Section 11

The Biological Environment - Assessment of Impacts

11 THE BIOLOGICAL ENVIRONMENT – ASSESSMENT OF IMPACTS

11.1 INTRODUCTION

This section describes the potential impacts, mitigation measures and subsequent residual impacts on the offshore biological environment as a result of the offshore aspects of the Humber Gateway scheme. In addition, the proposed monitoring and enhancement measures are discussed as appropriate.

The topics covered in this section include:

- intertidal ecology (*Section 11.2*);
- subtidal benthos (*Section 11.3*);
- fish (*Section 11.4)*;
- marine mammals (*Section 11.5*); and
- ornithology (*Section 11.6*).

In each section, the potential impacts as a result of construction, operation and decommissioning are considered.

11.2 INTERTIDAL ECOLOGY

11.2.1 SCOPE AND METHODOLOGY

Introduction and Scope of the Assessment

This section describes the biological assessment in the intertidal zone. The physical characteristics of the export cable and proposals for installation are described in detail in *Section 6*. In summary, the work will involve using horizontal directional drilling (HDD) techniques to install the export cable from a location landwards from the cliff edge to a location in the intertidal zone. This will involve some activity in the intertidal zone, which has the potential to result in impacts to intertidal ecology.

Similarly, if decommissioning involves removal of the cable, this might also result in disturbance of the intertidal zone and is therefore taken into consideration in this assessment.

Once installed, operational impacts are unlikely due to the fact that the cable will be buried. Operational impacts are therefore not included in this assessment.

Consultation

Natural England (formerly English Nature), Cefas and the Marine and Fisheries Agency (MFA) have reviewed the marine ecology survey report (presented in *Appendix C1*) and made a number of comments which have been taken into consideration in the assessment as appropriate.

Realistic Worst Case

The cable installation methodology is clearly defined (detailed in *Section 6*) and therefore there is only one possible scheme to assess.

Embedded Mitigation

The landfall design incorporates a number of embedded mitigation measures described that are described in detail in the Project Description (*Section 6*) to ensure that environmental impacts are minimised. These measures relate specifically to the following:

- use of Horizontal Directional Drilling (HDD) technique to drill a cable duct under the cliff and foreshore to a point in the intertidal zone rather than open cut, trenching or other techniques that would result in significant disturbance;
- use of rollers and slings, to move the cable duct across the foreshore and cliff edge, thus avoiding disturbance;
- use of an inert and non-toxic drilling fluid during HDD operations;
- removal of residual drilling fluids from site after use and disposal according to UK regulations; and
- best-practice techniques (e.g. appropriate vehicle use and maintenance) will be used at all times.

Methodology

Guidance Documents

Guidance documents relating to the generic requirements for intertidal assessment include the following:

- *Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA requirements Version 2* [(1)]; and
- *Nature Conservation Guidance on Offshore Wind Farm Development* [(2)].

Prediction Methods

The spatial scale of the construction impacts is defined by the area over which disturbance could potentially occur. The disturbance could be direct (e.g. physical habitat loss) or indirect (e.g. smothering by increased suspended sediments).

In addition, the sensitivity of the receptor is important. This largely depends on the receptor's ability to tolerate stress and change, hence this has been identified throughout this section as appropriate.

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(1) Defra, Cefas and DfT, 2004. Offshore wind farms: Guidance note for Environmental Impact Assessment in respect of FEPA and CPA requirements: Version 2.
(2) Defra, 2005. Nature Conservation Guidance on Offshore Wind Farm Development.

Significance Criteria

Impacts can be defined as being ***major***, ***moderate*** or ***minor significant impacts*** or resulting in ***no significant impact***. This is defined using a matrix approach to consider the magnitude of an impact in relation to the sensitivity of the receptor as previously described (*Table 11.1*). The use of these criteria in relation to the potential impacts to intertidal ecology has been conducted using professional judgement and with reference to published literature. This is discussed in further detail as appropriate throughout the assessment sections.

Table 11.1 Significance Criteria for Impacts to Intertidal Ecology

Degree of Effect / Magnitude	**Sensitivity of Receptor**		
	High	*Medium*	*Low*
High	***Major significant impact***	***Moderate significant impact***	***Moderate significant impact***
Medium	***Moderate significant impact***	***Moderate significant impact***	***Minor significant impact***
Low	***Moderate significant impact***	***Minor significant impact***	***No significant impact***
Imperceptible / negligible	***Minor significant impact***	***No significant impact***	***No significant impact***

11.2.2 ASSESSMENT OF POTENTIAL IMPACTS

Habitat and Community Disturbance during Cable Laying Activities

The terminals of each of the two cable ducts will be excavated from locations in the intertidal zone. There will be three heavy duty vehicles present during the HDD work, (backhoe loader, All Terrain Fork Lift (ATFL) and tractor / bowser unit). These vehicles are anticipated to be present in the intertidal area for a few weeks. Full details of the cable landfall works are shown in *Section 6*.

These vehicles will create tyre tracks in the substrate in the areas in which they are active, with the potential to crush fauna. The abundance of intertidal fauna at the site is low (i.e. 14 individuals, *Section 8.3.3*) such that the numbers of individuals likely to be injured or killed will have no material impact on the wider ecosystem. Furthermore, the intertidal community is adapted to tolerate a high degree of stress and to re-colonise quickly following disturbance events. The dynamic nature of the intertidal environment allows disturbed sediments to become redistributed quickly such that tracks will no longer be visible beyond a maximum of two tidal cycles.

The HDD bores will exit on the beach at least 72 m to the east of the cliff, which corresponds to the intertidal zone. As described in *Section 6*, a small 2 x 2 x 1 m HDD bore pit will be dug, in the intertidal zone, at low tide. As the tide recedes, the duct will be laid onto the beach on rollers to prevent dragging on the beach surface. This embedded mitigation will minimise damage to the beach surface. The pits in the intertidal area will be left to infill naturally. It is estimated that the holes will have refilled completely with sediment and will no longer be noticeable within a maximum of two tidal cycles. It is predicted any signs of physical impact will last no longer than two days once the beach-works are complete.

In summary, the magnitude of the impact is *low* (and short duration) and the sensitivity of the intertidal community is *low.* In addition to this, the ability of the intertidal community to recover from disturbance is good. For these reasons, ***no significant impacts*** to intertidal communities are anticipated as a result of cable laying activities.

Increased Suspended Sediment Concentrations in the Intertidal Zone during Construction

Suspended sediment concentrations in the intertidal zone will increase around the bore pits during the cable pull. Activities on the foreshore and intertidal zone are confined to a short period (estimated to be 22 days), thereby limiting potential impacts. The intertidal environment is highly dynamic, being perturbed regularly by storm events, and the intertidal fauna is characteristically tolerant of such an environment. This means that the communities are pre-adapted to physical disturbance and will recover rapidly from any alterations to the beach that may occur due to construction activities. The three invertebrate species identified on the site (*Section 8.3.3*) are common in this type of habitat and are able to re-establish quickly in disturbed areas.

The intertidal zone has naturally high levels of suspended solids, the area of potential impact is small (*low* magnitude of disturbance), and the species that inhabit the area are adapted to tolerate such levels (*low* sensitivity). ***No significant impacts*** are therefore anticipated.

Release of Drilling Muds during Construction

The drilling fluid used in the HDD process could potentially be released into the marine environment, particularly via the bore pit in the intertidal zone. The product proposed for use begins as a blended powder containing high quality Wyoming sodium bentonite. When mixed with fresh water, it becomes a tan to grey slurry of pH 10.2. This is a stable and inert drilling fluid that poses no environmental threat as bentonite is a non-toxic, naturally occurring clay mineral. However, this substance should still be prevented from entering the marine environment.

The project design contains embedded mitigation such that the majority of the drilling fluid is cycled out of the bore and replaced with freshwater. The design of the Drilling Fluids Circulation System ensures that the use of drilling fluids is kept to a minimum and prevents pools of drilling fluid from accumulating. Fluids extracted from the bore by this system are recovered by an excavating tractor and bowser and removed from the site for correct disposal. This vehicle will also be used to excavate and remove any drilling fluids that may be released into the bore pit when the HDD drill bit emerges into the pit. This constitutes embedded mitigation for spillage due to overuse.

As the bore pit will have a volume of 4 m^3, this is the maximum volume of drill fluid that could be released into the marine environment in the very unlikely event of a spill. This small volume would be dispersed into the marine environment by wave actions and currents, reaching imperceptible concentrations at the site within a matter of hours. As such, ***no significant impacts*** are anticipated to the environment or to the marine ecology due to the *low* magnitude (and short-term duration) of this disturbance and the *low* sensitivity of this environment to the inert and non-toxic nature of the substance.

Spills of Vehicle Fluids during Construction

There is potential for fluids such as oil or fuel to be spilt from the vehicles that will be used on the beach and intertidal area. Substances such as these are toxic to intertidal species and would also have harmful effects on sediment quality if released onto the substrate. However, high standards of maintenance and proper use will prevent the possibility of any such spillages from occurring. E.ON is committed to following best practice techniques including maintaining all equipment used on the project to high standards and to use fully trained technicians and operators. As such, impacts are extremely unlikely, however if they were to occur the magnitude of the disturbance would be *low*. In addition, the sensitivity of the intertidal benthos is *low* (due to the low species diversity and numbers). For these reasons, ***no significant impacts*** are anticipated as a result of accidental spills from onshore vehicles.

Disturbance of the Intertidal Substrate via the Removal of the Export Cables

There are two possible options for the decommissioning of the export cables in the intertidal zone. They may be left in-situ, or they may be removed for disposal. A decision will be made at the appropriate time in line with current best practice and with guidance from the relevant regulatory authorities.

Leaving the cables in-situ will have no perceivable environmental impact. The worst case scenario would be if the cables were removed through the bore hole as this would disturb and redistribute the beach sediments around the cable and cause vibration. Any impact caused by this activity would be localised and of short duration. Any vibration would be of sufficiently *low* magnitude that it is unlikely to result in any measurable effects to intertidal benthos. As the sensitivity of the intertidal benthos is considered *low*, ***no significant impacts*** to intertidal benthic communities are anticipated as a result of decommissioning the export cable.

Vehicle Activity on the Foreshore during Decommissioning

The removal of the export cable landfall would require vehicular access to the beach and intertidal zone. This will cause compression of the substrate beneath the tyres of the vehicles with the potential to crush fauna. Visible tracks will also be left in the substrate. As in the case of the construction phase, the disturbance is predicted to be of *low* magnitude. The abundance of intertidal fauna is sufficiently low that the numbers of individuals injured or killed will have no perceivable effect on the wider ecosystem. Furthermore, the intertidal community is adapted to tolerate a high degree of disturbance and to re-colonise quickly following disturbance events (*low* sensitivity). The dynamic nature of the environment allows disturbed sediments to become quickly redistributed such that tracks will no longer be visible beyond a maximum of two tidal cycles. As such, ***no significant impacts*** are anticipated from vehicle activity on the foreshore and in the intertidal zone during decommissioning.

11.2.3 MITIGATION MEASURES

There are no mitigation measures further to those embedded in the project design (*Section 11.2.1*).

11.2.4 RESIDUAL IMPACTS

The residual impacts are the same as the potential impacts described above, and there will therefore be ***no significant impacts***.

11.2.5 MONITORING

Consultation will be undertaken with Natural England (formerly English Nature) and Joint Nature Conservation Committee (JNCC) and any monitoring, if required, will be discussed and agreed. Any monitoring will developed in line with current best practice.

11.2.6 ENHANCEMENTS

No enhancements are proposed.

11.2.7 SUMMARY

The project design for the cable landfall installation incorporates embedded mitigation such that potential impacts will be minimised.

The potential and residual impacts to intertidal benthic communities are presented in *Table 11.2* and in summary ***no significant impacts*** are anticipated. This is primarily due to the predicted fast recovery rates of the intertidal zone and the resilience of the species present in this habitat.

Table 11.2 Summary of Impacts to Intertidal Communities

Impacts	Potential Impact Significance	Additional Mitigation (in addition to embedded mitigation)	Residual Impact Significance
Habitat and community disturbance during cable laying activities	*No significant impacts*	None	***No significant impacts***
Increased suspended sediment concentrations in the intertidal zone during construction	*No significant impacts*	None	***No significant impacts***
Release of drilling muds during construction	*No significant impacts*	None	***No significant impacts***
Spills of vehicle fluids during construction	*No significant impacts*	None	***No significant impacts***
Disturbance to the intertidal substrate via the removal of the export cables	*No significant impacts*	None	***No significant impacts***
Vehicle activity on the foreshore during decommissioning	*No significant impacts*	None	***No significant impacts***

11.3 SUBTIDAL BENTHOS

11.3.1 SCOPE AND METHODOLOGY

Introduction and Scope

This section describes the impacts predicted as a result of the construction, operation and decommissioning of the Humber Gateway project to subtidal benthic communities. Activities which have the potential to cause impacts include the following:

- vessel positioning during construction;
- seabed preparation;
- turbine and cable installation activities; and
- seabed loss as a result of the presence of foundations and scour protection, and any predicted scour.

It should be noted that the calculated areas of seabed and other data in this section are approximate and are based on the current knowledge of the engineering design.

Consultation

Natural England, JNCC, Cefas and the Marine and Fisheries Agency (MFA) have been consulted in relation to benthic ecological issues and their comments are recorded in *Appendix A*. Their key concerns can be summarised as follows:

- potential habitat loss associated with the physical presence of the turbine foundations;
- status and potential for impacts to *Sabellaria* communities; and
- status and potential for impacts to cobble reef communities.

These concerns have been taken into consideration in defining an appropriate scope for the assessment of impacts to subtidal benthos and where appropriate this is discussed in this section.

Natural England, Cefas and the MFA have also had the opportunity to comment on the stand alone reports which have been produced and presented in the appendices to this ES. Where appropriate, the comments have been taken into consideration in the assessment.

Realistic Worst Case

Construction Vessels

The realistic worst-case scenario for potential impacts to the seabed would result from the interaction of the jack up barges with the seafloor i.e. their 'footprints' resulting from the legs of the barges (otherwise known as spud-cans). In addition, cable laying activities involving lay barges would result in anchor scars on the seabed.

Jack-up barges have either four or six legs that are put down onto the seabed, once the jack up is positioned. The jack-up barge legs create spud-cans (depressions in the sea floor) which penetrate the seabed to a depth of up to 6 to 8 m [(1)]. Assuming that each spud-can has an area of 25 m^2 as specified in *Section 6*), *Table 11.3* describes the potential areas of disturbance resulting from the different layout options.

Table 11.3 Construction Vessel Footprint

Layout	MW	Foundation type	Number of turbines	Number of spud cans per vessel	Spud can area per vessel (m^2)	Total spud can coverage (m^2)	% coverage of total turbine site
1	3.6	Monopile	83	4	100	8,300	0.024%
				6	150	12,450	0.036%
2	3.6	Gravity Base	83	4	100	8,300	0.024%
				6	150	12,450	0.036%
5	7	Gravity Base	42	4	100	4,200	0.012%
				6	150	6,300	0.018%

The maximum area of seabed disturbance is predicted to result from turbine Layout 1 (3.6 MW monopile) and Layout 2 (3.6 MW gravity base). In these scenarios, the maximum area of seabed disturbed would be 12,450 m^2 (assuming six spud-cans).

In relation to cable laying activities, the use of a lay-barge (which relies on a series of anchor movements for vessel positioning), is likely to cause the greatest impact to the seabed. Each anchor is estimated to interact with a maximum of

(1) Greater Gabbard Offshore Winds Ltd, 2005. Greater Gabbard Offshore Wind Farm Environmental Statement.

20 m^2 of seabed at the point of contact. Large barges of this type require eight anchors that are deployed at approximately 500 m intervals along the entire cable length of 78 km (including both inter-array cables and export cables). The worst-case scenario for the scale of disturbance to the seabed is therefore predicted to be in the region of 0.025 km^2 (2.5 ha).

Turbine Foundations

The worst case foundation type will depend on the issue under consideration. The issues that need to be considered in the assessment and which relate to foundation type are as follows:

- increased suspended sediments as a result of seabed preparation and foundation installation activities; and
- direct seabed loss as a result of the foundation, scour protection and scour footprints.

In order to establish which of the options under consideration would result in the greatest impacts, the relevant predictions and calculations are presented below.

Table 11.4 provides information concerning the predicted suspended sediment concentrations resulting from preparation and installation of the monopile and gravity base foundations. This has already been discussed in detail in the water quality assessment (*Section 10.2)*.

Table 11.4 Predicted Suspended Sediment Concentrations (Monopile and Gravity Base Foundation Installation)

Location	Suspended sediment range (mg l^{-1})
At the monopile installation site	Up to 260
Within same tidal excursion as monopile being installed	Decreasing with distance
At the gravity base installation site	Up to 300
Within one tidal excursion from gravity base being installed	Decreasing with distance

The gravity base foundation represents the worst case in relation to the release of suspended sediments through seabed preparation and foundation installation activities. This option would result in localised levels of up to 300 mg l^{-1}, with typical values in the wider area being in line with background levels (20 mg l^{-1}). Turbine foundation dimensions and associated scour protection options are described in detail in *Section 6*. The different foundation types and associated scour protection will reduce the seabed habitat available for benthic communities by varying amounts as shown in *Table 11.5.*

Table 11.5 Seabed Coverage Associated with Different Foundations and Layout Options

Layout number	Number of turbines	Turbine foundation diameter (m)	Diameter with scour protection (m)	Foundation (including scour protection) area per turbine (m^2)	Total seabed coverage (m^2)	% coverage of total turbine site
1 (3.6 MW monopile)	83	4 6	8 12	50 113	4,172 9,388	0.012% 0.027%
2 (3.6 MW gravity base)	83	20	50	1,964	162,991	0.47%
5 (7 MW gravity base)	42	40	70	3,850	161,656	0.46%

The 3.6 MW gravity base (Layout 2) represents the worst case scenario as it has the largest footprint, covering a total seabed area of 162,991 m^2 (0.47% of the area of the Humber Gateway site).

Inter-Array and Export Cables

Table 11.6 sets out the different construction footprints that would be predicted as a result of the different cable installation techniques (jetting, ploughing and trenching) based on Layout 5.

Layout 5 (7 MW gravity base with nine strings of inter-array cables) represents the worst case in terms of longest inter-array cable route (58.5 km). The longest export cable route would be approximately 9.7 km assuming a route was adopted in the longer southern corridor. Two separate trenches will be created for two parallel cables (19.4 km length in total) within the corridor.

In order to calculate the worst case area directly disturbed during cable installation, the following assumptions have been made in relation to width of disturbed area [1]:

- ploughing width: 4 m;
- jetting width: 4 m; and
- trenching width: 6 m.

Table 11.6 Area Disturbed as a Result of Different Cable Installation Techniques (for Layout 5, Gravity Base)

Cable corridor length (export and inter array cables) (km)	Plough footprint (km^2)	Jetting footprint (km^2)	Trenching footprint (km^2)
77.86	0.31	0.31	0.47

Trenching represents the worst case in relation to total area of seabed affected during cable installation resulting in an area of 0.47 km^2 (47 ha) being disturbed.

However, it should be noted that in terms of suspended sediment concentrations, jetting represents the worst case scenario as discussed in the water quality section (*Section 10.2)*.

Scour Protection

Section 10.3 predicts the degree of scour that would result from the presence of turbine foundations both with and without scour protection (*Section 10.3.2*). In both bases, based on monitoring results of wind farms at similar sites (e.g. North Hoyle Offshore Wind Farm), the potential for scour at the Humber Gateway site is considered to be low. Site specific scour studies undertaken for the Humber Gateway site, predict a maximum scour depth of between 1.7 m and 2.6 m for monopile foundations and between 1 m and 2 m for gravity base foundations [2].

[1] Alcatel, 2007. Med-cable Environmental Impact Assessment.
[2] ABPmer, 2007. Humber Gateway Coastal Processes Embedded Mitigation Assessment.

Embedded Mitigation

Construction activities on the seabed have been designed to include embedded mitigation measures to minimise environmental impacts. Embedded mitigation measures that apply to subtidal benthos include the following:

- The inter-array and export cables will be buried at a sufficient depth of 1 to 3 m (which will allow the seabed to recover to its natural state).

- A benthic survey will be carried out prior to construction in order to locate *Sabellaria spp*. and to define any areas of cobble reef that might possibly be present. This will facilitate the micro-siting of the turbine locations and the micro-routing of the export cable route such that good examples of such habitats can be avoided. This approach will mitigate against significant disturbance or direct loss of important species or habitat and has been agreed with Natural England.

- Best-practice techniques including appropriate vessel maintenance will be used at all times.

- Anti-fouling paint will not be used on the sub-tidal surfaces, which will help species colonisation on the structures.

Methodology

Guidance Documents

The following best practice guidance documents have been referred to:

- *Offshore Wind Farms – Guidance Note for EIA in Respect of FEPA and CPA Applications,* Cefas, June *2004;* and

- *Wind Farm Development and Nature Conservation, BWEA March 2001.*

Prediction Methods

In order to predict the potential impacts resulting from construction, operation and decommissioning of the Humber Gateway project, the type and magnitude of any activities must be considered in relation to the extent and duration of the activity and the sensitivity of the receptor, in this case the seabed habitat and its associated fauna.

Seabed recoverability (the rate at which a habitat may return to its pre-disturbance state) is also an important factor to consider when determining the significance of an impact.

Cefas conducted a study in 2004 to improve the level of understanding regarding the timescales involved in seabed recovery following dredging operations. The study was conducted in a historically dredged area located approximately 100 km east of the Humber Estuary. The study demonstrated that areas of lower dredging intensity tended to recover to a greater degree than areas of higher dredging intensity because the sedimentary composition was maintained closer to that of the un-dredged reference sites.

Although the turbine and cable route construction activities will redistribute sediments to some degree in certain areas, the overall sedimentary composition of the seabed across the site will remain largely unchanged as all sediment sizes will be left on-site. The implication is therefore that seabed communities will recover rapidly. Sediments will mostly be left to redistribute naturally and will not be dumped in large amounts at any one location.

The sensitivity of subtidal benthos in the vicinity of the Humber Gateway site varies depending on the type of impact being considered.

Significance Criteria

In order to identify whether there is a ***major*, *moderate*** or ***minor significant impact*** or ***no significant impact***, a matrix has been developed which compares the degree or magnitude of the disturbance with the sensitivity of the receptor as shown in *Table 11.7*. Where professional judgement has been used, this is indicated in the text with an explanation of how the judgement has been made.

Table 11.7 Significance Criteria for Impacts to Subtidal Ecology

Degree of Effect / Magnitude	Sensitivity of Receptor		
	High	*Medium*	*Low*
High	***Major significant impact***	***Moderate significant impact***	***Moderate significant impact***
Medium	***Moderate significant impact***	***Moderate significant impact***	***Minor significant impact***
Low	***Moderate significant impact***	***Minor significant impact***	***No significant impact***
Imperceptible / negligible	***Minor significant impact***	***No significant impact***	***No significant impact***

It should be noted that for the purposes of this assessment, the sensitivity of the benthic communities present depends on the type of impact being considered.

For example, the sensitivity of benthic communities to temporary physical disturbance or smothering is considered to be *low,* on the basis that whilst the species present (including *Sabellaria* spp.) are not particularly mobile and necessarily move away to avoid impact, their natural ability to recover is high [(1) (2)].

When considering the sensitivity of benthic communities in relation to permanent habitat loss, the sensitivity is considered to be *medium* on the basis that the communities are likely to be altered for the lifetime of the project, they are relatively important in terms of commercial fisheries and there may also be localised areas of biodiversity interest (e.g. colonies of *Sabellaria* spp.).

When considering the magnitude of an impact, the area over which the impact is experienced by the receptor and the duration of the impact is taken into account.

(1) Holt T J, Rees E I, Hawkins S J & Seed R, 1998. Volume IX. Biogenic reefs: an overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project).
(2) Jackson A & Hiscock K, 2007. Sabellaria spinulosa. Ross worm. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/species/Sabellariaspinulosa.htm. [cited 04/07/2007].

These considerations have been applied and are further qualified in the assessments that follow.

It should also be noted that, in some instances, embedded mitigation has been incorporated into the project description to minimise the potential impacts. In some instances, this mitigation is sufficient to prevent any significant impacts from occurring. This is discussed as appropriate.

11.3.2 Assessment of Potential Impacts

Potential Impacts during Construction

Habitat and Community Disturbance as a Result of Construction Vessel Positioning

As shown in *Table 11.3*, the worst-case scenario in terms of potential total area disturbed as a result of construction vessel positioning, would be 12,450 m^2 or 0.036 % of the total turbine site.

The percentage of the total turbine site that will be affected is sufficiently small that the magnitude of the impact is considered to be *imperceptible*, especially as the spud-can holes would be likely to refill naturally in time. The sensitivity of the benthic communities present (as described in *Section 8.4.4*) is considered to be *low* (in the context of temporary disturbance), particularly in light of good predicted recoverability as previously discussed As such, ***no significant impacts*** are anticipated as a result of spud-can holes from jack-up barge activity within the Humber Gateway site.

In positioning the jack-up barges during construction activity, there is also the potential for up to six anchors to be used to maintain the barge position. Based on the worst case assumptions previously set out, each anchor is estimated to interact with approximately 20 m^2 of seabed, or up to 120 m^2 per barge (including some anchor dragging). Anchor mark dimensions vary according to the anchor design and the angle at which the anchor meets the seabed. Impacts caused by anchor positioning are small and temporary as the anchors are not left in-situ once construction is complete. Anchor marks are expected to refill with sediment and to be re-colonised easily by flora and fauna. In summary, the impacts are considered *imperceptible* in magnitude. As previously stated, the benthic habitats are considered to be of *low* sensitivity in the context of temporary disturbance. For these reasons, ***no significant impacts*** are anticipated as a result of anchor head penetration during jack-up barge activity within the wind farm site.

The boulder clay formations (mud huts) that are used by adult and juvenile lobsters are located approximately 1 km offshore and are therefore further inshore than the zone within which the jack-up barge activity will occur. As such, ***no significant impacts*** are anticipated.

In summary, ***no significant impacts*** from construction vessel activity (spud-cans and anchors) are anticipated.

Habitat and Community Disturbance during Inter-Array and Export Cable Installation

The following activities have the potential to result in impacts to benthic communities as a result of inter-array and export cable installation:

- vessel positioning during cable installation activities; and
- cable installation activity (trenching, jetting, ploughing).

The export cable construction corridor is 300 m wide and in this area, anchors will be used by the cable laying vessels, to pull themselves forward. Different types of cable laying vessel and barge are anticipated for the installation of the various sections of cable, as described in *Section 6*.

The worst-case scenario in terms of seabed impacts is the use of a lay-barge for the installation of the export cable. Lay-barge anchors can cause the formation of anchor mounds with localised impacts to seabed topography, particularly over boulder clays and other coarse sediments. As previously described, lay-barges require eight anchors that are deployed at approximately 500 m intervals along the cable route. Each anchor is estimated to interact with a maximum of 20 m^2 of seabed at the point of contact. The worst-case scenario for the scale of disturbance to the seabed is therefore predicted to be in the region of 0.022 km^2 (2.2 ha). The anchors will be repositioned with care by an accompanying tug in order to avoid unnecessary seabed disturbance.

The percentage of the total Humber Gateway site that will be affected by anchor interactions with the seabed is sufficiently small (in the context of the wider area) that the impact is considered to be of *low* magnitude, especially as the presence of the anchor arrays at each location are temporary and would be likely to refill and recover in time. Seabed disturbance will be localised and will cause minimal impacts in comparison with natural processes and other more widespread activities such as marine aggregate dredging. Given the *low* sensitivity of the benthic communities (in the context of temporary disturbance and recoverability), ***no significant impacts*** are anticipated.

Cables will be buried using ploughing, jetting or trenching techniques or a combination of these. As shown in *Table 11.6,* trenching is anticipated to cause the greatest degree of direct disturbance as it requires the widest corridor width (6 m). This includes the trench itself, and also the area adjacent to the trench onto which the excavated material is temporarily placed prior to back-filling. As such, trenching techniques are considered as the worst-case scenario in terms of habitat and community disturbance and loss. If trenching techniques are used to install all cables, the total anticipated area disturbed would be 47 ha (although it should be noted that trenching is a difficult and expensive process, and in reality will only be used in exceptional circumstances.) If jetting or ploughing techniques are used, the area of seabed to be directly affected would be less.

When considering the sensitivity of the benthic communities that might be affected as a result of trenching activity, it is important to acknowledge the presence of *Sabellaria* communities within the export cable corridor areas (as identified in the benthic and subsequent *Sabellaria* surveys). Through consultation with Natural England (formerly English Nature), E.ON have committed to undertaking a preconstruction *Sabellaria* survey in order to identify the locations of any aggregated *Sabellaria* species within the preferred cable route corridor. This commitment forms part of the embedded mitigation and will ensure that during the detailed design stage, the cable will be micro-routed such that impacts to *Sabellaria* spp are minimised. Cobble habitats will also be noted during the surveys and disturbance minimised as far as possible.

The percentage of the total Humber Gateway site and cable route areas that will be affected by cable installation is sufficiently small (in the context of the wider area) that the impacts are considered to be of *low* magnitude, especially as the trenches will be backfilled and will recover in time. Again, seabed disturbance will be localised and will cause minimal impacts in comparison with natural processes and other more widespread activities. Given the *low* sensitivity of the benthic communities (in the context of temporary disturbance and recoverability), ***no significant impacts*** are anticipated.

Increased Suspended Sediment Concentrations and Smothering

Construction activities including seabed preparation, foundation installation and cable-laying, have the potential to disturb sediments on the seabed and cause elevated suspended sediment concentrations via the suspension of sediment in the water column. Increased suspended sediment concentrations can:

- reduce primary productivity rates due to reduced light penetration of the water column;
- clog the feeding organs of filter feeding species; and
- affect the distance at which crustaceans can react to stimuli including the prey capture success of visual predators and scavengers (e.g. the brown crab *Cancer pagurus*).

Elevated suspended sediment concentrations could inhibit and reduce the availability of phytoplankton productivity rates due to reduced light penetration of the water column. In turn, this could reduce the availability of the zooplankton that feed on them and cause impacts for the wider food chain (e.g. filter feeders). As the predicted increases in suspended sediment concentrations are within natural variability (*Section 10.2*), the magnitude of change is considered to be *low*. The sensitivity of benthic communities to temporary change is considered to be *low*. As a result, ***no significant impacts*** are anticipated.

Resettling of disturbed fine sediments has the potential to result in the smothering of benthos. This may be partial smothering causing increased survival effort, or complete smothering that can lead to death particularly in some sessile organisms. The activities which have the potential to cause the greatest degree of disturbance to the seabed sediments are described in the water quality assessment (*Section 10.2*) and are summarised as follows:

- seabed preparation prior to the installation of gravity base foundations would involve the excavation of 1,885 m^3 of sediment; and
- drilling during monopile installation would generate 1,321 m^3 of sediment.

Any displaced material will be left in-situ, allowing it to disperse and re-profile naturally around the turbine foundations. Investigative work (e.g. further geotechnical investigations) will be carried out to determine whether or not this strategy is appropriate. If the need arises, the alternative strategy (which requires no further environmental information at this stage) will be to dispose of the material at a licensed spoil site. A FEPA licence application and Environmental Impact Assessment would, in this case, be required under Section 5 of the *Food and Environmental Protection Act 1985* for the disposal of the material, and a submission for a licence would be made as a separate application.

Numerical modelling (described in the water quality assessment, *Section 10.2,* and summarised in *Table 11.8*) indicates that the greatest upper range of suspended sediment (up to 300 mg l^{-1}) is associated with the installation of the gravity base foundation.

Table 11.8 Suspended Sediments

Location	Suspended sediment range
Monopile construction site	Up to 260 mg l^{-1} (typical values 20 mg l^{-1})
Within tidal excursion from monopile turbine	Decreasing with distance
Gravity base construction site	Up to 300 mg l^{-1} (typical values 20 mg l^{-1})
Within tidal excursion from gravity base turbine	Decreasing with distance
Cable route site	Up to 200 mg l^{-1} (typical values 5 mg l^{-1})
Beyond 1 km from cable route	Imperceptible

These elevated levels of suspended sediment concentrations are localised in nature and typical values across the area impacted are predicted to be in the region of 20 mg l^{-1} which is within the natural variability. Reduced light penetration as a result of elevated suspended sediments in the water column is predicted to be of short duration (*low* magnitude). As the sensitivity of the species present is also *low* given that the predicted suspended sediment concentrations are within natural variation, ***no significant impacts*** are predicted.

The extent of suspended sediment transport is dependent on the settling velocities of the sediments involved and also on the hydrodynamics occurring at the time. Coarse grained sediments will fall out of suspension quickly and are therefore unlikely to be transported over significant distances. Finer sediments such as chalk fines fall out of suspension much less readily and can therefore be transported over entire tidal excursions and remain in suspension for some time.

The significance of increased suspended sediment concentrations caused by construction activities must be balanced against the extent to which this occurs due to natural causes such as storm surges. Natural storm events frequently increase turbidity levels in the North Sea and as a result the benthic community in the Humber Gateway study area is largely adapted to turbid waters. *Sabellaria* spp., for example, are adapted to tolerate high levels of suspended solids and may even favour habitats that demonstrate this environmental parameter as they characteristically require suspended sediments for their tube-forming behaviour. Certain species of tunicate and ascidian, however, are slightly less tolerant to extreme turbidity over prolonged periods but these species have commonly been found in the same habitat as *S. spinulosa,* implying that they do possess some degree of tolerance.

During the Scoping phase, particular concern was raised by fishermen that increased suspended sediment concentrations during turbine and cable installation have the potential to adversely affect crustaceans. As described in *Section 10.2* suspended sediments in the area are naturally high and elevated concentrations arise frequently as a result of storm events. Modelling has estimated that the typical temporarily elevated suspended sediment concentrations that would result from installation of gravity base turbines or jetting along the cable route will be in the order of approximately 20 mg l^{-1}. This is within the range of background concentrations, although slightly greater than the average value of 12.6 mg l^{-1}. Modelling predicted that the maximum spatial extent of the 20 mg l^{-1} plume was approximately 8 km by 3 km.

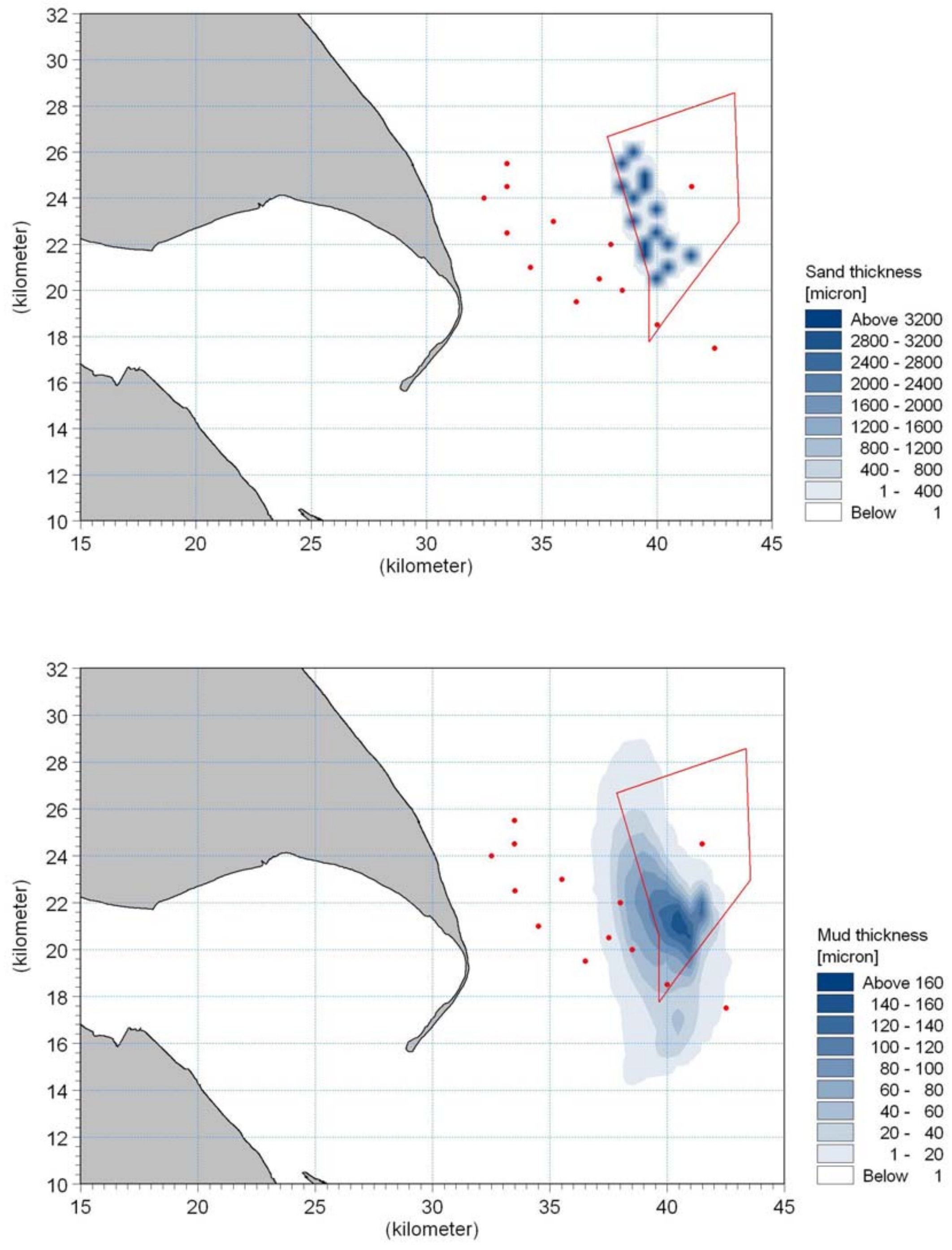
Crustaceans within this area may exhibit avoidance behaviour and those in the areas of highest suspended sediment concentrations may suffer physiological impacts. However, these impacts are anticipated to be highly localised and of short duration with no long term impacts on population stability. The degree of disturbance is therefore *low* although the receptor is of *moderate* sensitivity and overall only ***minor significant impacts*** to crustaceans are anticipated.

The greatest extent of seabed level change as a result of sedimentary deposition is associated with the gravity base foundation option (*Section 10.3.2)*. Maximum increases are predicted to be in the region of 3,200 µm (or the equivalent of three grains of sand). The mud sized material is anticipated to disperse over a wider area, however the greatest deposition is likely to be in the vicinity of the turbine site (1,200 µm and 160 µm for monopile and gravity base, respectively). This has been modelled and is summarised in *Figure 11.1.*

The area within which deposition is predicted to occur extends approximately 7 km (north to south) and 2 km (east to west) from the foundation installation locations. This indicates that depositional change may potentially occur at some of the sites identified supporting *Sabellaria* spp. Cobble habitats may also be present at these locations. However, at these locations it is predicted that the degree of change would be a maximum of 300 µm. *Sabellaria* spp. are able to successfully tolerate this degree of smothering, as are the other benthic species found in the area [(1)]. As the sensitivity of the community (in relation to smothering) and the magnitude of the impact are both *low,* ***no significant impacts*** in relation to increased suspended sediments in the water column and the consequential re-deposition on the seafloor and benthos are anticipated.

[(1)] Holt T J, Rees E I, Hawkins S J & Seed R, 1998. Volume IX. Biogenic reefs: an overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project).

Figure 11.1 Sediment Deposition from Construction of a Gravity Base



Note: Red dots indicate locations of Sabellaria communities identified during the benthic survey.

The worst case cable installation method in relation to the potential for increasing suspended sediment concentrations is jetting. Jetting fluidises sediments along a narrow trench, allowing the cable to fall into the trench and immediate burial to occur through settling of sediment. Jetting is predicted to result in some re-suspension and settlement of sediments. Whilst the cable installation method is currently unknown, this assessment considers its use for all cable burial in order to identify the worst case impacts.

Background concentrations of suspended sediments in the Humber region range between 8 and 128 mg l^{-1} in winter and 4 and 256 mg l^{-1} in summer[(1)]. Modelling has not been undertaken specifically to cover jetting activity, however the results from other aspects of the development imply that the potential level of increased turbidity caused by jetting will not be greater than background levels or those caused by natural conditions such as the Humber Estuary plume and storm surges. Suspended sediments can be expected to fall out of suspension within one tidal excursion from the source.

The coastal process modelling (*Section 10.3*) predicts an increase in seabed thickness in the order of 5.6 µm (equivalent to one grain of very fine silt). *Sabellaria* spp. have been reported as being tolerant of smothering by up to 5 cm of sand for up to several weeks [(2)] and to recolonise storm disturbed sediments within one year [(3)]. The implication is that recovery rates of any disturbed areas would be rapid. In the context of the wider region, only a small area of seabed will be affected and only a small number of individuals will be injured or killed. Most benthic species that inhabit the southern North Sea demonstrate this level of adaptability due to the frequency of disturbance through storm events. The magnitude of the impact is considered to be *low* (taking natural variability into consideration) and the sensitivity of the communities present is also *low* (due to the known recoverability). As such, ***no significant impacts*** as a result of resettlement of suspended sediments resulting from cable laying activities are anticipated.

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(1) Cefas, 2002. Southern North Sea Sediment Transport Study - Sediment Transport Report. Great Yarmouth Borough Council by HR Wallingford, Cefas/UEA, Posford Haskoning and Dr. Brian D'Olier

(2) Jackson A & Hiscock K, 2007. *Sabellaria spinulosa*. Ross worm. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 04/07/2007]. Available from: <http://www.marlin.ac.uk/species/Sabellariaspinulosa.htm>

(3) Holt T J, Rees EIS, Hawkins S J & Seed R, 1998. Biogenic Reefs (volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project).

Changes to Water Quality during Construction

Sediment concentrations of organic matter, polycyclic aromatic hydrocarbons (PAHs) and heavy metals were all found to be low in the development area (*Section 7.3.1*). Any water quality implications of sediment disturbance are thus *negligible*. As such, ***no significant impacts*** in relation to effects on benthic ecology from re-mobilised contaminants are anticipated.

To date, there have been no major leaks or spills from wind farm construction activities. As industry best practice will be used at all times, the likelihood of any such release within the scope of the Humber Gateway project is very small. Any accidental spillages that may occur are likely to be of sufficiently small volumes that dispersal in the water column will be rapid, and the sensitivity of the environment is therefore *low*. The likelihood that contaminants from leaks or spills would reach the benthic environment is therefore *negligible* so there will be ***no significant impacts*** to benthic ecology.

Noise and Vibration during Construction

Pile driving of monopile foundations is reported as causing noise levels in the range of 180 to 250 dB, with much of the energy concentrated in the 100 Hz to 2,000 Hz range [(1)]. Although the effects of noise on benthic species are poorly understood, behavioural changes may be induced in response to construction noise. Horridge [(2)] found statoliths in the common lobster *Homarus gammarus* to act as underwater vibration receptors, whilst Lovell et al [(3)] showed that the common prawn *Palaemon serratus* to be capable of hearing sounds within a range of 100 to 3,000 Hz. The North Sea shrimp *Crangon crangon* reacts to frequencies around 170 Hz by accelerating the backward flicking of the large second antennae [(4)]. This evidence implies that crustacea are able to detect and react to noise in the marine environment including the ranges created by marine construction activities.

Although the benthic community is likely to be habituated to ambient subsurface noise created by wave action or the busy shipping lane, the noise created by piling may cause alarm and fear mechanisms. This has been found to be the case during seismic explorations involving noise up to 250 dB at 10 - 120Hz [(5)]. Polychaetes tended to retreat into the bottom of their burrows or retract their palps, and bivalve species withdrew their siphons. The air-filled cavities within certain benthic invertebrate species may alter the transmission of sound waves through their bodies, which could potentially cause physiological damage.

Many species are more sensitive to physical vibration than to sound per se, which explains the obvious reactions to seismic exploration noise. It is possible, however, that the higher frequencies caused by piling are beyond the limit of detection for some species. Piling noise is in the same decibel range as seismic noise so some fear mechanisms and reactions may be encountered in subtidal benthic species. The extent of any stress, physiological damage or mortality would be localised around the monopile foundations where noise generation will be at the highest magnitude.

Pile driving is likely to have a negative impact on benthic species, particularly within the immediate vicinity of each turbine where noise levels will be highest. However, given that even high impacts are not anticipated to affect the wider ecosystem, the magnitude of impact is considered to be *low*, particularly having regard to the 'soft start' procedure that will be used. The localised and temporary nature of this impact means that the area is limited and communities will start to recover once piling ceases and as such, the sensitivity is considered also to be *low*. For these reasons, ***no significant impacts*** are anticipated.

Potential Impacts during Operation

Habitat and Community Alteration or Loss as a Result of the Physical Presence of the Turbine Foundations and Scour Protection

The 7 MW gravity base layout (Layout 5) represents the worst case scenario as it has the largest seabed footprint covering a total seabed area of 161,656 m^2 or 0.46 % of the total Humber Gateway site (*Table 11.5*), including scour protection.

The interaction between the foundation and the seabed will result in permanent habitat loss including cobble habitat that supports *Sabellaria* spp. The extent of this impact in a regional context is small given the overall size of adjacent comparable subtidal habitats. The degree of disturbance is therefore considered to be *low.* The duration of the disturbance is also an important factor and is considered long term as a result of the permanent nature of the structures. The benthic habitats and the species are considered to be of *medium* sensitivity (in

(1) Robinson S and Lepper P, 2007. Baseline Underwater Noise Measurements for the Humber Gateway Offshore Wind Farm. National Physical Laboratory and Loughborough University, UK.
(2) Horridge G A, 1966. Some recently discovered underwater vibration receptors in invertebrates. In: Barnes, H. (ed.), Some Contemporary Studies in Marine Science, George Allen and Unwin Ltd., London.
(3) Lovell et al, 2005. The hearing ability of the prawn *Palaemon serratus*. Comp. Biochem. Physiol. 140, 89-100.
(4) Heinisch and Weise, 1987. Sensitivity to movement and vibration of water in the North Sea shrimp *Crangon crangon* L. Journal of Crustacean Biology, 7(3):401-413.
(5) Richardson W et al, 1995. Marine Mammals and Noise, Academic Press.

the context of direct habitat loss). For these reasons, there will be ***minor significant impacts***.

Changes to Sedimentary Composition and Bathymetry by Scour during Operation

Scour will only occur where the seabed is erodable by the force of currents. There are no extensive areas of mobile sediments with the exception of the southern edge of the site (Physical Baseline, *Section 7*). Furthermore, the presence of serpulid worm tubes on the upper side of cobbles and boulders [(1)] implies that the sediments are seldom moved by currents or tides.

The coastal process modelling has predicted the degree of scour that would result from both monopile and gravity base foundations and the maximum scour depth is anticipated to be 2.6 m [(2)]. However, it should be noted that scour monitoring at similar sites indicate that the likelihood of scour both with and without scour protection is very low as previously discussed. As such, ***no significant impacts*** to subtidal benthic ecology are anticipated as a result of scour by the turbine structures (with or without scour protection).

Colonisation of Solid Surfaces during Operation

Materials placed in most marine environments become colonised by marine organisms. Initially, a surface organic film forms on submerged structures that is subsequently colonised by a variety of micro-organisms. As the community evolves, secondary colonists such as algal spores and the planktonic larvae of barnacles (cyprids) become established. This community then forms a habitat for tertiary colonists including a wide variety of invertebrate species. The presence of the biofouling community is likely to attract pelagic and mobile benthic predators, leading to an overall increase in localised biodiversity and abundance.

Species likely to colonise the foundation and tower structures in the Humber region have been summarised by Hiscock et al [(3)] and are shown in *Table 11.9*. Anti-fouling paints containing biocide will be used on the surfaces on the turbine structures where human access is required. This type of paint will not be used on the subtidal surfaces of the turbine structures so that colonisation will not be prevented.

Table 11.9 Examples of Species Likely to Colonise Submerged Turbine Structures

Intertidal zone	Shallow subtidal zone (<0.1 to 6 m depth)	Deeper subtidal zone	Scoured area and structure base
Green algae	Green, red and brown algae	Bryozoan sea mats	Encrusting bryozoan seamats
Encrusting lichen	Hydroid sea firs	Hydroid sea firs	Benthic crustacea (e.g. crab, lobster)
Barnacles	Barnacles	Barnacles	Barnacles
Solitary and clumped sea squirts	Annelids (e.g. Keeled tubeworm)	Solitary and colonial sea squirts	Annelids (e.g. Keeled tubeworm, Ross worm)
Bivalves (e.g. mussels)	Encrusting bryozoan seamats	Bivalves (e.g. mussels)	Bivalves (e.g. mussels, clams)
Molluscs (e.g. winkles, whelks)	Sea lettuce	Feather stars	Flatfish (Plaice, Sole)
Sea anemones	Sea anemones	Sea anemones	Pelagic fish (e.g. wrasse, bib, pollack)
Limpets	Sea sponges	Sea sponges	Sea sponges
Amphipod crustaceans	Amphipod crustaceans	Star fish	Star fish

Environmental parameters such as water temperature and current speed are controlling factors for the diversity and abundance of colonising communities, whilst storm events frequency affect the rate of succession. Generalised predictions can be made based on the fouling of other structures in similar environments such as the North Hoyle [(4)] and Blyth [(5)] Offshore Wind Farm projects. Post-construction monitoring surveys at these sites have since verified

[(1)] D'Olier B, 2003. Offshore Humber - Sites A,B,E - Geological desk study.
[(2)] ABPmer, 2007. Humber gateway Coastal Processes Embedded Mitigation Assessment.
[(3)] Hiscock K, Tyler-Walters H, Jones H, 2002. High level environmental screening study for offshore wind farm developments – Marine habitats and species project. Report from the Marine Biological Association to the Department of Trade and Industry New and Renewable Energy Programme. (AEA Technology, Environment Contract: W/35/00632/00/00).

[(4)] Bunker, F St P D, 2004. Biology and video surveys of North Hoyle wind turbines 11-13th August 2004. A report to CMACS Ltd by Marine Seen, Estuary Cottage, Bentlass, Hundleton, Pembs. SA7 5RN.
[(5)] Mercer T, 2001. Blyth Offshore Wind Farm: Post-construction Sublittoral Biological Survey. Aquatic Environments.

the community compositions. There is a high likelihood, therefore, that some or all of the species listed in *Table 11.9* will colonise the turbine and foundation structures following installation.

A conservative estimation of the surface area available for colonisation can be calculated using the dimensions of the various turbine options and the maximum water depth across the Humber Gateway site (*Table 11.10)*.

Table 11.10 Maximum Vertical Subtidal Surface Area for the Various Turbine Options

Layout number	MW	Foundation type (number)	Turbine foundation diameter (m)	Maximum water depth assumed across site (m)	Total subtidal vertical surface area (m^2)
1	3.6	Monopile (83)	4	21	21,906
1	3.6	Monopile (83)	6	21	32,859
2	3.6	Gravity base (83)	20	21	63,578
5	7	Gravity base (42)	40	21	82,362

The largest surface area possible arises from the gravity base option, providing 82,362 m^2 of vertical surface (assuming the maximum water depth of 21 m to occur across the entire turbine site).

The communities colonising each turbine are likely to be zoned according to depth, and to show variations in species richness, diversity and abundance as the spacing between the turbines will limit interactions to the most mobile species. If a Safety Zone surrounding each turbine is considered necessary and is implemented during operation, a degree of protection will be provided to the biofouling community on each turbine. The impact is therefore likely to be highly localised around the individual turbine structures. The degree of effect is therefore *low* but of *moderate* importance to regional benthic ecology given the total maximum area available for colonisation and the scarcity of other vertical surfaces in the region. For these reasons, a ***minor positive significant impact*** is anticipated.

Electromagnetic Fields during Operation

The electromagnetic fields associated with the generation of electricity have the potential to cause impacts on certain marine organisms, in particular elasmobranch fish. The Collaborative Offshore Wind Research into the Environment (COWRIE) group is currently leading on research in this area. Where relevant, these studies are described in the fish assessment section (*Section 11.4.2*).

The potential for electromagnetic fields to impact benthic invertebrates is poorly understood. However, monitoring studies conducted at Horns Rev in Denmark [(1)] and at North Hoyle [(2)] showed that the behavioural change in the benthic community that could be attributed to electromagnetic fields was *negligible*. Even if there was an impact to benthic communities, it would be very localised and in the context of the ecosystem in the wider area, the magnitude would be considered *low*. There will therefore be ***no significant impacts** to* benthic communities as a result of electromagnetic fields.

Cable Heating during Operation

The sustained flow of electrical current through the export cables has the potential to cause heating of the cables and the surrounding sediments due to electron resistance. This may have the potential to have localised affects on benthos by causing stress or increasing susceptibility to disease.

The Connecticut Siting Council conducted an analysis of heat radiation from buried high voltage DC cables during a planning application process for the Cross Sound Cable Interconnector project between New England and Long Island New York [(3)]. The findings showed that the sediments above the cables buried 1.8 m below the surface could be heated by 0.19˚C with only an imperceptible increase in adjacent water temperatures. This increase is within the range of naturally occurring temperature variations in the North Sea and can therefore be tolerated by benthic communities, and the sensitivity of the environment is therefore *low*.

The natural ranges of a number of commercially exploited species extend southwards to warmer waters, as far as West Africa in the case of the edible crab *Cancer pagurus*. Given the proposed cable burial depth (1 to 3 m), any heating effect will be *imperceptible* to benthos or the overlying water column. Accordingly, ***no significant impacts** to* benthic communities are anticipated as a result of cable heating.

(1) Bio/Consult, 2005. Infauna monitoring. Horns Rev Offshore Wind Farm. Annual Status Report, 2004.
(2) npower Renewables Limited, 2003. Baseline Monitoring Report. North Hoyle Offshore Wind Farm.
(3) http://www.eia.doe.gov/cneaf/pubs_html/feat_trans_capacity/water_sale.html

Noise and Vibration during Operation

7 MW turbines are predicted to have a noise output of no greater than 110 dB at hub height, measured according to the IEC 61400-11 standard [(1)]. There have been no predictions made for sub-sea operational noise and vibrations but subsea levels will be greatly reduced in comparison with atmospheric levels. As mean ambient subsea noise levels are within a range of 120 dB at 1 Hz for turbulence to 30 dB at 100 kHz for sporadic local surface noise, operational noise will be of *low* magnitude and low frequency. The noise levels will be comparable to existing baseline level caused by shipping and other marine activities, and the sensitivity of the environment is therefore *low.* Consequentially, any impact to subtidal benthic ecology caused by noise or vibration will be *imperceptible*. As the sensitivity of the receptor is low to medium, ***no significant impacts*** are anticipated.

Potential Impacts during Decommissioning

Disposal of Decommissioned Structures

The *OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations* that came into force in 1999 states that dumping or leaving wholly or partly in place disused offshore installations within the maritime area is prohibited. There are certain instances, however, where a permit can be approved for alternative disposal or dumping at sea of particular parts of the structures. It is possible that monopiles could be cut off below the seabed, leaving the foundations in place. Under such a permit, the concrete foundations of 7 MW gravity based turbines, and possibly the associated scour protection proposed by this development, may also be left in place. This is considered to be the worst case scenario as an area of 161,656 m^2 of the seabed would be permanently impacted.

E.ON is committed to undertaking best practice procedures in terms of decommissioning. A full review of best practice procedure will be undertaken at the appropriate time in order that the most appropriate decommissioning plan may be agreed with BERR and The Crown Estate.

Removal of Colonised Artificial Substrates through Decommissioning

Any communities that may have colonised the turbine and foundation structures over the lifetime of the Humber Gateway development will be removed with the turbines when they are eventually decommissioned. This will result in a localised reduction in biodiversity, refuge habitat and of a food resource for predators and grazers. As the colonising communities would be present only as a result of anthropogenic activities, any ecological loss as a result of the removal of the artificial substrate would only negate the minor positive impact observed as a result of the presence of the artificial structures.

Increased Suspended Sediment Concentrations and Smothering during Decommissioning

The removal of the foundation structures will cause the suspension of fine sediments and leave a cavity in the seabed. This may cause localised alterations to sediment movement and hydrodynamics and cause localised smothering of biota via the resettlement of suspended material. This is also true of cable removal if it is removed by trenching. If the cable is removed at the shore by being pulled through the bore, it will cause a minimal impact as the seabed surface will not be disturbed. The extent of suspended sediment and smothering impacts are likely to be comparable to those occurring during the construction phase, although there is potential for the impacts to be of shorter duration.

Disturbance of the seabed (resulting from removal of the cables and turbine structures) leading to an increase in suspended sediment levels and associated smothering effects will be similar to that caused by construction activities. However, the magnitude of impacts is likely to only be *low* and shorter in duration. The sensitivity of the community is *low* due to the ability of the species to recover from smothering as has been previously described, and any elevated turbidity caused by decommissioning of the project will be temporary. As a result, ***no significant impacts*** are anticipated in relation to increases in suspended sediments associated with decommissioning activities.

Changes to Water Quality Due to the Release or Spill of Construction Materials or Chemicals

Best practice techniques and procedures will be adopted during the decommissioning phase and the likelihood of any releases or spills of construction materials or chemicals will therefore be very *low.* Any accidental spillages that may occur are likely to be of sufficiently small volumes that dispersal in the water column will be rapid. The likelihood that contaminants from leaks or spills would reach the benthic environment is therefore negligible. As such, ***no significant impacts*** to subtidal benthic communities are anticipated.

[(1)] Robinson S and Lepper P, 2007. Baseline Underwater Noise Measurements for the Humber Gateway Offshore Wind farm. National Physical Laboratory and Loughborough University, UK.

11.3.3 Mitigation Measures

No further mitigation measures are proposed in addition to those already incorporated as embedded mitigation (*Section 11.3.1*).

11.3.4 Residual Impacts

The predicted residual impacts are the same as those described in the potential impacts section (*Section 11.3.2*).

11.3.5 Monitoring

The requirement for any post-construction surveys will be discussed with Natural England and JNCC. The objectives and designs of these surveys will be developed at the appropriate time in line with current best practice.

11.3.6 Enhancements

Following the colonisation of wind farm turbines and foundations by the communities described in *Section 11.3.2*, secondary communities can be supported that further enhance the region's biodiversity and abundance throughout the lifetime of the structures. The extent to which this will constitute a reef-effect as opposed to being simply small-scale localised colonisation depends on the level to which the turbine colonising communities interact. Recent studies [(1)] have shown that not all artificial structures placed in the marine environment develop into what can be termed as an artificial reef.

Nonetheless, the presence of turbine towers will increase habitat heterogeneity and potentially increase the attractiveness of the area for fish. If generic research shows this to be the case, then it may be considered to be more environmentally beneficial and cost-effective to leave the turbine foundations in place than to remove them on decommissioning.

[(1)] Linley E A S, Wilding T A, Black K, Hawkins A J S, and Mangi S, 2007. Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd to the Department of Trade and Industry, Contract No. RFCA/005/0029P.

11.3.7 Summary

The principal impacts to benthic ecology relate to loss of seabed habitat as a result of the presence of the physical scheme components (cables, turbine foundations and scour protection) during the operational phase. In addition, temporary disturbance, both in the form of temporary physical disturbance to the seabed and from increased suspended sediment concentrations as a result of seabed disturbance. The species that inhabit the area are largely considered to be well adapted to tolerate environmental disturbance and to have high recovery rates given that they inhabit a high energy environment that is prone to change through storm events.

Sabellaria alveolata and *S.spinulosa* are species of conservation importance that have been identified in the inshore area proposed for the cable route. Cobble habitats have also been identified as being important. As agreed with Natural England, further ecological surveys will be carried out prior to construction in order to assess the presence of *Sabellaria* spp., in order that the cable can be micro-routed to avoid disturbance to these species. The survey will also assess the cobble habitat found within the development site in order to assess its potential as cobble reef under the *Habitats Directive*. The results of this survey will facilitate any necessary micro-siting of the turbines in order that habitats of conservation importance may be preserved.

There may be a net environmental benefit brought to the ecosystem by the presence of the turbine and foundation structures through increased habitat heterogeneity and the localised increase in sessile epifauna associated with fixed substrates. The extent of this benefit will depend on environmental parameters such as current speeds that may prevent certain species from adhering to the structures. On decommissioning, any positive impacts in this regard would be negated if the structures were removed. The potential for long-lived predatory species to be poorly adapted to a sudden change in food resource availability will be assessed prior to decommissioning in order that any potential impacts may be mitigated.

A summary of potential and residual impacts to subtidal benthos is presented in *Table 11.11.*

Table 11.11 Summary of Impacts to Benthic Communities

Impact	Potential Impact Significance	Additional Mitigation (in addition to embedded mitigation)	Residual Impact Significance
Habitat and community disturbance as a result of construction vessel positioning	*No significant impacts*	None	***No significant impacts***
Habitat and community disturbance as a result of inter-array and export cable installation	*No significant impacts*	None	***No significant impacts***
Increased suspended sediment concentrations and smothering during construction	*Minor significant impacts to crustaceans*	None	***Minor significant impacts*** *to crustaceans*
	No significant impacts to all other species	None	***No significant impacts*** *to other species*
Changes to water quality during construction	*No significant impacts*	None	***No significant impacts***
Noise and vibration caused by construction activities	*No significant impacts*	None	***No significant impacts***
Habitat and community loss as a result of presence of turbine foundations and scour protection	*Minor significant impacts*	None	***Minor significant impacts***
Changes to sediment composition and bathymetry by scour	*No significant impacts*	None	***No significant impacts***
Colonisation of solid surfaces during operation	*Minor positive significant impacts*	None	***Minor positive significant impacts***
Electromagnetic fields during operation	*No significant impacts*	None	***No significant impacts***
Cable heating during operation	*No significant impacts*	None	***No significant impacts***
Noise and vibration during operation	*No significant impacts*	None	***No significant impacts***
Increased suspended sediment concentrations and smothering during decommissioning	*No significant impacts*	None	***No significant impacts***
Changes to water quality as a result of release or spills	*No significant impacts*	None	***No significant impacts***

11.4 FISH

11.4.1 SCOPE AND METHODOLOGY

Introduction

Using the baseline information in *Section 8.5*, and in accordance with current EIA guidance, the following sections address the potential impacts of the Humber Gateway development on the ecology of fish species in the area.

Throughout the construction, operation and decommissioning phases, activities occurring both above and below the seabed interact with seabed sediments and therefore have the potential to impact fish communities, migration routes, spawning activities and nursery areas of particular species. In addition, there are potential noise impacts, which could affect fish during construction and decommissioning and to a lesser extent during operation. There may also be potential impacts to sensitive species from electromagnetic fields from cable infrastructure during operation.

The fish ecology impact assessment investigates the potential impacts to the fish populations around the Humber Gateway site (International Council for Exploration of the Seas (IECS) rectangle 36F0-3). Fish species present within the central North Sea (ICES rectangles 35F0, 35F1, 36F0, 36F1, 37F0 and 37F1) that could be affected are also considered. The assessment gives priority to those species that are of high importance due to their commercial value or their protection status.

Consultation and Scope

Cefas [(1)] and Defra [(2)] guidance notes for EIA with respect to FEPA / CPA requirements identify a range of foreseeable issues affecting fish as the result of offshore wind farm construction. These guidelines suggest that the following aspects of fish biology should be assessed:

- feeding areas;
- spawning grounds;
- nursery grounds; and
- migration routes.

Issues specific to offshore wind farms that may affect fish populations include noise and vibration, electromagnetic fields and their influence on elasmobranchs, changes in habitat, changes in prey distribution and availability, loss of spawning or nursery grounds and obstruction to migration routes. As a general consideration, the Environment Agency also stresses the importance of assessing the impacts on migratory fish such as salmon.

Cefas and Natural England (formerly English Nature) were consulted on the scope of the fish survey work and the Marine and Fisheries Agency (MFA) had the opportunity to comment on the survey findings. Where appropriate, the comments have been taken on board in the assessment.

The baseline information has identified a number of fish species that are the most likely receptors of impacts from the Humber Gateway development. These fish species include cod *Gadus morhua*, herring *Clupea harengus*, whiting *Merlangius merlangus*, plaice *Pleuronectes platessa*, Dover sole *Solea solea*, sprat *Sprattus sprattus*, sea bass *Dicentrarchus labrax*, sandeels *Ammodytes* spp., lemon sole *Microstomus kitt* s, dab *Limanda limanda* , Atlantic salmon *Salmo salar*, sea trout *S. trutta* and twaite shad *Alosa fallax*. Many of these species have nursery, spawning and feeding grounds in or near the Humber Gateway site that could potentially be affected by the development.

In addition, there are several elasmobranch species, including thornback ray *Raja clavata* and lesser spotted dogfish *Scyliorhinus canicula* where impacts from electromagnetic fields will be considered in addition to an assessment of impacts on feeding, spawning and nursery habitats.

Realistic Worst Case

The realistic worst case in relation to the fish assessment will be the same as that which is described for the benthic assessment (*Section 11.3.1*).

Embedded Mitigation

Embedded mitigation measures that have the potential to reduce impacts to fish species can be summarised as follows:

(1) Cefas, 2004. Offshore Wind Farms: Guidance note for Environmental Impact Assessment in respect of FEPA and CPA Requirements. Prepared by Cefas on behalf of the MCEU.
(2) Defra, 2005. Nature Conservation Guidance on Offshore Wind farm Development. A guidance note on the implications of the EC Wild Birds and Habitats Directives for developers undertaking offshore wind farm developments. Version R1.9.

- The inter-array and export cables will be armoured and buried at a sufficient minimum depth of 1 m (maximum 3 m) to reduce electromagnetic fields (EMF) and their impacts on sensitive fish species (especially elasmobranchs).

- During construction, overnight working practices will be employed so that construction activities will be 24 hours, thus reducing the overall programme and the potential for impacts to fish communities in the vicinity of the Humber Gateway site.

- Soft start procedures during pile driving will be implemented. This involves reducing the piling hammer pressure and the subsequent sound level starting at a low level, gradually increasing to full piling pressure. This enables fish in the area disturbed by the sound levels to move away from the piling before any adverse impacts are caused. An assumption of a 100 kJ starting hammer energy for a soft start has been made, increasing to 1,800 kJ over 600 hammer strikes. This method has been agreed with statutory consultees and implemented for other UK offshore wind farms.

Methodology

Guidance Documents

The following guidance documents were used in relation to the assessment of impacts to fish:

- *Offshore Wind Farms – Guidance Note for EIA in Respect of FEPA and CPA Applications,* Cefas, June 2004; and

- *Wind Farm Development and Nature Conservation,* BWEA March 2001.

Prediction Methods

In order to predict the potential impacts resulting from construction, operation and decommissioning of the Humber Gateway project, the type and magnitude of any activities must be considered in relation to the extent and duration of the activity and the sensitivity of the receptor, in this case the fish populations in the area.

Construction disturbance to the seabed and subsequent impacts to fish are one-off events that cause a relatively small impact (compared to activities such as marine aggregate extraction that have much greater long term effects over a wider area). In many cases, the seabed can recover from dredging activities within 12 months, with the species assemblage present before activity returning within this period [1] and full recovery to the same biomass level being achieved within three years [2]. The implication is that the recoverability is high and that the sensitivity of fish species to disturbance is therefore low.

Significance Criteria

In order to define ***major***, ***moderate*** or ***minor significant impact*** or ***no significant impact***, a matrix has been developed which compares the degree or magnitude of the disturbance with the sensitivity of the receptor, as shown in *Table 11.7*. Where professional judgement has been used, this is indicated in the text with an explanation of how the judgement has been made.

Table 11.12 Significance Criteria for Impacts to Subtidal Ecology

Degree of Effect / Magnitude	**Sensitivity of Receptor**		
	High	*Medium*	*Low*
High	***Major significant impact***	***Moderate significant impact***	***Moderate significant impact***
Medium	***Moderate significant impact***	***Moderate significant impact***	***Minor significant impact***
Low	***Moderate significant impact***	***Minor significant impact***	***No significant impact***
Imperceptible / negligible	***Minor significant impact***	***No significant impact***	***No significant impact***

(1) van der Veer H W, Bergman M J N, and Beukema J J, 1985. Dredging Activities in the Dutch Waddensea: effects on macrobenthic infauna. Netherlands Journal of Sea Research, 19:183-190.
(2) Kenny A J., Rees H L, Greening J, and Cambell S, 1998. The effects of marine gravel extraction on the macrobenthos at an experimental dredge site off north Norfolk, UK. (Results 3 years post dredging). ICES CM 1998/V,14.

There are many fish species present in the vicinity of the Humber Gateway site, as described in *Section 8.5.* The area is important for migration, spawning and as a nursery area for different fish species at different times of year. It is not known how sensitive each fish species is to different impacts but it is likely to depend largely on the level of disruption (spatial magnitude, duration) to the function that is important to that species (e.g. migrating cod etc). Given that fish are mobile species and can potentially avoid disturbance, impacts are not anticipated to be significant in all instances. As such, fish are considered generally to be of *low* to *medium* sensitivity with the exception of the twaite shad, which is considered to be of *high* sensitivity given its European protected status.

When considering the magnitude of an impact, the area over which the impact is experienced by the receptor and the duration of the impact is taken into account. These considerations have been applied and are further qualified in the assessments that follow.

It should also be noted that in some instances, embedded mitigation has been incorporated into the project description to minimise the potential impacts. In some instances, the mitigation is sufficient to prevent any significant impacts from occurring.

11.4.2 ASSESSMENT OF POTENTIAL IMPACTS

Potential Impacts during Construction

Fish Community Disturbance as a Result of Construction Vessel Positioning

The potential for disturbance to benthic communities during vessel positioning is described in *Section 11.3.2.* As a worst case scenario, a jack-up barge with six legs would create six spud cans per vessel resulting in a predicted area of habitat disturbance equal to 0.036% of the total Humber Gateway site.

Fish species that use the area as a spawning ground generally have pelagic, buoyant egg stages. As such, they will move to other areas to spawn and will not be affected by the temporary disturbance. Of the fish species present, Dover and lemon sole will be affected to the greatest degree because these species spend the majority of their time in direct contact with the seabed.

As the total area affected is small, the magnitude of the impact will be *low*. The reduction in feeding grounds will also be small in the context of the wider area and as fish are mobile species they will move to adjacent areas. The sensitivity of the species is therefore considered to be *low* to *medium.* For these reasons, ***no significant impacts*** to ***minor significant impacts*** are anticipated in relation to vessel positioning during construction.

As described in *Section 11.3.2*, the impact of anchor scars will occur intermittently throughout the construction period and will be scattered across the Humber Gateway site and cable route areas. Given the low level of disturbance by vessel anchorage (*low* magnitude), the small size of the area affected, the relatively quick rate of seabed recovery, and mobility of the fish species (*low* sensitivity), ***no significant impacts*** are anticipated as a result of vessel anchor activity.

Fish Community Disturbance during Installation of the Inter-array and Export Cables

The export cable route and inter-connector cables lie within spawning areas for sole and lemon sole as well as nursery grounds for sprat, herring, lemon sole and plaice. Cable installation activities have the potential to cause displacement of these species during construction.

Cable installation activity also has the potential to cause displacement of prey items for juvenile and smooth hound *Mustelus mustelus* which inhabit the nearshore clay hut formations (*Section 8.4.3*) at locations where the cable crosses this habitat.

Given the short duration of the cable installation, the magnitude of the impact is considered to be *low.* The sensitivity of the area in relation to fish is also considered to be *low* to *medium*. For these reasons, ***no significant impacts*** to ***minor significant impacts*** are predicted as a result of inter-array and export cable installation.

Noise and Vibration during Construction

The main sources of noise during construction will be associated with pile driving activity. Other noise sources include cable laying activity and increased vessel traffic in the vicinity of the Humber Gateway.

Noise levels caused by pile driving are predicted to be up to 256 dB at 1 m, with much of the energy concentrated in the 100 Hz to 200 kHz range (*Appendix E3*).

Studies of a North Sea fish species have found that cod *Gadus morhua* can hear sounds between 1 and 160 Hz [(1)], herring *Clupea harengus* between 30 Hz and 4 kHz [(2)] and dab *Limanda limanda* between 30 and 250 Hz [(1)]. The data for

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(1) Sand O and Karlsen H E, 1986. Detection of infrasound by the Atlantic cod. J. Exp. Biol. 125, 197-204.
(2) Enger P S, 1967. Hearing in Herring. Comp. Biochem. Physiol. 22, 527-538.

Atlantic salmon *Salmo salar* are sparse and indicate hearing is poor with a narrow frequency span [(2)]. Cod and herring in particular are particularly sensitive to noise. For dab and salmon the noise detection distance has not been defined [(3)].

Although the fish community is likely to be habituated to ambient subsurface noise such as that created by shipping, the sporadic noise created by piling may cause alarm responses and at close proximity could potentially cause physiological damage. Herring in particular have a swim bladder that includes an extension into the inner ear structure [(4)]. Cod do not have this connection but the anterior of the swim bladder is in close proximity to the inner ear [(3)]. These species are at greater risk to noise and vibration. However, the extent of any risk of physiological damage or mortality would be localised around the monopile foundations during piling where noise generation will be at its highest magnitude.

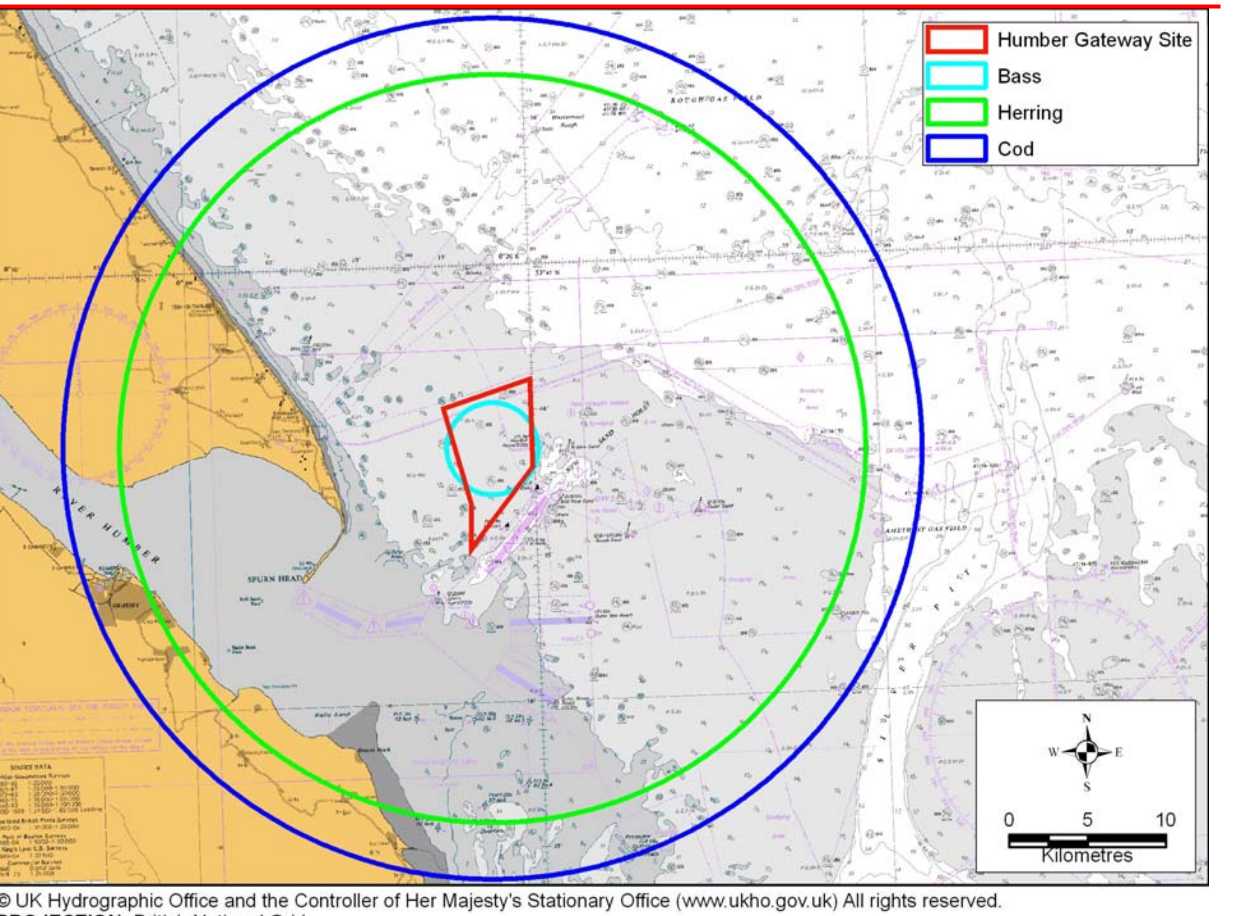
The impact on each fish species will range from avoidance reactions, through physical damage to mortality depending on their proximity to the pile driving activity. Possible behavioural responses to noise and vibration from pile driving may include avoidance reactions and changes in shoaling behaviour.

Site specific noise modelling predicted behavioural impact zones for a number of fish species as described in *Table 11.13* and *Figure 11.2.*

Table 11.13 Behavioural Impact Ranges and Auditory Impact Ranges

Species	Peak to peak perceived Source Level (dB_{ht}@1 m) for a 6 m diameter pile	Behavioural Impact Range (90 dB_{ht} range)
Cod	162	27.4 km
Herring	179	23.8 km
Dab	154	3.2 km
Bass	151	2.9 km

Figure 11.2 Behavioural Impact Ranges for Various Fish Species



PROJECTION: British National Grid

(1) Chapman C J and Sand O, 1974. Field studies of hearing in two species of flatfish *Pleuronectes platessa* (L.) and *Limanda limanda* (L.) (Family Pleuronectidae). Comp. Biochem. Physiol. 47A, 371- 385.
(2) Hawkins A D and Johnstone A D F, 1978. The hearing of the Atlantic salmon (*Salmo salar*). J. Fish. Biol. 13, 655-673.
(3) Thomsen F, Ludemann K, Kafemann R & Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish, biola, Hamburg, Germany on behalf of COWRIE Ltd.
(4) Popper A N , Plachta D T T, Mann D A & Higgs D, 2004. Response of clupeid fish to ultrasound: a review. ICES Journal of Marine Science 61, 1057-1061.

In order to reduce the impacts of pile driving noise and vibrations and reduce the potential for mortality of fish species, soft start procedures will be implemented as mitigation. This technique builds up the power and frequency of hammering over a prolonged period of at least 30 minutes [(1)].

Whilst piling noise is sufficient to cause auditory impacts to fish, in practice it is actually unlikely to occur because the soft start procedures will enable hearing sensitive species to move away from piling activity before full energy hammer piling (and auditory injury) occurs.

The noise modelling indicated behavioural impact zones up to 27.4 km for cod and 23.8 km for herring. Given the spatial extent of these impact zones, some behavioural impacts are anticipated during piling despite the incorporation of soft start piling. The worst case scenario in terms piling duration for 83 monopiles is 83 days of piling activity (based on a maximum of 24 hours per monopile). The significance of the impact will depend on the importance of the species present and the use of the site and cable route areas (e.g. spawning, migration etc). Impacts to migrating fish are discussed separately in the next section, whilst impacts to spawning and fish using the area as a nursery area are described below.

Due to the mitigation measures employed, the temporary duration of the noise and the small proportion of the fish population affected, the magnitude of disturbance is expected to be *low.* The fish species present are considered to be of *low* to *medium* sensitivity with the exception of twaite shad which is discussed separately in the next section. As a result***, no significant impacts*** to ***minor significant impacts*** are anticipated as a result of noise and vibration from piling activity.

Disruption of Migration Routes during Construction

A number of fish species are known to migrate through the Humber Gateway site and cable route areas during feeding, spawning and ontogenic migrations. Twaite shad, sea bass, sea trout, Atlantic salmon and juvenile flatfish migrate along the inshore cable route areas and cod, whiting, plaice and dab will also migrate through the Humber Gateway site in addition to the cable route. Construction activities including installation of turbine foundations and subsea cables and construction vessel movements have the potential to cause impacts to these species.

[(1)] Parvin S J. and Nedwell J R, 2005. A brief review of mitigation strategies for reducing the impact of piling noise during construction of the Greater Gabbard Wind Farm. Subacoustech Report No.636R0104.

At maturity, adult twaite shad stop feeding in their inshore habitats and move towards estuaries of suitable rivers between April and May [(2)]. During the construction period the increased turbidity from jetting (the worst case scenario for increased turbidity) as well as noise from pile driving and vessel activity have the potential to disturb migrating twaite shad and prevent some fish reaching their spawning grounds.

The *Southern North Sea Sediment Transport Study Phase 2* [(3)] reported background turbidity levels in the study area to be in the regions of 16 to 126 mg l^{-1} in winter and 4 to 256 mg l^{-1} in summer, showing a high degree of variation. Monitoring undertaken during jetting activities at the Nysted offshore wind farm demonstrated that sediment plumes typically remain close to the sea bed [(4)] during cable installation. The relative stability of the seabed at the Humber Gateway site (*Section 7.5*) compared to Nysted suggests that cable laying activities will not create a long-term, significant change to turbidity. Sediment from jetting during cable laying will remain close to the seabed, so it is unlikely that pelagic twaite shad will be affected by changes in turbidity. In addition, the North Sea is a dynamic environment and natural storm events frequently increase turbidity levels. Fish populations in the study area are therefore likely to be adapted to turbid waters.

Whilst the piling noise modelling (*Figure 11.2* and *Appendix E3*) did not specifically predict a behavioural impact range for twaite shad, the behavioural impact range for cod is estimated to be 27.4 km. For the purposes of this assessment and in order to ensure a worst case, this distance has been applied to the impact assessment for twaite shad. As the distance between the development area and the coast at the shortest point is as little as 8 km, impacts are predicted within the whole sea area between the Humber Gateway site and the coast. As a result, there is the potential for impacts to twaite shad migration during piling activity.

Noise from construction vessel activity may also affect twaite shad migration. As set out in the Project Description (*Section 6*), the worst case scenario for the installation of 83 turbines is one vessel making four vessel movements during cable laying. The addition of a single vessel in this area should not have any impact on the migration of fish as the fish in the area will be habituated to the

[(2)] Maitland P S and Hatton-Ellis T W, 2003. Ecology of the Allis and Twaite Shad. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.
[(3)] Cefas, 2002. Southern North Sea Sediment Transport Study - Sediment Transport Report. Great Yarmouth Borough Council by HR Wallingford, Cefas/UEA, Posford Haskoning and Dr. Brian D'Olier.
[(4)] ABPmer, Cefas & HR Wallingford, 2007. Review of Round 1 sediment process monitoring data – lessons learnt. Draft report under the Seabed and coastal processes research group, SED01.

activities of a number of vessels that use the inshore area as fishing grounds or cross the area on the way out to sea (*Section 12.6*).

Given its legal protection under UK and EU legislation, the sensitivity of this species is considered to be *high*. Based primarily on the extent of the behavioural impact zones but also in combination with the additional vessel movements, the magnitude of the impact to twaite shad is considered to be *medium,* particularly as twaite shad migration generally occurs in the inshore cable route areas. As such, ***moderate significant impacts*** are predicted to twaite shad migration. This assumes that there is a population of twaite shad present, despite the fact that only one individual was identified during the surveys.

As previously mentioned, other species which migrate in the cable route areas include sea bass, sea trout, sprat and many flatfish species either during spawning or feeding migrations or on passage to nursery grounds in the Humber Estuary.

Spawning of the main UK sea bass population occurs between February and May but the population off the Holderness Coast generally spawns between March and April. During the early part of the season spawning in the UK population occurs beyond the 12 nm zone, although there is no evidence to suggest this occurs off the Holderness Coast where inshore areas are the most likely spawning areas. Juveniles have, however, been noted in the Humber Estuary and spawning adults have been caught by fishermen, implying spawning takes place locally. Sea bass will migrate across the cable route throughout late spring, summer and autumn and could therefore be affected by both piling during turbine installation and cable installation activities.

Generally, sea bass are used to the high levels of turbidity experienced in the inshore area and should be unaffected by the temporary increase in turbidity. The behavioural impact range for sea bass is estimated to be 2.91 km (*Figure* 11.2 and *Appendix E3*). Given that this coast at its nearest point is 8 km away, it will be possible for sea bass to move inshore without suffering impacts from piling noise. Given the temporary nature of construction noise and the fact that only piling of the monopiles closest to the shore will impact migration, the magnitude of disturbance is predicted to be *low.* As sea bass is not protected, its sensitivity is considered to be *low* to *medium*. For these reasons, ***no significant impacts*** to ***minor significant impacts*** are predicted.

Sea trout spawn between late autumn and winter and sprat move inshore during winter and these migrations have the potential to be impacted by cable installation and the associated vessel activity. Sea trout and sprat also migrate across the cable route during spawning and over wintering migrations and are likely to be affected by construction activity. In addition, Atlantic salmon may also migrate through the area and may also be affected by construction activity. Salmonids generally have less well developed hearing than herring and are believed to show avoidance behaviour up to 1.4 km away from the source of a noise [(1)]. Given the fact that the predicted behavioural impact zone generally coincides with the site boundary and is not predicted to cause impacts to the area between the wind farm site and the coast, the magnitude of disturbance is predicted to be *low.* As both sea trout and salmon are considered to be of *low* to *medium* sensitivity, ***no significant impacts*** to ***minor significant impacts*** are predicted.

Sprat are likely to have similar hearing abilities to herring (23.8 km predicted behavioural impact zone, *Appendix E3*) and so could potentially be affected by piling activity within the area between the wind farm and the shore. Given the typical nearshore migration patterns and the fact that there is the potential for impacts within the cable route areas, the magnitude of the impact is predicted to be *medium.* Sprat are considered to be of *low* to *medium* sensitivity. As such, ***minor significant impacts*** to ***moderate significant impacts*** are predicted.

Migration of other species (cod, whiting, plaice, lemon sole and Dover sole) are widespread in their distribution and occur over a long period of time. The Humber Gateway site and cable route areas represent a small portion of the area used as a migration route by many of the gadoid (cod and whiting) and flatfish species (plaice, Dover sole and lemon sole). In addition, the disturbance to the populations in the area will be intermittent and temporary and over a small portion of their entire range. The disturbance to the cod, whiting, and flatfish populations is predicted to be *low* and the sensitivity of these species is considered to be *low* to *medium*. For these reasons, ***no significant impacts*** to ***minor significant impacts*** to gadoid and flatfish species are predicted.

Increased Suspended Sediment Concentrations during Construction

Construction activities including seabed preparation, foundation installation and cable-laying have the potential to disturb sediments on the seabed and cause elevated suspended sediment concentrations via the suspension of fine sediments in the water column. The predicted extent of such impacts and the worst case implications for benthic communities are described in *Section 11.3.2.*

Coastal process modelling indicates that the greatest upper range of suspended sediment (up to 300 mg l^{-1}) is associated with the installation of the gravity base

[(1)] Thomsen F, Ludemann K, Kafemann R, and Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish, biola, Hamburg, Germany on behalf of COWRIE Ltd.

foundation. Typical values across the area affected are in the region of 20 mg l^{-1} which is in line with natural variability as previously described.

Elevated suspended sediment concentrations could inhibit phytoplankton productivity rates due to reduced light penetration of the water column. In turn, this could cause impacts to planktivorous fish species by reducing the availability of zooplankton prey, which in turn graze on the phytoplankton. Elevated turbidity can also impact sessile filter feeding organisms as their feeding organs can become congested. The loss of these species may affect fish through the loss of prey. Elevated turbidity can also adversely impact the reactive distance and prey capture success of visual fish predators (such as salmon, bass, etc.). Reduced light penetration as a result of elevated suspended sediments in the water column is predicted to be of short duration (*low* magnitude). Due to the fact that fish species are mobile and therefore are able to avoid areas where high suspended sediment concentrations are present, they are considered to have *low* to *medium* sensitivity. As a result, ***no significant impacts*** to ***minor significant impacts*** are anticipated.

Increased sedimentation caused by sediments settling on the sea floor after suspension has the potential to affect every stage of fish life cycles. The predicted extend of seabed level change (due to sedimentary deposition associated with foundation installation) has been modelled and is described in *Section 11.3.2.* In summary, installation of the gravity base foundation is predicted to give rise to the greatest deposition, up to 3,200 µm locally (or the equivalent of three grains of sand) decreasing with distance. The benthic species in the affected area are able to successfully tolerate this degree of smothering and so should remain as a valuable food source for fish. Fish species found in the Humber region and Holderness coastal area are also considered to be tolerant of the high levels of turbidity experienced during storms and from the plume of sediment from the Humber Estuary. Being highly mobile, they are able to move away from areas of elevated turbidity, returning once the levels of suspended sediment have returned to normal.

During cable installation options, jetting represents the worst case scenario which would result not only in disturbance to the local sea bed but also a re-suspension of sediment in the local area, which may result in smothering or fragmentation of animal populations in the immediate vicinity. Adult and juvenile fish in the area are likely to move away during construction activity. However, any recently settled larvae are likely to be affected. In addition, any fish eggs in the area may be smothered and the embryos inside killed. As herring do not spawn in the vicinity of the export cable route or the turbine area, there will be no effect on herring embryos. As the impact magnitude is considered to be *low*, to receptors of *low* to *medium* sensitivity, ***no significant impacts*** to ***minor significant impacts*** are anticipated.

The ABP modelling predicts changes in seabed level in the order of 5.6 µm (equivalent to one grain of very fine silt) within the cable route areas (*Section 10.3.2*). Partial smothering may lead to stress and complete smothering can lead to death of sessile organisms. The loss of these species has the potential to impact the fish that use these areas as nursery grounds by removing a valuable food source. All activities that disturb the seabed and result in the death of organisms will cause an increase in the abundance of scavenging and opportunistic species. This may impact the fish species in the area by providing an alternative food source. Resettling of sediment may also impact spawning activities for some species of fish by smothering eggs and starving them of oxygen during development. The increased levels of sediment in the water column may also affect recently settled fish larvae or juveniles in nursery areas by smothering their gills (adult fish will avoid these areas) and cover habitats important to bottom dwelling species.

Increases in suspended sediment are expected to be temporary and intermittent and losses of early life stages and prey items will be minimal. Adult fish will move away from these areas and return when the sediment has settled and food sources have returned. The magnitude of the impact is considered to be *low to a low* to *medium* sensitivity receptor (with the exception of twaite shad which is discussed separately in the previous section). As such, ***no significant impacts*** to ***minor significant impacts*** are anticipated.

Changes to Water Quality during Construction

The re-suspension of sediments during construction has the potential to result in the release of sediment-bound contaminants, such as hydrocarbons, heavy metals and organic material into the water column, which may cause water quality issues. During construction activities, there is the potential for pollution of the water column to occur by synthetic polymers and hydrocarbons from spills or leaks of fuel, oil and construction materials including cementing and grouting materials, other lubricating oils and greases and drilling muds. The potential impacts to water quality are assessed in greater detail in *Section 10.2*.

A number of studies have demonstrated that high levels of hydrocarbon contamination in water have the potential to harm fish and in particular early life stages of fish. Fish embryos and larvae can be especially sensitive to environmental contaminants due to the damage of embryonic tissues. Currently there are no statutory guideline values for marine sediment contamination or its effect on fish. As described in *Section 10.2.1*, E.ON will employ construction vessels that are well maintained and comply with best practice. Therefore, the likely quantities involved in a potential spillage are small and the magnitude of change is therefore *low.* Dispersal rates would be high, and the environment would therefore be of *low* sensitivity. There will therefore be ***no significant impacts*** to fish as a result of water pollution.

Potential Impacts during Operation

Changes to Seabed Composition and Bathymetry by Scour during Operation

If scour occurs, it has the potential to cause impacts to fish populations by changing the composition of the seabed that fish may use for feeding, breeding or as a nursery habitat. This may cause fish to move to other areas.

Results from the North Hoyle offshore wind farm site in a comparable environment to the Humber Gateway site have shown little evidence of significant scour around turbine foundations. This may be explained by the bi-directional tidal current that erodes sediment during that first tidal phase and re-deposits it on the second phase. In addition, the scour modelling work concluded no significant impacts from scour would occur at the Humber Gateway site either with or without scour protection (*Section 10.3*). Thus, the level of scour will be minimal and the disturbance caused would be *imperceptible.* As the fish populations present are considered to be of *low* sensitivity, ***no significant impacts*** are anticipated.

Habitat and Community Alteration or Loss from the Physical Presence of the Turbine Foundations

As described in *Section 11.3.2,* the worst case scenario in relation to maximum area of seabed disturbance is Layout 2 (83 x 3.6 MW gravity base foundations plus associated scour protection). This option comprises 0.47% of the Humber Gateway site. The physical presence of the turbine foundations will reduce the seabed habitat available to fish as feeding, nursery and spawning grounds. The habitat loss beneath the turbines will be a long term effect throughout the lifetime of the project.

The fish species affected are highly mobile and will move to surrounding areas. The species using the area for spawning do not require specific habitat to spawn (Dover sole, lemon sole, sprat and sandeel) and their numbers have been shown to increase in the area of wind farms in other studies [(1)]. Recent surveys have also shown that herring no longer spawn in the area [(2)] so there is no potential for herring eggs to be affected. Taking into consideration the small amount of seabed habitat affected (*low* magnitude) and the mobility of the fish species in the area (*low* sensitivity) ***no significant impacts*** are anticipated.

Introduction of Artificial Habitats

The submerged surfaces of the turbines will become colonised over time by a number of encrusting and sessile organisms that are attracted to unexploited spaces [(3)]. The presence of hard structures, especially if covered in a potential food resource, is known to promote the aggregation of fish species [(4)]. In particular, bass, whiting and cod are known to shoal near to submerged structures such as wrecks and reefs. Thus, the turbines may provide additional habitat for species such as these. The presence of macroalgae and the colonising community are likely to attract fish species for feeding grounds, nursery grounds and to shelter from predation. The turbine area may also act as a refuge from fishing activity for many species. The level of protection offered to fish by the provision of habitats which serve to camouflage them may be more important for juvenile fish than for adults.

The artificial habitat created by the presence of the turbine structures is likely to increase localised fish abundance within the site, but is unlikely to impact overall fish biomass in the North Sea. In addition to the community of colonising invertebrates and algae, an increase in fish abundance in the area may lead to an overall increase in localised biodiversity and abundance that could be described as a net environmental enhancement.

Based on this discussion, the available information and professional judgement, the provision of artificial habitat by the turbine structures will constitute a ***minor positive significant impact***.

(1) Leonhard S B and Pedersen J, 2005. Hard Bottom Substrate Monitoring at Horns Rev Offshore Wind Farm. Annual Status Report 2004. BioConsult A/S report for Elsam Engineering.

(2) ICES, 2003. Report of the herring larvae surveys in the North Sea in 2002/2003. ICES CM 2003/ACFM: 12.

(3) Linley E A S, Wilding T A, Black K, Hawkins A J S, and Mangi S, 2007. Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd to the Department of Trade and Industry, Contract No. RFCA/005/0029P.

(4) Marine Conservation Society, 2000. Habitats Factsheet: Artificial Reefs. SP08/00

Noise and Vibration during Operation

During operation, turbines produce low frequency noise and vibration stimuli that fish would perceive as hydrodynamic motion around the turbine foundations [(1)]. Noise levels are of a much lower intensity than that caused during construction [(2)]. Operational noise levels and frequencies are unlikely to impair the ability of fish to distinguish between the movement of predators and prey and the motion generated by the turbine. The noise and vibration during operation is also unlikely to cause damage to fish in the same way that construction noise has the potential to. However, the noise associated with the initial 'start-up' of the turbines, particularly sudden noises, may result in an initial startle response followed by temporary avoidance of the area around the turbines.

Fish are expected to habituate to the noise and vibration caused during operation and reports from other wind farms suggest that fish are present and are possibly attracted to the turbines [(3)]. As previously described in this section, the presence of hard structures colonised by potential prey is known to promote aggregations of fish species [(4)] and suggests that fish are likely to return to the area during normal operation of the turbines. As the noise and vibration is unlikely to adversely affect the fish, the disturbance will be *imperceptible* to a receptor of *low* sensitivity. As a result, ***no significant impacts*** are anticipated in relation to noise and vibration during the operational phase of the Humber Gateway development.

Electromagnetic Fields during Operation

The export and inter-array cabling associated with the Humber Gateway development will generate electromagnetic fields that may be perceptible by some fish species that are electrically and magnetically sensitive. These species include elasmobranchs (sharks and rays), agnathans (sea and river lampreys) and some teleosts (eg flatfish, European eel, salmonids, and mackerel).

[(1)] Hoffman E, Astrup J, Larsen F, Munch-Petersen S and Strottrup J, 2000. The effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research.
[(2)] Madsen P T, Wahlberg M, Tougaard J, Lucke K and Tyack P, 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. Mar. Ecol. Progr. Ser. 309, 279-295.
[(3)] Birklund J, 2005. Surveys of hard bottom communities on foundations in Nysted Offshore Wind Farm and Schonheiders Pulle in 2004. DHI Water and Environment. Report to Energi E2 A/S.
[(4)] Marine Conservation Society, 2000. Habitats Factsheet: Artificial Reefs. SP08/00

Offshore power transmission widely use three-phase cables that are more efficient at transmitting power than the two wires of single phase cables. Within the three phase cables, there are three separate cores, each of which is shielded by an insulation screen, earthed to confine the electric field within the cable. This type of cable does not generate an electric field directly but an electromagnetic field (EMF) with two components, a magnetic field (B) component and an induced electric field (iE) component.

These EMF components have been assessed as being within the detection range of a number of sensitive fish species [(5)] and there is the potential for them to be adversely affected. Fish species that are magnetically sensitive may become disorientated when they come into contact with a magnetic field different to that of the Earth's. This could result in a temporary change in direction and may affect migration, depending on the strength of the source and its persistence over time.

However, whether any impact results from coming into contact with the cables associated with wind farms has not been fully determined. The most recent research from COWRIE[(5)] into the effects of wind farm cables and their electromagnetic fields concluded that even though these fields are within the range of detection by certain aquatic species no scientific guidance on impacts could be provided. Further research aims to determine whether electroreceptive elasmobranchs respond to anthropogenic EMFs of the type emitted by offshore wind farm sub-sea cables.

There is currently no evidence to suggest whether or not B fields have a detrimental affect on electromagnetically sensitive fish and their behaviour. Sensitive species would most likely be able to detect induced electric fields (iE fields) emitted by the cables up to 20 m from the source. The cable is to be buried between 1 and 3 m deep and provided with armour so that the impact of the iE-field is reduced. The most recent research on the Kentish Flats Offshore Wind Farm suggests that at maximum output the magnetic field produced by armoured cables buried 1.5 m below the surface is below that of the Earth's own magnetic field [(6)] and at the lower range detectable by elasmobranchs ($0.5\ \mu V\ m^{1}$).

Several potentially sensitive species are present in the Humber Gateway area, including thornback ray, lesser spotted dogfish and smooth hound. In addition, sea trout, sea bass, juvenile flatfish and the twaite shad use the inshore areas during their migration and there is the potential for those crossing the cabling route to become disorientated by the electromagnetic fields. Currently, there is

[(5)] CMACS, 2003. A baseline assessment of electromagnetic fields generated by offshore wind farm cables. COWRIE Report EMF-01-2002 66.
[(6)] CMACS, 2004. Kentish Flats Offshore Wind Farm. EMF Modelling and Interpretation for Electrosensitive Fish Species. CMACS Report J3025/v1.2/10-04,

no evidence that suggests that B fields generated by cables would have detrimental effects on the behaviour of sensitive species. Although significant effects on a few species have been reported, studies into the impact of iE-fields conclude that no significant adverse affects are evident and the definition of significant effects has been inconclusive [(1)]. Furthermore, the use of cable armouring and burial of the cable between 1 and 3 m will mediate the effects of electromagnetic fields produced by the inter-array and export route cables.

Thus, with cable burial (embedded mitigation), the disturbance caused by electromagnetic fields will be *low* to receptors of *low* to *medium* sensitivity. As a result, ***no significant impacts*** to ***minor significant impacts*** are anticipated.

Disruption of Migration Routes during Operation

Many of the fish species in the area undergo inshore-offshore migrations and there is the potential for the operational phase to disrupt the migration of some commercially important fish species. Physical obstruction by turbines and their foundations is unlikely to affect migration of fish species, particularly as gadoids and bass are often found around submerged structures, including wind turbines [(2)]. Many fish species are also known to aggregate close to noisy structures, including oil platforms where hearing specialists such as herring can often be found [(3)]. The noise of the turbines will also not impair the ability of fish to distinguish between the turbines and potential prey. The low level of noise will result in the degree of disturbance being *imperceptible.* Impacts to twaite shad, which are of *high* sensitivity, are predicted to be of ***minor significance***. The other fish species present in the area are considered to be of *low* to *medium* sensitivity, and as a result, ***no significant impacts*** to ***minor significant impacts*** are anticipated.

Cable Heating during Operation

The sustained flow of electrical current through the export cables has the potential to cause heating of the surrounding sediment and the seawater above. This may affect local fish populations by causing stress or increasing susceptibility to disease. In addition, the distribution of many North Sea fish species are determined by differences in temperature and any significant changes to water temperature could have important implications for the fish species present in the vicinity of the Humber Gateway site.
Given the minimum burial depth of 1 m, the likelihood for any heating to have a perceptible impact on the fish populations that live on the seafloor or occupy the waters above is negligible. Thus, the degree of disturbance will be *imperceptible* to receptors of *low* to *medium* sensitivity. Accordingly, ***no significant impacts*** are anticipated.

Potential Impacts during Decommissioning

Disposal of Decommissioned Structures

As noted in *Section 11.3.2*, the *OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations* that came into force in 1999 states that dumping or leaving wholly or partly in place disused offshore installations within the maritime area is generally prohibited.

E.ON is committed to undertaking best practice procedures in terms of decommissioning. A full review of best practice procedure will be undertaken at the appropriate time in order that the most appropriate decommissioning plan may be agreed with BERR and The Crown Estate.

Fish Community Disturbance as a Result of Decommissioning Activity

The disturbance impacts during decommissioning are likely to be no worse than those during construction. Temporary alteration of habitats will occur during the decommissioning phase from vessel activity and during removal of turbine foundations. Vessel activity is considered to be similar to the level during construction and so disturbance due to anchor damage and jack-up barge spud-cans, if they are used, will have the same impact. During removal of turbine foundations, the seabed available for feeding, spawning and nursery grounds will be reduced to the same degree as during the construction phase. Cable removal will have similar impacts and will result in the temporary removal of nursery, feeding and breeding grounds. This will result in the same degree of disturbance as during the construction phase. Therefore, the impacts are taken to be the same as those described for the construction impacts phase above and the assessment for the construction phase can be applied to the decommissioning phase. As communities in the area are likely to recover quickly and the area affected is small, there will be ***no significant impacts*** in relation to habitat and community alteration during decommissioning.

[(1)] Miller I, 2005. Offshore wind farms – the European Experience. CCW Policy Research Report 05/03.
[(2)] Westerberg, H, 1999. Impact studies of sea-based wind power in Sweden. Technische Eingriffe in Marine Lebensraume.
[(3)] CMACS, 2003. Chapter 5: Biological Environment in: Seascape Energy. Burbo Offshore Wind Farm Environmental Statement.

Disruption of Migration Routes during Decommissioning

Decommissioning activity will result in similar impacts to those described during construction with the exception of piling activity which will not occur during decommissioning.

Twaite shad, sea bass, sea trout, Atlantic salmon and juvenile flatfish migrate along the inshore margins and will be affected by the removal of export route cabling. Others, including cod, whiting, plaice and dab will cross both the cable route and the development area during ontogenic, spawning and feeding migrations and will be affected by removal of turbines and their foundations.

During decommissioning the disturbance to the populations in the area due to cable and turbine foundation removal will be intermittent and temporary. In addition, the disturbance during decommissioning will occur over a small portion of each species' entire range.

Due to its protection under UK and EU legislation, twaite shad is considered as a receptor of *high* sensitivity. However, as there will be a lack of piling, the disturbance is temporary and short lived and changes in turbidity will be within the normal range experienced, the degree of disturbance will be *low*. As a result the impact of decommissioning will result in ***moderate significant impacts***.

For the other species in the area, the reduction in noise in comparison to construction and the temporary and short duration nature of the disturbance will result in a *low* degree of disturbance. In addition, the area affected will represent a very small proportion of the range of the fish species present. The fish are considered to be of *low* to *medium* sensitivity. As a result, ***no significant impacts*** to ***minor significant impacts*** are anticipated.

Increased Suspended Sediment Concentrations during Decommissioning

It is likely that the impact of the removal of foundations and cables from the seabed will have similar effects on suspended sediment levels to those described during the construction phase. These activities will cause intermittent and temporary changes in turbidity, light penetration and sedimentation but the magnitude is considered to be of a lesser or similar extent as during construction. Thus, the magnitude is considered to be *medium* in terms of levels of disturbance and the receptor is considered to be of *low* to *medium* sensitivity in relation to changes in turbidity. As a result, ***no significant impacts*** to ***minor significant impacts*** are anticipated.

Noise and Vibration during Decommissioning

The level of noise experienced during decommissioning will be greatly reduced compared to the construction phase as there will be no requirement for pile driving. Although there is still the potential for loud noise to be generated this would be limited in frequency, duration and extent. Operations such as cutting and vessel movements during removal of turbines, towers, cables and bases from their foundations will only cause a temporary displacement of fish for the duration of the activity.

It is anticipated that the degree of disturbance from noise during decommissioning will be *imperceptible* due to the lack of any piling activity. Fish in the area are considered to be of *low* to *medium* sensitivity to noise. As such, ***no significant impacts*** are anticipated in relation to noise and vibration during decommissioning.

Changes to Water Quality during Decommissioning

The suspension of sediments during decommissioning has the potential to release contaminants which may be toxic to fish into the water column. Contamination may also result directly from construction activities from spills or leaks of fuel, oil and construction materials. Although accidental spillages and leaks may occur, the amounts involved are likely to be small and standard good practice will minimise the likelihood of such events. The impacts of changes to water quality on fish are likely to be of similar or lower magnitude to disturbances described during construction. Since the likely quantities involved in this type of spillage are small, dispersal rates high, therefore the magnitude of change is predicted to be *imperceptible* to a receptor of *low* to *medium* sensitivity. As a result, ***no significant impacts*** are anticipated.

Removal of Artificial Habitats during Decommissioning

During the operational lifetime of the Humber Gateway Offshore Wind Farm, the foundation and piling structures will have been colonised by a whole community of encrusting organisms, including invertebrates and macroalgae. During decommissioning, the foundations and piling will be removed and this community will be lost at the same time. This will result in the loss of biodiversity in the area and a reduction in prey items for predatory fish and juveniles using the areas as nursery grounds. There will also be the loss of additional habitat for some species and the loss of shoaling areas for gadoids, bass and other fish species.

This rapid change in habitat and food availability is unlikely to result in the significant loss of fish biomass as adult fish are highly mobile and will move to other areas where food can be found. Juveniles settling in the area may find food sources less available than when the foundations and pilings were in place and so higher mortality may be experienced. The removal of structures will negate any ecological gain due to the installation of the artificial structures.

11.4.3 Mitigation Measures

No mitigation measures are proposed other than the embedded mitigation measures described in *Section 11.4.1.*

11.4.4 Residual Impacts

The residual impacts will remain the same as the potential impacts described above.

11.4.5 Monitoring

Post construction survey requirements will be discussed with the relevant regulatory authorities including Cefas, Natural England and the Marine and Fisheries Agency. Any surveys will be developed in accordance with best practice.

11.4.6 Enhancements

The colonisation of turbine foundations, as described in *Section 11.4.2*, may support fish populations that further enhance the region's biodiversity. The extent to which this will constitute a reef-effect as opposed to simply aggregations of fish around the foundations will depend on the ability of the colonising community to provide prey items and shelter for the fish species in the area.

A further enhancement will be to make data available from baseline, post-construction, pre- and post-decommissioning surveys available to the public and relevant research organisations. This data will be invaluable in determining the effects of offshore wind farms and their effects on fish populations at various stages of development.

During the construction of the offshore structures E.ON intends to apply to the Secretary of State, under Section 95 of the *Energy Act 2004*, for temporary offshore safety zones (up to 500 m around areas of construction) to ensure the safety of project and third party personnel and equipment. In addition, E.ON will consult with maritime agencies and sea users on the need, if any, for a safety zone (up to 50 m) around each turbine during operation. If implemented, this would have implications for fish ecology as it has the potential to reduce fishing pressure in the development area around the turbines.

11.4.7 Summary

A summary of potential and residual impacts to fish is shown in *Table 11.14*. The principal impacts on fish ecology relate to loss and alteration of the feeding, spawning and nursery habitats and disruption of spawning migrations through construction and decommissioning activities, and the increased levels of turbidity that disturbance to the seabed will incur. The species that inhabit the area are largely well adapted to tolerate environmental disturbance and to have high recovery rates given that they inhabit a high energy environment that is prone to change through storm events. In addition, the majority of fish species in the area are highly mobile and move over large areas and so will move away from any disturbance and return once the area has returned to its original state or the disturbance has ceased. Generally, there are only ***minor significant impacts*** and the ecosystem is expected to recover well once the disturbance has ceased.

However, there is the potential for certain fish species, particularly the protected twaite shad, to have their alongshore migrations impacted by the construction activities. If the installation of cables in the export corridor (increasing turbidity across the migration route) and piling occur during the period that twaite shad migrate, there is the potential to impact their migration routes. The pile driving noise and increased turbidity during construction may act in combination to prevent some fish species from migrating along the inshore area and from reaching their spawning grounds. There could therefore be ***moderate significant impacts*** to this protected species without mitigation in place. This assumes that there is a population of twaite shad present, despite the fact that only one individual was identified during the surveys.

Migrations of other species occur over a wider area and much longer time periods, and the Humber Gateway site represents a small proportion of the total area over which these populations migrate. There will therefore be ***minor significant impacts*** to migrations of other fish species, in the worst case scenario.

Once the construction phase is complete and the wind farm is operational, there may be a net environmental benefit from the presence of the turbine and foundation structures. Colonising species that attach themselves to the foundations of the turbines will provide an additional prey source for some fish species, especially gadoids, herring and bass that are often found shoaling around submerged structures. The extent of this benefit will depend on the extent to which the hard surfaces of the turbine foundations are colonised and the availability of prey to the fish species in the area. In addition, the colonisation of the foundations may provide increased food resources for juvenile fish, thus increasing their survival in the vicinity of Humber Gateway site.

During decommissioning, similar impacts to those introduced during construction are to be expected. However, they are likely to be of lower magnitude, particularly because of the lack of pile driving noise. As a result, there will generally be ***no significant impacts*** during this phase although there will be some ***minor significant impacts*****.**

Table 11.14 Summary of Impacts to Fish

Impact	Potential Impact Significance	Additional Mitigation (in addition to embedded mitigation)	Residual Impact Significance
Fish community disturbance as a result of construction vessel positioning	*No significant impacts* to *minor significant impacts*	None	***No significant impacts*** to ***minor significant impacts***
Fish community disturbance during installation of inter-array and export cable	*No significant impacts* to *minor significant impacts*	None	***No significant impacts*** to ***minor significant impacts***
Noise and vibration during construction	*No significant impacts* to *minor significant impacts*	None	***No significant impacts*** to ***minor significant impacts***
Disruption of migration routes during construction	Twaite shad - *moderate significant impact*	None	Twaite shad - ***moderate significant impact***
	Spawning sea bass – *no significant impacts* to *minor significant impacts*	None	Spawning sea bass ***– no significant impacts*** to ***minor significant impacts***
	Sea trout and salmon – *no significant impacts* to *minor significant impacts*	None	Sea trout and salmon – ***no significant impacts*** to ***minor significant impacts***
	Sprat – *minor significant impacts* to *moderate significant impacts*	None	Sprat ***– minor significant impacts*** to ***moderate significant impacts***
	Gadoid and flatfish – *no significant impacts* to *minor significant impacts*		Gadoid and flatfish ***– no significant impacts*** to ***minor significant impacts***
Increased suspended sediment concentrations during construction	*No significant impacts* to *minor significant impacts*	None	***No significant impacts*** to ***minor significant impacts***
Changes to water quality during construction	*No significant impacts*	None	***No significant impacts***
Changes in seabed bathymetry and scour during operation	*No significant impacts*	None	***No significant impacts***
Habitat and community loss fro the presence of the turbine foundations	*No significant impacts*	None	***No significant impacts***
Introduction of artificial habitats during operation	*Minor positive significant impact*	None	***Minor positive significant impact***
Noise and vibration during operation	*No significant impacts*	None	***No significant impacts***
Electromagnetic fields during operation	*No significant impacts* to *minor significant impacts*	None	***No significant impacts*** to ***minor significant impacts***
Disruption of migration routes during operation	Twaite shad - *minor significant impact*	None	Twaite shad ***- minor significant impact***
	Sea trout, sea bass, salmon, sprat and many flatfish – *no significant impacts* to *minor significant impacts*	None	Sea trout, sea bass, salmon, sprat and many flatfish ***– no significant impacts*** to ***minor significant impacts***
Cable heating during operation	*No significant impacts*	None	***No significant impacts***
Fish community disturbance as a result of decommissioning activity	*No significant impacts*	None	***No significant impacts***

Impact	Potential Impact Significance	Additional Mitigation (in addition to embedded mitigation)	Residual Impact Significance
Disruption of migration routes during decommissioning	Twaite shad - *moderate significant impact* Sea trout, sea bass, salmon, sprat and many flatfish – *no significant impact* to *minor significant impact*	None	Twaite shad ***- moderate significant impact*** Sea trout, sea bass, salmon, sprat and many flatfish ***– no significant impact*** to ***minor significant impact***
Increased suspended sediment concentrations during decommissioning	*No significant impacts* to *minor significant impacts*	None	***No significant impacts*** to ***minor significant impacts***
Noise and vibration during decommissioning	*No significant impacts*	None	***No significant impacts***
Changes to water quality during decommissioning	*No significant impacts*	None	***No significant impacts***

11.5 MARINE MAMMALS

11.5.1 SCOPE OF THE ASSESSMENT

Introduction and Scope

This section assesses the impacts to marine mammals in the vicinity of the Humber Gateway wind farm and wider southern North Sea. The assessment process has taken into consideration the conservation value of marine mammals and the protection afforded to them through the relevant legislation (both national and international).

The main potential impacts identified for marine mammals relate to underwater noise. Marine mammals rely on sound for a range of behaviours such as communicating, hunting and navigating. Noise created during offshore wind farm construction, operation and decommissioning may interfere with these behaviours. In particular, high noise activities associated with wind farm development, such as piling, may cause impacts in four different zones, described by Richardson et al [(1)] as:

- the zone of audibility (within which the sound is both above the animals hearing threshold and detectable above background noise);
- the zone of responsiveness (the region within which behavioural reactions in response to the sounds occur);
- the zone of masking (the zone within which a sounds level may mask biologically significant sounds); and
- the zone of hearing loss, discomfort, or injury (the area within which sound level is sufficient to cause threshold shifts or hearing damage).

The baseline information (*Section 8.6*) has identified grey seals, harbour seals and harbour porpoises as being the most likely receptors for impacts from development.

In addition to noise impacts, impacts from electromagnetic fields and from prey disturbance are also considered.

(1) Richardson W J, Greene C R J, Malme C I and Thomson D D, 1995. Marine Mammals and noise. San Diego: Academic Press.

Consultation

Natural England (formerly English Nature) were consulted on the scope of the noise prediction work, as well as the scope of the marine mammal surveys and subsea noise surveys described in the baseline sections.

Natural England indicated that one of the key considerations in the assessment should be the potential impacts for grey seals at Donna Nook. A number of key mitigation measures were also discussed and are described in the embedded mitigation section and mitigation section (*Section 11.5.3*).

Realistic Worst Case

The worst case scenario in terms of noise impact is that piling will commence using 'soft start' (an embedded mitigation measure) and will continue without a break until the pile driving is completed. This is likely to take between 8 and 24 hours. A maximum of 83 days of piling activity would result if all 83 turbines took one day to install. In reality, the total number of days is likely to be less than this. It is assumed under the worst case, that that these days will be spread over a one year period.

Embedded Mitigation

Embedded mitigation of relevance to marine mammals consists of soft start piling procedures that will be implemented during all piling activity, whereby the hammer pressure and therefore sound level produced is started at a low level and gradually increased up to full piling pressure. This enables any marine mammals in the area disturbed by the sound levels to move away from the piling before any adverse impacts are caused. An assumption of a 100 kJ starting hammer energy for a soft start has been made, increasing to 1,800 kJ over 600 hammer strikes.

Methodology

Guidance Documents

The following guidance documents were used in relation to the assessment of impacts to marine mammals:

- *Offshore Wind Farms – Guidance Note for EIA in Respect of FEPA and CPA Applications,* Cefas, June 2004; and
- *Wind Farm Development and Nature Conservation,* BWEA March 2001.

Prediction Methods

In considering the significance of the impacts to marine mammals, the following has been taken into consideration:

- relative importance of the Humber Gateway site, informed by the baseline marine mammal surveys (*Appendix E1* and *Section 8.6*);
- background noise levels, informed by the baseline noise surveys (*Appendix E2* and *Section 8.8*);
- type of disturbance activity (i.e. piling, vessel movement);
- magnitude of the impact (i.e. piling noise predictions, *Appendix E3*); and
- length or duration of the potentially disturbing activity.

The numbers of individuals identified (harbour porpoise, grey seal and common seal) during the survey and analysis of existing literature implies a low to moderate abundance of these species in relation to the wider UK population. A seal haul out and breeding site exists at Donna Nook on the Lincolnshire coast.

A background noise survey was undertaken for the project, by National Physical Laboratory (NPL) during March 2007. The technical report is presented in *Appendix E2* and a summary of the results is presented in the underwater acoustic environment section (*Section 8.8*). The information from the survey provides a basis against which to assess noise which may be caused by the construction, operation and decommissioning of the wind farm.

In summary, results showed that the background levels were slightly higher than the mean levels reported from other sites in UK coastal waters. For example, average noise levels at the Humber Gateway site for the 200 Hz tonal band are approximately 87 dB re 1 $\mu Pa^2 Hz^{-1}$, compared to approximately 59 dB re 1 $\mu Pa^2 Hz^{-1}$ for the Inner Dowsing and Lynn wind farm sites in the central Wash area. Similar differences were seen at 2 kHz; approximately 69 dB re 1 $\mu Pa^2 Hz^{-1}$ for Humber Gateway site and approximately 36 dB re 1 $\mu Pa^2 Hz^{-1}$ at Inner Dowsing and Lynn [(1)]. The elevated levels of background noise at the Humber Gateway site were attributed to the high ship traffic present in the area. There was no reduction in overnight noise levels.

Modelling was undertaken for the project, by NPL in October 2007 in order to predict the likely noise levels produced by piling during wind farm construction.

[(1)] Centrica Ltd, 2007. Lincs Offshore Windfarm Environmental Statement.

The technical underwater acoustic field and impact prediction report is presented in *Appendix E3*. The assessment methodology used has been combined with recent subsea noise modelling work associated with other offshore wind farms [(2)], and has also taken into account concerns expressed by Natural England in relation to the prediction and assessment methodology. The criteria used for injury are based on those set out by the US National Marine Fisheries Service[(3)] and Kastak et al, 2005 [(4)].

In summary, the worst case scenario in terms of noise impacts for the site would be monopile foundations each with a diameter of 6 m. A noise source level of 244 dB re 1μPa m peak to peak, or a Sound Exposure Level (SEL) of 211 dB re 1 μPa^2 s-m was predicted, based on previous observations [(5)]. Modelling of a soft start piling procedure was also undertaken, giving an initial source level of 232 dB re 1μPa-m peak to peak, and a Sound Exposure Level of 199 dB re 1 μPa^2 s-m. Transmission loss curves were then calculated and used to predict the received levels along a number of transects radiating away from the site.

Based on this information, zones of impact were predicted for each of the relevant receptors, in this case harbour porpoise, grey seal and harbour seal. As both species of seal have very similar hearing abilities, they are considered together for the purposes of the noise modelling.

Very high noise levels have the potential to cause physical damage to marine mammals at very close ranges to the source. Levels of over 240 dB re 1μPa have been reported to cause damage to internal organs and even death [(6)]. Other physiological effects at greater distances include impairment of hearing ability which may be temporary and recoverable (Temporary Threshold Shift, TTS) or permanent (Permanent Threshold Shift, PTS). PTS is most likely to occur where an animal has been exposed to noise for a prolonged period or

[(2)] Parvin S J, Nedwell J R and Workman R, 2006. Underwater noise impact modelling in support of the London Array, Greater Gabbard and Thanet offshore wind farm developments. Subacoustech Report No. 710R0517 (Commercial-in-confidence).
[(3)] NMFS NOAA, 2006. Small Takes of Marine Mammals Incidental to Specified Activities; Rim of the Pacific (RIMPAC) Antisubmarine Warfare (ASW) Exercise Training Events Within the Hawaiian Islands Operating Area (OpArea), Federal Register; 71 (No. 78).
[(4)] Kastak D, Southall B I, Schusterman R J and Reichmuth C J, 2005. Underwater temporary threshold shift in pinnepeds: Effects of noise level and duration. J. Acoust Soc. Am, 118, p3154 – 3163.
[(5)] There are a number of different ways of measuring underwater noise levels.),.Peak pressure and peak-to-peak pressure metrics are used to measure impacts on marine mammals. Further information on underwater noise measurements are given in *Appendix E3.*
[(6)] Thomsen F, Ludemann K, Kafemann R and Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish. COWRIE Ltd.

where noise has started suddenly where an animal is close to the source. It is considered that marine mammals will typically exhibit avoidance behaviour in response to noise levels that could be sufficient to cause PTS or TTS.

For harbour porpoise, an SEL of 215 dB re 1 μPa^2 s could cause PTS, and a SEL of 195 dB re 1 μPa^2 s could cause TTS[1]. The SEL threshold for TTS in seals of interest was calculated at 183 dB re 1 μPa^2 s [2].

Permanent hearing damage in marine mammals can lead to serious effects on survival by impacting on a range of behaviours such as foraging and communication.

When calculating the SEL that would result in TTS or PTS, the cumulative impacts of repeated hammer strikes was taken into account, as was the ability of target organisms to move away from the sound, displaying an avoidance reaction. Target organisms were considered to move at an average speed of 1.5 m s^{-1}, meaning that they would be around 11km away from the noise source within two hours of the noise commencing.

Outside of the zone of possible physiological impact, marine mammals may exhibit behavioural responses to noise levels without showing physiological damage. This can result in a zone of avoidance around the noise source which differs between species based on their individual sensitivity to sound.
In this study, the transmission loss profiles and a 90 dBht reference sound level was used to model the likely behavioural responses by each species. The use of the 90 dBht threshold is in line with the approach taken by Parvin et al, 2006 [3].

Significance Criteria

The assessment criteria used to assess the magnitude and significance of impacts are given in *Table 11.15*.

[1] NMFS NOAA, 2006. Small Takes of Marine Mammals Incidental to Specified Activities; Rim of the Pacific (RIMPAC) Antisubmarine Warfare (ASW) Exercise Training Events Within the Hawaiian Islands Operating Area (OpArea), Federal Register; 71 (No. 78).
[2] Kastak D, Southall B I, Schusterman R J and Reichmuth C J, 2005. Underwater temporary threshold shift in pinnepeds: Effects of noise level and duration. J. Acoust Soc. Am, 118, p3154 – 3163.
[3] Parvin S J, Nedwell J R and Workman R, 2006. Underwater noise impact modelling in support of the London Array, Greater Gabbard and Thanet offshore wind farm developments. Subacoustech Report No. 710R0517 (Commercial-in-confidence).

Table 11.15 Magnitude of Impacts to Marine Mammals

Significance	Criteria
Major significant impacts	Death or physical injury (including Permanent Threshold Shift (PTS) in hearing).
	Permanent change to distribution of marine mammals.
Moderate significant impacts	Temporary effects on hearing (Temporary Threshold Shift).
	Temporary change to distribution of large numbers of marine mammals.
Minor significant impacts	Temporary avoidance of the development area by marine mammal species.
	Disturbance to foraging or temporary changes in behaviour.
No significant impacts	No predicted significant effect on behaviour.

These criteria are based on the types of responses to impacts from wind farm construction and operation and from commissioned studies (as described later in this section) on the specific impacts. Marine mammals are protected species and so activities that have the potential to impact on their survival at an individual or population level are considered to be ***major significant impacts***.

Deliberate Disturbance

Under the amended *Habitats Regulations* and the new *Offshore Marine Regulations*, it is an offence to deliberately disturb European Protected Species in such a way that it is likely that there will be a significant affect on:

- the ability of any significant group of animals of that species to survive, breed or rear or nurture their young; or
- the local distribution or abundance of that species [4].

[4] Joint Nature Conservation Committee, 2007. The deliberate disturbance of marine European Protected Species – Interim guidance for English and welsh territorial waters and the UK offshore marine area.

The only European Protected Species recorded in the Humber Gateway survey area was harbour porpoise. The amended *Habitats Regulations* therefore has implications for the impacts caused to this species by Humber Gateway. However, the Humber Gateway site is considered to support low to moderate populations of harbour porpoise and is not recognised as being important for the survival or reproduction of this species. Harbour porpoise is considered to be in Favourable Conservation Status (FCS) in UK waters [(4)]. There is an abundance of other suitable habitat in the vicinity of the development, and the species concerned are wide ranging and able to exploit this habitat.

The above is taken into consideration in the assessment presented in *Section 11.5.2*.

11.5.2 Assessment of Potential Impacts

Physical Effects to Marine Mammals from Piling Activity

Modelling was undertaken by NPL and conclusions were drawn on the basis of the application of soft start and the assumption that marine mammals would start to swim away from the noise source as soon as piling started. On this basis, a number of conclusions can be drawn regarding the effects of a single pile.

- The threshold for mortality (taken in other studies as 244 dB re 1µPa-m), would not be exceeded at any distance from the piling activity, as the noise source is not sufficiently intense to result in death even if an individual is close to the pile.
- Similarly, the PTS threshold (taken as 215 dB re 1 μPa^2 s), would not be exceeded at any distance during piling activity, because individuals will swim away from the noise source and will not therefore be exposed for sufficiently long to experience PTS.
- Individuals could potentially suffer TTS from a single strike if they are within 32 m of full energy piling activity. However, this will not occur as it is assumed that they will swim away as soon as the soft start piling commences, so they will be more than 32 m away when full energy piling commences.
- For dolphins and porpoises, if they are more than 3 m away from the pile when soft start piling starts they will have time to swim away to a sufficient distance to avoid TTS. It is extremely unlikely that they will be within 3 m when piling starts, as other activity involved in setting up the piling rig and other associated low level noise and activity is likely to ensure that they do not approach this close.
- For seals, TTS may occur if they are closer than 4 km when piling starts, even assuming soft start. This is because their high sensitivity to noise means that they would be unable to swim away to a sufficient distance to avoid a level of exposure that would result in TTS.

With regard to physical damage (PTS and TTS) from multiple piles, the conclusions remain the same as the individuals would have the same opportunity to exhibit the same avoidance response for each pile, assuming that only one pile is driven at any one time. No long term TTS impacts would therefore be anticipated as a result of piling activity at all 83 piles throughout the wind farm.

Although seal numbers are considered to be low to moderate within the Humber Gateway site, the fact that seals may experience TTS results in a ***moderate significant impact***. Dolphins and porpoises will not experience PTS or TTS.

Displacement of Marine Mammals due to Construction Noise

Previous studies suggest a zone of responsiveness in both harbour porpoises and seals is between 15 and 20 km for sound levels in excess of 220 dB re 1µPa peak to peak [(1)]. However, in practice the zone of responsiveness is unlikely to represent a zone of avoidance. Published sources suggests zones of avoidance of between 6 km and 20 km for harbour porpoises and between 3 km and 20 km for seals [(1) (2)].

The NPL modelling predicts zones within which behavioural changes are anticipated for the Humber Gateway project. This is discussed in detail in *Appendix E3* and summarised in *Figure 11.3.* In order to assess the worst case scenario, a 90 dBht reference sound level for each species was used to model the range estimates for behavioural responses.

The NPL modelling predicts that the distance at which a behavioural response is expected (Behavioural Impact Range) for the various species are as follows:

- for harbour porpoise, up to 11.4 km;
- for harbour seal, up to 8.9 km;
- for bottlenose dolphin, up to 6.2 km; and

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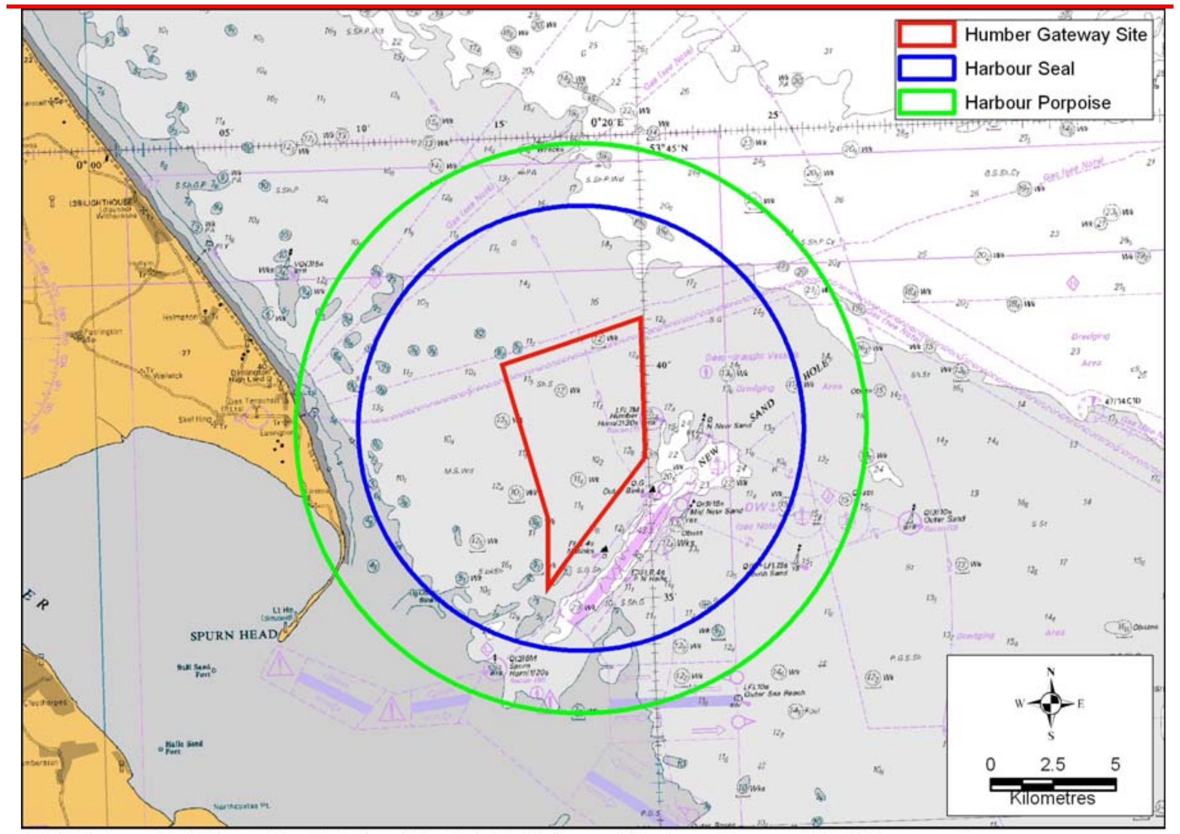
(1) Thomsen F, Ludemann K, Kafemann R and Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish. COWRIE Ltd.
(2) Parvin S J and Nedwell J R, 2006 Underwater noise survey during impact piling to construct the Burbo Bank Offshore Wind farm.

- for striped dolphin, 5.3 km.

Studies for other wind farms in British coastal waters have predicted much smaller zones of responsiveness. For example, modelling work undertaken for Burbo Bank Wind Farm in Liverpool Bay predicted zones of avoidance of 5 km for harbour porpoise (associated with piling activity for a 4.5 m diameter pile) [(1)]. Avoidance zones for installing a 6 m diameter pile would be larger and have been predicted at the Lincs Offshore Wind Farm as being 13 km for harbour porpoise [(2)].

Figure 11.3 Behavioural Impact Range Estimates for Various Marine Mammal Species



PROJECTION: British National Grid

Displacement associated with behavioural change is likely to only take place whilst piling is being undertaken. Studies at previous wind farm developments have demonstrated that harbour porpoises which avoided an area during piling returned relatively quickly after cessation of piling. Studies at Horns Rev offshore wind farm in Denmark showed that harbour porpoise were displaced up to at least 15 km from the site but returned within a few hours once piling ceased [(3)]. It is therefore considered likely that displacement of cetaceans from the Humber Gateway site will be temporary in nature, with animals returning to the area after cessation of piling, although it should be noted that piling will take place over a period of approximately one year (although not continuously). It is anticipated that displacement will also affect harbour porpoise prey species such that there will not be a loss of available food for harbour porpoise, which may forage outside of the noise impact zone in response to a redistribution of prey. It is, however, possible that given the elevated levels of background noise experienced around the site, cetaceans present in the area may be more tolerant of noise disturbance than those at other sites.

Given the low to moderate levels of harbour porpoise abundance and the short term and intermittent nature of the disturbance, ***minor significant impacts*** are anticipated.

The potential avoidance zone for seals has in the past been assumed to be similar to harbour porpoise [(4)]. However, using a 90 dBht reference sound level to model the Behavioural Impact Range suggested, the distance a behavioural response would be seen for the harbour seal was predicted to be 8.9 km (*Figure* 11.3). The zone therefore extends up to within 5 to 6 km of the seal colony at Donna Nook, potentially affecting the behaviour of seals moving to and from the Donna Nook colony. Studies associated with other wind farms in British coastal waters have predicted different zones of responsiveness. Modelling work undertaken for Burbo Bank Wind Farm in Liverpool Bay predicted zones of avoidance of 3 km for seals (associated with piling activity for a 4.5 m turbine) [(1)]. Avoidance zones for installing a 6 m pile would be larger and have been predicted at the Lincs Offshore Wind Farm as being 9 km for seals [(2)].

The baseline data suggests that the Humber Gateway site is not heavily used by seals for foraging. Tagging studies have shown that grey seals may forage from south of The Wash to north of St Andrew's Bay and up to 300 km offshore. This, together with their low use of the wind farm site, suggests that alternative foraging habitat will be available to seals during piling, if there is any avoidance of the area. In addition, it should be noted that Donna Nook is also the site of a military firing range. Although no live ammunition is used at the site, jet aircraft

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[(1)] Parvin S J and Nedwell J R, 2006. Underwater noise survey during impact piling to construct the Burbo Bank Offshore Wind Farm.
[(2)] Centrica Ltd, 2007. Lincs Offshore Windfarm Environmental Statement.
[(3)] Tougaard J, Ebbesen I, Tougaard S, Jensen T and Teilmann J, 2003. Satellite tracking of harbour Seals on Horns Reef. Use of the Horns Reef wind farm area and the North Sea. Fisheries and Maritime Museum, Esbjerg.
[(4)] Thomsen F, Ludemann K, Kafemann R and Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish. COWRIE Ltd.

make repeated low level flights over the area as part of training exercises, generating extremely high noise levels at take. Seals haul out and breed at Donna Nook despite this disturbance.

It has been shown that harbour seals will travel through a wind farm site during construction, indicating that they can become accustomed to piling noise, and that is does not necessarily interfere with behaviour [(1)]. At the Horns Rev Wind Farm in Denmark, piling took place within 4 km of a seal sanctuary containing the only breeding population of grey seal in the country. Tagging studies of both harbour and grey seals showed no behavioural impacts from construction activities throughout the construction process. However, studies at Nysted Offshore Wind Farm in the Baltic Sea reported that harbour seals spent less time out of the sea on haul out areas during piling operations [(1)].

Given the outer limits of the zone of responsiveness is some 5 to 6 km away from the breeding site at Donna Nook, the current high ambient noise levels, the ability of seals to tolerate and become accustomed to elevated noise levels discussed above, and the transient nature of the disturbance, indicate that piling noise is likely to result in a ***minor significant impact*** to seals in terms of disturbance during construction.

Masking of Marine Mammal Sounds during Construction

Masking occurs when sounds emitted by construction activity occur at the same frequency as sounds used by a receptor at levels which hide or mask that sound. Noise associated with wind farm construction activity, including increased vessel movement, piling activity and cable laying, may mask sounds used by marine mammals for a number of behaviours including foraging, navigation, or communication associated with mating, social interaction or individual identification.

There is little available information on masking in marine mammals in relation to wind farms. However, Thomsen et al (2006), reports that piling activity tends to produce very low noise emissions in the range used for sonar by harbour porpoises (120 - 150 kHz), and that due to the short signal duration of pile driving sounds, no significant masking should occur [(2)]. A zone of masking for harbour seals as a result of piling, which use much lower frequency signals between 200 Hz and 3,500 Hz has been calculated at over 80 km for sounds at 200 Hz [(2)].

[(1)] Tougaard J, Ebbesen I, Tougaard S, Jensen T and Teilmann J, 2003. Satellite tracking of harbour Seals on Horns Reef. Use of the Horns Reef wind farm area and the North Sea. Fisheries and Maritime Museum, Esbjerg.
[(2)] Thomsen F, Ludemann K, Kafemann R and Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish. COWRIE Ltd.

However, seals have good eyesight and rely much less on sound for foraging than porpoises.

Given the above and the physical and displacement impacts described in the previous sections, no additional masking impacts are anticipated as a result of piling activity. As no significant behavioural effects are anticipated, ***no significant impacts*** to harbour porpoise or harbour seals are anticipated as a result of piling activity.

Masking may also occur as a result of ship engine noise and hull borne vibration from construction vessels. Richardson et al [(3)] predict a zone of audibility of ship noise in the 2 kHz bandwidth for harbour porpoise of approximately 3 km, giving a zone of masking under 3 km radius. For harbour seals, a zone of audibility for the 2 kHz bandwidth was predicted to be similar to harbour porpoise, but for the 0.25 kHz content, a zone of masking of approximately 15 km radius was predicted [(3)].

However, the Humber region has a high level of vessel activity, with shipping lanes throughout the area and passing within 9 km of the seal colony at Donna Nook. The background noise survey found that noise levels were higher than mean levels reported for other sites in UK coastal waters, which includes noise generated from shipping. Both harbour porpoise and grey and harbour seals inhabit the area despite the elevated noise levels, and are therefore assumed to be accustomed to the noise levels and any masking which may occur as a result. In addition, the seal colony at Donna Nook is subject to further elevated noise levels from the military firing range.

Given the low to moderate numbers of marine mammals in the vicinity of the Humber Gateway site and the elevated baseline noise levels that marine mammals currently experience, no significant effect on behaviour is anticipated. As such, ***no significant impacts*** are anticipated as a result of masking from construction vessels.

Disturbance or Physical Effects from Increased Vessel Traffic during Construction

During the construction phase, there would be an increase in vessel traffic associated with the installation of offshore structures and cable laying. These vessels would include barges, jack-up rigs and tugs which are all slow moving vessels which produce a relatively wide spectrum including low frequency sound which may travel long distances. Sound produced would be of much lower

[(3)] Richardson W J, Greene C R J, Malme C I and Thomson D D, 1995. Marine Mammals and noise. San Diego: Academic Press.

magnitude than that produced by piling activity, but would be semi-continuous rather than pulsed.

The existing vessel traffic in the vicinity of the Humber Gateway site is already high, as previously described. Marine mammals in the area therefore already co-exist with high levels of acoustic disturbance caused by vessels and are likely to be habituated to these levels. A common response to vessel activity by marine mammals, especially timid species such as harbour porpoise, is to avoid the vessel either by diving or swimming away. However, seals are by their nature inquisitive and have been known to approach fishing vessels.

The heavy current use of the approach channels into the Humber Estuary and the low use of the Humber Gateway site suggest that there will be only a minor disturbance effect on marine mammals from noise generated by additional vessel traffic. In addition, avoidance behaviour suggests that physical injury to marine mammals is unlikely to occur. For these reasons, no significant changes to behaviour are anticipated and as such***, no significant impacts*** to marine mammals are anticipated.

Indirect Effects through Impacts on Prey Species during Operation

The marine mammals found in the project area are known to feed on a variety of different fish and cephalopod species and forage over large areas in search of prey. It is possible that prey species will be displaced as a result of construction noise and that there will therefore be an indirect affect on the abundance of prey available. However, given that marine mammals forage over very extensive ranges, it unlikely that prey will be displaced to the degree that foraging is significantly impaired. Any displacement impacts would be short lived (for the duration of construction at most), with fish expected to return after construction has ceased. No predicted changes to marine mammal behaviour are anticipated and as such, ***no significant impacts*** are predicted.

Physical Dispersion and Disturbance Caused by Turbines and Support Structures during Operation

The installation of turbines and an offshore substation has the potential to cause impacts as a result of the presence of new physical structures (where there was previously open water habitat). The presence of these structures may cause marine mammals to avoid the site, effectively reducing available open water habitat. However, it has already been demonstrated that marine mammals will forage over a wide area and do not use the development site in significant numbers. In addition, the Humber Gateway site may provide increased habitat for prey species such as gadoids, and the presence of increased levels off food may offset any avoidance of the site exhibited.

Studies at Horns Rev Offshore Wind Farm in Denmark have recorded both harbour porpoise and grey seals moving through the site, indicating that marine mammals will utilise operational wind farm sites [(1)].

The duration of any impact would be for the lifetime of the Humber Gateway development (up to 40 years). Given the recorded use of wind farm sites by marine mammals and the low to moderate current use of the Humber Gateway site, no significant behavioural changes are anticipated. As such, ***no significant impacts*** to marine mammals are anticipated.

Acoustic Disturbance from Turbine Noise and Maintenance Vessels during Operation

Operational wind turbines produce subsea noise through vibration of turbine components. The noise produced increases with wind speed, however background noise also increases through increased wave action and sediment movement so that the noise above background levels remains relatively constant [(2)]. Little is currently known about operational noise from existing wind farms, however Thomsen et al report that for a 1.5 MW turbine operating in wind speeds of 12 m s^{-1}, operational noise would be loudest at 160 Hz with a sound pressure level of 142 dB_{Leq} re µPa @ 1 m. This level of noise would be detectable by both harbour porpoises and seals at 100 m and may cause masking in seals up to 1 km [(2)].

Predictions for 3 MW turbines for the London Array offshore wind farm gave a source level of 110 dB re 1 µPa@ 1 m, similar to other figures quoted for 2 MW wind farms in Denmark, such as the 115 dB re 1 µPa@ 1 m recorded at Middlegrunden [(3)]. These figures would suggest that, certainly for moderate increases in turbine size, the sound levels produced are not necessarily higher for larger turbines.

Studies at Horns Rev (based on 2 MW turbines) suggest that although operational turbine noise is audible to harbour porpoises up to 100 m, it is unlikely to dissuade them from carrying out activities such as hunting or

(1) Tougaard J, Ebbesen I, Tougaard S, Jensen T and Teilmann J, 2003 Satellite tracking of harbour Seals on Horns Reef. Use of the Horns Reef wind farm area and the North Sea. Fisheries and Maritime Museum, Esbjerg.
(2) Thomsen F, Ludemann K, Kafemann R and Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish. COWRIE Ltd.
(3) Centrica Ltd. (2007) Lincs Offshore Windfarm Environmental Statement.

mating [1]. They also concluded that although the evidence was not especially robust, it was probable that the wind farm development had had a weak or no effect on harbour porpoises.

Any impact from operational noise would last for the lifetime of the wind farm (up to 40 years) but would be fully reversible after decommissioning.

Given the relatively small zone within which masking is predicted (100 m), behavioural impacts to harbour porpoise are considered to be negligible. As such, ***no significant impacts*** are anticipated to this species.

Minor significant impacts to seals are predicted given their slightly higher perception of lower frequency sound of the type generated by operational wind farms, and the possibility of masking occurring within 1 km of the Humber Gateway site boundary.

Masking associated with maintenance vessels will not be any more severe or frequent than that considered above for construction vessel impacts. As such, ***no significant impacts*** are predicted.

Impacts to Marine Mammals as a Result of Changes to Food Resources during Operation

Once construction has been completed, marine mammal prey species are expected to return to the Humber Gateway site. As there are no key habitats recorded from the site for any individual species, there is not expected to be a loss of important foraging habitat, and there is some discussion as to whether offshore wind farms may provide increased opportunities for foraging through producing a reef effect attracting elevated levels of fish to the site [2].

As no significant behavioural changes are anticipated, ***no significant impacts*** to marine mammals are predicted due to changes in food availability during operation.

[1] Tougaard J, Ebbesen I, Tougaard S, Jensen T and Teilmann J, 2003. Satellite tracking of harbour Seals on Horns Reef. Use of the Horns Reef wind farm area and the North Sea. Fisheries and Maritime Museum, Esbjerg.
[2] Linley E A S, Wilding T A, Black K, Hawkins A J S and Mangi S, 2007. Review of reef effects of offshore wind farm structures and their potential enhancement and mitigation. Report from PML Applications

Impacts from Electromagnetic Fields during Operation

Inter-array (approximately 58 km) and export cables (a total of approximately 16 km) will be buried at a depth of between 1 and 3 m. These sub-sea cables will generate electromagnetic fields (EMF) that some species are sensitive to, including many cetaceans [3].

There is currently a lack of research into how EMF affects cetaceans, however it is thought that cetaceans are magnetosensitive, using magnetic fields to aid navigation. It is possible therefore that EMF generated by sub sea cables may attract or repel species or simply interfere with navigation or orientation.

Monitoring of marine mammals at operational offshore wind sites such as Horns Rev has not shown any avoidance of sites, although no specific work has been undertaken focussing on EMF. Additionally, there is no evidence of other types of undersea cables that emit EMF (such as power cables or telecommunications cables) causing impacts on marine mammals [4].

As no significant changes to behaviour are predicted, ***no significant impacts*** to marine mammals are anticipated.

Impacts from Noise and Vessel Activity during Decommissioning

It has been assumed, for the purposes of this assessment, that decommissioning of the Humber Gateway wind farm will not cause any greater noise or vessel movements than those produced during construction. Similar vessels and methods would be used, with the exception of piling. As no significant behavioural changes are predicted, ***no significant impacts*** to marine mammals are anticipated.

Impacts to Marine Mammals through Loss of New Habitats during Decommissioning

Marine organisms can colonise new habitats very rapidly and it is likely that benthic organisms and fish will take advantage of new habitats described in *Section 11.3*. Marine mammals may learn to take advantage of this food

[3] Gill A B, Gloyne-Phillips I, Neal K J and Kimber J A, 2005. The potential affects of magnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms - a review. COWRIE Ltd.
[4] Thomsen F, Ludemann K, Kafemann R and Piper W, 2006. Effects of offshore wind farm noise on marine mammals and fish. COWRIE Ltd.

resource over the lifetime of the development, which would be lost after decommissioning.

The length of the decommissioning period has not been decided upon but if a similar timescale to construction is used, the impact could be assumed to develop over two to three years before becoming permanent after full decommissioning. This time scale would allow ample time for mobile fish species to disperse to other suitable habitat and for any marine mammals feeding on them to locate to these new habitats.

In addition, it has already been shown that marine mammals will travel over large distances to forage and it is unlikely that any species would become solely dependent on prey species in the development area. The impacts would negate any positive impacts experienced as a result of changes in habitat during operation.

11.5.3 Mitigation

Overview

As well as the soft start piling techniques which have already been included in the assessment of potential impacts, further mitigation measures will focus on detecting marine mammals in the vicinity of potentially damaging noise sources and managing activities appropriately. These measures are listed below.

Observation

Before construction work commences, a suitably qualified Marine Mammal Observer (MMO) will be appointed. This observer will visually monitor the area up to a distance of 500 m representing the effective visual observation range. A clear and formal chain of command and communication link between the MMO and piling master will be put in place before the onset of any piling works. In addition to trained observers, appropriate passive acoustic monitoring equipment will be used, such as hydrophones, to ensure that marine mammals cannot be detected in the vicinity.

MMOs will begin observations a minimum of 30 minutes prior to the commencement of any piling activities. Piling operations will not be allowed to start until half an hour has elapsed during which marine mammals have not been detected. If marine mammals are seen entering the area within 30 minutes of the soft start procedure, then the piling energy should remain at the same level for 30 minutes.

At times of poor visibility (e.g. night time, foggy conditions, sea state greater than that associated with force 4 winds etc) enhanced acoustic monitoring of the piling vicinity will be carried out prior to the onset of piling.

Clear lines of communication and reporting will be established between observers and the piling crew before construction begins in order to ensure that no piling is carried out until the observers are satisfied that no marine mammals are in the vicinity. If marine mammals are observed once piling is at full power they will be considered to have voluntarily entered the area with conditions as they are, and piling will continue. It should be noted that piling must sometimes be continuous once it has started as certain chalk types solidify if piling is not continuous.

Preventing the onset of piling until all marine mammals are at least 500 m away and implementing a soft start procedure will minimise any effects on marine mammals.

11.5.4 Residual Impacts

Introduction

Where additional mitigation results in a change to the potential impact significance, this is described below. The significance of all other impacts discussed in the potential impacts section, are predicted to remain the same after additional mitigation has been adopted.

Physical Effects to Marine Mammals from Piling Activity

The deployment of marine mammal observers (surveying areas of up to 500 m from piling activity) will ensure that no marine mammals are present in the immediate vicinity of any piling operations before they start. This, in addition to the soft start procedures in place, will ensure that all cetaceans will not experience TTS. In addition, marine mammals have sufficient time to move away from piling operations after soft start commences and therefore will not suffer any physical harm during piling activity. As there is still likely to be a minor degree of disturbance resulting in temporary changes in behaviour, temporary ***minor significant residual impacts*** to cetaceans are anticipated.

As seals have more sensitive hearing than cetaceans, the possibility remains that some seals may experience TTS as a result of piling operations. Therefore, temporary ***moderate significant residual impacts*** are anticipated to pinipeds during piling activity.

11.5.5 MONITORING

Monitoring will be undertaken in order to assess the predicted impacts on marine mammals as a result of the construction and operation of the wind farm. Monitoring requirements will be discussed with Natural England and are likely to include the collection of an observation log during construction activity.

In addition to delaying the onset of piling works in the presence of marine mammals, the MMOs will keep a detailed log of all sightings of marine mammals in the vicinity of piling operations. This information will add to the understanding of the use of the site by marine mammals and may be useful in refining model predictions which would be of benefit to future developments.

11.5.6 SUMMARY

A summary of potential and residual impacts is presented in *Table 11.16*.

After mitigation, ***moderate significant residual impacts*** are predicted to pinipeds as a result of the possibility of TTS due to construction noise. In all other cases, ***minor significant residual impacts*** or ***no significant residual impacts*** are predicted.

In addition, disturbance impacts from the development are predicted to be intermittent, short term and localised in nature (*Section 11.5.2*), and disturbance is likely to affect individuals or small groups of species only at any one time. Therefore under the terms of the *Habitats Regulations* and the *Offshore Marine Regulations,* although it is predicted that there will be disturbance of marine European Protected Species, it will not significantly affect the local distribution of the species present or their ability to survive, breed, rear or nurture their young.

Table 11.16 Impacts to Marine Mammals

Impact	Potential Impact Significance	Additional Mitigation (in addition to embedded mitigation of soft start procedures)	Residual Impact Significance
Physical effects to marine mammals from piling	Cetaceans - *No significant impacts* Pinipeds - *Moderate significant impacts*	Use of Marine Mammal Observers within 500 m of piling activity	Cetaceans - ***No significant impacts*** Pinipeds – ***Moderate significant impacts***
Displacement of marine mammals due to construction noise	Cetaceans - *Minor significant impacts* Pinipeds - *Minor significant impacts*	None	Cetaceans - ***Minor significant impacts*** Pinipeds - ***Minor significant impacts***
Masking of marine mammal sounds during construction	Cetaceans – *No significant impacts* Pinipeds – *No significant impacts*	None	Cetaceans – ***No significant impacts*** Pinipeds – ***No significant impacts***
Disturbance or physical effects caused by increased vessel traffic during construction	*No significant impacts*	None	***No significant impacts***
Indirect effects through impacts on prey species during operation	*No significant impacts*	None	***No significant impacts***
Physical dispersion and disturbance caused by turbines and support structures during operation	*No significant impacts*	None	***No significant impacts***
Acoustic disturbance from turbine noise and maintenance vessels during operation	Cetaceans - *No significant impacts* Pinipeds – *Minor significant impacts*	None	Cetaceans – ***No significant impacts*** Pinipeds – ***Minor significant impacts***
Impacts on marine mammals as a result of changes to food resources during operation	*No significant impacts*	None	***No significant impacts***
Impacts from Electromagnetic Fields during operation	*No significant impacts*	None	***No significant impacts***
Impacts from noise and vessel activity movement during decommissioning	*No significant impacts*	None	***No significant impacts***

11.6 ORNITHOLOGY

11.6.1 SCOPE AND METHODOLOGY

Introduction and Scope

This section assesses the potential impacts of the Humber Gateway offshore wind farm on ornithology.

The assessment process has taken into consideration the conservation values of the bird species present, the protection afforded to these species through the relevant legislation and key issues raised by consultees. The remainder of this section includes:

- an overview of the approach to the assessment;
- direct habitat loss impacts;
- impacts from disturbance;
- impacts from displacement;
- impacts on bird flight lines (i.e. barrier effect);
- collision risk impacts; and
- impacts on designated sites (see also *Section 14*).

Consultation

A full list of organisations consulted and their comments is provided in *Appendix A*. The key consultees with comments relating to ornithology were Natural England (formerly English Nature), the Royal Society for the Protection of Birds (RSPB) and Yorkshire Wildlife Trust (YWT).

Discussions with consultees raised a number of issues which have been taken into account in undertaking the assessment. Consultees considered the main issue to be collision risk. Other issues to be considered include habitat loss, disturbance, displacement, and the barrier effect.

The species for which collision risk assessment modelling would be undertaken were agreed in discussions with Natural England. It was agreed that the assessment would also consider the impacts on migrating passerines, although this would not include modelling of the effects.

Whilst not present in significant numbers at this site, Natural England also requested that pink-footed geese were included. This was largely to help assess the cumulative effect of Humber Gateway with the other wind farms in the Greater Wash (specifically on the north Norfolk populations of this species). Some of the migrating pink-footed geese are known to fly along the east coast to and from north Norfolk from northern England and Scotland. It was important in this context to understand the contribution of Humber Gateway to the collision risk and hence it is included in *Section 11.6.2*.

Consultees also identified a need for and assessment of the cumulative and in-combination effects with other developments and the effects on sites designated for their European and national importance for birds (e.g. Humber Flats, Marshes and Coast SPA / Ramsar / SSSI, Flamborough Head and Bempton Cliffs SPA / SSSI). These issues are considered in detail in *Sections 13* and *14*.

Realistic Worst Case

The options for the turbine layout are described in *Section 6: The Project Description*. The ornithological assessment has chosen the realistic worst case scenario for each assessment topic. These are as follows:

- *Direct habitat loss*. The realistic worst case is Layout 5, which comprises 42 x 7 MW gravity base foundations. This layout would cause the greatest amount of seabed loss.
- *Disturbance*: The realistic worst case predictions are to construct 83 turbines (Layout 1 and Layout 2 comprising 83 x 3.6 MW turbines), hence requiring the greatest number of vessel movements.
- *Impacts on flight lines*. The realistic worst case layouts are again Layout 1 and Layout 2, where the shortest distance between the turbines is approximately 588 m.
- *Collision risk assessment*. Layout 1 (3.6 MW turbine) has been identified as being the worse case scenario, as this involves the greatest numbers of turbines (83 turbines).

These are described in more detail in *Section 11.6.2*.

Embedded Mitigation

No embedded mitigation has been included which is specific to ornithology.

Prediction Methodology

Guidance Documents

In addition to the EIA Regulations, specific guidance documents which have been used in undertaking this assessment include:

- *Nature Conservation Guidance on Offshore Windfarm Development* [(1)];
- *Assessing Significance of Impacts from Onshore Windfarms on Birds Outwith Designated Areas* [(2)]; and
- *Guidelines for Ecological Impact Assessment in the United Kingdom* [(3)].

Prediction Methods

The majority of ornithological assessments on both onshore and offshore wind farms have been based on previous guidance, developed by SNH and the BWEA [(4)]. For the purposes of this assessment, a different approach has been used which is considered to be in line with recent progressions in ecological guidance in the UK.

The assessment of the significance of the potential impacts of the offshore components of the Humber Gateway development on birds has been based on an approach developed by Scottish Natural Heritage (SNH) for onshore wind farms. This approach is also similar to the approach described in the recent Institute of Ecology and Environmental Management (IEEM) guidelines for assessing ecological impacts.

The approach focuses on the concept of conservation status to determine whether an impact is ecologically significant. Conservation status is defined in the *Habitats Directive* and a modified version has been used in the recent guidance on assessing ecological impacts produced by IEEM to allow assessments to be made at any geographical level.

[(1)] Department of Environment, Food and Rural Affairs, 2005. Nature Conservation Guidance on Offshore Windfarm Development (Version R1.9). Defra.
[(2)] Scottish Natural Heritage, SNH. 2006. Assessing Significance of Impacts from Onshore Windfarms on Birds outwith Designated Areas.
[(3)] Institute of Ecology and Environmental Management (IEEM) 2006. Guidelines for Ecological Impact Assessment in the UK. IEEM.
[(4)] Percival S M, Band B & Leeming T, 1999. Assessing the ornithological effects of wind farms: developing a standard methodology. Proc. of the 21st British Wind Energy Association Conference.

The use of favourable conservation status as a means of determining significance is therefore in keeping with developments in ecological impact assessment, which has moved away from the use of matrices. The approach used in the *Environmental Liability Directive,* as a means of determining biodiversity damage is defined in terms of *"significant adverse effects on reaching or maintaining the favourable conservation status".*

The bird species that have been considered in this assessment are predominantly those species recognised as requiring special conservation measures including those which:

- form part of the qualifying interest of designated sites;
- are listed on *Annex I* to the *EC Wild Birds Directive (79/409/EC)*, Schedule 1 of the *Wildlife and Countryside Act, 1981* and amendments and non-statutory lists such as Red List Birds of Conservation Concern; and
- are regularly occurring migratory species.

The conservation status of a species is defined in the Habitats Directive as the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations. The guidance states that the conservation status of a species is considered 'favourable' when:

- *"population dynamics indicate that the species is maintaining itself on a long-term basis as a viable component of its habitats, and*
- *the natural range of the species is not being reduced, nor is likely to be reduced for the foreseeable future, and*
- *there is (and will probably continue to be) a sufficiently large habitat to maintain its population on a long-term basis."*

In order to arrive at a judgement of the effects on favourable conservation status, the following information has been used in the assessment:

- the number of individuals of a species lost, for example due to habitat loss, through displacement or collision, informed by the known sensitivities of species to disturbance, collision etc;
- the existing natural mortality of a species, and the added mortality that will result from the above losses;
- trends of each species within the geographical area under consideration, especially where a species is in decline;

- distribution of each species within the geographical area under consideration (i.e. strongholds, gaps); and
- mitigation and enhancement measures which will be implemented.

Consideration has also been given to the latest guidelines for Ecological Impact Assessment published by IEEM (2006) [(1)].

The cumulative impacts of the Humber Gateway project with other ongoing and proposed developments in the surrounding area are considered in *Section 13*.

Significance Criteria

An impact on a particular bird species has been judged as ***significant*** where the assessment shows that a discernable reduction in the favourable conservation status of a species is likely to occur at a particular geographical level. This includes stopping a recovering species from reaching favourable conservation status at a regional, national or international level.

11.6.2 ASSESSMENT OF POTENTIAL IMPACTS

Direct Habitat Loss Impacts

As described in *Section 11.3*, the construction and operation of the Humber Gateway project will result in temporary and permanent loss of seabed habitat as follows:

- permanent habitat loss will occur due to the turbine footprints and the offshore substation; and
- temporary habitat loss will result from the installation of the export and inter-array cables, and the use of the jack-up barges during construction of the wind turbines.

The loss of seabed habitat and any benthic species and fish species that it supports, may have impacts on bird species which feed on them.

The area of permanent habitat lost will depend on which layout option is progressed. The realistic worst case is Layout 5 (42 x 7 MW gravity base foundations). Even in this case, the total area of seabed lost will be small, with 52,779 m^2 (approximately 5.3 ha). This comprises only a very small percentage (0.15%) of the wind farm site *(Table 6.5)*. A small additional area will also be lost due to the foundations for the offshore substation, however, the area affected is likely to be equivalent to that lost due to the foundations for only one of the wind turbines (i.e. approximately 1,257 m^3 or 0.13 ha).

The effects of the permanent loss of sub-tidal benthos and fish have been assessed in *Sections 11.3* and *11.4* respectively, and ***minor significant impacts*** were predicted at worst.

The findings of the benthic surveys showed that the area does not support benthic fauna and habitats which would attract benthic feeding bird species such as common scoter and eider. This is reflected in the ornithological survey findings (*Section 8.7.4*), which recorded only occasional small flocks of these species. Where these species were noted, flocks were predominantly away from the Humber Gateway site.

The other bird species recorded during the ornithological surveys (*Section 8.7.4*) were predominantly piscivores (i.e. fish eating species), surface feeders or scavengers. Birds foraging on the surface or scavenging will not be significantly affected by the loss of seabed habitat.

The distribution maps (*Section 8.7.4* and *Appendix D1*) clearly show that the numbers of birds recorded on the Humber Gateway site are small and that the site does not currently provide an important feeding area for piscivorous bird species. For most seabird species, the surveys found the birds favouring waters further offshore to the east and north of the Humber Gateway site.

A sufficiently large area of foraging habitat will remain for bird species to allow them to maintain their populations in the long term, despite the loss of habitat for Humber Gateway. The natural range of the bird species using the offshore waters in the survey area will not be significantly affected and the loss will not prevent the bird species present from maintaining their viable status at any geographic level (i.e. nationally, regionally).

There will be no impacts on the favourable conservation status of any species due to direct loss of seabed habitat, and as such ***no significant impacts*** are predicted.

Temporary direct habitat loss will result from the laying of the inter-array and export cables. The area of seabed affected by installation of the export and inter-array cables will be a maximum of approximately 0.47 km^2 (47 ha) (*Table 11.6*). Even under the worst case scenario, where trenching is the construction method used, the recovery of the seabed and the benthic species it supports is expected

[(1)] Institute of Ecology and Environmental Management (IEEM), 2006. Guidelines for Ecological Impact Assessment in the UK. IEEM.

to be rapid. As a result, no significant impacts to the benthos (*Section 11.3.2*) and only minor significant impacts to fish (*Section 11.4.2*) are predicted. The laying of the export and inter-array cables is a one-off event, which takes place over a short time period in any one area, and occurs over a small area.

The distribution maps (*Section 8.7.4* and *Appendix D1*) show that the cable routes will not affect any important foraging areas used by birds. The recovery rate of habitats along the cable routes is also predicted to be rapid (*Section 11.3.2*). Again the favourable conservation status of bird species will not be affected and ***no significant impacts*** to birds are predicted.

Impacts from Disturbance

Disturbance to bird species using the area may arise from construction activities such as the movement of construction vessels, piling, and also from the effects of maintenance and decommissioning activities.

The majority of the seabird species recorded during the surveys (including northern gannet, gulls and terns) are considered to have a low vulnerability to disturbance by boats, and the effects on northern fulmar, skuas and little gull are considered negligible [(1)]. Northern fulmars, for example, are known to scavenge for food around fishing boats [(2)]. Auks are more sensitive to disturbance by boats than the species listed above, but the main species that are known to be sensitive to boats and most likely to be disturbed are divers, scoters and great cormorant [(1)]. The effects of boats on red-throated divers and common scoter have resulted in changes in survey approaches and the increased use of aerial survey techniques to record these species [(3)].

Experience from other offshore wind farms provides some anecdotal evidence of the effects of wind farm construction on sea birds. For example, initial monitoring findings suggested that piscivorous species such as gannet, were recorded moving towards North Hoyle Offshore Wind Farm during construction [(4)]. This may have reflected the movement of fish species as a result of the works. Subsequent monitoring at the site, has suggested this effect is less [(5)].

Construction activity also appeared to have little effect on species such as northern fulmar and black-legged kittiwake. Auks, like gannets, are piscivores, and in contrast they showed a more progressive shift away from North Hoyle Offshore Wind Farm during construction with similar findings at Horns Rev Offshore Wind Farm [(6)]. Therefore, the disturbance effects on these species may be slightly greater, supporting the vulnerability status in Garthe & Hüppop [(1)]. At Horns Rev, the distribution of northern kittiwake and common terns remained unchanged during construction of the wind farm, whilst herring gull numbers increase significantly [(6)].

The Humber Gateway ornithological surveys recorded only small numbers of bird species which are sensitive to boat disturbance such as red-throated divers, common scoter (and occasional great cormorant) in the survey area during the passage [(7)] and winter months (*Section 8.7.4*). There were only occasional records of these species within and in the immediate vicinity of the Humber Gateway site. Auks were common and widespread across the survey area especially during the post breeding period and are likely to be affected by construction activities on the Humber Gateway site. However, the main species recorded during the boat based survey were gulls (*Section 8.7.4*) which are known to be more tolerant of disturbance and often favoured areas off the mouth of the Humber, to the south of the Humber Gateway site.

Many seabirds undergo a post-breeding moult during the late summer and early autumn which can leave them flightless for a short period. During this time, substantial rafts can develop, especially of auks, with birds gradually moving southwards away from the Flamborough colony with the residual current. The surveys recorded higher densities of auks on the water in September, which was thought to be indicative of the presence of such moulting birds (*Section 8.7.4*). The flightless or semi-flightless nature of these flocks, together with the relatively high densities and numbers of individuals involved, leads to an increased vulnerability to impacts. In particular, the rafts are unable to quickly move out of an area in response to disturbance, deleterious water quality or changes in prey availability.

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(1) Garthe S & Hüppop O, 2004. Scaling Possible Adverse Effects of Marine Wind Farms on Seabirds: Developing and Applying a Vulnerability Index. Journal of Applied Ecology 41, 724-734.

(2) Mitchell P I, Newton S F, Ratcliffe N & Dunn T, 2004. Seabird Populations of Britain and Ireland. T & A D Poyser.

(3) Camphuysen C J, Fox A D, Leopold M F & Petersen I K, 2004. Towards Standardised Seabirds at Sea Census Techniques in Connection with Environmental Impact Assessments for Offshore Wind Farms in the UK Report commissioned by COWRIE. The Netherlands: Royal Netherlands Institute for Sea Research.

(4) Npower Renewables, 2006. Gwynt y Mor Offshore Wind Farm: Environmental Statement. Npower Renewables Ltd.

(5) http://www.npower-renewables.com/northhoyle/pdfs/fepa/0506chapter10.pdf.

(6) Christensen, Thomas KjÊr, Ib Clausager and Ib Krag Petersen, 2003. “Base-line investigations of birds in relation to an offshore wind farm at Horns Rev, and results from the year of construction,” produced by NERI.

(7) passage period covers the times of the year when migrating birds are moving between their breeding and wintering grounds.

It is likely that such rafts will occur throughout the survey area and may occur in the immediate vicinity of the Humber Gateway site. However, the site is some distance from the nearest breeding colony at Flamborough Head and Bempton Cliffs SPA (approximately 54 km to the north), and the surveys recorded the majority of auks in parts of the survey area away from the Humber Gateway site (*Section 8.6.4*). It is likely that any rafts which do occur will be small.

Construction work will be undertaken in a phased manner (i.e. work will not take place across the whole site simultaneously, rather work is likely to be ongoing only in one part of the site at any one time). This will help to restrict the area over which birds are disturbed at any one time.

The majority of the birds likely to be affected by the main construction works are piscivores. The assessment of the potential effects of noise on fish species predicts a temporary avoidance response in relation to piling noise, followed by a re-distribution of fish soon after the cessation of piling (*Section 11.4.2*).

Therefore, piscivorous bird species, especially auks, are considered likely to be temporarily displaced, along with their prey species. Auks were one of the most common groups of birds recorded during the surveys occurring in large numbers over a wide area with no particular concentrations within the Humber Gateway site (*Section 8.7.4*). Hence the construction activities such as piling are likely to affect only a comparatively small proportion of the population, and the effects will be temporary and localised around the works areas.

The location of the Humber Gateway site means that much of the existing shipping traffic lies to the south and east of the site and comprises shipping movements into and out of the Humber Estuary (*Section 9.10*).

The construction of Humber Gateway will increase the number of boat movements in the area over the short term, but only by a small number. The worst case predictions relate to the construction of 83 turbines (Layout 1 and Layout 2) over a two year period. Predicted boat movements are shown in *Table 11.17*.

Table 11.17 Construction Boat Traffic Summary

Approximate Total Trips	Trips per Year	Trips per Month	Approximate Trips per Day
157 (Heavy Vessels)	79	6 to 7 14 to 16 (6 months over summer)	1 trip every 4 to 5 days 1 trip every 2 days
819 (Light Vessels over a two year period)	410	34 68 (6 months over summer)	1 to 2 2 to 3

The exact ports and routes the vessels will use will only be decided at the time of the detailed design and procurement phase of the project. The use of the main shipping channel located immediately to the south of the Humber Gateway site would be unlikely to affect bird species or populations given the small number of additional boat movements. In addition, birds in the area will already be accustomed to much larger volumes of shipping traffic. The surveys recorded few birds in areas to the west of the Humber Gateway site, although small numbers of red-throated divers do occur in the shallower waters along the Holderness Coast over the passage and winter months (*Section 8.7.4*).

The main concentrations of birds were recorded further to the east and north of the Humber Gateway site, especially towards the Flamborough Head and Bempton Cliffs breeding colonies (*Section 8.7.4*). A route for vessels which approached the site from the north would be likely to disturb much larger numbers of birds including auks during the breeding and post breeding periods. During the post breeding period, rafts of several hundred seabirds, especially auks, may occur in the waters closer to the breeding colonies. These rafts arise as the adult birds are flightless, whilst they replace their primary wing feathers as part of their post breeding moult. Guillemot was the main auk species recorded during the surveys for the Humber Gateway, and adult guillemots can be flightless during the moult period for 45-50 days [(1)]. Whilst flightless, the birds are much more vulnerable to collisions as their ability to avoid vessels is greatly reduced.

The adult breeding population of guillemot at the Flamborough Head and Bempton Cliffs colony is 46,685 birds, reflecting a 43% increase between the Seabird Colony Register (SCR) census in 1985-87, and Seabird 2000 in 1998 to

[(1)] Parkin D & Perrins C, 2006. (Editorial Advisors) Birds of the Western Palaearctic Interactive (BWPi 2.0). BirdGuides Ltd & Oxford University Press.

2002 [1]. The mortality of breeding adults is approximately 5% per annum [2]. This means that approximately 2,335 adult birds are lost from the breeding population each year. In the event that a further 467 breeding adults are lost as a result of collision with vessels, then the overall adult mortality rate would be increased to 6%. It is possible that such numbers, or greater, could be affected if there are continued boat movements through areas supporting rafts of auks over the 45-50 day period when the birds are flightless. Whilst the population at Flamborough Head and Bempton has been increasing steadily, it is likely that the loss of breeding adults would result in an adverse impact on the favourable conservation status of the species in the short term, with potential ***significant impacts*** predicted at a local level. It is, however, unlikely that vessels will approach from the north but this assessment has been included for completeness.

The increase in the number of boat movements per day over and above existing levels in the area is small, and assuming a construction vessel route is identified which avoids the waters used more extensively by seabirds such as auks, relatively small numbers of birds are likely to be affected. The majority of the birds recorded are also species which are of low vulnerability to disturbance by boat traffic. There will still be sufficiently large areas to maintain the populations of the bird species affected, and both the natural range and the viability of the populations will be maintained. As such, there will be no impact on the favourable conservation status of any species, and ***no significant impacts*** are predicted.

The export cable route corridor will pass through an area which is not used by concentrations of foraging birds (*Section 8.7.4*). Red-throated divers were recorded in this area on occasions during the surveys, but only in low numbers. In addition, the installation of the export cable will be completed in a very short time period (approximately two weeks), and hence any impacts will be over a short time period.

Regular scheduled maintenance visits will be required to and from the Humber Gateway site once it is operational. Approximately 93 service vessel trips are expected a year, plus a further 10 rigid inflatable boats (RIBs) trips throughout the operational phase. There are also likely to be other visits required for unscheduled maintenance. The selection of the maintenance base will be finalised as part of the procurement process. The maintenance visits will be only a small number in comparison to the construction works, and ***no significant impacts*** are predicted.

(1) Mitchell P I, Newton S F, Ratcliffe N & Dunn T, 2004. Seabird populations of Britain and Ireland. T & A D Poyser.

(2) Harris M P, Wanless S, Rothery P, Swann R L & Jardine D, 2000. Survival of Adult Common Guillemots *Uria aalge* at Three Scottish Colonies. *Bird Study* **47**, 1-7.

Impacts Due to Displacement

Displacement may occur during the operational phase, resulting in loss of foraging/roosting areas. This is described below.

The most numerous species recorded were gulls and auks. Gull species were common throughout the wider area as shown by the findings of the aerial surveys for the Greater Wash Strategic Area [3]. The main gull species recorded during the Humber Gateway surveys, was the black-legged kittiwake. Whilst this species was regularly recorded within the Humber Gateway site, it was also recorded widely across the survey area, with the aerial surveys undertaken for the Greater Wash Strategic Area showing the main concentrations recorded further offshore from the wind farm site and also to the north [3]. The wind farm site and immediate surrounds did not support any particularly significant concentrations (*Section 8.7.4* and *Appendix D1 Humber Gateway Seabird Survey*). Monitoring at North Hoyle recorded a number of black-legged kittiwake and other gulls (and auks) within and around the operating wind farm. Gulls in particular, have been recorded within other operational wind farms including Horns Rev in Denmark.

Little gull was recorded during the passage period (*Section 8.7.4*). Whilst the surveys recorded some little gulls within the Humber Gateway site, the main concentrations were predominantly further offshore, especially between 15 and 20 km offshore. The aerial surveys undertaken for the Greater Wash Strategic Area show much greater concentrations of little gull in the offshore waters further south of the Humber Gateway site including off the mouth of the Wash [3]. The birds are largely pelagic at this time and the Humber Gateway site was not identified as an important foraging area for the species.

Small numbers of tern species were recorded flying across the Humber Gateway site, but there was little evidence of foraging on the site (*Section 8.7.4*). The aerial surveys undertaken for the Greater Wash Strategic Area show much greater concentrations of terns in the waters off the north Norfolk coast [3].

Auks were commonly recorded across the survey area throughout the year. The common guillemot was the most frequently recorded species (*Section 8.7.4*). Auk species showed some displacement during the construction stages of the North Hoyle Offshore Wind Farm and continued to show a shift away from the wind farm during the operational stages. Whilst they were recorded within the operating wind farm site, they were less abundant compared with their distribution recorded pre-construction. The surveys for the Humber Gateway site recorded auks predominantly in the waters surrounding the site. Whilst the numbers of auks within the Humber Gateway site increased during the post

(3) DTI, 2006. Aerial Surveys of Waterbirds in Strategic Wind Farm Areas: 2004/05.

breeding period (July to October), this reflects a dramatic increase in the numbers of auks throughout the survey area (*Appendix D1 Humber Gateway Seabird Survey*). No particularly significant concentrations of feeding or loafing birds were recorded within the Humber Gateway site. The aerial surveys for the Greater Wash Strategic Area recorded concentrations of auks further south off the mouth of the Wash and further east off the north Norfolk coast [(1)].

The majority of northern fulmar, northern gannet and skua records were to the north of the wind farm site and further offshore, with few records on or close to the wind farm site (*Section 8.7.4*). This is not dissimilar to the findings of the DTI aerial surveys and those shown in Stone et al (1995) [(2)]. The wind farm site was not an important foraging area for either of these species. Gannet was also observed flying within the outer edges of the wind farm on some surveys at the operational North Hoyle Offshore Wind Farm. Gannets are also known to forage over very extensive areas.

Very few divers, shearwaters, petrels, cormorants and shags were recorded during the site surveys. This is consistent with Stone et al (1995) [(3)]. The majority of divers were inshore of the Humber Gateway site or to the north and are unlikely to be unaffected. This is corroborated by the aerial surveys undertaken for the Greater Wash Strategic Area which show much greater concentrations of divers further north of the Humber Gateway site, in the inshore waters off East Yorkshire and south off Humber Gateway site off the Lincolnshire coast, off the mouth of the Wash and in the inshore waters off the north eastern coast of Norfolk [(1)]. Similarly there were few records of manx shearwater within the Humber Gateway site or in its immediate surrounds. Most records were of birds either to the north or south and further offshore. Only three petrels were recorded during the boat based surveys, and occasional cormorants and shags. There were only occasional records of wildfowl and all in relatively small numbers.

The survey findings (*Section 8.7.4*) have shown that the Humber Gateway site does not support important concentrations of foraging or roosting seabirds or waterfowl, and that the wind farm site was of low importance to these species in the regional context (*Section 8.7.4*). Sufficient habitat remains in the wider area for these species and in areas which are more favoured by the birds. As a result, displacement is only likely to affect a very small proportion of the birds recorded in the survey. Such effects will not affect the range or viability of the species. No impact on the favourable conservation status of any species is predicted, hence ***no significant impacts*** are anticipated as a result of displacement.

Impacts on Flight Lines

The construction of a wind farm may cause birds to change their flight lines in response to the perceived barrier presented by a row of turbines. This is also sometimes referred to as the “barrier effect”. This can result in birds undertaking longer flight routes to avoid crossing the turbine arrays, or prevent them from reaching breeding, feeding or roosting grounds [(4)].

The findings from recent monitoring at other smaller operational wind farm sites in Denmark and Sweden have recorded few birds within the wind farm sites. Monitoring at North Hoyle has shown that seabirds have been recorded within the wind farm, but noted that some species such as auks may be less abundant within the wind farm [(5)]. At the Danish and Swedish sites, many species (including those on migration) were found to adjust their flight paths and fly around the sites, including species that are present in the waters around the Humber Gateway site, such as gannet.

Some birds were however, recorded passing through the wind farms between the turbines, including flocks of eider at the Utgrunden Wind Farm in Sweden. Gulls and terns were the only species regularly recorded within the wind farm at Horns Rev, and most often towards the margins of the site rather than in the middle.

Monitoring has been undertaken around the North Hoyle Offshore Wind Farm, where the turbine separation is approximately 270 m (north / south) and 720 m (east / west). The bird species recorded most regularly within the wind farm were gulls and auks, although the latter were usually recorded on the water rather than in flight [(5)]. Cormorants, and some gulls (usually lesser black-backed and herring gulls) were occasionally recorded on the turbines bases even whilst the turbines were operating. However, greater numbers were usually seen on the anemometer mast. Observations outwith the survey recording periods, recorded gannets on one occasion lowering their flight height as they passed through the

[(1)] DTI, 2006. Aerial Surveys of Waterbirds in Strategic Wind Farm Areas: 2004/05.
[(2)] Stone C J, Webb A, Barton C, Ratcliffe N, Reed T C, Tasker M L, Camphuysen C J & Pienkowski M W, 1995. An Atlas of Seabird Distriubution in North-West European Waters. JNCC, Peterborough.
[(3)] Stone C J, Webb A, Barton C, Ratcliffe N, Reed T C, Tasker M L, Camphuysen C J & Pienkowski M W, 1995. An Atlas of Seabird Distribution in North-West European Waters. JNCC, Peterborough.
[(4)] Department for Environment, Food and Rural Affairs, 2005. Nature Conservation Guidance on Offshore Windfarm Development: A Guidance Note on the Implications of the EC Wind Farm Birds and habitats Directive for Developers Undertaking Offshore Windfarm Developments Version R1.9. DEFRA.
[(5)] Npower Renewables, 2006. Gwynt y Mor Offshore Wind Farm: Environmental Statement. Npower Renewables Ltd.

wind farm, and flying in a 'scalloped flight' around the edge of the wind farm (i.e. flying into the wind farm and then out around the turbines [(1)].

The realistic worst case layouts in relation to potential displacement are Layout 1 and Layout 2, where the shortest distance between the turbines is approximately 588 m. Much of the activity by breeding gulls such as black-legged kittiwake was to the north of the wind farm site closer to the colony, further offshore (e.g. little gull), or further south off the mouth of the Humber Estuary (e.g. mew gull). No significant wildfowl, wader or passerine movements were recorded through the wind farm site during the surveys. The main species whose flight lines may be affected by the Humber Gateway given their recorded distribution or behaviour, are gannet and gulls (mainly little gull, mew gull and black-legged kittiwake). Auks are commonly recorded across the area but there were no obvious flight lines across the wind farms between auk breeding colonies and foraging grounds.

Much of the gannet flight activity was recorded across the waters inshore and offshore from the Humber Gateway site. Northern gannets can fly very long distances to feed from their breeding colonies. Gannets flying from breeding colonies in the north to feeding grounds in the south will have to travel an additional distance to fly around the Humber Gateway site. However, it is considered unlikely to result in considerable additional energy costs to these species.

In conclusion, the natural range of the birds will not be affected and a sufficiently large area of habitat will be maintained. The impacts on flight lines from the Humber Gateway are not likely to affect the favourable conservation status of any species, hence ***no significant impacts*** are predicted.

Collision Risk Assessment (CRA)

Introduction

The risk of birds colliding with offshore wind farms is considered to be an important issue [(2)], and is one that has been raised in relation to Humber Gateway by consultees including Natural England, RSPB and YWT.

[(1)] Robinson P, 2005, Pers Comm.
[(2)] Langston R H W and Pullen J D, 2003. Wind farms and birds: an analysis of the effects of wind farms on birds, and guidance on environmental assessment criteria and site selection issues. Report by BirdLife to the Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats (Berne Convention), Strasbourg.

Monitoring undertaken during the operational phase of Horns Rev and Nystead offshore wind farms in Denmark [(3)] [(4)], and at Utgrunden and Yttre Stengrund in the Kalmar Sound in Sweden [(5)], has not recorded any significant collision effects.

Only one collision event was recorded from these wind farms (at the Yttre Stengrund Wind Farm), when four out of a flock of 310 eider were seen to fall into the water when the outer flank of the flock was struck by a rotor. Three of these four birds were observed flying away quickly from the area and hence only one bird was assumed to have been killed during this event. No collisions have been observed during monitoring at the Danish sites or at North Hoyle Offshore Wind Farm in Liverpool Bay.

These studies have recorded birds predominantly taking avoidance action between 1 and 2 km from the turbines. The birds were then observed flying around the turbines rather than passing through the centre of the wind farm. At Horns Rev this included divers and common scoter. At Horns Rev, where birds did enter the wind farms, they appeared to adjust their flight to pass through the wind farm in parallel to the turbine rows. These adjustments were found to be less precise at night. The monitoring studies at North Hoyle and in Denmark have taken place during the daytime or included night-time monitoring during periods of good visibility. The studies in the Kalmar Sound in Sweden reported similar findings during periods of poor visibility.

Birds have been recorded colliding with coastal wind farms (e.g. at Blyth Harbour Wind Farm and at the port of Zeebrugge) and those on offshore islands (e.g. Smøla off the coast of Norway). The location of the Humber Gateway site and the bird activity differs from that of the Blyth Harbour and Zeebrugge Wind Farms, and the bird species affected by the Smøla Wind Farm are not present near the Humber Gateway site. Similar impacts are not, therefore, predicted.

At the Humber Gateway site, the clearance between the blade tip at its lowest point and the water surface will be approximately 22 m at mean high water springs (MHWS), and the upper tip height will be 172 m. The numbers and heights of the birds recorded in flight during the boat surveys and the height

[(3)] Christensen T J & Hounisen J P, 2005. Investigations of Migratory Birds During Operation of the Horns Rev Offshore Wind Farm. NERI.
[(4)] Kahlert J, Petersen I K, Fox A D, Desholm M & Clausager I, 2004. Investigations of birds during construction and operation of Nysted offshore wind farm at Rodsand. Annual status report 2003. Report commissioned by Energi E2 A/S 2004. Ronde, Denmark: National Environmental. Research Institute.
[(5)] Pettersson J, 2005. The impact of offshore wind farms on bird life in southern Kalmar Sound, Sweden. A final report based on studies 1999-2003. Report for the Swedish Energy Agency. Lund, Sweden: Lund University.

bands within which they occur are presented in *Section 8.7.5* and *Appendix D1 Humber Gateway Seabird Survey*.

The survey findings for Humber Gateway show that the percentage of birds flying at a height which may result in a collision is relatively consistent throughout the surveys (i.e. both within the site and in the control area) (*Table 11.18*).

Table 11.18 Numbers and Percentages of Birds Flying at Collision Risk Height

Period	Survey Area	Number of Birds Recorded in Flight	Numbers of Birds at Collision Risk Height	Percentage
October 2003 – June 2004	Wind Farm	264	58	22
July 2004 – December 2005	Wind Farm	1,402	352	25
October 2003 – June 2004	Control Area	477	98	21
July 2004 – December 2005	Control Area	1,058	216	20

Table 11.18 shows that the majority of the birds (75% to 80%) were recorded on the water or in flight at heights below the rotor swept area, and will not therefore be at risk of collision with the rotors. However, around 25% of the flights were within the rotor swept area and included small percentages of species that were regularly recorded during the surveys such as northern gannet, black-legged kittiwake and common gull, and species such as pink-footed goose and eider. Further collision risk assessment was therefore carried out as described below.

Collision Risks Predicted at the Humber Gateway Offshore Wind Farm

General Approach to Collision Risk Assessment (CRA)

The CRA has been undertaken using the model described in SNH (2000) [1] and Band et al (in de Lucas et al, 2007 [2]). The CRA involves a two stage calculation which provides a theoretical assessment of collision risk that assumes the birds take no action to avoid the turbines. The number of birds colliding with the turbines per annum is then the product of these two stages.

Stage 1 – Number of Birds Passing through the Risk Window per Annum

The Stage 1 calculation estimates the overall number of birds passing through the rotor swept area. This requires a risk window to be calculated (i.e. the width of the wind farm perpendicular to the general flight direction of birds through the site determined from the field surveys, multiplied by the maximum turbine height). The proportion of birds flying within the altitude range of the rotor sweep was calculated for a realistic worst case scenario in accordance with the 'Rochdale Envelope', based on flight heights from the boat based surveys.

When considering the worst case turbine size / layout in terms of collision risk a single 7 MW turbine has the greatest rotor sweep area of the turbine options being considered. However it is also important to consider the overall swept area which will result across the whole wind farm. If the 7 MW turbine is chosen, the wind farm will comprise only 42 turbines, whilst if the 3.6 MW turbine is chosen the wind farm would comprise 83 turbines. Despite the smaller rotor sweep of a 3.6 MW turbine, the number of them would result in a greater overall rotor swept area, and hence the risk of a bird flying through the swept area is actually higher. As a result, the 3.6 MW layout was identified as being the worse case scenario in terms of the collision risk and was therefore used for the modelling.

The number of birds in flight was expressed as 'birds per hour', based on flights from 129 hours of observations. The total movements for the year were extrapolated assuming that there was no difference in the diurnal and nocturnal activity (24 hours of movement). All birds recorded in flight within the rotor sweep area (i.e. 22 m to 129 m at MHWS) were used in the collision risk modelling, with all of those birds assumed to pass through the risk window.

(1) Scottish Natural Heritage, 2000. Windfarms and Birds: Calculating a Theoretical Collision Risk Assuming No Avoiding Action. SNH Guidance Series, SNH.
(2) de Lucas M, Janss, G F E & Ferrer M (eds), 2007. Birds and Wind Farms: Risk Assessment and Mitigation. Quercus/Libreria Linneo.

The number of birds passing through the rotor swept area (A) was then calculated using A = N x πR^2 where N is the number of rotors and R is the rotor radius. The numbers of birds passing through the rotor area was derived for the 3.6 MW wind farm layout identified above. In this instance, the total rotor swept area of the layout exceeded the risk window by 15% due to turbine overlap in the risk window plane.

Stage 2 – Probability of a Bird Being Hit when Flying through the Rotor

The second stage calculates the probability of birds passing through the rotor swept area colliding with the rotor blades. The probability of collision was based on the following measurements:

- the size of the individual species moving through the site, including body length and wingspan;
- breadth and pitch of the turbine blades;
- rotational speed of the turbine; and
- flight speed of the bird.

Bird flight speeds were taken from Campbell & Lack (1985) [(1)] and body measurements from Perrins (1998) [(2)].

The probability of a bird colliding increases with increased rotational speed. Several parameters used in the model can vary, for example the pitch of the blades is variable as this is continuously re-positioned to take advantage of optimum wind conditions, depending on the direction of the wind.

The following assumptions have been made in the modelling:

- a rotor speed of 13 revolutions per minute;
- a pitch angle of 90°; and
- a chord width of approximate 5 m.

The probability of collision (Stage 2) is then multiplied by the expected number of bird passes through the rotor swept area (Stage 1), in order to produce an estimate of the likely collision rate. It is important to note that this assumes the birds exhibit no avoidance behaviour.

(1) Campbell B & Lack E, 1985. A Dictionary of Birds T & A D Poyser.
(2) Perrins C, 1998. The Complete Birds of the Western Palearctic on CD-ROM. Oxford University Press (OUP), Oxford.

Collision Rate

In practice birds do exhibit avoidance behaviour. This is avoidance, either of the whole wind farm (usually termed displacement), or of the moving rotors (usually termed avoidance). Both of these factors contribute to the avoidance rate which is important in the CRA, but they are separate processes [(3)].

The inclusion of an avoidance factor, which represents the proportion of birds which are likely to take effective avoiding action, allows a more realistic prediction of the probable number of avian collisions. For example, a 50% avoidance factor would mean that five out of ten birds flying towards a wind farm would avoid the obstacle, and five would enter the wind farm site and thus be at risk of colliding with the turbines.

There are no detailed avoidance factors available for offshore wind farms exhibiting similar environmental characteristics to the proposed Humber Gateway project. Avoidance rates determined by research studies for a number of sites in Europe, involving direct observations and fatality calculations, are all above 97%, with the majority at 99% and above (*Appendix D2, Humber Gateway Collision Risk Assessment*). However, this assessment has adopted a precautionary approach, and used a range of collision factors (0%, 50%, 95%, 97% and 99%) to estimate the potential collision risk with the wind farm. Avoidance factors of 0% and 50% are clearly extremes, but serve to illustrate the magnitude of the effect that could occur, for example during periods of reduced visibility, strong wind etc.

Approach to Collision Risk Assessment (CRA) for Migrating Pink-footed Geese Anser brachyrhynchus

An additional and specific CRA was undertaken for pink-footed geese. The main aim of this assessment was to determine whether there was a risk of the Humber Gateway Offshore Wind Farm, along with the other offshore wind farms in the Greater Wash, having any cumulative collision risk effect on populations of pink-footed geese that are known to migrate to and from the north Norfolk coast.

The modelling of the collision risk to pink-footed geese generally followed a similar approach to that used for the seabirds. The approach included the use of a worst case expected passage population of pink-footed geese likely to move along the Yorkshire coast (estimated to be 75,000 birds based on data provided by Natural England). This scenario was then considered assuming two migration

(3) Band W, Madders M, Whitfield D P, 2005, Developing field and analytical methods to assess avian collision risk at wind farms. In De Lucas, M, Janss, G and Ferrer, M (eds) Birds and Wind Power. Barcelona, Spain: lunx Edicions, in press.

movements (autumn and spring) along the east coast, and thus through the vicinity of Humber Gateway site.

Realistically, it is unlikely that all birds moving along the coast would move through the Humber Gateway site, with only a small percentage of the migratory movements likely to pass through the wind farm. Therefore, the modelling assumes that 25% of the movement is actually through the wind farm site, i.e. that the movement of approximately 75,000 individuals is evenly distributed across the coastal margin of an approximately 20 km band with the wind farm consisting of approximately 25% of this band. This is considered to be a realistic worst case scenario, given that a movement biased towards the coast (e.g. inshore of the wind farm) would be potentially more likely.

Following a worst case scenario approach, all pink-footed geese were assumed to fly within the altitude range of the rotor sweep. However, again this is considered to be extremely unlikely (see below).

In addition, an avoidance factor of 90% has been used, compared with 95% for other species modelled. This was discussed and agreed with RSPB and was set lower to take account of the nocturnal migration flight activity of this species. This may also be an over-precautionary figure given the avoidance factors for geese based on direct observations at other coastal wind farms (*Appendix D2 – Seabird Collision Risk Assessment*) which show that avoidance rates were largely above 97%.

Findings of Main Collision Risk Assessment (CRA) - Overview

The losses predicted due to collisions of birds with the Humber Gateway are provided in *Appendix D2 – Seabird Collision Risk Assessment*. The species for which the collision risk assessment was undertaken were agreed in consultation with Natural England and are listed in *Table 11.19.* The predicted number of collisions per annum for each species using a range of avoidance rates (95%, 97% and 99%) is also presented in *Table 11.19.*

Table 11.19 Predicted Collision Rates (Number of Birds Colliding per Annum)

Species	**Number of Collisions p.a. for Different Avoidance Rates**		
	95%	**97%**	**99%**
red-throated diver *Gavia stellata*	3	2	1
Northern gannet *Morus bassana*	18	11	4
great skua *Catharacta skua*	1	1	1
Arctic skua *Stercorarius parasiticus*	1	1	1
little gull *Athene noctua*	4	2	1
black-headed gull *Larus ridibundus*	4	2	1
mew (common) gull *Larus canus*	161	97	33
black-legged kittiwake *Rissa tridactyla*	34	20	7
herring gull *Larus argentatus*	13	8	3
great black-backed gull *Larus marinus*	64	38	13
lesser black-backed gull *Larus fuscus*	13	8	3
sandwich tern *Sterna sandvicensis*	10	6	2
common tern *Sterna hirundo*	3	2	1
Arctic tern *Sterna paradisaea*	2	1	1
'commic' tern *Sterna* spp.	11	7	3

In addition to the above species, the specific pink-footed goose *Anser brachyrhynchus* movements were also modelled at 90% avoidance (*Table 11.20*).

It should be noted that this modelling used some extreme worst case assumptions and will therefore over-state the degree of impact. In particular, there is evidence that many long distance migration flights by geese occur at altitudes of well over 1,000 m (see below), which would be clear of the turbines altogether. It is therefore very likely that the actual number of collisions will be considerably less than the figures indicated by the modelling.

Table 11.20 Predicted Collision Rates per Annum of Pink-footed Geese (90% avoidance rate)

Scenarios	**Number of collisions out of an east coast movement of 75,000 individuals**
Number of collisions p.a.	519

For a number of these species, the predicted losses are very small and will not be significant. The impacts of the losses on the populations for species with greater losses are considered in the following sections. The assessments have been based on a conservative assumption of a 95% avoidance rate.

Findings of Collision Risk Assessment (CRA) - Northern Gannet Morus bassana

The surveys found gannets to be largely absent from the waters on and around the Humber Gateway site during the winter, and only a few birds were observed during the early part of the breeding season prior to May. The greatest numbers occurred during the main breeding season (from May to August), but there was a continued presence of birds in September and October. Observations of gannets increased closer to the local breeding colony at Bempton, and the flight directions suggested that most of the birds recorded during the surveys were associated with this colony. It is unlikely that Humber Gateway will affect birds from other breeding colonies.

The British summer population is estimated to be some 227,000 pairs and the population is steadily increasing in Britain and Europe [1] [2] [3]. The colony at Bempton is the only mainland gannet breeding colony on the east coast of England and gannets form part of the qualifying interest of the Flamborough Head and Bempton Cliffs SPA. In line with the national trend, this colony has also been increasing in size steadily over the last 30 to 40 years. Surveys undertaken between 1968 and 70 recorded only 18 Apparently Occupied Sites / Nests (AOS / AON) but this had increased to 2,552 by the time of the surveys for Seabird 2000, and to approximately 3,500 AONs at the last count in 2004 [4]. For the purposes of this assessment, it has been assumed that increases in the population of the colony have continued since and that the population in 2007 is approximately 4,000 AONs.

The loss of an additional 18 birds (at 95% avoidance) due to the Humber Gateway project (*Table 11.19*) represents a small increase in this mortality by approximately 0.23% to 8.23% (*Table 11.21*).

[1] Mitchell P I, Newton S F, Ratcliffe N & Dunn T, 2004. Seabird Populations of Britain and Ireland. T & A D Poyser.
[2] www.birdlife.org/datazone/species/BirdsInEuropeII/ BiE2004Sp3652.pdf.
[3] Mead C, 2000. The State of the Nation's Birds. Whittet Books, Suffolk.
[4] Melling T, RSPB, 2007. Pers. Comm.

Table 11.21 Mortality Rate Impacts on Northern Gannet from Collisions

Breeding Population	Natural Adult Mortality Rate (%)	Number of Birds Lost from Population	Number of Collisions (95% Avoidance)	Increase in Mortality Rate due to Humber Gateway	Revised Mortality Rate
8,000 birds at Bempton	8	640	18	0.23%	8.23%

This also takes no account of the significant numbers of non-breeding birds which are likely to be present and sub-adult birds, as up to the age of four the mortality rate of gannets is very high, approximately 70%. The number of birds which may be lost is small as is the increase in mortality rate. This is also a colony which has been increasing in size over the last few decades and is continuing to do so and there is no threat to its distribution in this area, its range or its ability to maintain a viable population. The predicted losses from Humber Gateway will not affect the favourable conservation status of northern gannet and ***no significant impacts*** are predicted on the gannet populations either at a national level or at the Bempton colony.

Findings of Collision Risk Assessment (CRA) - Pink-footed Goose Anser brachyrhynchus

Pink-footed geese start to arrive in Britain during early to mid September with numbers building in early to mid October, when peak numbers occur at the major northern sites in the UK. The distribution of geese changes over the winter period with peak numbers at English sites recorded in mid-winter. From January / February there is a migration northwards with peaks in the northern UK sites during late March / April [5] [6].

[5] Mitchell C & Hearn R D, 2004. Pink-footed Goose Anser brachyrhynchus (Greenland/Iceland population) in Britain and Ireland 1960/61 – 1999/2000. Waterbird Review Series, The Wildfowl & Wetlands Trust/Joint Nature Conservation Committee, Slimbridge.
[6] Fox A D, Mitchell C, Stewart A, Fletcher J D, Turner J V N, Boyd H, Shimmings P, Salmon D G, Haines W G, and Tomlinson C, 1994. Winter movements and site-fidelity of pink-footed geese Anser brachyrhynchus ringed in Britain, with particualr emphasis on those ringed in Lancashire. Bird Study, 41, 221-234.

Numbers of pink-footed geese in north Norfolk have increased since the early 1990s and in recent years approximately half the UK wintering population has been recorded from this area in mid-winter. A record count in north Norfolk of 147,250 birds was made in December 2004 [(1)]. The wintering populations of pink-footed geese in Britain are continuing to increase [(1)].

Birds of the Humber wintering population moving south during the early part of the winter are unlikely to fly across the Humber Gateway site given its location over 8 km off the coast. Similarly, given the flock's inner estuary location, it is considered extremely unlikely that significant regular offshore diurnal movements occur during the wintering period in relation to movements between feeding and roosting sites on and around the Humber Gateway site.

However, winter movements recorded from individually marked birds show movements between Scotland and north Norfolk [(2)]. Observations from Spurn and during Humber Gateway ship-based seabird surveys show that birds fly south and parallel to the east coast of England, probably towards The Wash and other areas along the north Norfolk coast (e.g. peak of approximately 6,500 birds recorded flying south on 5 November 2005). Migrating birds have also been observed flying across Bridlington Bay and following the coast south [(3)]. Land-based sea watching is most likely to record birds within about 5 km of the coastline (i.e. inshore of the Humber Gateway site). Data on the relative densities of pink-footed geese movements with distance from shore are not known. However, it would be expected, given the lateral coastal nature of the movement undertaken by the pink-footed geese down the east coast, that concentrations would be largely within sight of land, but with movements potentially 'cutting corners' across embayments and estuary mouths. As such, it is not expected that flock movements would be concentrated offshore, in the vicinity of the Humber Gateway site, but more likely predominantly undertaken within 5 km of the coast.

In addition to these coastal movement observations, ringing recoveries show that some of the birds recorded in north Norfolk have arrived there via sites in Lancashire, having flown cross-country rather than along the east coast of England [(4)], although an accurate quantification of the relative importance (in terms of movement numbers) between the East Coast route and the cross-country route are not possible.

Data have been provided by Natural England [(5)] for pink-footed goose movements past east coast observatories in the autumn and early winter of 2005 and 2006. These data indicate that approximately 60,500 pink-footed geese moved down the east coast in the autumn of 2005, with a lesser amount in 2006, this reduction possibly reflecting a lower recording effort that year. Assuming that not all movements were recorded, it is suggested that a figure of approximately 75,000 pink-footed geese may move down the east coast margin each year, with a similar number returning during the spring. This accounts for approximately 50% of the total Wash / north Norfolk population, with additional movements into this area undertaken by flocks crossing the UK mainland, many from staging areas in southwest Scotland and northwest England. The scenario that was modelled has therefore assumed that approximately 50% of the population moves along the east coast (based on the Natural England data).

The increases in mortality based on the collision risk modelling findings are presented in *Table 11.22*.

Table 11.22 Effects on Mortality Rates of Pink-footed Geese due to Collisions with Humber Gateway Offshore Wind Farm

Parameter	**Number of collisions out of east coast movement of 75,000 individuals**
% assumed to fly though wind farm	25%
predicted collisions per annum	519
British population	192,000
% additive mortality [1]	0.27%
annual mortality	13.70%
% increase in mortality [2]	1.97%

Note[1] % additive mortality = collisions per annum / British population.
Note [2] % increase mortality= % additive mortality / annual mortality

The findings indicate increases in mortality rates of approximately 2%. As previously noted, this figure is for a series of extreme worst cases with a lower

(1) Banks A N, Collier M P, Austin G E, Hearn R D & Musgrove A J, 2006. Waterbirds in the UK 2004/05: The Wetland Bird Survey. BTO/WWT/RSPB/JNCC. Thetford.
(2) Fox A D, Mitchell C, Stewart A., Fletcher J D, Turner J V N, Boyd H, Shimmings P, Salmon D G, Haines W G, & Tomlinson C, 1994. Winter movements and site-fidelity of pink-footed geese *Anser brachyrhynchus* ringed in Britain, with particular emphasis on those ringed in Lancashire. Bird Study, 41, 221-234.
(3) Carr G, 2007, Pers Comm.
(4) Wernham C, Toms M, Marchant J, Clark J, Siriwardena G & Baillie S, 2002. The Migration Atlas - Movements of the Birds of Britain and Ireland. T & A D Poyser.
(5) Natural England, 2007. Pers. Comm.

avoidance rate than that calculated at coastal wind farms [(1)]. It also assumes that all the geese flying through the wind farm do so at rotor height, which in practice is unlikely, and there is evidence, that many long distance migration flights by geese occur at altitudes of well over 1,000 m [(2)]. Coupled with the scarcity of records of pink-footed geese from the boat and aerial surveys, this suggests that the actual mortality rates are likely to be lower than those shown in *Table 11.22.*

In addition, the trends in the wintering populations of pink-footed goose have shown a steady increase since the mid 1960's, which is continuing. This increase is also occurring despite the continuing loss of birds through shooting. Hence the population is expected to be more able to tolerate some increases in mortality rates. It is not expected, therefore, that the distribution of this species will be affected and that the favourable condition status of pink-footed goose will be maintained. ***No significant impacts*** on pink-footed goose due to collisions are predicted.

Findings of Collision Risk Assessment (CRA) - Little Gull Larus minutus

Large numbers of little gulls are recorded off the North Yorkshire/Humber coast in autumn with over 10,000 birds recorded on a single occasion off Spurn in September 2003 [(3)]. The Environmental Statement for the Lincs Offshore Wind Farm estimated the regional population to be 32,000, based on aerial survey data. It is likely that this population also ranges north to latitudes covering the Humber Gateway site. The findings of the surveys, including the dedicated little gull survey, indicate that the birds occur well offshore, typically over 10 km from land, with the largest concentrations between 15 km and 20 km offshore (*Section 8.7.4*). This is broadly in agreement with the findings of other studies which found substantial flocks between 15 and 25 km off the Holderness Coast [(3)].

The loss of an additional four birds (at 95% avoidance) due to Humber Gateway (*Table 11.19*) represents a small increase in this mortality by approximately 0.013% to 17.013% (British wintering population) (*Table 11.23*).

[(1)] Fernley J, Lowther S & Whitfield P, 2006. A Review of Goose Collisions at Operating Wind Farms and Estimation of the Gosse Avoidance Rate. Natural Research Ltd / West Coast Energy / Hyder Consulting.
[(2)] Ebbinge B S & Buurma L S, 2000. Mid Winter Movements of Geese in the Netherlands as Risk to Aviation Safety. International Bird Strike Committee. IBSC25/WP-OS5, Amsterdam, 17 – 21 April 2000.
[(3)] Hartley C, 2004. Little Gulls at Sea Off Yorkshire in Autumn 2003. British Birds 97.

Table 11.23 Mortality Rate Impacts on Little Gull from Collisions

Population	Natural Adult Mortality Rate (%) [(4)]	Number of Birds Lost Due to Natural Causes	Number of Collisions (95% Avoidance)	Increase in Mortality Rate Due to Humber Gateway	Revised Mortality Rate
32,000 (Regional autumn passage population)	17	5,440	4	0.013%	17.013%

The autumn population is also likely to comprise a large number of juvenile birds, and whilst no mortality data are available for juveniles [(4)], it is expected that it will be much higher than the adult mortality rate. The natural losses in any one year are therefore likely to be greater than 5,444 and the percentage addition due to collision with Humber Gateway even lower. Since this will not affect the conservation status of the little gull populations, ***no significant impacts*** are predicted.

Findings of Collision Risk Assessment (CRA) - Mew (Common) Gull Larus canus

Mew gulls breed across the Palaearctic and in North America, on coasts and at inland sites, and spend the winter inland on estuaries and at sea. The breeding population in Britain and Ireland is 49,780 pairs [(5)]. However, its breeding distribution is virtually confined to Scotland and northwest Ireland. This was reflected in the surveys findings which recorded mew gulls around the wind farm site between autumn and spring of the survey years, with a near absence from July to September. Hence, ***no significant impacts*** are predicted on the breeding mew gulls.

Ringing studies show that the wintering mew gulls originate particularly from Norway, Sweden, Finland, Denmark, the Baltic States and western Russia. Although there is some tendency for birds from northern Norway to winter further north and birds from Denmark and the Baltic States further south, this trend is by no means distinct and it is likely that many birds migrating into Britain across the

[(4)] Balmer D & Peach W, 1997. Review of Natural Avian Mortality Rates. BTO.
[(5)] Mitchell P I, Newton S F, Ratcliffe N & Dunn T, 2004. Seabird Populations of Britain and Ireland. T & A D Poyser.

northern North Sea move further south during the winter [1]. The mew gull winter population in Britain is estimated at 900,000 birds [2].

The loss of an additional 161 birds (at 95% avoidance) due to Humber Gateway (*Table 11.19*) represents a small increase in this mortality by approximately 0.018% to 14.018% (British wintering population) (*Table 11.24*).

Table 11.24 Mortality Rate Impacts on Mew (Common) Gull from Collisions

Population	Natural Adult Mortality Rate (%)	Number of Birds Lost Due to Natural Causes	Number of Collisions (95% Avoidance)	Increase in Mortality Rate Due to Humber Gateway	Revised Mortality Rate
900,000 (British wintering population)	14	126,000	161	0.018%	14.018%

The wintering population is however, likely to comprise a number of juvenile and immature birds, and the mortality rates for birds up to the age of three years is much greater (76%). It is likely that the natural mortality will exceed the 126,000 quoted above and hence the additional 161 may add even less of an increase to the mortality rates.

No effects are predicted on the favourable conservation status of mew (common) gull given the low numbers of birds which are likely to be lost compared to the population size and the small increases in mortality rates which result. Therefore, ***no significant impacts*** are predicted on mew (common) gull populations from collision with the wind farm.

(1) Wernham C, Toms M, Marchant J, Clark J, Siriwardena G & Baillie S, 2002. The Migration Atlas - Movements of the Birds of Britain and Ireland. T & A D Poyser.
(2) http://blx.bto.org/birdfacts/results/ bob5900.htm.

Findings of Collision Risk Assessment (CRA) - Black-legged Kittiwake Rissa tridactyla

The kittiwake is the most abundant gull in the world [3]. They are present at their breeding colonies for approximately half of the year, with breeding adults (birds at least three years old) returning to the same colony year after year. During the breeding season the birds typically range close to the colonies and birds have been recorded around the wind farm site. The nearest nesting colonies to the Humber Gateway site are at Bempton Cliffs including Flamborough Head (approximately 55 km north). The nearest breeding sites to the south are well over 100 km away on the coastline of southern Norfolk and northern Suffolk, and birds from these colonies are unlikely to occur on or around the wind farm site during the breeding season.

Whilst some birds start visiting breeding colonies when they are two years old, for the purposes of this assessment it has been assumed that the population that is likely to be affected is the breeding population associated with colonies on the Humberside and North Yorkshire coast. The breeding population of black-legged kittiwake at Flamborough Head and Bempton Cliffs is part of the qualifying interest of the SPA and 83,370 pairs were recorded in 1987. However, the local black-legged kittiwake population, in common with much of the east coast of Britain, has however been decreasing at the rate of about 5% per annum for the last 10 years [3]. This decline is evident in the breeding Flamborough Head and Bempton Cliffs population, where Mitchell et al (2004) [3] reports an approximately 50% decrease in the number of apparently occupied nests (AON) from the Seabird Conservation Review (SCR) census that took place between 1985 and 1988, to 42,659 (85,318 birds), and a total of 50,587 AON (101,174 birds) along the Humberside and North Yorkshire coasts. These more recent figures have been used in the assessment.

The annual adult survival rate in kittiwakes is 0.835 [1]. Wernham et al (2002) [4] cites a report by Aebischer and Coulson (1990) [5] that states annual adult mortality in males at about 20%, and at about 17% in females, and that most mortality occurs outwith the breeding season (i.e. when the birds are oceanic). For the purposes of this assessment, a 17% figure has been used as a worst case. This mortality rate does not take account of the presence of any young birds, which would have the effect of reducing the rate even further. The loss of

(3) Mitchell P I, Newton S F, Ratcliffe N & Dunn T, 2004. Seabird Populations of Britain and Ireland. T & A D Poyser.
(4) Wernham C, Toms M, Marchant J, Clark J, Siriwardena G & Baillie S, 2002. The Migration Atlas - Movements of the Birds of Britain and Ireland. T & A D Poyser.
(5) Aebischer N J & Coulson J C, 1990. Survival of the Kittiwake in Relation to Sex, Year, Breeding Experience and Position in the Colony. Journal of Animal Ecology 59: 1063-1071.

an additional 18 birds (at 95% avoidance) due to the Humber Gateway project (*Table 11.19*) represents a small increase in this mortality by approximately 0.23% to 8.23% (*Table 11.25*).

Table 11.25 Mortality Rate Impacts on Black-legged Kittiwake from Collisions

Breeding Population	Natural Adult Mortality Rate (%)	Number of Birds Lost Due to Natural Causes	Number of Collisions (95% Avoidance)	Increase in Mortality Rate Due to Humber Gateway	Revised Mortality Rate
101,174 (Flamborough Head and Bempton Cliffs / Humber and North Yorkshire Adult breeding population)	17	17,200	34	0.3%	17.03%

Humber Gateway is also the only wind farm which is within the typical foraging range of these species. Whilst there has been a decline in kittiwake populations, the main effect on the national population trends over the past 30 years has been due to changes in the marine environment which have affected stocks of fish prey [(1)], and increased predation from the expanding great skua populations. No effects are predicted on the favourable conservation status of breeding black-legged kittiwake given the low numbers of birds which are likely to be lost and the small increases in mortality rates which result. Therefore ***no significant impacts*** are predicted on black-legged kittiwake populations from collision with the wind farm.

Outside the breeding season kittiwakes are largely oceanic and the birds are known to make extensive movements to avoid atmospheric depressions. Wernham et al (2002) [(2)] reports that much of the ringing of kittiwakes has been undertaken on birds in northeast England and Scotland, with recoveries of young birds reared in Britain as far west as the coasts of Greenland and North America. On the European side of the Atlantic, recoveries are predominantly in the North Sea or off the coast of northern Europe in autumn, with some records further south towards the Bay of Biscay and the west coast of Iberia in the winter. Birds that are three years old (approaching breeding age) tend to remain closer to their natal areas than in previous years. Little is known about the winter movements of the same birds from year to year, or the winter population numbers.

However, from what is known about kittiwake dispersion and movements over the winter, any winter mortality is likely to impact on a population in orders of magnitude larger than the local breeding population. The British and Irish total alone amounts to nearly 900,000 adult birds, the rest of the North Sea populations amounting to over 1,200,000 and colonies further north in Iceland, Faeroes and Svalbard/Bear Island with about 2,500,000 adult birds. As a proportion of such a large population, which may also mix with birds from the West Atlantic, any wind farm mortality during the winter (when most mortality identified at the Humber Gateway site occurs) will be orders of magnitude lower in significance than that during the summer. No effects are predicted on the favourable conservation status of wintering black-legged kittiwake, and as such ***no significant impacts*** are anticipated.

Findings of Collision Risk Assessment (CRA) - Great Black-Backed Gull Larus marinus

There are no breeding colonies of great black-backed gull in the vicinity of the Humber Gateway site. Most of the east coast colonies are further north in Scotland. Great black-backed gulls were predominantly recorded in the waters on and around the wind farm site during the autumn passage and winter months, with few records during the spring passage or breeding season.

This species has an extensive breeding range across the North Atlantic and adjacent seas, from Baffin Island and the Foxe Channel in the west to Novaya Zemlya and Ostrov Vaygach in the east. Norway and Iceland host most of the world population with Britain and Ireland close behind [(1)]. While British and Irish breeders are largely sedentary, birds from Norway tend to move south across the North Sea to the east coast of Britain, particularly the southeast. This movement begins in July and peaks in September. Numbers remain high through the winter until birds start to return to Norway in February. While it is clear that a high proportion of the world population of great black-backed gulls winters in the North Sea region (over 300,000 birds), the exact number associated with particular areas is difficult to determine, particularly with immature birds ranging more

[(1)] Mitchell P I, Newton S F, Ratcliffe N & Dunn T, 2004. Seabird Populations of Britain and Ireland. T & A D Poyser.
[(2)] Wernham C, Toms M, Marchant J, Clark J, Siriwardena G & Baillie S, 2002. The Migration Atlas - Movements of the Birds of Britain and Ireland. T & A D Poyser.

widely [1]. The British winter population is estimated to be approximately 40,000 birds [2].

No data on survival and mortality rates is available for great black-backed gull [2]. Assuming that mortality in this species is not dissimilar to other larger gulls, such as lesser black-backed and herring gulls and great skuas, a mortality rate of approximately 7% has been used in this assessment.

The loss of an additional 64 birds (at 95% avoidance) due to the Humber Gateway project (*Table 11.19*) represents a small increase in this mortality by approximately 0.16% to 7.16% (British breeding population) and 0.02% to 7.02% (North Sea wintering population) (*Table 11.26*).

Table 11.26 Mortality Rate Impacts on Great Black-backed Gull from Collisions

Population	Natural Adult Mortality Rate (%)	Number of Birds Lost Due to Natural Causes	Number of Collisions (95% Avoidance)	Increase in Mortality Rate Due to Humber Gateway	Revised Mortality Rate
40,000 (British breeding population)	7	2,800	64	0.16%	7.16%
300,000 (North Sea wintering population)	7	21,000	64	0.02%	7.02%

No effects are predicted on the favourable conservation status of great black-backed gull given the low numbers of birds which are likely to be lost and the small increases in mortality rates which result. Therefore ***no significant impacts*** are predicted on great black-backed gull populations from collision with the wind farm.

[1] Wernham C, Toms M, Marchant J, Clark J, Siriwardena G & Baillie S, 2002. The Migration Atlas - Movements of the Birds of Britain and Ireland. T & A D Poyser.
[2] http://blx.bto.org/birdfacts/results/ bob6000.htm.

Findings of Collision Risk Assessment (CRA) - Common Tern Sterna hirundo

Common terns are summer visitors returning to breeding colonies in April from wintering areas, mainly off the coast of West Africa. Post fledging dispersal can start as early as July and continues into October. Apart from British birds many birds from northern Europe are known to pass through Britain [3].

Although some common tern colonies occur on the Lincolnshire coast it is largely recorded during passage of the Holderness Coast. Small numbers were recorded during the spring passage. However, the majority of records from this study were made during the autumn, with usage peaking in August, but with passage also recorded during July and September. A number of birds were identified as 'commic' (i.e. they could not be distinguished from Arctic terns), and as the vast majority of identified terns were common these 'commic' terns records have been assumed to be common, and the data has been combined for this collision risk assessment.

The British breeding population is about 12,000 pairs, but passage of birds from further north may nearly double that number, so it is possible that the passage population may as large as 40,000 birds.

The adult mortality rate of common terns is approximately 10% [4]. The loss of an additional 14 birds (at 95% avoidance) due to the Humber Gateway Offshore Wind Farm (*Table 11.19*) represents a small increase in the natural mortality rate of the breeding population by approximately 0.06% to 10.06% and of the passage population by 0.04% to 10.04% (*Table 11.27*).

[3] Wernham C, Toms M, Marchant J, Clark J, Siriwardena G & Baillie S, 2002. The Migration Atlas - Movements of the Birds of Britain and Ireland. T & A D Poyser.
[4] BTO 2006. http://blx1.bto.org/birdfacts/results/bob6150.htm

Table 11.27 Mortality Rate Impacts on Common Tern from Collisions

Population	Natural Adult Mortality Rate (%)	Number of Birds Lost Due to Natural Causes	Number of Collisions (95% Avoidance)	Increase in Mortality Rate Due to Humber Gateway	Revised Mortality Rate
24,000 birds (Regional autumn passage population)	10	2,400	14	0.06%	10.06%
40,000 birds (Passage population)	10	4,000	14	0.04%	10.04%

This does not account for any juvenile and immature birds for which no survival / mortality data is available, and hence the additional 11 may add even less of an increase to the mortality rates.

No effects are predicted on the favourable conservation status of common tern given the low numbers of birds which are likely to be lost and the small increases in mortality rates which result. Therefore, ***no significant impacts*** are predicted on common tern populations from collision with the wind farm.

Findings of Collision Risk Assessment (CRA) - Sandwich Tern Sterna sandvicensis

Sandwich terns are summer visitors to Britain, with a breeding population of 13,000 pairs [(1)]. They are highly nomadic and entire colonies may move site within a year or two in response to changing conditions. Nevertheless, the broad distribution of sandwich terns in Britain and Ireland has remained similar over the last 30 years [(2)], with sites in East Anglia (Scolt Head) and Northumberland (Farne Islands and Coquet Island) key along the east coast. The local Norfolk population comprises 4,275 pairs or 8,550 birds, and the Northumberland populations approximately 3,700 between them [(2)].
Post breeding dispersal starts in late June and during July and August there is post fledging dispersal in both directions between Britain and the Netherlands. Birds also move both south and north within Britain and Ireland during this period. The North Sea population is estimated to be in the order of 80,000 birds.

No data is available on the mortality rate of adult or juvenile sandwich terns [(3)], however it has been assumed that their survival rates are not dissimilar to those of common tern (i.e. 10%). The loss of an additional 10 birds (at 95% avoidance) due to the Humber Gateway site (*Table 11.19*) represents a small increase in the natural mortality rate of the breeding population by approximately 0.013% to 10.013% (*Table 11.28*).

Table 11.28 Mortality Rate Impacts on Sandwich Tern from Collisions

Population	Natural Adult Mortality Rate (%)	Number of Birds Lost Due to Natural Causes	Number of Collisions (95% Avoidance)	Increase in Mortality Rate Due to Humber Gateway	Revised Mortality Rate
80,000 birds (North Sea population)	10	8,000	10	0.013%	10.013%

This above does not account for any juvenile and immature birds, and hence the additional 10 birds may add even less of an increase to the mortality rates. No effects are predicted on the favourable conservation status of sandwich tern given the low numbers of birds which are likely to be lost and the small increases in mortality rates which result. Therefore***, no significant impacts*** are predicted on sandwich tern populations from collision with the wind farm.

Findings of Collision Risk Assessment (CRA) - Passerines

Many passerine species are regularly recorded in large numbers at the Spurn Bird Observatory, particularly in the autumn (*Appendix D1 Humber Gateway Seabird Survey*). Similar events are often recorded at other observatories along the east coast of the UK, and it is likely that this is indicative of a broad front of migration which occurs along the east coast. Records at the coast may not, however, be representative of particular areas of open water some 8 km offshore.

Only small numbers of passerines were recorded by the boat based surveys, but migration events are known to be influenced by weather conditions [(4)] and some

(1) BTO 2006. http://blx.bto.org/birdfacts/results/bob6110.htm.
(2) Mitchell P I, Newton S F, Ratcliffe N & Dunn T, 2004. Seabird Populations of Britain and Ireland. T & A D Poyser.
(3) http://blx.bto.org/birdfacts/results/bob6110.htm.
(4) Elkins N, 1983. Weather and Bird Behaviour .T & A D Poyser.

species are known to migrate at night. It is acknowledged, therefore, that boat based surveys may miss some migration events for the following reasons:

- they are only single monthly surveys and may not occur during the days when the main migration is taking place;
- they are not usually undertaken when the winds are strong as this can cause rough seas and best practice guidance is to avoid surveys in certain sea states; and
- they are undertaken during the daylight hours.

Bird movements offshore towards the Humber Gateway site were recorded using a radar unit at a coastal location near the Spurn Bird Observatory in October 2004. The main operating distance of the radar was up to approximately 7 km, and a comparison of radar tracks with birds observed at distances of 6 to 12 km showed that far more records were made from the boat observations than from radar.

A migration event was recorded by the radar unit on the 27 October, and this coincided with records of over 1,100 fieldfare at Spurn on both the 27 and 28 October, and over 1,400 redwing and 1,800 starlings on the 28 October. More tracks were detected at between 6 and 12 km offshore on the 27 October. However, it was unclear how many of these birds had crossed the Humber Gateway site, and if so at what height they had crossed the site. The main period when the majority of the records were made was between 0800 and 1300 (i.e. during the daylight hours), indicating that not all migration events occur at night.

This also suggests that similar migration activity would have been observed during the boat surveys if it occurred during the day. As no such activity was recorded during the boat surveys, it suggests that either there were no migration events during the surveys, or that any birds doing so were flying at a height above that which would result in a collision risk. It has been suggested that in the colder air masses of North America and Europe, that most small passerines fly at heights of typically 250 to 500 m at night (i.e. above the rotor swept area), and that chaffinches fly high across the North Sea to Britain with an easterly tail wind, but in westerly winds fly low along the continental shelf and cross into southern England at the Pas de Calais [(1)].

Even in the event that large numbers of passerines flew across the Humber Gateway site at rotor height at night, it is unlikely that all the birds would collide with the turbines. Similarly, any flock flying through the wind farm is likely to be only part of a much broader front of migration. As such, not all birds on migration will fly through the wind farm. This was suggested by tracks from the radar study on the 27 October 2004, which recorded westerly bird movements along the coast including south of Spurn Point and north beyond Easington, and various bird reports from the region including the Hull Valley Wildlife Reports (2001, 2002) [(1)], Flamborough Ornithological Group, the Filey Brigg Bird report and from Lincolnshire. All of these reports note the arrival of winter visitors to the UK in October especially thrush species.

Whilst the number of birds in such passerine flocks may be relatively high, the proportion of these species which is likely to cross the wind farm site is small given the broad front migration. In addition, populations of these species are also high as are their natural mortality rates compared with seabirds. For example, blackbird annual adult survival rates are approximately 65% (i.e. a mortality rate of 35%), robin adult survival 42% (mortality 58%). Juvenile survival rates for these species are typically lower than the adult survival rates.

Given the above, it is unlikely that the conservation status of passerines will be affected by the number of birds lost, or any increases in mortality as a result. The distribution of these species within the local area or more widely will not be affected. Therefore, ***no significant impacts*** to passerines are anticipated.

11.6.3 MITIGATION MEASURES

The surveys recorded large numbers of birds on the water (particularly auks during the September surveys) throughout the survey area, including small numbers on the Humber Gateway site. These were thought to include moulting birds which would be flightless and hence less able to avoid sources of disturbance. Any significant rafts of moulting birds will be avoided by vessels associated with the development where practicable and compatible with operational requirements.

11.6.4 RESIDUAL IMPACTS

If construction vessels travel to Humber Gateway from a port to the north of the site, particularly one near Flamborough Head, a significant impact is predicted to moulting birds. However, following the implementation of mitigation measures described in *Section 11.6.3*, these impacts would be avoided. No impact on the favourable conservation status of any species is predicted, and as such ***no residual significant impacts*** are anticipated.

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(1) Hull Valley Wildlife Group 2001 and 2002, Hull Valley Wildlife Reports 1999 and 2001. Hull Valley Wildlife Group.

All other predicted residual impacts are the same as those described in the potential impacts section.

11.6.5 Enhancements

It is unlikely that the Humber Gateway project will allow much opportunity for enhancements for birds, although an increase in fish in and around the turbines may provide additional foraging resources for some bird species.

11.6.6 Monitoring

Monitoring requirements will be discussed and agreed with Natural England, and are expected to be in line with the current practice for the ornithological monitoring of offshore wind farms in the UK.

11.6.7 Summary

A summary of potential and residual impacts is presented in *Table 11.29*.

The permanent habitat loss anticipated as a result of the Humber Gateway wind farm will only comprise a small area and will not have significant impacts on feeding areas for bird species. Temporary habitat loss due to the laying of the export and inter-array cables will be short term and recovery is expected to be rapid. ***No significant impacts*** on bird species are predicted.

The Humber Gateway site was not identified as important for foraging birds. Species known to be sensitive to boats were only present in the survey area in small numbers, and often at times of year when construction work will not be occurring. Some temporary disturbance of birds is predicted, especially for piscivores as they follow their fish prey species but ***no significant impacts*** are predicted. It is possible that rafts of moulting seabirds, predominantly auks, will be present in the survey area and on the Humber Gateway site in the autumn months, especially during September. The route by which construction vessels will access the Humber Gateway site is yet to be confirmed. If this is from a southerly direction, ***no significant impacts*** are predicted. If the route is from the north, mitigation measures will be implemented to ensure that no significant impacts result to these moulting birds. As a result of this mitigation, ***no residual significant impacts*** are predicted.

Once Humber Gateway is operational, ***no significant impacts*** are predicted as a result of displacement. The most numerous species recorded are gulls, a group which has been recorded within and close to other operating offshore wind farms.

There were no obvious flight lines across the site between nesting colonies and foraging areas, with species such as gannet largely passing further inshore and offshore. Much of the flight activity was over the waters to the north of the Humber Gateway site, closer to the breeding colonies. No significant movements of wildfowl or passerines were recorded through the Humber Gateway site during the surveys. As such ***no significant impacts*** are predicted as a result of impacts on flight lines.

The predicted losses due to collisions are low, with no significant increases in mortality rates. Hence ***no significant impacts*** on populations are predicted as a result of the Humber Gateway Offshore Wind Farm.

Table 11.29 Summary of Impacts to Birds

Impact	**Potential Impact Significance**	**Additional Mitigation (in addition to embedded mitigation)**	**Residual Impact Significance**
Impact from direct habitat loss	*No significant impacts*	None	***No significant impacts***
Impacts from disturbance	Vessel route from north: *Significant impacts at a local level*	Rafts of moulting birds will be avoided where practicable and compatible with operational requirements.	***No significant impacts***
	Vessel route from other directions: *No significant impacts*	Rafts of moulting birds will be avoided where practicable and compatible with operational requirements.	***No significant impacts***
Impacts due to displacement during operation	*No significant impacts*	None	***No significant impacts***
Impacts on flight lines during operation	*No significant impacts*	None	***No significant impacts***
Impacts from collision during operation	*No significant impacts*	None	***No significant impacts***
Impacts during decommissioning	*No significant impacts*	None	***No significant impacts***