can be expected to lead to an outflow of cargo oil or bunker oil once every 227 years. This is an increase of 14 %. For the 3 MW version this is an incident once every 7.2 years and a cargo or bunker oil spill once every 177 years.

In principle no significant negative impact is expected on the surveillance of or communication with shipping traffic. To monitor the security of the 3 wind farms it will be advisable to set up an additional SRK radar.

6 CONCLUSION

Belwind has taken the initiative to build an offshore wind farm in the North Sea, to be located on the Bligh Bank off the Belgian coast. The aim of the project is to construct, maintain and exploit an offshore wind farm generating an output of around 330 MW. This capacity could supply approx. 340,000 households with electricity. The completion of this wind farm will help to achieve the objective of the authorities as regards renewable energy (6% by 2010).

To assist with the decision-making process concerning the licence 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 must describe the construction, exploitation, dismantling as well as the cable installation.

The lay-out plans for the wind farm investigated in the EIA are based on either the base variant where 66 turbines of 5 MW will be installed or the alternative where 110 turbines of 3 MW. At the moment of realisation, a choice will be made within the range of 3 to 5 MW. These variants are hence on the under and upper limit of this power range. This is also true for the technical characteristics of the wind turbines and the other parts of the wind farm. Generally it can be stated that the effects of a wind farm with a power per wind turbine within the 3-5 MW range will be not more harmful than the effects of a wind farm for turbines of either 3 MW or 5 MW. The offshore wind farm will be equipped with either 3-bladed or 2-bladed wind turbines. Further more, 1 wind measuring mast and 2 power stations are considered. The power will be transported to either Ostend or Zeebrugge via 2 underground cables. The necessary controls regarding security and operation of the wind farm will be put in place, as well as illumination, marking and signposting. It will take 2 years to build the farm and its life expectancy will be 20 years minimum.

During the installation phase there will be temporary disturbance as a result of the activities. With gravity foundations a considerable amount of surplus sand will have to be laid up in the concession area. As a result of the activities (ship movements, pile-driving, use of a crane , ...) the sound level will temporarily increase underwater and above the water. There will be a temporary loss of benthic habitat 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. Species sensitive to disturbance and sea mammals will probably leave the area, but return after the construction phase. No effects are anticipated for other users of the BPNS. There is a slightly higher risk of shipping accidents and environmental damage as a result of the shipping traffic to the project site.

During the *exploitation phase* there will be some effects also. Potential erosion in the area around each turbine will be prevented by the installation and monitoring of erosion protection around each turbine. The risk of water and soil pollution is extremely small. During the exploitation of this wind farm approximately 4 % greenhouse gas emissions will be prevented in comparison with traditional power stations. The wind farm will only be vaguely visible in exceptionally clear weather conditions. For the majority of fauna species there will (virtually) be no impact at all. The creation of hard substrates will lead to an enhanced and changed biodiversity. During the exploitation phase the wind farm may cause hindrance to bird species that are sensitive to disturbance and collisions. Sea mammals could be troubled by the vibrations, noise, maintenance activities and change in food sources during the exploitation phase.

The effect on the avifauna and sea mammals during the exploitation phase is judged to be slightly negative. A positive effect is expected on traditional fishing in the vicinity. A floating collision could cause a leak in a cargo tank or bunker tank resulting in an outflow of cargo oil or bunker oil; this is expected to happen once every 500 years for the 5 MW basis and once in 300 years for the 3 MW version. For bunker oil and cargo oil combined the risk of an outflow increases by 6 % for the basic 5 MW version, and by 9 % for the 3 MW version. In principle there is not expected to be a significant negative influence on the surveillance of and communication with the shipping traffic.

The effects during the dismantling phase will be similar to those during the installation phase. The effects depend on whether the foundation (or part of it) and the erosion protection are removed. The choice whether or not to remove the erosion protection and the foundation is best made at the end of the exploitation and based on the 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 and disappear after a time. Not much is known about the influence of electromagnetic radiation, noise and vibrations and the local warming of the seabed during the exploitation but it will be restricted to the near vicinity.

In view of the position and distance of the installation in relation to neighbouring countries some limited *border crossing effects* can be expected concerning the Netherlands. Of all the disciplines that were considered, only a limited effect can perhaps be expected for the disciplines of noise, sea view and safety.

For the cumulative effects (effects of the three 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. In total almost 7 million m³ of sand will be laid up as a result of the excavation required if each of the projects were to opt for gravity foundations for all wind turbines, which is highly unlikely. The cumulative effect will, due to phasing of the activities, be smaller than the sum of the effects. 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 SO2, NOx and CO2. 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 area between the turbines; 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 – often directly proportional to the space occupied, which in reality is relatively small - per wind farm. 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 the 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. For the three wind farms, 810 MW of installed power altogether, a collision or floating collision with a wind turbine on one of the three wind farms is expected to occur once every 9 years for the 5 MW basic version, based on worst-case calculations, whereby this can be expected to lead to an outflow of cargo oil or bunker oil once every 227 years. In principle no significant negative impact is expected on the surveillance of or communication with shipping traffic.