7 Biological Environment

7.1 Benthic Ecology

7.1.1 Summary of Effects and Mitigation

7.1.1.1 This chapter presents an assessment of the likely significant effects of the construction, operation and decommissioning of the three proposed wind farm sites on benthic ecology, including seabed habitats and associated communities.

7.1.1.2 Information supporting this assessment has been collected from a site specific survey and data review as explained in Chapter 4.2 (Benthic Ecology).

7.1.1.3 The receptors that have been considered within this chapter include seabed habitats and the assemblages of species that are typically associated with each habitat type (collectively known as biotopes).

Summary of Effects

7.1.1.4 The effects on benthic ecology that were assessed for the three proposed wind farm sites include:

- Permanent net reduction in the total area of original habitat as a result of the placement of the foundations of wind turbine generators and the met mast on to the seabed;
- Temporary seabed disturbances and effects on fauna as a result of seabed preparatory works, cable laying activities and contact of legs of construction and decommissioning vessels on seabed;
- Habitat and associated community change as the result of the introduction of hard structures and subsequent colonisation by encrusting and attaching fauna;
- Temporary fining of particulate habitats, smothering and scour effects on benthic fauna;
- Change in physical processes (sediment erosion / accretion rates) as a result of the placement of turbines; and
- Seabed contamination and increased bio–availability of pollutants to seabed faunal and flora populations.

Proposed Mitigation Measures and Residual Effects

7.1.1.5 Primary mitigation includes best practice construction site management. The Environmental Management Plan (EMP) will control the use and storage of materials during the construction of the wind farms and will mitigate for accidental spillages or releases of chemicals, such as fuels, lubricants and grouting materials, into the marine environment and prevent harm to the benthic ecology.

7.1.1.6 Additional mitigation will include the adoption of good practice in relation to control of non–indigenous species (NIS).

7.1.1.7 As described within Chapter 4.2 (Benthic Ecology), no sensitive benthic ecological receptors with respect to nature conservation have been identified within the boundaries of the three proposed wind farm sites from the desk study and the site specific survey. No specific mitigation measures to avoid or minimise potential impacts on features of nature conservation importance at the offshore generating station are therefore warranted.

Table 7.1-1 Impact Assessment Summary

Effect	Receptor	Pre–Mitigation Effect	Mitigation	Post–Mitigation Effect
Construction				
Temporary Direct Seabed Disturbances	Sand and gravel sediment habitats and communities (biotopes)	Minor	Adherence to EMP	Minor
Temporary Indirect (sediment) Disturbances		Not significant – Minor	Adherence to EMP	Not significant – Minor
Seabed Deposition of Sediment Arisings from Drilling of Jacket Piles		Minor	Adherence to EMP	Minor
Seabed Contamination as a Result of Accidental Spillage of Chemicals		Up to major	Adherence to EMP	Minor
Operation				
Net Reduction of Area of Seabed Habitat	Sand and gravel sediment habitats and communities (biotopes)	Minor	N / A	Minor
Habitat and Associated Community Change	Sand and gravel sediment habitats and communities (biotopes) Indigenous populations	Moderate	Adherence to EMP Adoption of protocol to minimise risk in relation to spread non–indigenous species Monitoring arrangements to be put in place	Minor
Effects on Physical Processes and Related Biological Changes	Physical processes Sand and gravel sediment habitats and communities.	Not significant – Minor	N / A	Not significant – Minor
Temporary Direct Seabed Disturbances during Operation	Sand and gravel sediment habitats and communities	Not significant	Adherence to EMP	Not significant
Seabed Contamination as a Result of Accidental Spillage of Chemicals	Water quality and benthic species	Up to major	Adherence to EMP	Minor

Effect	Receptor	Pre–Mitigation Effect	Mitigation	Post–Mitigation Effect
Decommissioning				
Temporary Direct Seabed Disturbances	Sand and gravel sediment habitats and communities	Minor	Adherence to EMP	Minor
Temporary Indirect (sediment) Disturbances	Sand and gravel sediment habitats and communities	Minor	Adherence to EMP	Minor
Seabed Contamination as a Result of Accidental Spillage of Chemicals	Water quality and benthic species	Up to major	Adherence to EMP	Minor

7.1.2 Introduction

7.1.2.1 This chapter presents an assessment of the likely significant effects of the construction, operation and decommissioning of the three proposed wind farm sites on benthic ecology, including seabed habitats and associated communities.

7.1.2.2 The majority of effects on benthic ecology have been assessed as being of **minor significance**. This reflects the local and / or short term nature of the associated effects and the generally low intolerance of benthic ecological receptors present within the boundaries of the three proposed wind farm sites. The exception to this is the potential effects of habitat and community change. This is assessed as **moderate** and reflects the potential of new hard substrates, represented by the turbine foundations and scour protection material, to be colonised by non–indigenous species impact upon indigenous benthic populations. Seabed contamination via accidental spillages of oils, fuel or grouting material may have up to **major significant** impacts on benthic ecology subject to the nature of the spill. Following mitigation, all residual effects have been estimated as **minor** to **insignificant**.

7.1.3 Details of Impact Assessment

7.1.3.1 The three proposed wind farms will have a range of short and long term direct and indirect effects on benthic ecology. Short term direct effects will occur as a result of the placement of anchors and feet (jack–up legs and spud cans) of construction vessels on the seabed as well as trenching and backfilling activities associated with the installation of inter–array cables. Longer term direct effects will occur as a result of the placement of turbine foundations and scour protection material on the seabed. Indirect effects will relate to the raising of sediment plumes as a result of construction activities on the seabed and associated sediment smothering and scour effects over adjacent habitats. Effects of heat and EMFs during the operation of the inter–array cables are not considered to be of significance to benthic invertebrate ecology. This is due to the partial shielding of emissions that will be achieved through cable burial and the general insensitivity of invertebrates based on current observations. Likely significant effects of EMF and heat from the cables are discussed in Chapter 10.1 (Benthic Ecology).

7.1.3.2 Information supporting this assessment has been collected from a site specific survey and data review as explained in Chapter 4.2 (Benthic Ecology).

7.1.4 Rochdale Envelope Parameters Considered in the Assessment

7.1.4.1 Relevant parameters defining the 'Rochdale Envelope' realistic worst case scenario for each likely significant effect on benthic ecology are presented in Table 7.1-2 below. The parameters selected are drawn from the range of development options set out in the Project description in Chapter 2.2 (Project Description) insofar as these are relevant to the consideration of likely significant effects on benthic ecology, representing the "realistic worst case" in terms of likely effects on benthic ecology.

Table 7.1-2 Rochdale Envelope Parameters Relevant to the Benthic Ecology Effect Assessment

Type of Effect	Rochdale Scenario Assessed
Construction & Decommissioning	
Temporary Direct Seabed Disturbances	**Maximum footprint of 5.99 km^2 based on the following factors, equating to 2.03 % of the total area of the three proposed wind farm sites:** • Total area of spud cans per jack–up barge (assume six legs per barge) = 420 m^2; • Number of visits per installation / decommissioning = two; • Dredge affected area exposed (i.e. not occupied by the turbine foundation and scour material) = 6,600 m^2 per turbine; • 339 turbines (if lowest rated options installed); • One met mast foundation; • Total length of inter array cables = 572 km; • Trench affected width during installation and decommissioning = 6 m; and • Deployment of up to six anchors of maximum weight 12 Te and dimensions 4.5 m wide by 3.64 m long by 1.7 m high with a shaft of 5.3 m and likely to penetrate 1 m into sediment and nominal 5 m^2 area of seabed disturbance. Anchors to be deployed every 500 m along length of inter–array cables.
Temporary Indirect (sediment) Disturbances	• Fine sediments arising from seabed preparation and installation of 339 gravity base turbine foundations for turbines together with the installation of 572 km inter–array cables transported within tidal currents movements.
Temporary Seabed Deposition of Sediment Arisings from Drilling of Jacket Piles	**Example footprint of 0.28 km^2 assuming the following, equating to 0.09 % of the total area of the three proposed wind farm sites:** • Drill arisings from each pile to cover an area of 208.6 m^2 (assumes 353 m^3 arisings are deposited over a small area to form a cone with peak of 5.1 m above seabed and with base 16.3 m diameter); • 339 turbines (if lowest rated options installed); and • No. pin piles per foundation = four.

Type of Effect	Rochdale Scenario Assessed
Operation	
Net Reduction of Seabed Habitat	**Maximum loss of 3.76 km² of seabed habitats based on the following factors, equating to 1.27 % of total area of the three proposed wind farm sites**: • Placement of gravity base foundations of 65 m diameter = 3,317 m² per turbine; • Scour protection material = 3,770 m² per foundation; • Cable protection associated with up to 4 J tubes per turbine assuming protection required up to 100 m distance from turbine and at 10 m width = 4,000 m² per turbine; and • 339 turbines (if lowest rated options installed).
Habitat and Associated Community Change	**Maximum footprint of 2.63 km² based on the following factors, equating to 0.89 % of the total area of the three proposed wind farm sites:** • Scour protection material = 3,770 m² per foundation; • 339 turbines (if lowest rated options installed); • One met mast foundation; and • Cable protection associated with up to 4 J tubes per turbine assuming protection required up to 100 m distance from turbine and at 10 m width = 4,000 m² per turbine.
Effects on Physical Processes and Related Biological Changes.	• Development of secondary scour; • Change in tidal flow and sediment transport rates; and • Change in wave climate.
Temporary Direct Seabed Disturbances	**Maximum footprint of 0.71 km² based on the following factors, equating to 0.24 % of the total area of the three proposed wind farm sites:** • Total area of spud cans per jack–up barge (assume six legs per barge) = 420 m²; • No. of visits for O&M purposes during life of project (25 years) = five; and • 339 turbines (if lowest rated options installed).

7.1.4.2 Note that decommissioning activities are also likely to have effects on benthic ecology receptors but these are usually regarded as being comparable to those that occur as a result of construction activities. As a result, the effects of construction and decommissioning activities on benthic ecology are considered together.

7.1.5 EIA Methodology

7.1.5.1 This chapter uses the concepts of effect magnitude and receptor sensitivity in the determination of overall effect and draws upon established methods used by the Institute of Ecological and Environmental Management (IEEM, 2010) to define associated criteria (see paragraphs 7.1.5.3 to 7.1.5.11 below). Once identified using the typical "source – pathway – receptor" model, likely significant effects are defined in terms of their likely significance within the context of the pre–defined magnitude and sensitivity components. The following methodology explains how both effect magnitude and receptor sensitivity is determined and how these two assessment components combine to determine overall significance of effects.

7.1.5.2 The assessment of significance of effects on benthic ecology is based on an initial two phased approach to determine i) the magnitude of the likely significant effects and ii) the sensitivity of the receptor. The criteria used to classify both effect magnitude and receptor sensitivity have been substantially guided by current marine impact assessment guidelines (IEEM, 2010) although some of the criteria for determining magnitude have been further tailored based on a comprehensive review of scientific evidence and experiences from offshore renewable development and other relevant sectors (Wilhelmsson *et al*., 2010). The following describes the criteria used to define magnitude and sensitivity with respect to assessment of the likely significant effects on benthic ecology of the three proposed wind farms.

Magnitude of Effect

7.1.5.3 The magnitude of the effect on benthic ecology is defined in terms of the following criteria:

- **Spatial extent** – the geographical extent of an effect. Typically this includes consideration of effects at local (i.e. within the boundaries of a wind farm turbine array), regional, (i.e. a specific water body of comparable physical attributes), national and international scales and typically expressed as a percentage of the total area of the development;
- **Duration** – the temporal aspect of the effect. Guidance offered by Wilhelmsson *et al*., (2010) suggests temporal scales based on the different phases of the actual development thus short term effects are those which occur within the construction phase, long term effects are those that occur through the operational phase whilst permanent effects are those that are still detectable after decommissioning;
- **Frequency** – the number of occurrences of an activity causing an effect per unit of time; and
- **Reversibility** (where appropriate) – whether the effect can be reversed i.e., conditions can be returned to that of the baseline prior to the effect occurring either through natural processes or intervention as mitigation.

7.1.5.4 The magnitude of effect is categorised as ‘High’, ‘Medium’, ‘Low’ or ‘Negligible’ based on the quantification of the above parameters. This process of quantification can necessitate a degree of subjectivity as decisions are based on professional judgement and experience (IEEM, 2010), although underpinned by a strong evidence–base and quantified data where possible. Table 7.1-3 below presents the specific parameters used to facilitate the definition of effect magnitude.

Table 7.1-3 Assessment of Magnitude of Effect (Source: modified from Wilhelmsson *et al*., 2010)

Characteristic	Description	Categories of Effect Magnitude	
Spatial Extent	The geographic area of influence where the effect is noticeable against background variability	Negligible	Within 10 m from source or < 0.1 % of the development area
		Low	10 to 100 m from source of < 1 % of the development area
		Medium	100 to 1,000 m from source or < 10 % of the development area
		High	> 1,000 m from source or > 10 %of the development area

Characteristic	Description	Categories of Effect Magnitude	
Duration	The temporal extent the effect is noticeable against background variability	Negligible	Potential through construction / operation phase
		Low	Through construction phase
		Medium	Through operational phase
		High	Effect persists beyond the operational and decommissioning phases
Frequency	How often the effect occurs	Negligible	Occurs at five year intervals or greater
		Low	Occurs at intervals of between one and five years
		Medium	Occurs on a monthly basis
		High	Occurs at least on a weekly basis
Severity	The degree of change – toxicity, mass, volume, concentration	Negligible	Should not influence or have very small impacts on size or structure of assemblage
		Low	Should have small impacts on size or structure of assemblage
		Medium	Impacts could moderately influence species assemblages, generally or for particular species
		High	Impacts could significantly influence size or structure of species assemblages, generally or for particular species

Sensitivity of Receptor

7.1.5.5 When a receptor is judged to be exposed to an effect, its overall sensitivity to that effect (the effect) is determined. As for magnitude, this process incorporates a degree of subjectivity and expert opinion (IEEM, 2010) to apportion 'High', 'Medium', 'Low' or 'Negligible' categories.

7.1.5.6 The sensitivity of a particular receptor incorporates a variety of criteria including its ability to adapt, its tolerance of the effect and its potential to recover following an effect. In this assessment chapter, benthic ecological receptors have been classified into biotopes for which considerable quantities of sensitivity information exist via the Marine Life Information Network (MarLIN) website (www.marlin.aco.uk). MarLIN is a charitable organisation funded and supported by the UK statutory nature conservation authorities, DEFRA and associated executive agencies to provide sensitivity assessments for UK marine species and biotopes. The MarLIN sensitivity assessments therefore provide an accepted framework within which effects can be described based on tolerance and recovery criteria to various effects (factors). Evidence / confidence categories caveat the determination of sensitivity within the MarLIN framework, although in this assessment, a degree of expert judgement and reference to relevant industry experience in other sectors is also made to further refine the overall effect. Importantly, the biotope level allows a degree of flexibility in community structure which might fluctuate in response to natural or anthropogenic influences, i.e. demersal fishing.

7.1.5.7 This assessment also considers the value of the receptor as an intrinsic component of its sensitivity, be it in terms of its nature conservation, rarity at a particular geographical scale or functional role within the wider ecosystem as described under the relevant impact terminology (see Table 7.1-4 below). IEEM (2010) also attribute social / community and economic values. Valuable ecological assets are usually identified within national and international legislation and / or through local or national nature conservation plans, such as UK Biodiversity Action Plans (UK BAPs). Important species and habitats may be afforded protection through the designation of sites of nature conservation under national and / or international statutes. The presence of a legislative hierarchy relating to nature conservation provides a range of convenient standards on which to assist the evaluation of the sensitivity and associated impact significance of the receptor. Areas which are not currently designated but nevertheless fulfil criteria for designation are assessed and considered in the same way as designated features with respect to assignment of effect significance and mitigation (IEEM, 2010). Designated sites are described in detail in Chapter 4.1.

7.1.5.8 Many species and biotopes lie outside current policy and legislative frameworks but are considered of importance nonetheless, as a result of their functional roles within the wider ecosystem. This is especially relevant where particular features fall under broader habitat classifications with high conservation value, i.e. a sand biotope which forms part of an Annex I sandbank habitat or which falls under the broader “subtidal sands and gravels” UK BAP habitat. Table 7.1-4 below presents categories of receptor sensitivity used in this assessment.

Table 7.1-4 Assessment of Receptor Sensitivity (Source : MarLIN, modified)

Characteristic	Description	Sensitivity Categories	
Adaptability	How well a receptor can adapt to an effect.	Very high	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) and is expected to recover only partially over a very long period of time (> 25 years) or not at all (negligible recoverability).
		High	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) and is expected to recover over a long period of time (between 10 and 25 years) (low recoverability).
		Medium	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) but is expected to recover within 10 years (medium recoverability).
		Low	The habitat or species can be destroyed or killed (low tolerance) or damaged (medium tolerance) but is expected to recover within one to five years (high recoverability).
Tolerance	The ability of a receptor to be either affected or unaffected (temporarily and / or permanently) by an effect.	Very high	Species important for the structure and / or function of the biotope or its identification are likely to be killed and / or the habitat is likely to be destroyed by the impact under consideration.
		High	The population of species important for the structure and / or the function of the biotope or its identification may be reduced or degraded by the impact under consideration, the habitat may be partially destroyed, or the viability of a species population, diversity and function of a community may be reduced.

Characteristic	Description	Sensitivity Categories	
Tolerance (continued)	The ability of a receptor to be either affected or unaffected (temporarily and / or permanently) by an effect.	Medium	Species important for the structure and / or function of the biotope or its identification will not be killed or destroyed by the impact under consideration and the habitat is unlikely to be damaged. However the viability of a species population or the diversity / functionality in a community will be reduced.
		Low	The impact does not have a detectable impact on the structure and / or function of a biotope or the survival or viability of species important for the structure and / or function of the biotope or its identification.
Recoverability	A temporal measure of how well a receptor recovers following exposure to an effect.	Very high	Partial recovery is only likely to occur after about ten years and full recovery may take over 25 years or never occur.
		High	Only partial recovery is likely within ten years and full recovery is likely to take up to 25 years.
		Medium	Only partial recovery is likely within five years and full recovery is likely to take up to ten years.
		Low	Full recovery will occur over many months or years but should be complete within about five years.
Value	The scale of importance (conservation status / importance), rarity (geographical extent relative to the potential area impacted) and worth (socioeconomic, biodiversity).	Low	The habitat / species hold no conservation importance, are widespread and play key role in the ecosystem.
		Medium	The habitat / species hold regional conservation importance, are widespread and play a key role within the ecosystem.
		High	The habitat / species hold national conservation value.
		Very high	The habitat / species hold international conservation status.

Evaluation of Significance of Effects

7.1.5.9 Having described the effect that the proposal has on the benthic ecological receptor, the EIA process requires a level of significance to be assigned to that effect. This is achieved through a synthesis of the magnitude and sensitivity components to determine the significance of effect. A statement of the significance of effect is used to summarise the evaluation process in terms of positive or negative effects, and is defined using the following four categories:

- **Not significant**: an effect that is predicted to be indistinguishable from natural background variation using conventional monitoring techniques. The effect is not significant in the context of the nature conservation objectives or legislative requirements;
- **Minor significance**: the effect will be measurable in the short term and / or over local scales (with or without mitigation) using standard monitoring techniques. The effect does not affect nature conservation objectives and falls within legislative requirements. Effects are typically reversible;

- **Moderate significance**: the effect will be measureable in the long term and over a broad to very broad spatial scale and is likely to have a measurable effect on wider ecosystem functioning. It does not affect nature conservation objectives or legislative requirements. Effects may be reversible; and
- **Major significance**: a permanent effect which has a measurable effect on wider ecosystem functioning and nature conservation objectives and exceeds acceptable limits or standards.

7.1.5.10 A conceptual diagram of how effect significance is determined for this assessment is provided below in Table 7.1-5. With respect to this assessment, a significant effect will be any effect that is of minor significance and above.

Table 7.1-5 Matrix for Determining Significance of Effect from Magnitude and Sensitivity on Benthic Receptors

		Sensitivity			
		Negligible	**Low**	**Medium**	**High**
Magnitude	**Negligible**	Not significant	Minor significance	Minor significance	Moderate significance
	Low	Minor significance	Minor significance	Moderate significance	Moderate significance
	Medium	Minor significance	Moderate significance	Moderate significance	**Major significance**
	High	Moderate significance	Moderate significance	**Major significance**	**Major significance**

Uncertainty of Data

7.1.5.11 It is important to establish the uncertainty of data that are used to predict the magnitude of effects and the sensitivity of receptors, as the level of confidence in the decisions made on significance depend on it. The assessments presented within this chapter attempt to define the level of uncertainty in each case and draw upon the evidence / confidence criteria employed by MarLIN as part of their species and biotope sensitivity assessments. The availability and quality of other data sources used to underpin the assessment are also considered. There are three levels of uncertainty, as follows:

- **Low uncertainty**: Interactions are well understood and documented. Receptor sensitivity has been investigated in relation to the specific factor under assessment. Predictions relating to effect magnitude are modelled and / or quantified. Information / data have very comprehensive spatial coverage / resolution;
- **Medium** uncertainty: Interactions are understood with some documented evidence. Receptor sensitivity is derived from sources that consider the likely effects of a particular factor. Predictions are modelled but not validated and / or calibrated. Information / data have relatively moderate spatial coverage / resolution; and
- **High uncertainty**: Interactions are poorly understood and not documented. Predictions are not modelled and maps are based on expert interpretation using little or no quantitative data. Information / data have poor spatial coverage / resolution.

Identifying Likely Significant Effects of the Development on Benthic Ecology

7.1.5.12 Predicted effects of the three proposed offshore wind farm developments have been described within the request for scoping opinion (Moray Offshore Renewables Ltd. (MORL, 2010)) and are summarised in Table 7.1-6 below.

7.1.5.13 In the following paragraphs, effects are categorised as either direct or indirect and both will have specific effects on benthic ecology. CEFAS (2004) describe direct effects as those arising from construction activities such as the installation of turbine foundations, scour protection material and cables. They may also include effects from the jack–up legs or spud cans of jack–up barges or anchors of other construction vessels on the seabed. Direct effects on the benthos may include a permanent net loss of original seabed habitat as a result of turbine foundations being placed directly onto the seabed as well as temporary seabed disturbances from cable laying, spud legs and anchors with subsequent recovery of the habitat and associated communities once the disturbances have abated.

7.1.5.14 Indirect effects on benthic ecology relate to the dispersion and re–distribution of fine sediments disturbed by the construction activities (CEFAS, 2004) via the prevailing tidal currents. Effects can include sediment smothering of the seabed, causing a fining of particulate habitats and burial of sessile fauna as well as increased sediment scouring effects over and above natural background effects.

7.1.5.15 Cumulative assessment is presented in Chapter 14.1 (Benthic Ecology).

Table 7.1-6 Anticipated Effects on Benthos

Physical Change		**Anticipated Effects on Benthic Ecology**
Direct	• Foundations of turbines; • Scour protection; material; • Inter–array cables; and • Placement of jack–up feet or spud can and / or anchors and chains on the seabed.	Permanent net reduction in the total area of original habitat as a result of the placement of turbine foundations on to the seabed.
		Temporary seabed disturbances and effects on fauna as a result of seabed preparatory works, cable laying activities and contact of legs of construction and decommissioning vessels on seabed. Recovery of habitat and species is forecast to occur following cessation of the disturbance.
		Habitat and associated community change as the result of the introduction of hard structures and subsequent colonisation by encrusting and attaching fauna.
Indirect	• Re–distribution of fine sediments arising from construction activities; • Change in baseline hydrodynamics; and • Accidental spillages of fuels, oils or chemicals.	Temporary fining of particulate habitats, smothering and scour effects on benthic fauna.
		Change in physical processes (sediment erosion / accretion rates) as a result of the placement of turbines.
		Seabed contamination and increased bio–availability of pollutants to seabed faunal and flora populations.
Cumulative Effects (See Chapter 14.1: Benthic Ecology)	Effects resulting from the combined effects of the three proposed wind farm sites and offshore transmission infrastructure with other sea projects and activities generating similar effects both temporally and spatially and considered in the context of background variability.	

7.1.6 Primary Impact Assessment: Three Proposed Wind Farm Sites

7.1.6.1 The following assesses the effects of the realistic worst case Rochdale Envelope design parameters of the three proposed wind farm sites on benthic ecology. Receptors taken forward from the baseline studies for consideration within the assessment of potential effects on benthic ecology include:

- Benthic biotopes recorded and classified during the site specific survey (Chapter 4.2: Benthic Ecology and Technical Appendices 4.2 A & 4.2 B); and
- Benthic species recorded during the site specific survey (Chapter 4.2: Benthic Ecology and Technical Appendices 4.2 A & 4.2 B).

Construction

Temporary Direct Seabed Disturbances

7.1.6.2 Seabed habitats will be temporarily directly disturbed as a result of placement of the feet of construction vessels (jack–up barges) and the installation of inter–array cables. In addition, cable laying barges will typically deploy up to six heavy anchors in an array around the vessel to enable accurate positioning for cable installation. These anchors will leave a series of scars on the seabed. Berms of sediment may also be deposited on the seabed as a result of displacement and side casting of material from trenches constructed during cable installation. Small mounds of sediment may also be created at each anchor site as a result of the anchor being pulled through the sediment on initial deployment or recovery. Temporary sediment disturbances related to the preparation (levelling) of the seabed by dredging prior to receipt of gravity base foundations and associated scour protection material will also occur. Whilst much of this prepared seabed will be subsequently occupied by the foundation and scour protection material, other areas of prepared seabed will remain exposed. Taking all of these disturbance activities into account, the total maximum area of temporary direct disturbance is predicted to be 5.99 km^2 equating to 2.03 % of the total area of the three proposed wind farm sites. Effects will be temporary, negative and short term and will cease following construction operations.

7.1.6.3 These temporary direct seabed disturbances are of potential interest as they will result in a series of seabed depressions, including holes left by the feet of spud legs and linear scars where inter–array cables have been buried, resulting in a change in the benthic ecology relative to baseline conditions. In addition, there is the potential for damage to benthic fauna as a result of crushing, compaction and abrasion effects causing loss of species diversity, abundance and biomass within the footprint of the effect. Sessile and sedentary fauna will be most susceptible due to their limited ability to move away from affected areas. Dredging for installation of gravity base foundations will remove the sediment and the animals which live within it.

7.1.6.4 Experience from the marine aggregates industry (e.g. van Moorsel & Waardenburg, 1991; Kenny & Rees, 1996; Sardá *et al*., 2000; Boyd *et al*., 2004, 2005; Desprez 2007; Barrio–Frojan, 2008; Hill *et al*., 2011) shows that recovery of the benthic ecology follows a general pattern of succession of colonisation once seabed disturbances abate, but that the rate at which this is achieved typically depends upon a number of factors including the prevailing hydrodynamic and sediment transport regime, the severity of the original effect and the nature of the baseline community and surrounding populations. As assessed in Chapter 6.2 (Sedimentary and Coastal Processes), it is estimated that it will take up to two years for anchor scars to be in–

filled and eroded from the seabed and up to five years for the pits created by the legs of jack–up barges to flatten and disappear subject to the frequency of large wave events and associated seabed erosion and sediment re–suspension rates. With respect to physical effects associated with cable installation then recovery of seabed habitats within these timescales would appear reasonable as the same dynamic processes would also erode and in–fill the linear trench marks and associated sediment berms remaining on the seabed post cable installation. BERR (2008) suggests that in sand and gravel sediments ploughed or jetted trenches are rapidly in–filled following cable installation suggesting rapid restitution of seabed habitats although in more cohesive clay sediments with limited ambient sediment transport for in–filling, recovery may take longer or a permanent scar may exist on the seabed. Since a key aim of the selected cable installation techniques will be to retain as much of the original sediment as possible for backfilling, to achieve the required burial depth, then it is reasonable to suggest that potential release of sediments will be limited and associated effects of installation of inter–array cables on local benthic communities will be of low magnitude and local spatial scale. Back–filling and / or retention of sediment within the trenches will facilitate the subsequent restitution of seabed habitats following installation of the inter–array cables.

7.1.6.5 Re–colonisation of affected areas by benthic fauna will be via passive import of larvae and active migration of adults from adjacent non affected areas. Full recovery of communities to baseline conditions will depend upon the rate at which the habitat recovers in terms of its particle size characteristics and stability, although partial recovery of fauna will occur very quickly as a result of settlement of species whose particular traits include high fecundity and mobility as well as tolerance to unstable sediment conditions during periods of in–filling.

7.1.6.6 Areas which retain baseline sediment conditions post construction would be expected to be colonised quickly. With reference to MarLIN (www.MarLIN.ac.uk) the principal biotopes present within the three proposed sites including FfabMag and MedLumVen are predicted to recover within six months to five years following sediment disturbances. In contrast, in–fill sediment material is typically more mobile and represents a comparatively unstable habitat which supports a relatively impoverished fauna compared to pre–construction conditions. These in–filled areas may take longer to recover to baseline conditions depending upon the rate at which substrate stability is restored. Evidence from the marine aggregates industry suggests recovery periods of seven years may be required to restore benthic fauna to pre–dredge conditions in stable sand and gravel habitats (Boyd *et al*., 2004) particularly where effects are high frequency and of long duration (i.e. repeated dredging events over years. However, with respect to wind farm effects, CEFAS review of compliance monitoring in relation to licences under the Food and Environment Protection Act 1985 at existing Round 1 and Round 2 wind farm sites (CEFAS, 2010) shows that so far, the construction of offshore wind farms has had no detectable effect on benthic ecology over and above the natural variation. CEFAS however, also conclude that the short period over which monitoring has been taken thus far is probably insufficient to detect any long term change.

7.1.6.7 In summary therefore, temporary direct effects will be limited to the direct area of the footprint of the activity (negligible spatial scale) and will only occur over 2.03 % of the total area of the three proposed wind farm sites. Recovery of the seabed and associated communities is expected within five or seven years, subject to the rate of habitat restoration, and well within the life time of the Project. Both effect magnitude and receptor sensitivity are therefore assessed to be low. Accordingly, effect significance is considered to be minor. The spatial scale of temporary seabed disturbances is quantifiable and associated effects are based on empirical evidence and experiences including experimental observations from other sectors. Uncertainty associated with this assessment is therefore low.

Temporary Indirect (Sediment) Disturbances

7.1.6.8 Seabed preparatory work including dredger over–spill, placement of turbines and installation of inter–array cables are likely to suspend fine sediments into the water column increasing suspended sediment concentrations (SSCs) in the locale. Suspended sediments from these sources will be transported via tidal currents for re-settlement over adjacent seabed areas. This effect is of potential interest as the re-settlement of sediment back to the seafloor may have negative indirect effects on benthic ecology including smothering and scour of seabed communities causing a loss of species diversity, abundance and biomass where effects are significant. Sessile epifaunal species may be particularly affected by increases in SSCs as a result of potential clogging or abrasion of sensitive feeding and respiratory apparatus. Larger, more mobile animals, such as crabs, fish, shrimps and prawns are expected to be able to avoid any adverse SSCs and areas of deposition. Effects will be temporary, negative and of short duration and will cease on completion of the construction activity. Effect magnitude will therefore be low. Note that the majority of the seabed sediment material will be loaded into a dredger hopper and transported away from the site and thus will not be available for redistribution on the seabed.

7.1.6.9 As explained in Chapter 3.5 (Sedimentary and Coastal Processes), local benthic faunal communities within the boundaries of the three proposed wind farm sites may be expected to be naturally exposed to levels of SSCs measuring 100s to 1,000s mg / l and which occur during periods of extreme wave events. Numerical modelling undertaken (Technical Appendix 3.4 B) showed that the maximum localised increase in SSC from dredging works is predicted to be 30 to 35 mg / l depending upon the state of the tide and water depth and that this level of effect will be contained within 50 to 100 m downstream of the dredger. SSC will be further reduced to 20 mg / l within 1,000 m of the point of disturbance and to 10 mg / l within 3,000 m. These levels are therefore well within the natural variation to which local benthic communities are exposed. The duration of the effects of raised SSCs from dredging are forecast to last up to one hour after the cessation of dredging and are therefore much shorter than the duration of effects arising from natural storm events which may last hours or days. Local accumulation of sediment from dredging is predicted to be < 1 mm.

7.1.6.10 For cable installation via jetting and open trenching, the results of the numerical modelling presented in Technical Appendix 3.4 B suggested that increases in SSCs may potentially occur above the range of natural variation but that this will be highly localised around the point of disturbance (up to 25 to 50 m) and will be of short duration (up to eight minutes in medium sands and three days in fine sediment material). Depth of burial over adjacent seabed areas will be between tens and hundreds of centimetres within 50 m of the activity with subsequent re–suspension and dispersion of this material to ambient levels occurring over successive tidal movements and large wave events. Finer grained sediment particles will be dispersed beyond 50 m of the initial disturbance and as a result of natural tidal current and wave generated water movements. The average thickness of these finer sediment deposits is forecast to be < 1 mm (Technical Appendix 3.4 C). The modelled results presented in Technical Appendix 3.4 B are consistent with the emerging view of potential effects of cable burial activities (BERR, 2008) which suggest that whilst variable, only low levels of sediment are mobilised during cable installation activities resulting in low levels of deposition around the cable trench.

7.1.6.11 With respect to effects on local receiving benthic biotopes, MarLIN employs a benchmark for assessment of the sensitivity to raised SSCs of a change of 100 mg / l for one month. For assessment of the effects of sediment smothering, a benchmark of 5 cm depth of burial by sediment for up to one month is considered. As discussed above, these benchmarks will generally not be exceeded with the exception of areas within 50 m metres of sediment disturbances where burial by sediment up to tens and hundreds of centimetres may occur. This would cause smothering of benthos and loss of species diversity, abundance and biomass. The severity of this effect depends upon the duration of this burial and the time taken for natural wave and tidal processes to re–suspend and further disperse disturbed sediments to ambient levels. Note that the predicted spatial scale of this effect (50 m) is a very worst case scenario and ignores the likelihood that much of the material from the cable trenches will be removed as large chunks and will be side cast immediately adjacent to the trench for back filling (see Technical Appendix 3.4 C).

7.1.6.12 The site specific survey (Technical Appendix 4.2 A and Chapter 4.2: Benthic Ecology) showed that local biotopes are predominately sedimentary and are characterised by sediment dwelling species which will be tolerant to predicted sediment influences within the natural variation. Active burrowers will be able to re–locate to preferred feeding depths following burial and those which feed upon surface and sub–surface deposits may actually benefit from raised SSCs as a result of increased food availability (Rayment, 2008). Characteristic sediment biotopes of the three proposed wind farm sites have low intolerance to the effects of both sediment smothering and increase in suspended sediments and will recover very quickly (within 6 months) following abatement of the disturbances (Rayment, 2008). Sessile epifauna very close to cable installation activities (i.e. within 50 m) will be more susceptible to the effects of raised SSCs and sediment smothering, as explained above, but these species were largely represented by sparse growths of hydroids and bryozoans and no important sessile epifaunal communities were noted during the site specific survey. The possible exception to this was the area of coarse sediment distributed mainly within the Stevenson site and represented by the SS.SCS.CCS biotope (see Figure 4.2-6, Volume 6 a). Sensitivity assessment (Tyler–Watts, 2008) of the closely related PomB biotope suggested a high intolerance to sediment smothering but low intolerance to increases in suspended sediment and that recovery, following cessation of these disturbances, will be immediate or complete within weeks or months. This reflects the opportunistic traits of the characterising species such as the bryozoans, hydroids, barnacles and calcareous tube worms and their capability to rapidly colonise previously disturbed substrates. As noted during consultation with the Inshore Fisheries Group (Chapter 4.2: Benthic Ecology), bryozoan and hydroid communities are believed to be important for the settlement of the spat of the King scallop (*Pecten maximus*) and squid (*Loligo spp*.) eggs. The rapid recovery capability of local bryozoan and hydroid species following sediment disturbances suggests no long term significant effects to important scallop and squid benthic habitat. Furthermore, the SS.SCS.CCS biotope comprised very coarse gravel and cobble material which is highly unlikely to be ejected into the water column and transported any great distance over surrounding seabed area as a result of the proposed construction activities. Consequently, effects on component sessile epifaunal communities will be highly localised to the point of initial disturbance and will be limited in duration to the period of the activity following which, rapid recovery will occur.

7.1.6.13 Effects on benthic ecology over and above the natural variation are therefore predicted to be highly localised and temporary, lasting for the duration of the construction activity only. Effect magnitude is therefore considered to be low. Local receiving habitats within the three proposed sites are predominately sedimentary in nature and are characterised by sediment burrowing animals and are thus expected to be tolerant to temporary light sediment deposition. Receptor sensitivity is therefore regarded as low. Indirect sediment effects are therefore considered to be of **minor significance**.

7.1.6.14 It is worth noting at this point that Chapter 6.2 (Sedimentary and Coastal Processes) identifies a far field area of accumulation of fine sediments arising from foundation installation activities located approximately 10 km to the south of the three proposed wind farm sites. This far field accumulation will occur over the life of the construction phase of the Project and is predicted to result in a thickness of deposit of < 1.0 mm. The seabed habitats and associated communities in this far field, deeper water area correspond to the muddy fine sand biotope SS.SMU.CFiMu.SpnMeg (Connor *et al*., 2004) (see Chapter 4.2: Benthic Ecology). Light settlement (< 1.0 mm) of fine sediment material is therefore highly unlikely to significantly adversely affect the physical characteristics of the biotope or affect the associated sediment dwelling fauna. Despite this biotope being a component of the Scottish draft Priority Marine Feature "burrowed mud" (Chapter 4.2: Benthic Ecology), it is assessed to have low intolerance to the effects of both sediment smothering and raised suspended sediments against the respective benchmarks described above. Sensitivity is therefore judged to be negligible. Effects (< 1.0 mm sediment deposition) are forecast to be well within these benchmark criteria and so effect magnitude is similarly judged to be negligible. The significance of the potential effects of far field sediment effects on benthic ecology is therefore regarded as **not significant**.

7.1.6.15 The concentrations of raised suspended sediments have been modelled and the sensitivity of receiving biotopes is well understood. Previous monitoring at existing offshore wind farm sites shows no detectable effects as a result of indirect sediment effects. Uncertainty associated with this assessment is therefore considered to be low.

Seabed Deposition of Sediment Arisings from Drilling of Jacket Piles

7.1.6.16 The deposition of sediment arisings from drilling activities will not occur under the gravity base scenario but is worth considering nonetheless ensuring all realistic worst case effects on benthic ecology are assessed in keeping with the principles of the Rochdale Envelope. This effect is specific to the jacket foundation option and it is therefore appropriate that related effects are assessed in the event that this alternative is eventually selected. Effects relate to the deposition of drill arisings onto the seabed and are of potential interest as a result of associated smothering and scour effects on benthic communities. Note that drilling will only be employed in certain areas that are resistant to piling and so many parts of the proposed wind farm sites may not be affected by the deposition of drill arisings. Effects will be temporary, negative and of short duration and will cease following completion of the construction phase, therefore Effect Magnitude is regarded as low.

7.1.6.17 The realistic worst case scenario (Table 7.1-2 above) draws upon a set of assumptions made within Technical Appendix 3.4 C which includes the deposition of arisings from each drilled pile within a small area on the seabed to form a cone with a maximum thickness at its centre of 5.1 m and with a base of 16.3 m. If all piles are drilled (which is highly unlikely to occur) then this would equate to an area of deposition of 0.28 km^2 or 0.09 % of the total area of the proposed wind farm sites.

7.1.6.18 Whilst of small (negligible) spatial scale, deposition of sediment arisings on the seabed up to a depth of 5.1 m will bury and smother the fauna directly below the deposit causing loss of species diversity, abundance and biomass within the effect footprint. It is likely that the depths of deposition predicted will be too great to permit sediment dwelling fauna to re–burrow to preferred depths resulting in damage and loss of these species. The spatial effect, however, is negligible and will be largely restricted to the footprint of the foundation. Species most likely to be affected include sedentary or sessile animals with limited movement. Larger, more mobile animals such as fish, crabs and prawns are likely to be able to move away from adversely affected areas. Crabs and prawn species that are buried in the sediment will be less likely to be able to avoid sediment smothering effects and may therefore also be lost due to deposition of drill arisings.

7.1.6.19 It is more likely however, that these sediment arisings will be re–distributed as a result of tidal current movements creating a layer of sediment on the seabed extending downstream from the drill operation. Furthermore, and subject to the frequency of large wave events, these sediment deposits will be gradually eroded and further dispersed over time. Receiving seabed habitats within the three proposed sites are predominately sedimentary and would therefore be expected to be tolerant (low sensitivity) of temporary settlement of sediments and locally raised SSCs. Consequently, effects associated with deposition of sediment arisings from drilling of piles are forecast to be of **minor significance**.

7.1.6.20 The severity and spatial extent of the related effects are not known at this stage and will depend upon the number of drilling operations and the nature of the arisings and associated depths of burial that occur. In addition, the duration of the effect will also depend upon the wave and tide conditions at the time of release for dispersion of the drill arisings. However, the nature of the receiving seabed habitats and communities and their likely responses to sediment deposition and raised SSCs are well understood. Accordingly the uncertainty associated with the current assessment is considered to be moderate.

Operation

Net Reduction of Area of Seabed Habitat

7.1.6.21 With reference to the Rochdale Envelope scenario described in Table 7.1-2 above, it is predicted that a maximum of 3.76 km^2 or 1.27 % of the existing seabed habitat will be lost as a result of the direct placement of turbine foundations as well as the associated scour protection and cable protection material onto the seabed. The effect is of potential concern as it will result in a reduction in the total area of original seabed habitat.

7.1.6.22 However, given the small spatial scale, relative to the size of the development area, and the wider availability of comparative habitats throughout the outer Moray Firth, as indicated by Mapping European Seabed Habitat (MESH) data, only a low magnitude of effects on the ecosystem functions provided by these habitats is forecast based on subjective opinion. The effect will be long term, and negative lasting for the duration of the operational phase of the wind farms but will also be reversible upon decommissioning.

7.1.6.23 None of the biotopes within the footprint of the turbine foundations are considered rare, geographically restricted or of specific conservation importance. Effects on biotope diversity or designated nature conservation features are not therefore forecast. The dominant sand and gravel biotopes fall under the umbrella of the broader UK BAP subtidal sand and gravel classification although the small spatial scale of the effect and the wider availability of comparable habitats within the wider region, means that component species and habitats will be sufficiently represented within the outer Moray Firth post construction. Key ecosystem functions of sand and gravel habitats include the provision of suitable inshore nursery grounds for fish including commercially targeted species. These habitats also have an important biodiversity role and support a wide range of different invertebrate assemblages reflecting the often complex interactions with particle size distribution, water depth and prevailing hydrodynamic regime, amongst other factors. These habitats also support sandeel, which are important prey items for commercial fish, birds and marine mammals. A sandeel survey of the entire Round 3 Zone (Chapter 4.3: Fish and Shellfish Ecology) indicates that they are not present in significant numbers within the proposed wind farm sites, but that their occurrence does mirror that of their predators. The small spatial scale of the predicted effect in relation to the size of the development area and wider regional availability of comparable habitats suggests any effect on a biodiversity or functional role will be low.

7.1.6.24 The effect of the reduction of seabed habitats will be long term lasting for the duration of the development after which the total area of habitat will be restored following decommissioning and removal of turbine foundations and scour material. However, in view of the very small spatial extent of the effect, effect magnitude is considered to be low. Ecosystem functioning of component habitats is not predicted to be significantly affected and so receptor sensitivity is regarded to be low. Accordingly the effect of the direct placement of turbines on the seabed is judged to be of **minor significance**.

7.1.6.25 The effect is quantifiable and sufficient, albeit predictive, MESH data exist to indicate wider context for this assessment. Uncertainty associated with this significance level is therefore low. The final layout of the turbine array will not influence the significance of the effect as the assessment is based on comparable habitats existing throughout the site.

Habitat and Associated Community Change

7.1.6.26 Although the operation of the three proposed wind farms will result in the loss of 1.27 % of the original seabed habitat as assessed above, a substantial proportion of this will become new habitat, as represented by scour and cable protection material, and which will be available for colonisation by attaching and encrusting species such as barnacles, hydroids and bryozoans. The effect of this is of potential interest as the new habitat type and colonising fauna will be different from baseline conditions. The increase in the availability of hard substrata is of further potential interest as it increases the risk of enhancing the spread of non–indigenous species, such as the Japanese ghost shrimp, *Caprella mutica*. The effects will be long term lasting for the duration of the operation of the wind farms. Effects associated with the spread of non–indigenous species may last beyond decommissioning. During consultation on the draft Environmental Statement (ES), Marine Scotland requested that impact significance associated with the increased risk of enhanced spread of NIS should be moderate. Regardless of the whether an increase or decrease in biodiversity will occur as a result of the introduction of new substrate, the effect is judged to be as negative as it will result in a change in habitat and species assemblages from baseline conditions. The following investigates the consequences of a change in habitat and community conditions and assesses the likely significance of associated effects on benthic ecology.

7.1.6.27 The placement of scour and cable protection material on the seabed will change the ambient sedimentary habitats to a more heterogeneous coarse, hard substrate habitat. With reference to the Rochdale Envelope scenario under consideration in Table 7.1-2 above, the total footprint of the protection material on the seabed will be 2.63 km^2 or 0.89 % of the total area of the three proposed wind farm sites.

Protection material will be in place for the life of the development after which it will be removed on decommissioning. As such, the duration of effects will be long term and reversible.

7.1.6.28 Hard structures, including the actual column of the turbine as well as the scour and cable protection material, will provide suitable stable substrate for attachment for a range of encrusting and attaching species (epifauna) including mussels, barnacles, tubeworms sponges, hydroids (sea firs) and bryozoans (sea mats) as well as algae (seaweeds) within shallow water depths where sufficient light is available for photosynthesis. In a predominantly sedimentary environment, this is likely to increase local species diversity as well as the abundance and biomass of epifaunal organisms. The placement of scour material will increase habitat complexity and provide refuge / micro–niche and feeding opportunities for a range of larger more mobile species creating a reef effect and attracting a variety of fish, molluscs and crustaceans such as wrasse, brown crab, pacific oyster and common mussels (Linley *et al*., 2007).

7.1.6.29 Picken (1986) offers valuable insight into the types of attaching epifaunal organisms that might be expected to colonise the structures within the three proposed sites as a result of historic studies on the fouling organisms of artificial structures in the Moray Firth, including those within the adjacent Beatrice Field. Structures were initially colonised by barnacles and tubeworms within the first year of placement. Over the following two to three years, these became overgrown with common mussels together with growths of seaweeds in the uppermost 5 m of water. These growths were succeeded after four years by hydroids which dominated surfaces below the seaweeds together with soft corals and the ascidians sea squirts.

7.1.6.30 Further insight into the types of species likely to develop on the scour and cable protection material is provided by the site specific benthic ecology survey (Technical Appendix 4.2 A). This included a review of naturally occurring coarse sediment habitats within the three proposed wind farm sites and the animals that reside within them. This survey recorded a typical suite of hydroids and bryozoans together with sponges, soft coral, edible sea urchin and squat lobster. Recent experiences at the Egmond aan Zee offshore wind farm in the Dutch North Sea and the Horns Rev offshore wind farm in the Danish North Sea found a vertical zonation of epifaunal species colonising turbine columns including high densities of common mussels together with barnacles, common starfish, worms, crabs, bryozoans and hydroid at upper most depths, whilst tube dwelling amphipods, anemones and hydroids dominated surfaces below 10 m. Scour protection rocks supported crab, oyster and slipper limpets and appeared to provide refuge and food for fish such as cod and pouting (BioConsult, 2005; Lindeboom *et al*., 2011).

7.1.6.31 Hard structures (turbines and scour and cable protection material) within the three proposed wind farm sites are therefore likely to be colonised by communities of sessile epifauna and larger mobile epibenthos with species being imported or migrating from adjacent areas in the Moray Firth. Whilst clearly having, potential for greater habitat and species richness and diversity, there will be a change in these receptors from baseline conditions. The spatial scale of the change will, however, be minor (covering 0.89 % of the total area of the three proposed wind farm sites) but of medium duration, lasting for the duration of the operation of the wind farm. Severity will however, be negligible as the colonising species will be the same as those already present within the wider Moray Firth area. Impact significance of habitat and associated community change is therefore judged to be **minor**. With respect to the spread of non–indigenous species, however, the operational phase of the wind farm may have greater significance as assessed further below.

7.1.6.32 Offshore renewable developments in the North Sea are likely to increase in number in the near future and, as they have been shown to act as stepping stones for several species (Svane and Petersen, 2001, c.f. Petersen and Malm, 2006), this has raised concerns about their effect as facilitators for NIS. Previous examples of wind farm sites at which NIS have been recorded include:

- The acorn barnacle Elminius modestus: Thornton Bank, Southern North Sea (Kerckhof *et al*., 2009, 2010) and Kentish Flats, Southern North Sea (EMU, 2008);
- The giant barnacle *Megabalanus coccopoma*: Thornton Bank, Southern North Sea (Kerckhof *et al*., 2009, 2010);
- The slipper–limpet *Crepidula fornicata*: Thornton Bank, Southern North Sea (Kerckhof *et al*., 2009, 2010) and Egmond aan Zee, Southern North Sea (Bouma and Lengkeek, 2009);
- The Pacific Oyster *Crassostrea gigas*: Egmond aan Zee, Southern North Sea (Bouma and Lengkeek, 2009);
- The Asian sea squirt *Styela clava*: Kentish Flats, Southern North Sea (EMU, 2008);
- The giant midge *Telmatogeton japonicus* (Non–marine species): Thornton Bank, Southern North Sea (Kerckhof *et al*., 2009, 2010); and
- The Japanese skeleton shrimp *Caprella mutica*: Horns Rev.

7.1.6.33 The importance of NIS has been recently highlighted as a result of its inclusion as a qualitative descriptor for determining good environmental status under the Marine Strategy Framework Directive. However, the management of NIS is still evolving and remains at an early stage mainly due to limited knowledge of the ecology of the species involved. In consultation, SEPA recommended that the developers draw up and adopt a protocol to minimise risks of introducing marine invasive species (Chapter 4.2: Benthic Ecology).

7.1.6.34 Most of the NIS in the marine environment have been identified in intertidal and coastal environments with wind farms potentially acting as a corridor for NIS species to settle and establish (Olenin *et al*., 2010; ICES, 2009). This is because each turbine column creates an intertidal environment offshore and therefore offers favourable conditions. Some of the NIS classified as problematic (OSPAR, 2010), or as having deteriorating effects (DEFRA, 2011) have in fact been found at wind farms sites (e.g. *Crassostrea gigas* or *Styela clava*), although not as major components of the faunal community. However the intertidal environment created by wind turbine columns appears to be favourable for some NIS. Summarising a series of MarLIN surveys of harbours and marinas in Scotland, Ashton *et al*., (2006) identified several NIS including the skeleton shrimp, *Caprella mutica* at Lossiemouth. This species is known to have rapidly spread throughout the UK (Cook *et al*., 2007). The proximity and invasive characteristics suggest that this NIS could colonise the three proposed wind farm sites during its operational phase, the environmental implications of which, as with other NIS, are unknown. The Defra (Non Native Species Secretariat) (www.nonnativespecies.org) risk assessment for *Caprella mutica* concluded that this species is capable of expanding its current geographical range via drifting weed or hull fouling of ships and boats, aquaculture activity and in ballast waters. Successful eradication was considered unlikely and priority was placed on the prevention of the colonisation of new regions.

7.1.6.35 The likely significant effects of NIS on biodiversity and legislative requirements (Marine Strategy Framework Directive) are currently unknown and so the uncertainty associated with this particular assessment is high. Consequently the significance of the effects of NIS is regarded as **moderate**, in recognition of Marine

Scotland request (see Chapter 4.2: Benthic Ecology) and reflects the potential for *C. mutica* and other NIS to colonise the turbines of the proposed sites.

Effects on Physical Processes and Related Biological Changes

7.1.6.36 Benthic habitats and associated communities are strongly influenced by seabed sediment type and stability which are themselves typically functions of prevailing hydrodynamic and wave regimes. Effects of the wind farms on physical processes are therefore of potential interest as they may lead to changes in baseline benthic ecological conditions. Effects will be long term, lasting for the duration of the operation of the wind farms but reversible upon decommissioning. This assessment considers (1) potential local effects of individual turbines on substrate conditions and (2) wider scale (site level) effects of the array of turbines on tidal currents and waves and related changes in benthic ecological conditions.

7.1.6.37 (1) At the local (individual turbine) level, secondary scour of the seabed (i.e. scour around the edges of scour protection material) may occur as a result of locally accelerated near bottom currents. Associated effects on benthic ecology would include increased habitat instability and modification as a result of winnowing and erosion of finer grained particles from the affected seabed sediments. This may change the composition of affected benthic communities including exclusion of species with particular sensitivity to disturbance although complete defaunation is highly unlikely. The extent of the influence of secondary scour is broadly related to the nature of the scour material itself and is therefore not considered to extend beyond a few 10s of metres from its outer edge, as observed at Thornton Bank where gravity bases and associated scour protection already exist (ABPmer, 2010). The spatial extent of the effect is therefore considered to be negligible or low although duration of effect will be medium, lasting for the duration of the operation of the wind farms. With these aspects in mind, effect magnitude is judged to be low. Receptor sensitivity will be low as community structure would be altered in affected areas but recovery of biotopes will be occur within months to five years as assessed above. Accordingly, impact significance is judged to be **minor**.

7.1.6.38 Effects associated with sediment material eroded from areas of secondary scour and adding to the overall sediment thickness deposited over adjacent seabed areas are likely to be negligible because the eroded sediment will not be released all at once but will instead be released over time as scour develops. Consequently, the total volume of sediment of secondary scour areas will not be released in one event but gradually over successive tides. Effect magnitude is therefore considered to be low as the contribution from scour to the total volume of disturbed sediment available for re–settlement will be very small at any one time. Deposition will also be temporary as successive tides and wave events will repeatedly re–mobilise the sediment for further dispersion to ambient levels. In addition, the receiving habitats within the three proposed wind farm sites are predominantly sedimentary and so will be expected to be tolerant (exhibit low sensitivity) to light re–settling of sediment material. Significance of this effect is therefore forecast to be **minor**.

7.1.6.39 (2) At the wider (array) scale, the presence of a maximum of 339 turbines (as the Rochdale Envelope "realistic worst case") has the potential to influence tidal flow speeds and prevailing wave climate resulting in changes to the sediment transport pathways and associated effects on benthic ecology. Numerical modelling (Chapter 3.4: Hydrodynamics – Wave Climate and Tidal Regime) shows that the operation of the wind farms will reduce mean spring tide flow speeds by a few centimetres a second mainly within the proposed wind farm sites only. Additionally, the frequency and magnitude of wave events which mobilise and contribute to the sediment transport are forecast to reduce relative to the baseline situation. The effect of this is predicted to be a slight retention of sediments within the three proposed wind farm sites compared to pre–construction conditions, although it is likely that any accumulated sediments will be continually dispersed via future storm events. Significant sediment smothering and burial of fauna is not therefore forecast and effect magnitude is regarded as negligible. The receiving habitats are predominately sedimentary and / or are not considered sensitive to light accumulation of sediments. Biotopes are characterised by sediment dwelling species which are expected to be tolerant to predicted light sediment effects. Likely significant effects on physical conditions and related biological changes due to the operation of the wind farms are therefore anticipated to be **not significant**.

7.1.6.40 The small predicted change in mean flow speeds is unlikely to significantly modify or concentrate plankton populations over and above current conditions and effects on related food resource availability for benthic communities is predicted to be **not significant**.

7.1.6.41 The effects have been subject to numerical modelling and therefore uncertainty associated with this assessment is low.

Temporary Direct Seabed Disturbances During Operation

7.1.6.42 Ongoing operations and maintenance, major interventions and overhauls of turbines is estimated to involve five vessel visits per turbine during the life of the Project (25 years). This equates to one seabed disturbance event of 420 m^2 spatial extent (relating to total area of spud legs on seabed) occurring every five years for each turbine. Over the course of a single year, this equates to a total of 0.028 km^2 or 0.01 % of the area of the three proposed wind farm sites.

7.1.6.43 The spatial extent and duration of this effect are therefore negligible. Biotopes have high recoverability and will recover within a few months to five years as assessed above and within the intervening five years between vessel visits to each turbine. As such receptor sensitivity is low. Accordingly, associated effects are expected to be **not significant**.

Effects of EMFs and Heat

7.1.6.44 Electro–magnetic field (EMF) and heat emissions from inter–array cables will be generated during the operation of the scheme. Detailed assessments of the effects of EMFs and heat from inter–array cables on benthic ecology are considered collectively with those arising from the export cable corridor (see Chapter 10.1: Benthic Ecology). The worst case scenario in these regards will be that which requires the greatest lengths of inter–array cables to be installed (i.e. 339 turbines, if lowest rated turbines are installed) and OSPs located outwith the boundaries of the three proposed wind farm sites.

Decommissioning

7.1.6.45 Effects of decommissioning activities will be comparable to those arising during the construction of the wind farms or where cables and other structures beneath the surface of the seabed are left in–situ, then effects will be much less. Removal of turbine foundations and scour material will disturb seabed sediments for subsequent re–distribution over adjacent areas resulting in potential smothering effects as assessed above. The dominant sediment habitats and communities will be tolerant to these effects (as assessed) and the significance of related effects is expected to remain **minor**.

7.1.6.46 Removal of the turbines will result in the removal of the epifaunal communities attached to them. A reduction in epibenthos to pre–construction conditions is therefore predicted. Exposed seabed areas are expected to be rapidly re-colonised with full restitution of the habitats and biotopes expected within five years, subject to the condition of the seabed substrate and stability compared to the baseline situation.

7.1.6.47 Removal of turbines upon which sensitive and / or protected species, such as the cold water coral *Lophelia pertusa*, have become attached would constitute a negative effect. Current precedent for assessment in this regard includes the MV Hutton oil and gas platform decommissioning programme which regarded *Lophelia pertusa* as an opportunist suggesting that this is sufficient reason for it not to affect the decommissioning outcome of this facility (British Petroleum, 2006). With regard to the current development, statutory consultation will be required to confirm requirements within the decommissioning programme and to ensure that the potential for effects on protected species are properly assessed. There are no records of *Lophelia pertusa*, or any other protected species likely to attach to the turbines, occurring within the vicinity of the proposed wind farms at Smith Bank although some records exist of its presence within the Southern Trench (see Chapter 4.2: Benthic Ecology). Furthermore, *L. pertusa* typically occurs at depths of greater than 150 m and is rarely found attached to hard substrata (Peckett, 2003). Consequently, the likelihood of this species becoming established on the turbines within the three proposed wind farm sites is very low.

Accidental Spillages of Chemicals

7.1.6.48 Accidental spillages or release of chemicals such as grouting, fuel and oil during the construction, operation and decommissioning phases of the wind farms may potentially contaminate seabed sediments. The severity of this effect on benthic ecology depends upon the quantities and nature of the spillage / release, the dilution and dispersal properties of the receiving waters and the bio–availability of the contaminant to benthic species. At this stage, the quantities and types of material which might conceivably enter the marine environment in this way are not known and so scale and magnitude of effects are unquantifiable at present. In the worst case scenario, the potential significance of an accidental spillage would be **major**. Accidents are by definition unknown and the uncertainty associated with this effect is therefore high.

7.1.7 Proposed Monitoring and Mitigation

Construction, Operation and Decommissioning

7.1.7.1 Monitoring requirements will be confirmed in consultation with the regulatory authorities.

7.1.7.2 Development of and adherence to an Environmental Management Plan (EMP) compliant with ISO14001 or BSA 555, will limit the risk of accidental spillages or releases occurring or ensure that adequate contingency is in place (i.e. Marine Pollution Contingency Plan) to resolve any incidents quickly. Also, establishment of an Environmental Mitigation and Monitoring Plan (EMMP) will identify appropriate measures to avoid or minimise adverse effects on marine life.

7.1.7.3 Within the scoping opinion, SEPA have recommended that developers draw up and adopt a protocol to minimise risks of introducing marine invasive species.

7.1.8 Residual Impacts – Primary Impact Assessment

7.1.8.1 Table 7.1-1 above summarises residual effects on benthic ecology following the introduction of proposed mitigation measures.

7.1.9 Secondary Assessment: Individual Wind Farm Sites

7.1.9.1 As explained in Chapter 4.2 (Benthic Ecology), the three proposed wind farm sites differed in terms of their biotope composition. MacColl for instance comprised a deeper water, offshore sediment biotope whilst Stevenson was found to support coarse sediment / cobble habitats not recorded within the other two sites. Telford was characterised by a comparatively homogenous and impoverished sand biotope. In recognition of the variation in biotope composition between the three proposed wind farm sites, it was considered that a secondary assessment was warranted. In this instance, the secondary assessment has considered the presence of coarse sediment habitats and associated communities recorded within the Stevenson site which were different from the sediment biotopes found within Telford and MacColl and which may respond differently to the following effects drawn from Table 7.1-4 above:

- Temporary direct seabed disturbances during construction; and
- Temporary indirect (sediment) disturbances during construction.

7.1.9.2 Other effects, including operational effects of the wind farm proposals, are considered to have the potential to cause generic effects across the three sites regardless of biotope composition or design permutations. These have therefore already been appropriately addressed in the primary assessment above and are therefore not included here.

7.1.9.3 The Rochdale parameters considered within this secondary assessment are the same as those assessed above (Table 7.1-2). This included the maximum number of turbines (assuming lowest rated turbines are installed) of between 100 and 139 per wind farm site and the installation of gravity base foundations with scour protection. Drilling of foundations is not considered in this secondary assessment as it is presently unknown if any of the three proposed wind farm sites warrant additional drilling operations over other wind farm sites. The primary assessment above dealt with a maximum worst case scenario of all turbine foundations requiring drilling.

Temporary Direct Seabed Disturbances During Construction

7.1.9.4 The primary assessment above explained that the direct effects of temporary seabed disturbances will be minor as the characterising soft sediment biotopes have the capacity to rapidly recover following cessation of the disturbance with full recovery expected within five years equating to low receptor sensitivity. As further explained, stable gravel habitats may take slightly longer to recover (up to seven years) subject to the severity and frequency of the original effect. This relates to reduced rates of weathering and erosion of seabed effects in coarse sediments compared to seabed effects in softer sediment habitats. Additionally, where depressions in the coarse gravel seabed are in–filled with transient sediment material then a localised change in habitat type to sandy gravel will occur. Benthic ecological recovery from effects associated with direct seabed disturbances within the Stevenson site may therefore take longer compared to effects occurring within the Telford and MacColl sites and equating to low or medium receptor sensitivity. However, despite the comparatively longer recovery period, effects will be within the footprint of the effect such that effect magnitude will be negligible. Accordingly, the significance of the effect is therefore judged to be **minor**.

Temporary Indirect (Sediment) Disturbances During Construction

7.1.9.5 Whilst temporary indirect effects are considered to be of minor significance (see primary assessment above), the coarse sediment substrates within the Stevenson site are characterised by epifaunal communities which may be comparatively more susceptible to sediment smothering and scour effects associated with construction activities, compared to the sediment dwelling communities that dominate the Telford and MacColl sites. The epifaunal species recorded within Stevenson have already been assessed as being relatively intolerant to smothering and scour effects and can suffer damage to sensitive feeding and respiratory apparatus in adverse sediment conditions leading to a loss of these fauna where effects are significant. In addition, spat of King scallop depend upon hydroid and bryozoan communities for successful settlement and development so that loss of these communities through significant sediment smothering and scour may have secondary adverse effects on King scallop recruitment (effects on King scallop recruitment are discussed further in Chapter 7.2: Fish and Shellfish Ecology).

7.1.9.6 However, only very small quantities of fine sediments (if any) are associated with these coarse gravel habitats suggesting that only limited adverse effects on raised SSCs and sediment smothering and scour will occur. Any disturbed gravel or cobble particles will re–settle back to the seabed very quickly and in close proximity to the point of initial disturbance. This means that the magnitude and spatial extents of temporary direct disturbance effects will be substantially reduced compared to those occurring within finer, softer substrates. Spatial effects will be very small and effect magnitude is likely to be low. Recovery of coarse sediment biotopes is forecast to be rapid and is expected to be complete within weeks or months following cessation of the disturbance. This equates to low receptor sensitivity and reflects the opportunistic traits of the characterising epifauna within the Stevenson site (see primary assessment above). Accordingly, the significance of the effects of indirect sediment disturbances is judged to be **minor**.

Table 7.1-7 Secondary Assessment Summary

Effect	Telford	Stevenson	MacColl
Construction and Decommissioning			
Temporary Direct Seabed Disturbances	Minor	Minor	Minor
Temporary Indirect (sediment) Disturbances	Minor	Minor	Minor

Sensitivity Assessment

7.1.9.7 The following paragraphs assess the likelihood and significance of the combined effects of the construction, operation and decommissioning of any combination of two of the individual wind farms on benthic ecology (i.e. Telford + Stevenson, Telford + MacColl or MacColl + Stevenson). Results of the assessment are summarised in Table 7.1-8 below.

7.1.9.8 Following the same reasoning as adopted when carrying out the Secondary Assessments, for the purposes of the Sensitivity Assessment, only the following effects have been identified as having the potential to be affected by the combination of wind farms to be constructed:

- Combined indirect sediment effects; and
- Incremental loss of total original seabed habitat.

Combined Indirect Sediment Effects

7.1.9.9 Interaction between sediment plumes from individual sites may give rise to combined indirect sediment effects if construction in individual wind farm sites occurs at the same time. However, associated effects on benthic ecology are likely to be minor given the low effect magnitude and low receptor sensitivity as assessed during the primary assessment above. Also, sediment plumes arising from contemporaneous construction activities will tend to travel along parallel tidal axes so that they will generally not converge or overlap suggesting limited, if any, opportunity for combined sediment effects to occur on benthic ecology. The probability of this combined effect actually occurring is therefore low. The minor significance and low probability of this combined effect will be the same regardless of the development permutations of the individual sites.

Incremental Loss of Original Seabed Habitat

7.1.9.10 The placement of successive turbine foundations and scour material on the seabed within each of the proposed wind farm sites will lead to an incremental loss of original seabed habitat. For the purposes of the consideration of combined effects, such incremental loss is only relevant for the sediment biotopes. Coarse gravel and cobble biotopes were only found within the Stevenson site and so will not be subject to combined incremental loss. The effect will be long term lasting for the duration of the operation of the wind farms but reversible upon decommissioning.

7.1.9.11 As explained within the primary assessment above, only a very small area of seabed will be lost under the worst case "gravity base" scenario and effect magnitude is accordingly judged to be low. Significant effects on ecosystem functioning are not forecast as sufficient habitat will remain throughout the operational phase of the wind farms. None of the sediment biotopes are geographically restricted and no loss in biotope diversity is considered likely. Accordingly, the significance of this combined effect is regarded as minor. The significance of this effect will remain as **minor** regardless of the development permutations of the three proposed wind farm sites.

Table 7.1-8 Sensitivity Assessment Summary

Effect	Telford + Stevenson	Telford + MacColl	Stevenson + MacColl
Construction and Decommissioning			
Temporary Indirect (sediment) Disturbances	Minor	Minor	Minor
Operation			
Incremental Loss of Original Seabed Habitat	Minor	Minor	Minor

7.1.10 Proposed Monitoring and Mitigation: Secondary / Sensitivity Assessment

7.1.10.1 No mitigation over and above that identified within the primary assessment is considered necessary.

7.1.11 Habitats Regulations Appraisal

7.1.11.1 Impacts from the construction, operation and decommissioning of the generating station on benthic ecology do not give rise to Habitats Regulations Appraisal concerns.

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7.2 Fish and Shellfish Ecology

7.2.1 Summary of Impacts and Mitigation

Summary of Effects

7.2.1.1 The likely effects considered for assessment on fish and shellfish receptors are as follows:

- Construction & decommissioning:
  - Temporary disturbance of the seabed (increased suspended sediment concentrations and sediment re-deposition); and
  - Underwater noise.
- Operation:
  - Loss of habitat;
  - Introduction of new habitat;
  - Electromagnetic fields (EMFs); and
  - Changes to fishing activity.

7.2.1.2 For the purposes of this assessment and in the absence of detailed information on decommissioning schedules and methodologies, it is assumed that any effects derived from the decommissioning phase will, at worst, be of no greater significance than those derived from the construction phase.

Proposed Mitigation Measures, Monitoring and Residual Effects

7.2.1.3 In general terms, the likely effects of the construction phase on fish and shellfish species have been assessed to be of minor significance. An exception to this is construction noise, which has been identified as having potential to result in significant effects (above minor) namely on cod, herring, salmon and sea trout.

7.2.1.4 The impact assessment on these species has taken a precautionary approach, where conservative assumptions have had to be applied as a result of the uncertainty surrounding currently available information on the use that these species may make of the area of the three proposed wind farms during the construction phase.

7.2.1.5 In order to mitigate this uncertainty, MORL is committed, in consultation with Marine Scotland and the relevant fisheries stakeholders, to undertake additional survey work and monitoring with the objective of increasing the confidence in this impact assessment and identifying whether mitigation is required and, if so, to define feasible measures in order to reduce the significance of the likely effects.

7.2.1.6 Some surveys, such as the sandeel (a key prey species for other fish species) survey were undertaken in consultation with Marine Scotland pre-application during their optimal survey periods the results of which are included in this assessment. Due to the seasonal nature of these surveys, MORL expects that specific surveys and monitoring will be defined and implemented at the appropriate time of year in consultation with Marine Scotland and other stakeholders.

7.2.1.7 In addition to the monitoring / mitigation above, soft start piling will be used with the aim that mobile species are not exposed to the highest noise levels during construction.

7.2.1.8 Likely significant effects (above minor) have not been identified for the operational phase of the three proposed wind farm sites on fish and shellfish ecology. Cable burial will reduce exposure of electromagnetically sensitive species to the strongest EMFs that exist at the "skin" of the cable owing to the physical barrier of the substratum (OSPAR, 2008). Similarly where burial is not feasible cable protection will ensure that fish and shellfish receptors are not in direct contact with the cable and hence with the strongest EMFs.

7.2.1.9 A summary of the fish and shellfish ecology impact assessment pre and post monitoring / mitigation is outlined in Table 7.2-1 below.

Table 7.2-1 Impact Assessment Summary

Effect	Receptor	Pre- Monitoring / Mitigation Effect	Monitoring / Mitigation	Residual Effects
Construction / Decommissioning				
Temporary Disturbance to Seabed	Fish and Shellfish	Negative Minor Probable	None	Negative Minor Probable
	Herring	Negative Minor Probable	None	Negative Minor Probable
	Sandeels	Negative Minor Probable	None	Negative Minor Probable
Noise	Plaice	Negative Minor Probable	Soft start piling	Negative Minor Probable
	Salmon and sea trout	Negative Minor-Moderate Probable	Soft start piling Monitoring / survey work to increase assessment confidence and / or mitigation measures where required	Negative Minor Probable
	Cod	Negative Moderate-Major Probable	Soft start piling Monitoring / survey work to increase assessment confidence and / or mitigation measures where required	Negative Minor Probable
	Whiting	Negative Minor Probable	Soft start piling	Negative Minor Probable

Effect	Receptor	Pre- Monitoring / Mitigation Effect	Monitoring / Mitigation	Residual Effects
Noise (Continued)	Herring	Negative Moderate Probable	Soft start piling Monitoring / survey work to increase assessment confidence and / or mitigation measures where required	Negative Minor Probable
	Larvae and Glass eels	Negative Minor Probable	None	Negative Minor Probable
	Shellfish	Negative Minor Unlikely	Soft start piling	Negative Minor Unlikely
Operation				
Loss of Habitat	Fish and shellfish in general	Not significant Probable	None	Not significant Probable
	Spawning herring	Negative Minor Unlikely	None	Negative Minor Unlikely
	Sandeels	Negative Minor Probable	None	Negative Minor Probable
Introduction of New Habitat	Fish and shellfish in general	Negative / Positive Minor Probable	None	Negative / Positive Minor Probable
	Edible crab	Positive Minor Probable	None	Positive Minor Probable
EMFs	Elasmobranchs	Negative Minor Probable	Cable burial / protection	Negative Minor Probable
	River and Sea Lamprey	Negative Minor Unlikely	Cable burial / protection	Negative Minor Unlikely
	Salmon and Sea trout	Negative Minor Probable	Cable burial / protection	Negative Minor Probable
	European eel	Negative Minor Probable	Cable burial / protection	Negative Minor Probable

Effect	Receptor	Pre- Monitoring / Mitigation Effect	Monitoring / Mitigation	Residual Effects
EMFs (Continued)	Other fish species	Negative Minor Unlikely	Cable burial / protection	Negative Minor Unlikely
	Shellfish species	Negative Minor Unlikely	Cable burial / protection	Negative Minor Unlikely
Operational Noise	All (General)	Negative Minor Unlikely	None	Negative Minor Unlikely
	Cod	Negative Minor Probable	Monitoring / survey work to increase assessment confidence	Negative Minor Probable
Changes to Fishing Activity	All (General)	Below moderate	None	Below moderate

7.2.2 Introduction

7.2.2.1 This chapter provides an assessment of the likely significant effects of the construction, operation and decommissioning phases of Telford, Stevenson and MacColl Wind Farms on fish and shellfish resources. The assessment of effects resulting from the development of the offshore transmission infrastructure (OfTI) is provided in Chapter 10.2 (Fish and Shellfish Ecology) and the assessment of cumulative effects in Chapter 14.2 (Fish and Shellfish Ecology). An assessment of the Project, incorporating the three proposed wind farm sites and transmission infrastructure can be found in Chapter 12.1 (Whole Project Assessment).

7.2.2.2 The following chapters and appendices support this assessment, and can be found as:

- Chapters 3.5 and 6.2 (Sedimentary and Coastal Processes);
- Chapter 3.6 (Underwater Noise).
- Chapters 4.2 and 7.1 (Benthic Ecology);
- Chapter 4.3 and Technical Appendix 4.3 A (Fish and Shellfish Ecology); and
- Chapters 5.1 and 8.1 (Commercial Fisheries);
- Technical Appendix 4.3 B (Salmon and Sea Trout Ecology and Fisheries);
- Technical Appendix 4.3 C (Sandeel Survey Results);
- Technical Appendix 4.3 D (Electromagnetic Fields Modelling);

7.2.3 Rochdale Envelope Parameters Considered in the Assessment

7.2.3.1 For the purposes of this assessment a realistic worst case scenario, taking account of the engineering parameters with the potential to cause the greatest effect upon fish and shellfish resources, has been described.

7.2.3.2 In general terms, it is considered that the installation of the maximum number of turbines (smallest rated turbines scenario using 3.6 MW turbines in site 1 and 5 MW in the next two constructed sites) will constitute the worst case scenario for all fish and shellfish receptors as this would result in the greatest total seabed footprint and number of construction related operations.

7.2.3.3 Further identification of the realistic worst case based on more detailed parameters of wind farm design will depend upon the likely significant effect being considered:

- For assessment of noise during construction, the use of 2.5 m pin piles will be considered worst case (Chapter 3.6: Underwater Noise);
- For loss of habitat and introduction of new habitat, the worst case assumes the use of gravity bases of 65 m diameter, as these will result in the greatest footprint and largest introduction of hard substrate;
- For temporary disturbance of seabed in relation to increased suspended sediment concentrations and sediment re-deposition, both dredging associated to seabed preparation for installation of gravity bases and drilling to facilitate installation of pin-piles will be considered. In addition, the use of energetic methods, such as jetting and ploughing, will also be assessed for inter array cable installation; and
- For assessment of EMFs the maximum length of cabling and the use of 66 kV AC inter array cables is considered worst case as these parameters will result in the largest area being affected and the strongest associated magnetic fields.

7.2.3.4 The worst case scenarios used for assessment are summarised in Table 7.2-2 below and further described in the relevant impact assessment paragraphs below.

Table 7.2-2 Rochdale Envelope Parameter Relevant to the Fish and Shellfish Ecology Impact Assessment

Potential Effect	Rochdale Envelope Scenario Assessed
Construction & Decommissioning	
Temporary Disturbance of the Seabed	• Seabed preparation for GBS installation: ○ Max. number of turbines installed: 339; ○ Max. base diameter: 65 m; and ○ Dredger affected width: 125 m. • Drilling to facilitate pin pile installation: ○ Max. number of turbines 339; ○ Max. pile diameter: 2.5 m; and ○ Max. number of piles per foundation: four. • Inter-array cable burial: ○ Trenching by energetic means (i.e. jetting and dredging). • Max. total inter-array cabling length: 572 km; • Target trench depth: 1m; and • Trench affected width per trench: 6 m: ○ Max. number of cables in a trench: one.

Potential Effect	Rochdale Envelope Scenario Assessed
Noise	• Installation of turbine foundations: o Max. number of turbines installed: 339; o Max. pile diameter: 2.5 m; o Max. number of piles per foundations: four; and o Max. number of simultaneous piling operations: six. • Installation of one met mast: o Monopile: 4.5 m diameter.
Operation	
Loss of Habitat	**Max. net reduction of seabed habitat of 3.76 km² based on the following factors, equating to 1.27 % of total area of the three proposed wind farm sites:** • Placement of gravity base foundations of 65 m diameter = 3,317 m² per turbine; • Scour protection material = 3,770 m² per foundation; • Cable protection associated with up to 4 J tubes per turbine assuming protection required up to 100 m distance from turbine and at 10 m width = 4,000 m² per turbine; and • 339 turbines (if lowest rated options installed).
Introduction of New Habitat	**Maximum footprint of 2.63 km² based on the following factors, equating to 0.89 % of the total area of the three proposed wind farm sites:** • Scour protection material = 3,770 m² per foundation; • 339 turbines; • One met mast foundation; and • Cable protection associated with up to 4 J tubes per turbine assuming protection required up to 100 m distance from turbine and at 10 m width = 4,000 m² per turbine.
Operational Noise[1]	Maximum number of turbines: 339
EMFs	Inter-array cable: • Type: AC; • Max. voltage: 66 kV; • Max. total inter-array cabling length: 572 km; and • Target trench depth: 1 m.
Changes to Fishing Activity[1]	Max. number of turbines: 339

7.2.4 EIA Methodology

Significance Criteria

7.2.4.1 The impact assessment methodology used for the evaluation of effects on fish and shellfish species is described below. The significance criteria used are based on the

[1] Limited information available for detailed worst case definition. The maximum number of turbines is assumed to constitute worst case.

magnitude of the effects and on the sensitivity of the receptors. Both magnitude of effect and receptor sensitivity have been assigned using professional judgement. The parameters used to define these take account of the IEEM (2010) impact assessment guidelines.

Magnitude of Effect

7.2.4.2 The magnitude of the effect has been assigned based on the following considerations:

- **Extent of effect**, referring to the full area over which the effect occurs (e.g. noise impact range);
- **Duration of effect**, referring to the duration over which the effect is expected to last;
- **Frequency of the effect**; and
- **Reversibility**: Irreversible effects are those from which recovery is not possible within a reasonable timescale. Reversible (temporary) are effects from which spontaneous recovery is possible or, for which effective mitigation is both possible and an enforceable commitment has been made.

Sensitivity

7.2.4.3 The sensitivity of the receptor has been assigned taking account of its degree of adaptability, tolerance and recoverability to the potential effect. In addition the following parameters have been considered:

- **Timing of the effect**, referring to whether effects are caused during critical life-stages or seasons (e.g. spawning season and migration); and
- **Ecological value**, referring to conservation status of the receptor (i.e. protected to the European level and / or national level) and importance in the area (e.g. species of importance as prey to other marine organisms and species of commercial importance).

Significance

7.2.4.4 The significance of an effect is defined using the following categories:

- **Not significant**: an effect that is predicted to be indistinguishable from natural background variation using conventional monitoring techniques. The effect is not significant in the context of the nature conservation objectives or legislative requirements;
- **Minor significance**: the effect will be measurable in the short term and / or over very local scales using standard monitoring techniques. The effect does not affect nature conservation objectives and falls within legislative requirements. Effects are typically reversible;
- **Moderate significance**: the effect will be measurable in the long term and over a broad to very broad spatial scale and is likely to have a measurable effect. It may affect nature conservation objectives and legislative requirements. Effects may be reversible; and
- **Major significance**: a permanent effect which has a measurable effect on wider ecosystems functioning and nature of conservation objectives and exceeds acceptable limits or standards.

7.2.4.5 The significance of an effect is determined taking account of the magnitude of the effect and the sensitivity of the receptor using the matrix below (Table 7.2-3). In addition to these significance ratings whether the predicted effect is considered positive or negative is also described. Those effects assessed to be above minor (moderate and major) are considered to be significant for the purposes of environmental impact assessment.

Table 7.2-3 Impact Assessment Significance Criteria

Impact Assessment Significance Criteria		Sensitivity of Receptor		
		Low	**Medium**	**High**
Magnitude of Impact	**Negligible**	Not significant	Minor	Minor
	Small	Minor	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

7.2.4.6 The impact assessment below uses the best knowledge that is currently available on sensitivity of particular species / species groups, it should however be noted that some limitations exist. Where required, surrogates (similar species / species groups for which information is available), have been used to inform this assessment. In addition, as a result of uncertainties in relation to the distribution of some species and the use that they may make of the area of the three proposed wind farm sites, particularly in the case of migratory species, a number of conservative assumptions have been made. Where applied, these are detailed in the following paragraphs.

7.2.4.7 For certain effects, the limited information available to date does not allow for the impact assessment to follow the standard methodology described above, as data gaps make defining magnitudes of effect and identification of receptors and their sensitivity difficult. In those instances, the impact assessment has been based on a literature review of current knowledge of the particular effect and the receptors under consideration and on indirect evidence from monitoring studies carried out in operational wind farms. Where this is the case, it is described in the following paragraphs.

7.2.4.8 In light of the limitations of the impact assessment described above the probability for each potential effect to occur has been assessed as “certain / near certain”, “probable”, “unlikely” and “extremely unlikely”. The definition of the probability categories used in the assessment is given below as provided in the IEEM (2010) guidelines:

- **Certain / near certain**: probability estimated at 95 % or higher;
- **Probable**: probability estimated above 50 % but below 95 %;
- **Unlikely**: Probability estimated above 5 % but less than 50 %; and
- **Extremely unlikely**: Probability estimated at less than 5 %.

7.2.4.9 Probabilities have been assigned taking into account the available evidence for an effect to occur, the degree of available baseline information on the ecology of the receptors and the use that they make of areas relevant to the proposed Telford, Stevenson and MacColl wind farm sites.

7.2.5 Primary Impact Assessment: Three Proposed Wind Farm Sites

7.2.5.1 Fish and shellfish species are expected to be affected in different ways, depending on the use that particular species make of the area of the three proposed wind farm sites, and their ecology and life stage under consideration (i.e. migratory species and degree of mobility).

7.2.5.2 As described in Chapter 4.3 (Fish and Shellfish Ecology) and Technical Appendix 4.3 A (Fish and Shellfish Ecology Technical Report), a number of species are known to spawn and have nursery areas in the Moray Firth and in areas relevant to the three proposed wind farm sites. Some of these (i.e. sandeels and herring) lay their eggs on the seabed and may therefore be particularly sensitive to the effects of seabed disturbance. In addition, sandeels and herring (together with sprat) are considered to be of importance as prey species in the area, not only for other fish but also for marine mammals and seabirds (see Chapter 7.3: Marine Mammals and Chapter 7.4: Ornithology).

7.2.5.3 Migratory diadromous species of conservation importance, particularly salmon and sea trout, European eel and river and sea lamprey, may transit the development areas during migration and in some cases (particularly sea trout) as part of their foraging activity (Technical Appendix 4.3 A: Fish and Shellfish Ecology Technical Report and 4.3 B: Salmon and Sea Trout Fisheries and Ecology Technical Report).

7.2.5.4 In addition, fish and shellfish species of commercial importance and elasmobranch species, (some of which are also of conservation importance), are also present in areas relevant to the three proposed wind farm sites (See Chapter 4.3: Fish and Shellfish Ecology and Technical Appendix 4.3 A: Fish and Shellfish Ecology Technical Report).

7.2.5.5 The likely significant effects considered for assessment on fish and shellfish ecology are as follows:

- Temporary disturbance of the seabed;
- Underwater noise;
- Loss of habitat;
- Introduction of new habitat;
- Electromagnetic fields (EMFs); and
- Changes to fishing activity.

7.2.5.6 The above effects have been separately assessed for the construction / decommissioning phases and the operational phase. For the purposes of this assessment and in the absence of detailed information on decommissioning schedules and methodologies, it is assumed that any effects derived from the decommissioning phase will, at worst, be of no greater significance than those derived from the construction phase. Cumulative effects arising from other marine developments are discussed separately in Chapter 14.2 (Fish and Shellfish Ecology).

Construction

7.2.5.7 The likely significant effects of the construction phase on fish and shellfish ecology are assessed below. Effects considered for assessment are as follows:

- Temporary disturbance of the seabed; and
- Noise during construction.

Temporary Disturbance of the Seabed

7.2.5.8 The physical disturbance of the seabed associated to construction works will result in an increase in suspended sediment concentrations (SSCs) and subsequent sediment re-deposition. This could indirectly result in an effect on fish and shellfish species.

7.2.5.9 Construction activities resulting in increased SSC and sediment re-deposition are described in detail in Chapter 6.2 (Sedimentary and Coastal Processes). These include the following:

- Dredging as part of seabed preparation for installation of gravity base foundations;
- Drilling to install jacket pin piles; and
- Cable trenching by energetic means (i.e. jetting and ploughing).

7.2.5.10 As described in Chapter 6.2 (Sedimentary and Coastal Processes), the increase in SSC expected in the immediate vicinity of construction vessels (50 to 100 m) is: 30 to 35 mg / l for dredging as part of seabed preparation for gravity bases and 30 to 40 mg / l for drilling for the installation of pin piles, reducing to 20 mg / l or less in the main plume by 500 to 1,000 m downstream and to 10 mg / l or less by 2,000 to 3,000 m downstream. These effects are expected to only occur during and up to an hour after dredging / drilling. After this time SSCs are reduced to < 4 mg / l above ambient levels due to dispersion and deposition. Local effects around construction vessels may be potentially in excess of this but will be very localised and short term. An indication of the expected typical sediment plume resulting from dredging overspill is given in Figure 7.2-1, Volume 6 a (this assumes installation of ten foundations in sequence). As shown for the most part, the predicted increases in SSCs associated to the sediment plume are very small (< 1 mg / l). Inter-array cable installation will have a relatively higher magnitude of effect on suspended sediment, although the effect will be short term (order of seconds to minutes) and will be largely localised to the cable installation location (main effect within tens of metres). Taking the short term and localised nature of the expected significant increases in SSCs the effect of increased SSCs is considered to be of small magnitude.

7.2.5.11 Some accumulation of fine material (silts and clays) is expected to occur south of the three proposed wind farm sites as a result of dredging for seabed preparation and drilling to facilitate pin pile installation. The estimated thickness of the deposits is less than 1mm, accumulating gradually over the whole construction period and it is likely to be both undetectable in practice and subject to progressive dispersion in this time by natural processes (Chapter 6.2: Sedimentary and Coastal Processes).

7.2.5.12 In the case of drilling associated with pin pile installation, localised conical accumulations of sandy material in the near vicinity of each foundation (within up to 200 m) are also expected up to 1 to 5 m thick. (Chapter 6.2: Sedimentary and Coastal processes). An example of the potential worst case footprint of the temporary seabed deposition of sediment arisings from drilling of jacket piles is given below (See Chapter 7.1: Benthic Ecology):

7.2.5.13 Example footprint of 0.28 km^2 (approx. 0.09 % of the total area of the three proposed wind farm sites) assuming:

- Drill arisings from each pile to cover an area of 208.6 m^2 (assumes 353 m^3 arisings are deposited over a small area to form a cone with peak of 5.1 m above seabed and with base 16.3 m diameter);
- 339 turbines (if lowest rated options installed); and
- No. of pin piles per foundation = four.

7.2.5.14 It should be noted that drilling will be employed in areas that are resistant to piling and therefore many areas within the three proposed wind farm sites will remain unaffected.

7.2.5.15 Taking the very small area where significant sediment re-deposition is expected to occur (only around foundations where drilling is required for pin pile installation) the effect of sediment re-deposition is considered to be of small magnitude.

Eggs and Larvae

7.2.5.16 Life stages such as eggs and larvae will not be able to avoid disturbed areas as they may passively drift (if pelagic) or remain (if demersal / benthic) in areas where construction works are being undertaken. Eggs and larvae are generally considered to be more sensitive to suspended sediment effects than later life stages, although sensitivities vary between species. Rönnbäck and Westerberg (1996) found that at concentrations above 100 mg / l, the mortality of cod eggs increased. Studies carried out on eggs of freshwater and estuarine fish suggest hatching success may be reduced at concentrations of 500 to 1,000 mg / l (Auld and Schubel, 1978). Messieh *et al*., (1981) were unable to detect any deleterious effect on herring eggs hatching at SSCs as high as 7,000 mg / l, whilst Griffin *et al*., (2009) suggest that the attachment of sediment particles on herring eggs may lead to retarded development and reduced larval survival rates at sediment concentrations as low as 250 mg / l. In the case of larvae, vision is impeded as the water becomes more turbid. In addition, fine silt may adhere to the gills and cause suffocation (De Groot, 1980). Eggs and larvae are considered receptors of medium sensitivity and the effect of increased SSCs is assessed to be negative, of **minor significance** and probable.

7.2.5.17 In addition to increased SSCs, fish eggs could be affected by re-deposition of suspended sediment. This is of particular importance to species which lay their eggs on the seabed, such as sandeels and herring. Messieh *et al*., (1981) reported that burial of herring eggs under a thin veneer of sediment caused substantial mortality. In addition to direct effects, sediment re-deposition could result in a temporary loss of spawning grounds for these species, in the event that the characteristics of the substrate changed significantly and made the grounds unsuitable for spawning. De Groot (1980) suggests that altering the structure of the spawning grounds of herring may affect stocks because herring in spawning condition may be unable to locate their normal spawning grounds and as a result shed their eggs on less optimal sites. Taking the above into account, sandeels and herring are considered receptors of medium sensitivity. It should be noted, however, that there is little potential for a significant overlap between herring spawning grounds and sandeel areas with areas where significant sediment re-deposition may occur (limited to the immediate vicinity of the foundations and only where drilling is required to facilitate pin pile installation) (see Chapter 6.2: Sedimentary and Coastal Processes)

7.2.5.18 The effect of sediment re-deposition on sandeels and herring is therefore assessed to be negative, of **minor significance** and probable.

Adult and Juvenile Fish

7.2.5.19 Adult and juvenile fish, being mobile, will be able to avoid localised areas disturbed by significant increased SSCs. If displaced, juveniles and adults would be able to move to adjacent undisturbed areas within their normal distribution range. In the case of migratory species, assuming fish are migrating through the site, increased SSCs may result in localised disturbance to migration. An indication of the risk to fish and their habitat at different levels of increased SSC above background conditions is given in Table 7.2-4 below, as provided in Birtwell (1999).

Table 7.2-4 Risk to Fish and their Habitat at Different Levels of Increased SSC (Birtwell, 1999)

Sediment Increase (mg / l)	Risk to Fish and their Habitat
0	No risk
< 25	Very low risk
25 to 100	Low risk
100 to 200	Moderate risk
200 to 400	High risk
> 400	Unacceptable risk

7.2.5.20 In light of the above, juvenile and adult fish, including diadromous migratory species, are considered of low sensitivity. The effect of increased SSCs is therefore considered to be negative, of **minor significance** and probable.

Shellfish Species

7.2.5.21 The principal shellfish species present in areas relevant to the three proposed wind farm sites are, with the exception of squid, of limited mobility (i.e. scallops, *Nephrops*, crabs and lobsters). It is therefore likely that these will remain in areas disturbed by increased SSCs whilst construction works are taking place. In addition, they could be affected by smothering as a result of sediment re-deposition. Increases in SSC in the case of filter feeders such as scallops, could also potentially affect their ability to feed. Experiments carried out in New Zealand with the scallop *Pecten novaezelandiae* found that for a period of time less than a week, this species coped with suspended sediment concentrations < 250 mg / l, whilst for periods greater than a week suspended sediment concentrations > 50 mg / l may have led to decreased growth (Nicholls *et al*., 2003).

7.2.5.22 Examples of the degree of sensitivity to smothering, increased SSC and displacement for a number of shellfish species found within the three proposed wind farm sites and in the wider Moray Firth for which the Marine Life Information Network (MarLIN) provides species specific information are given in Table 7.2-5 below(MarLIN, 2011).

Table 7.2-5 Sensitivity to Smothering, Increased SSC and Displacement of Shellfish Species (Source: MarLIN, 2011)

Receptor	Smothering	Increased SSC	Displacement
Edible Crab	Very low	Low	Not sensitive
King Scallop	Low	Low	Not sensitive
Nephrops	Not sensitive	Not sensitive	Very low

7.2.5.23 Taking the information above and MarLIN's examples of sensitivity for species for which species specific information is available (Table 7.2-5 above) into account shellfish species are considered to be of low sensitivity. The effect of increased suspended sediment concentrations and sediment re-deposition on shellfish species is assessed to be negative, of **minor significance** and probable.

7.2.5.24 It is recognised that in addition to indirect effects through increased suspended sediment and sediment re-deposition, the disturbance of the seabed associated to construction works may result in a direct effect on species and life stages of limited mobility such as shellfish species, demersal eggs, etc. (i.e. if unable to avoid construction machinery) and in a localised loss of habitat (i.e. due to the physical presence of jack up vessel legs on the substrate and seabed preparation works for installation of gravity bases). As indicated in Chapter 7.1 (Benthic Ecology), a maximum area of 5.99 km^2 of seabed habitat will be disturbed over the construction phase (2.03 % of the total area of the three proposed wind farms). It should be noted, however, that only discrete areas will be disturbed at a given time, and that disturbance will be short term. The majority of fish and shellfish species present in the area are relatively mobile and their distribution ranges large in comparison to areas potentially being disturbed at a given time. Direct effects associated to temporary seabed disturbance during construction have therefore not been considered for assessment on fish and shellfish species. Likely significant effects on the benthic community derived from this are assessed in Chapter 7.1 (Benthic Ecology).

Noise

7.2.5.25 A number of wind farm construction related activities generate underwater noise and vibration. These include suction dredging, drilling, operational noise, impact piling, cable laying, rock placement, seismics, trenching and vessel noise.

7.2.5.26 In order to assess the likely significant effect of construction noise on fish, modelling was undertaken using the dB_{ht} (Species) metric, which allows for effect ranges be defined taking account of species specific sensitivities (as described below). The noise modelling methodology is described in detail in Chapter 3.6 (Underwater Noise). The criteria for the assessment of effects on fish is summarised in Table 7.2-6 below.

Table 7.2-6 Noise Assessment Effect Criteria

Level dB_{ht} *(Species)*	Effect
≥ 75	Mild avoidance reaction by the majority of individuals. At this level individuals will react to the noise, although the effect will probably be transient and limited by habituation.
≥ 90	Strong avoidance reaction by virtually all individuals
> 110	Tolerance limit of sound; unbearably loud
> 130	Possibility of traumatic hearing damage from single event

7.2.5.27 The noise modelling undertaken to support this impact assessment has focused on species for which there is detailed information on their hearing ability and which represent different ranges of hearing capabilities and sensitivity to noise. These are dab (*Limanda limanda*), salmon (*Salmo salar*), cod (*Gadus morhua*) and herring (*Clupea harengus*). The effect of construction noise on larvae, other life stages of species of limited mobility (i.e. glass eels) and shellfish species is addressed separately in paragraphs 7.2.5.45 and 7.2.5.46 of this chapter. A summary of the hearing ability of the species used for noise modelling purposes is given below, based on information provided in Thomsen *et al*., (2006).

Fish Species

7.2.5.28 Dab does not possess a swim bladder. Sound travels directly to the otolith organ via tissue conduction. As a result, dab is only sensitive to particle motion. The species is relatively insensitive to sound and hears over a very restricted range of frequencies. Dab hears in a frequency range between 30 to 250 Hz. Dab is chosen in order to represent other fish species of very low sensitivity to sound, especially flatfish without a swim bladders. For the purposes of this assessment dab has been used as a surrogate for plaice (Chapter 3.6: Underwater Noise).

7.2.5.29 Atlantic salmon possess a swim bladder which is not always completely filled. In addition, it is disconnected from the skull. Hawkins and Johnstone (1978) concluded that the swim bladder plays no part in hearing of the species. Salmon have been found to respond only to low frequency tones (below 380 Hz) with best hearing (threshold 95 dB re 1 µPa) at 160 Hz. In addition, there is evidence that juvenile *Salmo salar* smolts are sensitive to very low frequency sound, avoiding localised high intensity sounds less than 10 Hz (Knudsen *et al*., 1994). For the purposes of this assessment salmon has been used as a surrogate for sea trout.

7.2.5.30 Cod has a gas-filled swim bladder. Although there is no direct connection between the swim bladder and ear, the anterior of the swim bladder is in close proximity to the inner ear. Therefore, this species is more sensitive to sound than both dab and Atlantic salmon. Cod has been used as a surrogate for whiting for the purposes of this assessment (Chapter 3.6: Underwater Noise).

7.2.5.31 Herring, like all members of the order *Clupeiformes*, has a swim bladder and inner ear structures which are responsible for their special hearing capabilities. Structural specialisations include an extension of the swim bladder which terminates within the inner ear. Herring hears in an extended range of frequencies between 30 Hz and 4 k Hz, with a hearing threshold of 75 dB re 1 µPa at 100 Hz.

7.2.5.32 As previously mentioned, there are a number of construction related activities which generate underwater noise. A comparative indication of the impact ranges of noise on the species modelled at the 90 dB_{ht} and 75 dB_{ht}(Species) level for different construction activities is provided in Table 7.2-7 below and further detailed in Chapter 3.6 (Underwater Noise).

Table 7.2-7 Impact Ranges at the 90 dB_{ht} and 75 dB_{ht} (Species) Level for Different Construction Activities

Activity	Species	90 dB_{ht}(*Species*) Impact Range (m)	75 dB_{ht}(*Species*) Impact Range (m)
Suction Dredging	Cod	7	39
	Dab	1	7
	Herring	13	65
	Salmon	1	5
Cable Laying	Cod	1	20
	Dab	< 1	1
	Herring	8	66
	Salmon	< 1	1
Rock Placement	Cod	2	25
	Dab	< 1	4
	Herring	6	62
	Salmon	< 1	4
Trenching	Cod	1	16
	Dab	< 1	< 1
	Herring	< 1	27
	Salmon	< 1	2
Vessel Noise	Cod	< 1	8
	Dab	< 1	< 1
	Herring	1	10
	Salmon	< 1	< 1

7.2.5.33 As suggested by Table 7.2-7 above the majority of construction activities have negligible impact ranges on fish. An exception to this is impact piling which is the activity predicted to result in the greatest effect on fish species (for further details, see Chapter 3.6: Underwater Noise). This activity therefore forms the basis of this part of the impact assessment. The assessment of noise on fish has been primarily focused on the outputs of the modelled 90 dB_{ht} (Species) impact ranges, at which the greatest behavioural effects are to be expected.

7.2.5.34 Noise at the 130 and 110 dB_{ht} (Species) level, above which possibility of traumatic hearing damage and unbearably loud sounds may be expected respectively, would only occur in close proximity of where piling is taking place (order of 10s to 100s of metres at 130 dB_{ht} (Species) level and order 100s to few 1,000s of metres at the 110 dB_{ht} level, depending on species specific hearing abilities (Table 7.2-8 below). It should be noted, that soft start piling will be used with the aim that mobile species are not exposed to the 110 and 130 dB_{ht} (Species) levels, as this will allow fish to leave the vicinity of the foundations before the highest noise levels are reached.

Table 7.2-8 130 dB_{ht} and 110 dB_{ht} (Species) Impact Ranges Associated to Piling of a 2.5 m pile by Species

Species	130 dB_{ht} (Species) Range (m)	110 dB_{ht} (Species) Range (m)
Cod	120	2,300
Dab	10	240
Herring	230	3,500
Salmon	< 10	90

7.2.5.35 Three different construction scenarios considering three different construction programmes were modelled (see Chapter 3.6: Underwater Noise). These are as follows:

- A five year build programme utilising one installation vessel installing two pin piles in a 24 hour period;
- A three year build programme utilising two vessels for the majority of the period, each installing two pin piles in a 24 hour period; and
- A two year build programme if six vessels are used, each installing two pin piles in a 24 hour period.

7.2.5.36 Piling will be undertaken during a limited time within each build programme described above. For the noise worst case scenario, based on conservative assumptions, the following parameters are considered:

- Four pin piles per WTGs;
- Max. number of 339 WTGs; and
- At 260 minutes per pile.

7.2.5.37 Assuming a five year building programme (one construction vessel), the average percentage of piling days will constitute 13 % of the total building programme.

7.2.5.38 It is considered that the simultaneous use of six vessels across the three sites constitutes the worst case scenario as this will result in the largest area being affected at a given time. The shorter duration of noise related effects if simultaneous piling takes place should however be recognised. The outputs of the three scenarios modelled are provided in Chapter 3.6 (Underwater Noise) including 90 dB_{ht} and 75 dB_{ht} *(Species)* contour ranges for the four species modelled. The maximum, minimum and mean 90 dB_{ht} and 75 dB_{ht} *(Species)* impact ranges at each location modelled are provided in Table 7.2-9 below by species.

7.2.5.39 Concerns were raised during consultation as part of the EIA process with regard to the sensitivity of juvenile fish and in particular salmon and sea trout smolts. To address this issue a report on ontogenic development of auditory sensitivity in fish was commissioned (Technical Appendix 3.6 A: Underwater Noise Technical Report). This concluded that the experimental evidence suggests that the juveniles of marine fish are no more sensitive to sound than the adults of the species. Furthermore, in some cases it appears that there is a degree of insensitivity to sound of juveniles when compared with adults, implying some protection from the adverse effects of noise. In light of this, juvenile fish have been assessed using the same criteria as that used for evaluation of the effect of impact piling on adults.

7.2.5.40 A comparative indication of the expected 90 dB_{ht} *(Species)* noise effects for the four species modelled is given for a single piling operation (2.5 m pile) in Figure 7.2-2, Volume 6 a. Additionally, this provides an indication of the expected spatial disturbance by species (at the 90 dB_{ht} *(Species)* level) using the five year build programme which considers the use of only one installation vessel.

7.2.5.41 Dab and salmon are expected to exhibit strong avoidance reactions (90 dB_{ht} *(Species)* level) only in close proximity to the foundations, whilst cod and herring are expected to avoid wider areas (See Table 7.2-9 below and Figure 7.2-2, Volume 6 a).

Table 7.2-9 Maximum, Minimum and Mean Impact Ranges Modelled by Species at the 90 dB_{ht} and 75 dB_{ht} Levels at Different Locations for a 2.5 m Pile.

Modelled Location	Species	90 dB_{ht} Impact Range (km)			75 dB_{ht} Impact Range (km)		
		Max.	Min.	Mean	Max.	Min.	Mean
1	Cod	25	18	21	67	32	49
	Dab	3.9	3.7	3.8	22	17	20
	Herring	31	22	26	77	32	53
	Salmon	1.5	1.5	1.5	9.5	8.5	9
2	Cod	24	20	22	68	41	56
	Dab	3.9	3.9	3.9	22	19	21
	Herring	30	24	27	79	41	62
	Salmon	1.5	1.5	1.5	9.7	9.3	9.4

Modelled Location	Species	90 dB$_{ht}$ Impact Range (km)			75 dB$_{ht}$ Impact Range (km)		
		Max.	Min.	Mean	Max.	Min.	Mean
3	Cod	23	20	22	68	36	57
	Dab	3.9	3.8	3.8	21	19	20
	Herring	29	24	27	80	36	63
	Salmon	1.5	1.5	1.5	9.4	9.1	9.2
3a	Cod	23	19	21	66	33	54
	Dab	3.8	3.8	3.8	21	18	20
	Herring	29	23	26	76	33	60
	Salmon	1.5	1.5	1.5	9.3	8.8	9.1
4	Cod	22	19	20	64	28	50
	Dab	3.6	3.5	3.5	19	17	18
	Herring	28	23	25	74	28	55
	Salmon	1.5	1.5	1.5	9	8.3	8.6
5	Cod	23	19	22	65	22	51
	Dab	3.9	3.8	3.8	21	18	20
	Herring	29	22	26	77	22	57
	Salmon	1.5	1.5	1.5	9.5	8.9	9.2
5a	Cod	22	18	21	60	22	49
	Dab	3.7	3.6	3.6	20	17	19
	Herring	27	22	25	71	22	55
	Salmon	1.5	1.5	1.5	9.1	8.5	8.8
6	Cod	21	18	20	59	22	47
	Dab	3.5	3.4	3.5	19	16	18
	Herring	26	22	24	70	22	53
	Salmon	1.5	1.5	1.5	8.7	8.2	8.5

7.2.5.42 In order to support the assessment and provide an indication of the ecological significance of the predicted noise impact ranges, the location and extent of spawning grounds is provided for herring, cod and plaice and, in the case of salmon, the location of SAC rivers (Figure 7.2-3 to Figure 7.2-6, Volume 6 a). Note that in the particular case of herring, given their dependence on the presence of a coarse substrate for spawning, the distribution of gravel and sandy gravel (based on BGS data) available to the Orkney / Shetland stock is also shown in Figure 7.2-6, Volume 6 a. As previously mentioned, the impact assessment is primarily based on the 90 dB_{ht} *(Species)* noise contours. However, in the case of salmon, given its conservation status, the importance of their fisheries to the local, regional and national level in Scotland 75 dB_{ht} *(Species)* levels have also been used to form the basis for assessment.

Impact Assessment

7.2.5.43 Taking account of the above impact ranges, the magnitude of the effect of construction noise has been defined as follows:

- Based on the noise modelling outputs for dab (surrogate for plaice) the magnitude of the effect is considered to be small (Table 7.2-9 above and Figure 7.2-3, Volume 6 a);
- Based on the noise modelling outputs for salmon (surrogate for sea trout) and taking into account the 75 dB_{ht} levels, the magnitude of the effect is considered to be small-medium (Table 7.2-9 above and Figure 7.2-4, Volume 6 a); and
- Based on the noise modelling outputs for cod (surrogate for whiting) and herring, the magnitude of the effect is considered to be medium (Table 7.2-9 above and Figures 7.2-5, and 7.2-6, Volume 6 a).

7.2.5.44 The sensitivity of the receptors modelled, based on their ecological importance and the use that they make of the three proposed wind farm sites and the wider area and the significance of the predicted effects is given below:

- Plaice have defined spawning and nursery grounds in areas relevant to the proposed sites (Figure 7.2-3, Volume 6 a). These are however relatively large and considered of low intensity (Ellis *et al*., 2010). Plaice is therefore considered a receptor of low sensitivity. The effect of noise on plaice is assessed to be negative, of **minor significance** and probable;
- In the absence of detailed information on the migratory routes of salmon and sea trout it is assumed that they transit the proposed sites as part of their normal migration. In addition they are assumed to transit the proposed sites as part of their foraging activity (particularly sea trout). It should be noted, however, that areas in the immediate vicinity of the rivers will not be affected and hence fish will not be disturbed immediately prior to river entry or immediately after leaving the rivers at the 90 dB_{ht} or 75 dB_{ht} levels. In addition, there is little potential for barrier effects to take place given the relatively small expected ranges for these species at the 90 dB_{ht} level, at which the strongest behavioural responses would be expected (Table 7.2-9 above and Figure 7.2-4, Volume 6 a). Taking the above into account and given the conservation status of salmon and sea trout and the importance of their fisheries to the local and national level in Scotland, they are considered of medium sensitivity. The effect on salmon and sea trout is assessed to be negative, of **minor-moderate significance** and probable;
- The cod population of the Moray Firth is genetically distinct from other North Sea populations and spawning activity has been low in recent years. In addition they are known to use the Moray Firth as a nursery ground (Technical Appendix 4.3 A: Fish and Shellfish Ecology Technical Report). Noise contours at the 90 dB_{ht} *(Species)* level could overlap with a significant area of their spawning and nursery grounds (Figure 7.2-5, Volume 6 a). The uncertainties in relation to the

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current extension and relative importance of these grounds should however be recognised. The sensitivity of cod is considered to be medium-high. The effect of piling noise on cod is therefore assessed to be negative, of **moderate to major significance** and probable;

- Whiting (for which cod has been used as a surrogate), have defined spawning and nursery grounds in the area relevant to the proposed sites. However these are comparatively large. They are considered receptors of low sensitivity. The effect on whiting is therefore assessed as negative, of **minor significance** and probable; and
- Herring are known to spawn in the Moray Firth and use the Firth as a nursery ground. They are important as prey species for a number of other marine organisms. In addition they are substrate specific spawners needing the presence of an adequate coarse substrate on which to lay their eggs. It should be noted however, that the highest intensity of herring spawning tends to take place in the area between the Orkney and the Shetlands in most years and that gravelly substrate is available to the Orkney / Shetland stock in various areas unaffected at 90 dB_{ht} (*Clupea harengus*) levels (see Figure 7.2-6, Volume 6 a). Herring are considered receptors of medium sensitivity and the effect is assessed to be negative, of **moderate significance** and probable.

Other Fish Species Present in the Proposed Wind Farm Sites

7.2.5.45 The level of hearing specialisation in fish is assumed to be associated with possession of a swim bladder and whether this is connected to the ear. Fish with specialist structures are considered of highest sensitivity, non-specialists with swim bladder of medium sensitivity and non-specialists without swim bladder of lowest sensitivity (Nedwell *et al*., 2004). Based on this classification, likely magnitudes of effect have been assigned to a number of species of importance in the Moray Firth area (i.e. species of conservation or commercial importance, key prey species) for which noise modelling has not been undertaken and direct surrogates have not been defined as follows:

- For flatfish species and other species which lack a swim bladder, namely sandeels, elasmobranchs, anglerfish, river lamprey and sea lamprey, the magnitude of effect may be similar to that assigned to dab (small);
- For species with a swim bladder but not connected to the ear, namely, haddock and European eel, the magnitude of effect may be between that assigned to cod (medium) and that assigned for dab (small); and
- For species which possess a connection between the swim bladder and the ear such as sprat, the potential magnitude of effect may be similar to that assigned to herring (medium).

7.2.5.46 It should be noted that data on hearing ability exist for a limited number of species and extrapolation of hearing capabilities between different species, and especially those that are taxonomically distant, should be undertaken with caution (Hastings and Popper, 2005). The potential magnitude of effect and the sensitivity of the species above is summarised in Table 7.2-10 below. Given the limitations and qualitative nature of the assessment, significance ratings and probabilities have not been defined. The limitations and the qualitative nature of the noise assessment for the species which have not been modelled and for which direct surrogates have not been defined should therefore be recognised and only be taken as an indication of likely significant effects.

Table 7.2-10 Qualitative Assessment for Species not Modelled and Without Defined Surrogates Based on Potential Magnitude of Effects and Receptor Sensitivities

Species	Potential Magnitude of Effect	Sensitivity of Receptor	Magnitude of Effect
Sandeels	Small	• Important prey species; and • Known to be present in the Moray Firth area. The results of the site specific survey undertaken, however, suggest that within the three proposed wind farm sites there are not extensive areas supporting important sandeel populations. Substrate specific.	Medium
Elasmobranchs	Small	• Most species are of conservation Importance; • Generally more prevalent in the north and west of Scotland than in the Moray Firth; and • Some with nursery grounds defined in the proposed sites (spurdog, spotted ray and thornback ray).	Low-Medium
River and Sea Lamprey	Small	• Conservation importance; and • Potentially transiting the site during migration (lack of detailed information on migration).	Medium
Anglerfish	Small	• Commercially important; and • High intensity nursery area in the sites.	Medium
Haddock	Small to Medium	• Commercially important; and • Nursery grounds in the area and spawning grounds in the proximity of the proposed sites, however comparatively large.	Low
European Eel	Small to Medium	• Conservation importance; and • Potentially transiting the site during migration (lack of detailed information on migration).	Medium
Sprat	Medium	• Important as prey species; and • Spawning and nursery grounds in the area, however these are comparatively large.	Low-Medium

Life Stages of Limited Mobility

7.2.5.47 Life stages of limited mobility such as larvae, and in the case of European eel, their juvenile form (glass eels), will not be able to avoid areas where the highest noise levels are reached during construction, assuming they drift through the proposed wind farm sites. Although there is limited information on the effect of piling noise to date on early life stages of fish, research recently carried out by the Institute for Marine Resources and Ecosystem Studies (IMARES) (Bolle *et al*., 2011) suggests that the assumption of 100 % of larvae mortality within a radius of 1,000 m around a piling site (used in the Appropriate Assessment of Dutch offshore wind farms) is too conservative. Bolle *et al*., (2011) found no significant effects in the larval stages analysed at the highest exposure level (cumulative SEL = 206 dB re 1μPa^{2}s) which represented 100 pulses at a distance of 100 m from piling. It is recognised that the results, based on sole (*Solea solea*) larvae, should not be extrapolated to fish larvae in general as inter-specific differences in vulnerability to sound exposure may exist. The findings, however suggest that larval mortality would only occur within a few hundred metres from where piling is taking place. On this basis, the magnitude of the effect is considered small. The sensitivity of larvae and glass eels is considered medium and the effect is assessed as negative, of **minor significance** and probable.

Shellfish Species

7.2.5.48 The majority of shellfish species present in areas relevant to the proposed sites, with the exception of squid, have limited mobility in comparison to most fish species, hence they may not be able to avoid areas in close proximity to piling operations. The hearing mechanism of invertebrate species is currently not well understood. They are generally assumed to be less sensitive to noise than fish due to the lack of a swim bladder. Recent studies, however, have found that species such as the shrimp (*Palaemus serratus*) and the longfin squid (*Loligo pealeii*) are sensitive to acoustic stimuli and it has been suggested that these species may be able to detect sound similarly to most fish, via their statocysts (Lovell *et al*., 2005; Mooney *et al*., 2010). No species specific information on the sensitivity of *Nephrops*, crabs and lobsters is currently available, however, they are expected to be present in areas relevant to the three proposed wind farm sites in relatively low numbers, being more prevalent in other areas within the region. Squid are seasonally present in the Moray Firth to spawn and, as previously mentioned, may potentially be affected by noise in a similar way as fish. They are however mobile and mainly occur in coastal areas to the south of the proposed sites.

7.2.5.49 Scallops are the principal commercial shellfish species targeted in the proposed sites. Whilst detailed information on the hearing ability of scallops is currently lacking, they are not considered to be sensitive to noise (MarLIN, 2011).

7.2.5.50 In light of the above, the magnitude of the effect of noise on shellfish is considered small and the sensitivity of shellfish low. The effect on shellfish species is assessed to be negative, of **minor significance** and unlikely.

7.2.5.51 It should be noted that a number of research initiatives are currently being funded by DEFRA to increase the understanding of the effects of anthropogenic noise on marine life, including the following:

- Sound waves, Effects of underwater noise on coastal fish and crustaceans behavioural responses in the field (Newcastle University);
- The impact of anthropogenic noise on fish and invertebrates at the individual, population and community level (Bristol University); and
- Monitoring ambient noise for the Marine Strategy Framework Directive (CEFAS).

7.2.5.52 The outcomes of the above studies are anticipated to further contribute to the understanding of the effect of noise on fish, particularly at the behavioural level.

Operation

7.2.5.53 The potential effects of the operational phase on fish and shellfish ecology are assessed below. The following effects have been considered for assessment:

- Loss of habitat;
- Introduction of new habitat;
- EMFs;
- Operational noise; and
- Changes to fishing activity.

Loss of Habitat

7.2.5.54 The installation of the three proposed wind farms will result in a loss of habitat for fish and shellfish species proportional to their total footprint. As indicated in Table 7.2-2 above, a maximum net reduction of seabed habitat of 3.76 km^2 may occur. This accounts for 0.99 % of the total area of the three proposed wind farm sites.

7.2.5.55 In light of the small worst case area of seabed expected to be lost, the magnitude of the effect is considered to be negligible.

7.2.5.56 Further to the above direct loss of seabed area, the introduction of the wind farm infrastructure could result in changes in the distribution of seabed sediment in the development area during the operational phase, which could potentially result in an indirect loss of habitat to some species. As detailed in Chapter 6.2 (Sedimentary and Coastal Processes), however, changes to tidal, wave and sediment transport regime due to the presence of the wind farm foundations are expected to be not significant. The potential for changes in sediment type and sediment distribution within the site and the wider area to have an effect on fish and shellfish species are therefore not considered further.

7.2.5.57 The majority of fish and shellfish species present in the area have relatively wide distribution ranges. These vary depending on the species under consideration but are consistently large relative to the predicted loss of habitat of 3.76 km^2. In general terms, given the available area to fish and shellfish species they are considered of low sensitivity and loss of habitat is assessed as **not significant** and probable. An exception to this are spawning herring and sandeels, which given their dependence on the existence of a suitable substrate are assessed separately below.

7.2.5.58 Herring requires the presence of a coarse substrate for spawning. They are demersal spawners and, assuming eggs are laid within the site, there is potential for the introduction of the proposed wind farm infrastructure of the Telford, Stevenson and MacColl sites to result in a direct loss of spawning grounds. An indication of the available coarse substrate to the Shetland / Orkney stock and the total worst case loss of habitat is given in Figure 7.2-7, Volume 6 a, based on BGS data (showing gravel and sandy gravel areas) together with the wider spawning grounds defined in Coull *et al*., (1998). Taking the extent of likely areas potentially suitable for herring spawning, herring is considered to be a receptor of medium sensitivity to loss of habitat. The effect of loss of habitat on spawning herring is considered to be negative, of **minor significance** and unlikely.

7.2.5.59 In the case of sandeels, a loss of habitat could occur if wind farm infrastructure is placed in areas where they are present. Sandeels are substrate specific and inhabit discreet patches of the seabed. As mentioned in Chapter 4.3 (Fish and Shellfish Ecology), MORL commissioned a sandeel survey to investigate the distribution of sandeels across the three proposed wind farm sites and the Western Development Area. Sandeels were caught in low numbers across the three proposed wind farm sites ranging from 0 to 40 individuals. Whilst sandeels are considered to be present in the Smith Bank and in the wider Moray Firth, the results of the sandeel survey suggest that within the three proposed wind farm sites there are not extensive areas supporting important sandeel populations. Taking the above into account sandeels are considered of medium sensitivity and the effect due to habitat loss is assessed to be negative, of **minor significance** and probable.

7.2.5.60 Research carried out at Horns Rev, where sandeel population specific monitoring has been undertaken, suggests that the construction of the wind farm has not had any detrimental long term effect on sandeels in the area (Stenberg *et al*., 2011).

Introduction of New Habitat

7.2.5.61 The sub-surface sections of turbine towers, foundations, scour protection and concrete mattressing / rock dumping for cable protection (where required) will result in the introduction of hard substrate which is expected to be colonised by a number of organisms, including a range of encrusting and attaching species (epifauna) such as mussels, barnacles, tubeworms, sponges, hydroids, etc. This is likely to increase local species diversity as well as the abundance and biomass of epifaunal organisms (Chapter 7.1: Benthic Ecology). The introduction of the structures will replace areas of existing predominantly sandy or slightly gravelly biotopes with communities typical of harder substrates.

7.2.5.62 The increase in diversity and productivity of seabed communities may have an effect on fish resulting in either attraction or increased productivity (Hoffman *et al*., 2000). The potential for marine structures, whether man-made or natural, to attract and concentrate fish is well documented (Sayer *et al*., 2005; Bohnsack, 1989; Bohnsack & Sutherland,1985; Jorgensen *et al*., 2002). However, whether these structures act only to attract and aggregate fish or actually increase biomass is currently unclear.

7.2.5.63 The impact assessment methodology described in 7.2.4 above is not considered practicable for assessment of likely significant effects derived from the introduction of new habitat, given the difficulty of assigning both sensitivities to potential receptors and a magnitude to the likely effect. Furthermore, receptors may change through the operational phase of the Telford, Stevenson and MacColl sites as changes in the benthic community take place. The assessment of this effect will therefore be based on a review of current knowledge and on evidence from monitoring programmes undertaken in operational wind farms and other offshore infrastructures.

7.2.5.64 Studies carried out in Sweden in operational wind farms suggest that the structures may function as combined artificial reefs and fish aggregation devices (FADs) for demersal and semi-pelagic fish (Wilhelmsson *et al*., 2006). This was concluded on the basis of the greater abundance of fish found on and near monopiles. Wilhelmsson *et al*., (2006) pointed out that added structures on the monopiles may attract species that would not have otherwise been present and suggested that the changes in abundance of some species could result in positive local effects on commercial species, provided local increases on the species that they prey upon also occur.

7.2.5.65 A review on the short term ecological effects of the offshore wind farm Egmond aan Zee (OWEZ) in the Netherlands, based on two year post-construction monitoring (Lindeboom *et al*., 2011), found only minor effects upon fish assemblages, especially near the monopiles, and it was suggested that species such as cod may find shelter within the wind farm. Data collected by pelagic and demersal surveys indicated the presence of a highly dynamic fish community, with large differences between the catches before the wind farm was built and when the wind farm was operational. A switch in the dominance of pelagic species from herring to sandeels and an increase in the species richness of demersal species in the first year after construction was recorded. Those changes were however also observed in reference areas and it was concluded that it was unlikely to be caused by the presence of the wind farm. At OEWZ, an exclusive significant increase inside the wind farm was found for sole (*Solea solea*), whiting (*Merlangius merlangus*) and striped red mullet (*Mullus surmuletus*) during summer, whereas a significant decrease was found for lesser weever (*Echiinchthys vipera),* both in summer and in winter. However, no clear explanation was found for the change in abundance of these species (Lindeboom *et al*., 2011).

7.2.5.66 During post-construction monitoring work at the operational wind farm of Horns Rev in Denmark, it was estimated that the loss of infaunal habitat derived from the introduction of hard bottom habitats provided 60 times increased food availability for fish and other organisms in the wind farm area compared to the native infaunal biomass (Leonhard and Pedersen, 2005). A succession in the number of fish species was observed when comparing the results of surveys undertaken in March and in September and it was suggested that it could be a result of seasonal migrations of fish species to the turbine site for foraging. Bib (*Trisopterus luscus*) were observed, presumably partly feeding on crustaceans on the scour protection, together with schools of cod. Other species such as rock gunnel (*Pholis gunnellus*) and dragonet (*Callionymus lyra*) were commonly found inhabiting caves and crevices between the stones. In addition, pelagic and semi-pelagic fish such as sprat, mackerel and lesser sandeel seemed to be more frequently recorded than previously (Leonhard and Pedersen, 2005). The Horns Rev monitoring follow-up report recently published (Stenberg *et al*., 2011) which examined the changes in the fish community seven years after construction, indicates that the introduction of hard substrate resulted in minor changes in the fish community and species diversity. Fish community changes were observed due to changes in densities of the most commonly occurring fish, whiting and dab, however this reflected the general trend of these fish population in the North Sea. The introduction of hard substrate was however found to result in higher species diversity close to each turbine with a clear (horizontal) distribution, which was most pronounced in the autumn, when most species were registered. New reef habitat fish such as goldsinny wrasse (*Ctenolabrus rupestris*), viviparous eelpout (*Zoarces viviparous*) and lumpsucker (*Cyclopterus lumpus*) were found to establish themselves on the introduced reef area (Stenberg *et al*., 2011). As previously mentioned, sandeel populations specific monitoring carried out in Horns Rev suggests that the construction of the wind farm has not had a detrimental long term effect on the overall occurrence of sandeels in the area (Stenberg *et al*., 2011).

7.2.5.67 Research carried out at Lysekil, a test wave power park off the Swedish west coast, found significantly higher abundance of fish and crabs on the foundations compared to the surrounding soft bottoms. Fish numbers were however not found to be influenced by increased habitat complexity (Langhamer and Wihelmsson, 2009).

7.2.5.68 The results of fish monitoring programmes carried out in operational wind farms in the UK do not suggest major changes in fish species composition, abundance or distribution have occurred. At North Hoyle, changes in the diversity of organism or the species composition of the benthic and demersal community were not found. The annual post-construction beam trawl survey indicated that most of the fish species were broadly comparable to previous years and within the long term range, with some species showing recent increases and decreases, but broadly mirroring regional trends (CEFAS, 2009). At Barrow, pre and post-construction otter trawl survey results from the wind farm area showed similar patterns of abundance, with the most frequently caught fish being dab, plaice, whiting and lesser spotted dogfish. Results from control locations showed a similar pattern, and found no significant differences between the catches of the two most abundant species (dab and plaice) before and after installation of the wind farm, or between the numbers caught at control locations and within the wind farm area after the wind farm was constructed (CEFAS, 2009).

7.2.5.69 It has been suggested by Linley *et al*., (2007) that the introduction of wind farm related structures could extend the distribution of some mobile species such as crabs, lobsters and fin fish, as a result of increased habitat opportunities. For example: during post construction monitoring, it was found that the wind farm site at Horns Rev was being used as a nursery area by juvenile edible crabs (Leonhard and Pedersen, 2005). Colonisation of structures by commercial shellfish species has also been reported at the artificial reef constructed in Poole Bay in 1989, where attraction and loyalty was demonstrated for European lobster (*Homarus gammarus*) and edible crabs (*Cancer pagurus*) within three weeks of deposition (Collins *et al*., 1992; Jensen *et al*., 1994). In addition, evidence of reproductive activity for a number of shellfish species such as spider crabs, velvet crabs and presence of berried females of lobster was also found (Jensen *et al*., 1992). Based on the experience at Horn Rev and Poole Bay, Linley *et al*., (2007) suggest that the edible crab may be among the early colonisers of operational wind farms. As suggested by the findings of the above monitoring studies, there may be potential for the area to be used as nursery and spawning area for this species.

7.2.5.70 Based on the information provided above, it is considered that in general terms effects on the fish and shellfish species due to the introduction of new habitat will be of **minor significance** and probable. This effect may be positive or negative depending on the species under consideration (i.e. positive for species for which feeding opportunities are increased and protection is found within the array and negative for other species if subject to increased predation within the site). In the particular case of edible crab, it is considered that a positive effect of **minor significance** and probable could also occur.

7.2.5.71 It should be noted, that further to the introduction of new habitat, other factors such as the potential effect of EMFs, operational noise and changes to fishing activity within and in the vicinity of the proposed sites could further result in changes to the distribution of sensitive fish and shellfish species. These potential effects are separately addressed in the following paragraphs.

Electromagnetic Fields (EMFs)

7.2.5.72 The inter array cables of the three proposed wind farms will be three core AC cables up to 66 kV. These will generate an electric field (E) and a magnetic field (B). The total E field cancels itself out to a large extent and the remaining E field is shielded by the metallic sheath and cable armour. The varying magnetic field (B), however, produces an associated induced electric field (Ei), therefore both B and Ei fields will be generated by inter array cables during the operational phase of the three proposed wind farms.

7.2.5.73 Normandeau *et al*., (2011) modelled expected magnetic fields using design characteristics of 24 undersea cable projects and found for eight out of the ten AC cables modelled that intensity of the field was roughly a direct function of voltage (ranging from 33 kV to 345 kV), although separation between the cables also influenced field strengths. The predicted magnetic fields were strongest directly over the cables and decreased rapidly with vertical and horizontal distance from the cables. Inter-array cables within the three sites will be buried to a target depth of 1 m, although this may not always be feasible due to the nature of the seabed. Cable burial does not completely mitigate B or Ei fields although it reduces exposure of electromagnetically sensitive species to the strongest EMFs that exist at the "skin" of the cable owing to the physical barrier of the substratum (OSPAR, 2008). In instances where adequate burial cannot be achieved, alternative protection such as mattresses or rock placement will be used. Benthic and demersal fish and shellfish species will therefore not be directly exposed to the strongest EMFs as a result of the physical barrier that burial and cable protection constitute.

7.2.5.74 An estimate of the B fields expected to be produced by the worst case inter-array cables proposed (66 kV) is given in Plate 7.2-1 below. The methodology used and the full results of the EMF modelling are provided in Technical Appendix 4.3 D. A significant reduction in the strength of the B field is expected to occur by 5 m from the seabed (assuming 1 m burial). Similarly, the expected B fields are predicted to rapidly decrease horizontally with distance from the cable (within few metres). The E fields induced by these B fields, will as a result, also similarly decrease with distance from the source. The potential effects of EMFs on fish and shellfish species will therefore be influenced by the position of particular species in the water column relative to water depth. In the three proposed sites, water depths range from 38 to 57 m.

7.2.5.75 It should be noted, that the B fields expected to be produced by inter-array cables are in all cases well below the Earth's magnetic field (assumed to be 50 μT).

7.2.5.76 Given the relatively small area where EMF related effects may occur, limited to the immediate vicinity of the cables, the magnitude of the effect of EMFs is considered to be small.

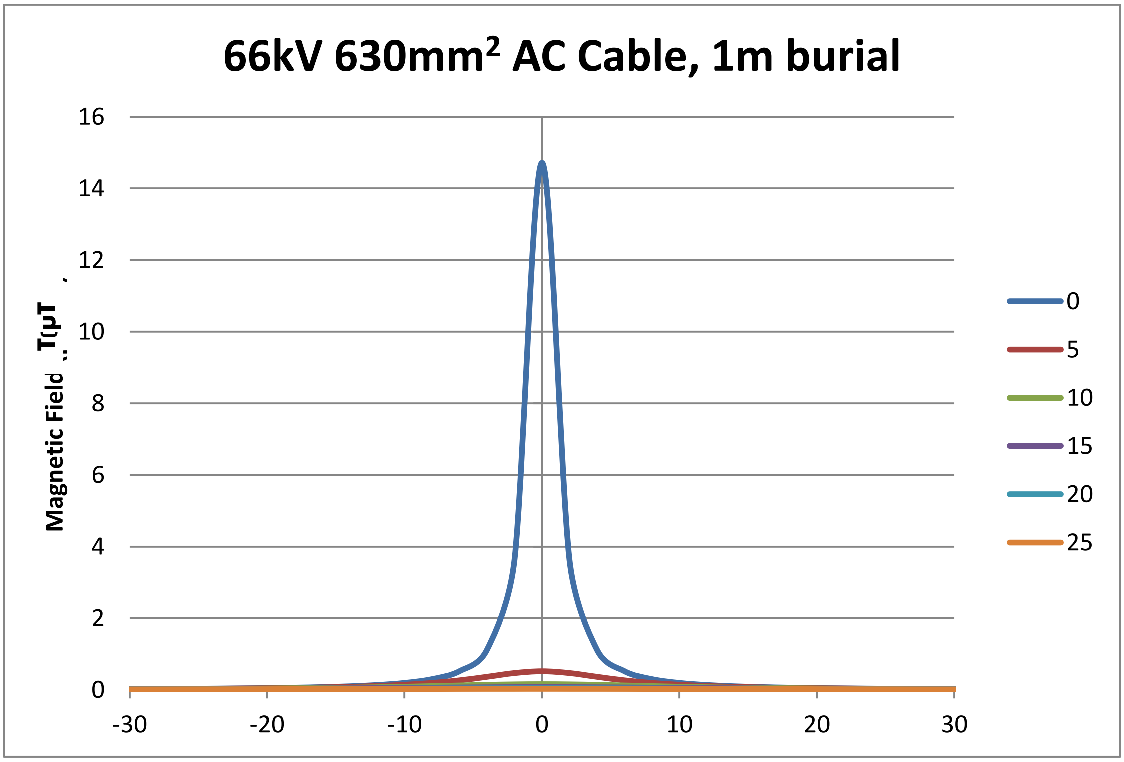

Plate 7.2-1 Magnetic Field Expected from 66 kV AC Inter-Array Cables Assuming 1 m Burial

Table 7.2-11 Species for which there is Evidence of a Response to E Fields in UK Waters (Gill *et al.*, 2005)

Species / Species Group	Latin Name
Elasmobranchs	
Lesser Spotted Dogfish	*Scyliorhinus canicula*
Blue Shark	*Prionace glauca*
Thornback Ray	*Raja clavata*
Round Ray	*Rajella fyllae*
Agnatha	
River Lamprey	*Lampetra fluviatilis*
Sea Lamprey	*Petromyzon marinus*
Teleosts	
European Eel	*Anguilla anguilla*
Cod	*Gadus morhua*
Plaice	*Pleuronectes platessa*
Atlantic Salmon	*Salmo salar*

Table 7.2-12 Species for which there is Evidence of a Response to B Fields in UK Waters (Gill *et al.*, 2005)

Species / Species Group	Latin Name
Elasmobranchs	
All Elasmobranchs posses the ability to detect magnetic fields	
Agnatha	
River Lamprey	*Lampetra fluviatilis*
Sea Lamprey	*Petromyzon marinus*
Teleosts	
European Eel	*Anguilla anguilla*
Plaice	*Pleuronectes platessa*
Atlantic Salmon	*Salmo salar*
Sea Trout	*Salmo trutta*
Yellowfin Tuna	*Thunnus albacores*

Species / Species Group	Latin Name
Crustaceans	
i.e. Lobster, Crabs, Shrimps and Prawns	Specific cases non-UK • *Decapoda; Crangon crangon* (ICES, 2003) • Isopoda: *Idotea baltica* (Ugolini and Pezzani,1995) • Amphipoda: *Talorchestia martensii* (Ugolini, 1993) and *Talitrus saltator* (Ugolini and Macchi, 1988)
Molluscs	
i.e. Snails, Bivalves and Squid	Specific case non-UK • Nudibranch: *Tritonia diomedea* (Willows, 1999)

7.2.5.77 It should be noted that information related to the sensitivity of marine species to EMFs is limited to date. Species for which there is evidence of a response to E fields and B fields are given above in Table 7.2-11 and Table 7.2-12 respectively.

7.2.5.78 An assessment of the likely significant effect of EMFs on sensitive receptors expected to be present in the area of the wind farms is given below by species / species group. It is recognised that the information available to date in relation to the implications of EMF related effects, particularly in terms of behavioural effects is limited. This is particularly evident in the case of diadromous migratory species for which limited research has been undertaken to date.

7.2.5.79 A study is currently being carried out by MSS into the potential behavioural effect of EMFs on European eel and Atlantic salmon smolts. The results of this study will provide further detail in terms of the behavioural reactions that may be triggered by the EMFs associated to offshore wind farm cables. The results of this study will be released towards the end of 2012. An outline of the methodology of MSS research is given in Technical Appendix 4.3 D.

Elasmobranchs

7.2.5.80 Elasmobranchs are the main group of organisms known to be electrosensitive, possessing specialised electroreceptors, Ampullae of Lorenzini. These species naturally detect bioelectric emissions from prey, conspecifics and potential predators / competitors (Gill *et al.,* 2005). In addition, they are known to either detect magnetic fields using electronsensory systems or through a yet-to-be described magnetite receptor system (Normendaeu *et al*., 2011). Magnetic field detection is thought to be used as a means of orientation in elasmobranches, however, evidence for magnetic orientation by sharks and rays is limited (Meyer *et al.*, 2005) and there is currently debate on the actual mechanisms used (Johnsen and Lohmann, 2005).

7.2.5.81 Both attraction and repulsion reactions associated with E-fields in elasmobranch species have been observed. Gill and Taylor (2001) found limited laboratory based evidence that the lesser spotted dogfish avoids DC E-fields at emission intensities similar to those predicted from offshore wind farm AC cables. The same fish were attracted to DC emissions at levels predicted to emanate from their prey. Marra (1989) found evidence of a communication cable being damaged by elasmobranchs (*Carcharhinis spp*. and *Pseudocarcharias kamoharai*). Further research on EMFs and elasmobranchs (Gill *et al*., 2009) found that two benthic species, lesser spotted dogfish and thornback ray, were able to respond to the EMFs of the type and intensity associated with sub-sea cables. The responses found were however not predictable and did not always occur; when there was a response this was species dependant and individual specific, suggesting that some species and their individuals are more likely to respond by moving more or less within the zone of EMF (Gill *et al*., 2009).

7.2.5.82 Information gathered as part of the monitoring programme undertaken at Burbo Bank suggested that certain elasmobranch species (sharks, skates and rays) do feed inside the wind farm and demonstrated that they are not excluded during periods of low power generation (CEFAS, 2009). Monitoring at Kentish Flats found an increase in thornback rays, smooth hound and other elasmobranchs during post construction surveys in comparison to surveys undertaken prior to construction. There appeared, however, not to be any discernible difference between the data for the wind farm site and reference areas, including population structure changes, and it was concluded that the population increase observed was unlikely to be related to the operation of the wind farm (CEFAS, 2009).

7.2.5.83 As described in Technical Appendix 4.3 A, the majority of elasmobranch species potentially transiting the three proposed wind farm sites, are in most cases more frequently found in the north and west coast of Scotland. The three proposed wind farm sites however fall within defined nursery grounds for a number of these, namely spurdog, thornback ray and spotted ray. Given the conservation status of most elasmobranch species, the potential for the proposed sites to be used as a nursery ground for some of them, and the evidence of their ability to detect E fields, they are considered of medium sensitivity. The effect of EMFs on elasmobranchs is therefore assessed to be negative, of **minor significance** and probable.

River and Sea Lamprey (Agnatha)

7.2.5.84 Lampreys possess specialised ampullary electroreceptors sensitive to weak, low-frequency electric fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983). Whilst responses to E fields have been reported for these species, information on the use that they make of the electric sense is limited. It is likely however that they use it in a similar way as elasmobranches to detect prey, predators or conspecifics and potentially for orientation or navigation (Normadeau *et al*., 2011). Chung-Davidson *et al*., (2008) found, based on experiments carried out on sea lamprey, that weak electric fields may play a role in their reproduction and it was suggested that electrical stimuli mediate different behaviours in feeding-stage and spawning-stage sea lampreys.

7.2.5.85 Both river and sea lamprey are species of conservation importance, with sea lamprey being a primary reason of selection of the River Spey SAC in the Moray Firth. Whilst the behaviour and distribution of both species in the marine environment is poorly understood, there is potential for both to transit the three proposed wind farm sites during migration. EMFs generated by the inter-array cables may result in behavioural effects on these species and limited disturbance during migration, assuming they use the electric sense for navigation. Lampreys are therefore considered of medium sensitivity and the effect of EMFs on them of negative, of **minor significance** and unlikely.

European Eel

7.2.5.86 European eel are known to possess magnetic material of biogenic origin of a size suitable for magnetoreception (Hanson *et al.*, 1984; Hanson and Walker, 1987; Moore and Riley, 2009) and are thought to use the geomagnetic field for orientation (Karlsson, 1985). In addition, their lateral line has been found to be slightly sensitive to electric current (Berge, 1979; Vriens and Bretschneider, 1979).

7.2.5.87 A number of studies have been carried out in relation to the migration of eels and the effects of EMFs derived from offshore wind farm cables. Experiments undertaken at the operational wind farm of Nysted detected barrier effects, however correlation analysis between catch data and data on power production showed no indication that the observed effects were attributable to EMFs. Furthermore, mark and recapture experiments showed that eels did cross the export cable (Hvidt *et al.*, 2005). Similarly research by Westerberg (1999) on HVDC cables and eel migration found some effects associated to the magnetic disturbance were likely to occur on eel migration although the consequences appeared to be small. In addition, no indication was found that the cable constituted a permanent obstacle to migration, either for adult eels or for elvers.

7.2.5.88 Further research, where 60 migrating silver eels were tagged with ultrasonic tags and released north of a 130 kV AC cable, found swimming speeds were significantly lower around the cable than in areas to the north and south (Westerberg and Lagenfelt, 2008). It was noted that no details on the behaviour during passage over the cable were recorded and possible physiological mechanisms explaining the phenomenon were unknown. Based on the results of Westerberg and Lagenfelt (2008) before publication, Öhman *et al*., (2007) suggested that even if an effect on migration was demonstrated, the effect was small, and on average the delay caused by the passage was approximately 30 minutes. Based on the above, European eel is considered of medium sensitivity and the effect of EMFs of negative, of **minor significance** and probable.

7.2.5.89 As previously mentioned, MSS is currently undertaking research into the behavioural effect of EMFs on European eel. It is anticipated that the results of MSSs study will contribute to increase the current knowledge in this field

Salmon and Sea Trout

7.2.5.90 Research carried out on salmon and sea trout indicates these species are able to respond to magnetic fields (Formicki *et al*., 2004; Tanski *et al*., 2005; Sadowski *et al*., 2007; Formicki and Winnicki, 2009). Furthermore, Atlantic salmon possess magnetic material in their lateral line, of a size suitable for magnetoreception (Moore *et al*., 1990), and are able to respond to electric fields (Rommel and McLeave, 1973). Most of the limited research undertaken on the subject on these species, has however, been focused on physiology based laboratory studies. Research under these conditions has found that EMFs can elicit localised physiological responses on the two species (McCleave and Richardson, 1976; Vriens and Bretshneider, 1979; Hanson *et al*., 1984; Formicki *et al*., 1997, 2004). It is however recognised that laboratory based responses to a stimulus do not necessarily imply that the same behavioural response will be triggered at sea. Öhman *et al*., (2007) point out that detection of stimuli may not necessarily lead to behavioural responses in fish and that senses that detect magnetic fields are not the only means of spatial orientation, as vision, hearing and olfaction as well as hydrographic and geoelectric information could all be used for spatial orientation.

7.2.5.91 Since the strength of EMFs decreases exponentially with distance to the source, the magnitude and intensity of the potential movement and behavioural effects on salmonids, as in other pelagic species, would be closely linked to the proximity of the fish to the source of EMF. Gill and Barlett (2010) suggest that if there is going to be any effect on the migration of salmon and sea trout, this will be most likely dependent on the depth of water and the proximity of the rivers to a development site. It should be noted that the proposed sites are located at a considerable distance from shore and any salmon and sea trout river. Salmon and sea trout transiting the area of the three proposed wind farm sites will for the most part, not be exposed to the strongest EMFs as they normally swim in the upper metres of the water column during migration (Technical Appendix 4.3 B: Salmon and Sea Trout Ecology and Fisheries Technical Report). Water depths in the area of the proposed wind farm sites range from 38 to 57 m). As shown in Plate 7.2-1 above, the predicted B fields are expected to decrease significantly by 5 metres from the seabed In addition, as previously mentioned, even at the seabed (assuming 1 m burial) the expected B fields produced by the proposed inter-array cables will be well below the Earth's magnetic field.

7.2.5.92 Based on the information provided above, and given the conservation importance of both salmon and sea trout, the potential for these species to transit the three proposed sites during migration and as part of their foraging activity (particularly in the case of sea trout), they have been assigned medium sensitivity. The effect of EMFs on salmon and sea trout is therefore considered negative, of **minor significance** and probable.

7.2.5.93 It is anticipated that the findings of MSSs current research into the behavioural responses of migratory fish to EMFs will contribute to increase the current knowledge in this field.

Other Fish Species

7.2.5.94 As indicated in Table 7.2-11 and Table 7.2-12 above, further to the species described above, there is some evidence of a response to EMFs in other teleost species such as cod and plaice. The results of monitoring programmes carried out in operational wind farms do not, however, suggest that EMFs have resulted in a detrimental effect on these species. Lindeboom *et al*., (2011) suggest that the presence of the foundations and scour protection and potential changes in the fisheries related to offshore wind farm development, are expected to have the most effect upon fish species and that noise from the turbines, and EMFs from cabling do not seem to have a major effect on fish and other mobile organisms attracted to the hard bottom substrates for foraging, shelter and protection (Leonhard and Pedersen, 2006). In line with this, research carried out at the Nysted offshore wind farm (Denmark), focused on detecting and assessing possible effects of EMFs on fish during power transmission (Hvidt *et al.,* 2005), found no differences in the fish community composition after the wind farm was operational. Whilst effects on the distribution and migration of four species were observed (European eel, flounder, cod and Baltic herring), it was recognised that the results were likely to be valid on a very local scale and only on the individual level, and that an effect on a population or community level was likely to be very limited.

7.2.5.95 In general terms it is considered that fish species / species groups other than those previously assessed are receptors of low sensitivity. The effect on these species is therefore considered to be negative, of **minor significance** and unlikely.

Shellfish Species

7.2.5.96 Limited research has been carried out to date on the ability of marine invertebrates to detect EMFs. Whilst there is to date no direct evidence of effects to invertebrates from undersea cable EMFs (Normandeau *et al.,* 2011), the ability to detect magnetic fields has been studied for some species and there is evidence in some of a response to magnetic fields, including molluscs and crustaceans (Table 7.2-12 above). Research undertaken by Bochert and Zettler (2004), where a number of species, including the brown shrimp (*Crangon crangon*) and mussels (*Mytilus edulis*) both found in UK waters, were exposed to a static magnetic field of 3.7 mT for several weeks, found no differences in survival between experimental and control animals. The functional role of the magnetic sense in invertebrates is hypothesized to be for orientation, navigation and homing using geomagnetic cues (Cain *et al*., 2005; Lohmann *et al*., 2007). Concern has therefore been raised on the potential for shellfish species which undertake migrations to be affected by EMFs. Edible crab and European lobster are both species commercially important in the Moray Firth and undertake inshore / offshore seasonal migrations. As suggested by fisheries data (Chapter 5.1: Commercial Fisheries), these species are principally found along the Caithness coast, in coastal areas off Fraserburgh and, to a lesser extent, in coastal areas in the southern Moray Firth. Whilst there is no detailed information on the extent and preferred migration routes used by these species in the Moray Firth, given the central location of the three proposed wind farm sites, there may be potential for these species to transit the site during migration. Research undertaken on the Caribbean spiny lobster (*Panulirus argus*) (Boles and Lohmann, 2003) suggest that this species derive positional information from the Earth's magnetic field. Limited research undertaken with the European lobster, however, found no neurological response to magnetic field strengths considerably higher than those expected directly over an average buried power cable (Ueno *et al*., 1986; Normandeau *et al*., 2011).

7.2.5.97 Indirect evidence from monitoring programmes undertaken in operational wind farms do not suggest that the distribution of potentially magnetically sensitive species of crustaceans or molluscs have been affected by the presence of submarine power cables and associated magnetic fields. In this context, however, the lack of shellfish specific EMFs monitoring programmes should be recognised.

7.2.5.98 Based on the above, shellfish species are considered receptors of low sensitivity. The effect on shellfish species is considered to be negative, of **minor significance** and unlikely.

Operational Noise

7.2.5.99 During the operational phase of a wind farm, noise is principally generated by the turbine's gear boxes and transferred into the water and sediment through the towers and foundations (Lindell, 2003). Sound emissions during this period are expected to be in the low-frequency range (Westerberg, 1994; Degn, 2000; Lindell, 2003). Detailed information on the likely effects of operational noise on fish and shellfish is limited to date, it is however generally accepted that the effects of operational noise are restricted to masking of communication and orientation signals, rather than causing damage or consistent avoidance reactions (Wahlberg and Westerberg, 2005). The implication of these will depend on the ecology and use that particular species make of the area of the three proposed wind farm sites and its vicinity and on the hearing ability of different species.

7.2.5.100 The assessment of operational noise has assumed the maximum number of turbines. It should be noted that there is a lack of species / species group specific knowledge on the effects of operational noise to allow for sensitivities and receptors being described. The assessment has therefore been based on a literature review of current knowledge on the subject and on indirect evidence derived from the results of monitoring programmes carried out in operational wind farms.

7.2.5.101 Walhberg and Westerberg (2005) studied the responses of three species representing various hearing capabilities (i.e. cod and Atlantic salmon) to operational wind farm noise and found that noise was detected at a distance between 0.4 to 25 km at wind speeds of 8 to 13 m / s. Operational noise was found not to have any destructive effects upon the hearing ability of fish, even within distances of a few metres and it was estimated that fish would only be consistently scared away from wind turbines at ranges shorter than about 4 m, and only at high wind speeds (higher than 13 m / s).

7.2.5.102 Based on operational noise data measurements at the Svante wind farm in Sweden (estimated to peak at 120 dB at 16 Hz), Vella *et al*., (2001) concluded that noise levels appeared to be outside the behavioural reaction sensitivities of most species for which data was available. However, the authors noted that some effect could be apparent in species such as cod. Cod and other gadoids, such as haddock are known to be able to produce low frequency sounds during spawning (Hawkins and Chapman, 1966; Hawkins and Rasmussen, 1978; Nordeiede and Kjellsby, 1999; Fudge and Rose, 2009). Hawkins and Amorim (2000) suggest that the sound produced by haddock serves to bring male and female fish together and that sound also plays a role in synchronising the reproductive behaviour of the male and the female. Similarly, Brawn (1961) suggests that sounds produced by cod are used to attract females during spawning. Studies undertaken by Westerberg (1994) found the catch ability of cod and roach (*Rutilus rutilus*) increased by a factor of two within 100 m of a wind turbine when the rotor was stopped under otherwise similar conditions and did not find significant changes in the swimming behaviour of European eel when passing at a distance of 0.5 km from a small (200 kW single-unit) offshore wind turbine.

7.2.5.103 Measurements of operational noise at a series of UK wind farm sites (Nedwell *et al.*, 2007) indicated that in general, the level of noise generated was very low. The study calculated the operational noise levels that would be encountered by various species using dB_{ht} units. When the results were averaged across all of the fish species considered, the noise levels within the wind farms were found to be just over 2 dB_{ht} higher than background noise levels in waters surrounding the wind farm sites. The level of variation is well within the spatial and temporal variations that are typically encountered in background noise, and hence it was concluded that, while there might be a small net contribution to noise in the immediate vicinity of the wind farm, this is no more than is routinely encountered.

7.2.5.104 Post construction monitoring of hard substrate communities at Horns Rev (Leonhard and Pedersen, 2005) found, based on comparisons with fish fauna on shipwrecks in other parts of the North Sea, that there was similarity in the species observed including benthic species. It was pointed out that there was no indication that noise or vibration from the turbines had any effects on the fish community. In line with this, as previously described, post construction monitoring undertaken in operational wind farms does not suggest that major changes in the distribution and abundance of fish and shellfish species have occurred, hence if operational noise is having any effect this is expected to be very limited.

7.2.5.105 Based on the above it is considered that operational noise will result in an effect negative, of **minor significance** and unlikely on fish and shellfish species in general. In the case of spawning cod and haddock, assuming operational noise interferes with mating calls during the spawning period, given the location of spawning grounds relative to the three proposed wind farm sites and the localised effect of the potential effect of operational noise (limited to the area of the three proposed sites and their vicinity), the effect is considered negative, of **minor significance** and probable.

Changes to Fishing Activity

7.2.5.106 Changes to fishing activity as a result of the installation of the three proposed wind farm sites could potentially affect fish and shellfish species. Primarily this would be species commercially targeted and / or caught as by-catch, although a wider range of organisms may also be affected due to changes in seabed communities associated to seabed disturbance.

7.2.5.107 Physical disturbance to habitat arising from the passage of fishing gear over the seabed occurs in a number of ways (Kaiser *et al*., 2003):

- Disturbance to upper layers of seabed causing short term re-suspension of sediment, re-mineralization of nutrients and contaminants, and re-sorting of sediment particles;
- Direct removal, damage, displacement or death of a proportion of the animals and plants living in or on the seabed;
- A short term attraction of carrion consumers into the path of fishing gear; and
- The alteration of habitat structure.

7.2.5.108 A reduction in fishing activity in the three proposed wind farm sites may have some benefits to seabed communities, This could in turn benefit fish and shellfish species, provided the productivity of the area increases. In addition, target and by-catch species would be positively affected through a direct decrease in fishing mortality on a site specific basis. The potential displacement of fishing into other sensitive areas should however be recognised (i.e. in areas of spat settlement).

7.2.5.109 The principal commercial species targeted within the proposed wind farms by gear type are scallops by dredgers and, to a lesser extent, squid by bottom trawlers (Chapter 8.1: Commercial Fisheries). A fishing exclusion zone of 50 m will be established around each turbine, and fishing activity may continue in the sites during the operational phase, although a reduction in the level of activity may occur (Chapter 8.1: Commercial Fisheries). The degree to which fishing may be reduced in the proposed wind farm sites and the areas where fishing effort may be potentially displaced are however currently unknown. As noted above, fish and shellfish receptors may benefit as a result of a reduction in fishing activity, however, for a net benefit to occur fishing activity should not be displaced to equally or more productive / sensitive areas. Whilst the potential for changes to fishing activity to have an effect on fish and shellfish receptors is recognised, given the numerous uncertainties to this respect (e.g. actual degree of fishing reduction and areas where fishing effort may be displaced) it is not possible for a meaningful assessment to be made. However, on the basis that fishing will continue to be possible in the wind farms during the operational phase, it is not expected that a significant effect (above minor) associated to this may occur.

Decommissioning

7.2.5.110 As previously mentioned, in the absence of detailed decommissioning schedules and methodologies, it is assumed that the likely significant effects during this phase will at worst be as those assessed for the construction phase. It should be noted, however, that piling is not envisaged to be required during decommissioning and hence, effects associated to noise during this phase will likely be significantly smaller than those assessed for the construction phase above.

7.2.6 Proposed Monitoring and Mitigation

Construction and Decommissioning

7.2.6.1 In general terms, the likely effects of the construction phase on fish and shellfish species have been assessed to be of minor significance. An exception to this is construction noise, which has been identified as having potential to result in significant effects (above minor) namely cod, herring, salmon and sea trout.

7.2.6.2 The impact assessment on these species has taken a precautionary approach, where conservative assumptions have had to be applied as a result of the uncertainty surrounding currently available information on the use that these species may make of the area of the three proposed wind farms during the construction phase.

7.2.6.3 In order to mitigate this uncertainty, MORL is committed, in consultation with Marine Scotland and the relevant fisheries stakeholders, to undertake additional survey work and monitoring with the objective of increasing the confidence in this impact assessment and identifying whether mitigation is required and, if so, to define feasible measures in order to reduce the significance of the likely effects.

7.2.6.4 Some surveys, such as the sand eel (a key prey species for other fish species) survey were undertaken in consultation with Marine Scotland pre-application during their optimal survey periods the results of which are included in this assessment. Due to the seasonal nature of these surveys, MORL expects that specific surveys and monitoring will be defined and implemented at the appropriate time of year in consultation with Marine Scotland and other stakeholders.

7.2.6.5 In addition to the monitoring / mitigation above, soft start piling will be used during construction with the aim that mobile species are not exposed to the highest noise levels.

Operation

7.2.6.6 No likely significant effects (above minor) have been identified on fish and shellfish for the operational phase of the three proposed wind farm sites. As previously mentioned in the assessment of EMFs above, cable burial will reduce exposure of electromagnetically sensitive species to the strongest EMFs that exist at the "skin" of the cable owing to the physical barrier of the substratum (OSPAR, 2008). Similarly, where burial is not feasible, cable protection will ensure that fish and shellfish receptors are not in direct contact with the cable and hence with the strongest EMFs.

7.2.7 Residual Effects – Primary Impact Assessment

7.2.7.1 The residual effects associated to the construction / decommissioning and operational phase of the wind farm are given in Table 7.2-1 above. This takes account of the monitoring and mitigation measures described above which will be applied to receptors for which significant effects (above minor) have been identified. The undertaking of monitoring and mitigation will result in the significance of the identified effects being reduced. A summary of the impact assessment by effect and receptor is given above in Table 7.2-1 above.

7.2.8 Secondary Assessment: Individual Wind Farm Sites

7.2.8.1 For the purposes of the secondary assessment, the effects for which a moderate significance was assigned in the primary assessment have been taken forward for assessment.

7.2.8.2 The significance of effect for each of the three proposed wind farm sites, has been derived taking into account the following assumption: although the baseline characteristics are broadly considered uniform across the three proposed wind farm sites and the worst case parameters for each of the sites are the same, it is not the case that an individual site constitutes a third of the effect identified in the primary assessment. Instead, the site specific effect may be proportionally larger than its contribution to the primary assessment.

7.2.8.3 The primary assessment identified significant effects in relation to construction noise on a number of species, namely, herring, cod, salmon and sea trout. For the purposes of the secondary assessment, it has been considered that the use of two piling vessels in each site constitutes the worst case scenario. The noise impact ranges described in 7.2.5 of this chapter, taking simultaneous piling at two locations, have therefore been taken as an indication of the extent of the expected noise effect. In light of the comparatively smaller extent of the noise impact ranges, and the shorter duration and frequency of the effect of piling for the separate construction of individual sites, the magnitude of the effect has been defined as follows:

- Salmon and sea trout: small;
- Cod: medium; and
- Herring: medium.

7.2.8.4 The uncertainties in relation to the use that these species make of each individual site are as described above in the primary assessment and therefore the sensitivity of the species is considered to be as previously defined for the three proposed wind farms sites:

- Salmon and sea trout: medium;
- Cod: medium; and
- Herring: medium.

7.2.8.5 Taking the above into account the following significance has been assigned to construction noise related effects on the relevant species:

- Salmon and sea trout: negative, minor and probable;
- Cod: negative, moderate and probable; and
- Herring: negative, moderate and probable.

7.2.8.6 A summary of the secondary assessment is provided in Table 7.2-13 below.

Table 7.2-13 Secondary Assessment Summary

Effect	Receptor	Telford	Stevenson	MacColl
Noise	Salmon and Sea Trout	Negative Minor Probable	Negative Minor Probable	Negative Minor Probable
	Cod	Negative Moderate Probable	Negative Moderate Probable	Negative Moderate Probable
	Herring	Negative Moderate Probable	Negative Moderate Probable	Negative Moderate Probable

7.2.9 Sensitivity Assessment

7.2.9.1 As described in 7.2.8 of this chapter, the significance of effects is not considered to differ between individual sites. The sensitivity assessment is expected to be a function of the significance of effects assessed previously for individual sites, and to result in additive effect significances when considering combinations of projects.

7.2.10 Proposed Monitoring and Mitigation: Secondary / Sensitivity Assessment

7.2.10.1 As indicated in the secondary assessment above, construction noise is considered to have potential to result in a significant effect (above minor) on cod and herring. The impact assessment on these species has taken a precautionary approach, where conservative assumptions have had to be made due to the lack of current knowledge on the use that they may make of the area of the three proposed wind farms.

7.2.10.2 As indicated in the primary assessment, in view of the current level of uncertainty, MORL is committed to undertaking appropriate survey work and monitoring with the objective of increasing the confidence in the impact assessment and identifying whether mitigation is required. This will be carried out in consultation with Marine Scotland and other relevant stakeholders. If required, MORL is committed to defining feasible measures in order to reduce the significance of the likely effects to levels that are satisfactory to both regulators and stakeholders.

7.2.10.3 The specific requirements of the surveys and monitoring to be undertaken and, where deemed necessary, the mitigation measures to be implemented, are yet to be defined. Consultation with Marine Scotland will be ongoing post-application for these to be agreed.

7.2.10.4 It should be noted that in addition to the monitoring / mitigation measures above, soft start piling will be used with the aim that mobile species are not exposed to the highest noise levels during construction of each individual site.

7.2.11 Residual Effects: Secondary / Sensitivity Assessment

7.2.11.1 Taking into account the monitoring and mitigation measures described above, which will be applied to receptors for which significant effects (above minor) have been identified, the residual effect of the construction phase of each individual site is considered, at worst, to result in effects of minor significance on fish and shellfish.

7.2.12 Habitats Regulations Appraisal

7.2.12.1 Atlantic salmon and sea lamprey are qualifying features and primary reasons for selection of a number of SAC sites in the Moray Firth area. As indicated in Chapter 4.1 (Designated Sites), SACs are strictly protected sites designated under the EC Habitats Directive. As part of the Habitats Regulations, it is required that the effects of the three proposed wind farm sites on the SAC populations of these species be assessed.

7.2.12.2 In addition to the species mentioned above, freshwater pearl mussels are also a primary reason for selection of a number of SACs in the Moray Firth area. Given the location of the three proposed wind farm sites relative to the habitat of the species (restricted to freshwater), it is not considered that freshwater pearl mussel SAC populations will be directly affected through construction / decommissioning or operation of the wind farms. It is however recognised that SAC populations of this species may be indirectly affected if significant effects on their host species (salmon and sea trout in particular) occur.

7.2.12.3 As specified in the JNCC and SNH scoping response (28 / 10 / 2010), the SACs needing assessment in relation to fish and shellfish resources are as follows:

- Berriedale & Langwell Waters SAC;
- River Evelix SAC;
- River Moriston SAC;
- River Oykel SAC;
- River Spey SAC; and
- River Thurso SAC.

7.2.12.4 The qualifying status of the relevant SAC species and the conservation objectives of each SAC are given in Table 7.2-14 below.

Table 7.2-14 Qualifying Status of SAC Species and SAC Conservation Objectives

SAC	Species with Qualifying Status	Conservation Objectives
Berriedale & Langwell Waters	**Atlantic salmon**: Primary reason for SAC selection	• To avoid deterioration of the habitats of Atlantic salmon or significant disturbance to Atlantic salmon, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: 1. Population of the species, including range of genetic types for salmon, as a viable component of the site; 2. Distribution of the species within the site; 3. Distribution and extent of habitats supporting the species; 4. Structure, function and supporting processes of habitats supporting the species; and 5. No significant disturbance of the species.
River Evelix	**Freshwater pearl mussel**: Primary reason for SAC selection	• To avoid deterioration of the habitats of freshwater pearl mussel or significant disturbance to freshwater pearl mussel, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: 1. Population of the species as a viable component of the site; 2. Distribution of the species within the site; 3. Distribution and extent of habitats supporting the species; 4. Structure, function and supporting processes of habitats supporting the species; 5. No significant disturbance of the species; 6. Distribution and viability of the species' host species; and 7. Structure, function and supporting processes of habitats supporting the species' host species.

SAC	Species with Qualifying Status	Conservation Objectives
River Moriston	**Freshwater pearl mussel**: Primary reason for SAC selection **Atlantic salmon**: Qualifying feature for SAC selection	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: 1. Population of the species, including range of genetic types for salmon, as a viable component of the site; 2. Distribution of the species within the site; 3. Distribution and extent of habitats supporting the species; 4. Structure, function and supporting processes of habitats supporting the species; 5. No significant disturbance of the species; 6. Distribution and viability of freshwater pearl mussel host species; and 7. Structure, function and supporting processes of habitats supporting fresh water pearl mussel host species.
River Oykel	**Freshwater pearl mussel**: Primary reason for SAC selection **Atlantic salmon**: Qualifying feature for SAC selection	Idem as above
River Spey	**Freshwater pearl mussel**; Primary reason for SAC selection **Atlantic salmon**: Primary reason for SAC selection **Sea lamprey**: Primary reason for SAC selection **Otter**: Primary reason for SAC selection	Idem as above
River Thurso	**Atlantic salmon**: Primary reason for SAC selection	Idem as for the Berriedale & Langwell Waters SAC

7.2.12.5 For the SACs detailed above the effects on the relevant fish and shellfish qualifying species have been assessed (taking account of their conservation objectives) using the following criteria:

- Deterioration of the habitats of the qualifying species;
- Significant disturbance to the qualifying species;
- Changes in the distribution of the species within the site; and
- Changes in the distribution and extent of habitats supporting the species.

7.2.12.6 In addition, in the particular case of Atlantic salmon and freshwater pearl mussel SAC populations, the following criteria have also been taken into account for assessment:

- Changes to the population of the species, including range of genetic types of salmon as a viable component of the site; and
- Changes to the distribution of freshwater pearl mussel host species and to the structure, function and supporting processes of habitats supporting fresh water pearl mussel host species.

7.2.12.7 It should be noted that, as indicated by the JNCC / SNH in their scoping response, in the case of salmon, it is not possible to conclusively identify from / to which SAC watercourses any particular individuals (post smolts or adults) are coming or going. The assumption that all individuals are SAC salmon should therefore be made. As a result the effects identified for salmon are considered to be applicable to any of the relevant SACs. In the case of freshwater pearl mussel, as any effect on the SAC populations could only be a result of their host species being adversely affected (salmon and sea trout) the same limitation applies. In order to assess likely effects on freshwater pearl mussel SAC populations it has therefore been assumed that the effects identified for Atlantic salmon apply to the freshwater pearl mussel's host species in the relevant SACs.

7.2.12.8 A summary assessment of the likely effect of the three proposed wind farms on the relevant Atlantic salmon, freshwater pearl mussel and sea lamprey SAC populations is given in Table 7.2-15 below. This takes account of the impact assessment for these species provided in Table 7.2-1 above after monitoring / mitigation measures have been implemented.

Table 7.2-15 Assessment of Effects on Qualifying Species in the Relevant SACs per Criterion

Species	Criterion	Assessment
Atlantic Salmon	1	The salmon SACs are located at a considerable distance from the three proposed wind farms sites. The habitat of the SACs will not be subject to any direct deterioration as a result of the construction / decommissioning or operation of the three proposed wind farms. Deterioration of the marine habitats of Atlantic salmon could however occur. Chapter 7.1 Benthic Ecology predicts negligible to minor effects on benthic habitats associated with the three proposed wind farms. In 7.2.5 of this chapter, it is predicted that minor effects associated to loss of habitat and introduction of new habitat and no potential for effects above minor associated to changes to fishing activity to occur.
	2	In 7.2.5 of this chapter, it is predicted that disturbance through increased SSC, sediment re-deposition, noise during construction, and EMFs has been assessed to be of minor significance.
	3	Changes to the distribution of the species are not expected in the site as no significant disturbance to the species or its habitat has been identified (See assessment against criteria 1 and 2 for Atlantic salmon above).
	4	As assessed for criteria 1 for Atlantic salmon above.
	5	As assessed in criteria 1, 2, 3 and 4 for salmon above.
Freshwater Pearl Mussel	1	The freshwater pearl mussel SACs, are located at a considerable distance from the three proposed wind farms sites. The habitat of the SACs will not be subject to any direct deterioration as a result of the construction / decommissioning or operation of the three proposed wind farms.

Species	Criterion	Assessment
Freshwater Pearl Mussel (continued)	2	Given the distribution of freshwater pearl mussel (restricted to the freshwater habitat) direct disturbance to the species has no potential to occur
	3	Given the distribution of the species (restricted to the freshwater habitat) direct changes to the distribution of the species in any of the SACs associated to the three proposed wind farms has not potential to occur.
	4	As assessed for criteria 1 for freshwater pearl mussel above.
	6	As assessed for criteria 1, 2, 3, 4 and 5 for salmon above.
Sea Lamprey	1	The Spey SAC is located at a considerable distance from the three proposed wind farms sites. The habitat of the SAC will not be subject to any direct deterioration as a result of the construction / decommissioning or operation of the three proposed wind farms. Deterioration of the marine habitats of sea lamprey could however occur: In 7.2.5 of this chapter, it is predicted that minor effects associated to loss of habitat and introduction of new habitat and no potential for effects above minor associated to changes to fishing activity to occur.
	2	In 7.2.5 of this chapter, it is predicted that disturbance through increased SSCs, sediment re-deposition, construction[2] and operational noise, and EMFs to result in effects of minor significance on sea lamprey
	3	Changes to the distribution of the species are not expected in the site as no significant disturbance to the species has been identified to either its habitat or the species itself(See assessment against criteria 1 and 2 for sea lamprey above)
	4	As assessed for criteria 1 for sea lamprey above

7.2.13 References

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7.3 Marine Mammals

7.3.1 Summary of Effects and Mitigation

7.3.1.1 This chapter presents an assessment of the potential significant effects of the construction, operation and decommissioning of the three proposed Telford, Stevenson and MacColl offshore wind farms on marine mammal receptors. The assessment incorporates a series of conservative assumptions about the potential impacts of noise on marine mammals. If these assumptions are confirmed, the assessment represents likely significant effects.

Summary of Effects

7.3.1.2 The effects on marine mammals that were assessed include:

- Temporary displacement caused by increased noise levels during construction, in particular during piling activity;
- Permanent hearing damage resulting from increased noise levels, in particular during piling activity;
- Risk of collision with vessels and ducted propellers;
- Risk of effect on foraging or social interactions of marine mammals from increased suspended sediment;
- Secondary effects associated with changes with prey availability;
- Risk of stranding associated with electromagnetic field (EMF) emissions;
- Effects of non-toxic and toxic contamination; and
- Long term avoidance resulting from operation and maintenance activity and the presence of offshore structures.

Proposed Mitigation Measures and Residual Effects

7.3.1.3 Primary mitigation during construction will include adherence to the Joint Nature Conservation Committee (JNCC) protocol for minimising the risk of injury to marine mammals from piling noise. Currently, this protocol involves the use of marine mammal observers and 'soft start' piling procedures. All effects assessed within this chapter are residual effects that could occur assuming these, or future, best practice guidelines are implemented. In addition, all vessels will operate within designated routes to minimise the risk of collision with vessels involved in the construction, operation and decommissioning of the wind farms, ensuring predictable vessel movement.

7.3.1.4 MORL is working with The Crown Estate (TCE) and other offshore wind developers to investigate and develop mitigation measures that may be implemented to reduce either the level of noise at the source or noise propagation.

7.3.1.5 Table 7.3-1 below summarises the predicted residual effects on marine mammal receptors.

Table 7.3-1 Primary Impact Assessment Summary

Effect	Receptor	Pre-Mitigation Effect	Mitigation	Post-Mitigation Effect
Construction				
Disturbance / Displacement **Hearing Damage** **Collision Risk** **Reduction in Prey Sources** **Reduction in Foraging Ability**	Harbour seal	*	None additional to JNCC protocol for minimising risks to marine mammals. Designated vessel routes.	No significant long term impact
	Grey seal	*		No significant long term impact
	Harbour porpoise	*		No significant long term impact
	Bottlenose dolphin	*		No significant long term impact
	Minke whale	*		No significant long term impact
Operation				
Disturbance / Displacement **Collision Risk** **Stranding due to Electromagnetic Fields** **Long Term Changes in Prey Availability** **Toxic Contamination**	Harbour seal	Not significant	Designated vessel routes.	Not significant
	Grey seal	Not significant		Not significant
	Harbour porpoise	Not significant		Not significant
	Bottlenose dolphin	Not significant		Not significant
	Minke whale	Not significant		Not significant
Decommissioning				
Hearing Damage **Disturbance / Displacement** **Collision Risk** **Reduction in Prey Sources** **Reduction in Foraging Ability**	Harbour seal	*	Best practice guidelines once issued by JNCC or equivalent. Designated vessel routes.	Not significant
	Grey seal	*		Not significant
	Harbour porpoise	*		Not significant
	Bottlenose dolphin	*		Not significant
	Minke whale	*		Not significant

* The modelling on which the assessment is based has been undertaken including mitigation measures (JNCC protocol and designated vessel routes) and therefore pre-mitigation effects are not separately identified.

7.3.2 Introduction

7.3.2.1 The aim of this assessment is to describe the significance of effects that specific activities associated with offshore wind farm development may have on marine mammal populations within the proposed development sites (Telford, Stevenson and MacColl) and within the Moray Firth as a whole. All of the plates that are referred to in the chapter are either presented in Volume 6 a or in the supporting technical appendices.

7.3.2.2 A full review of potential effects on marine mammals and the methodologies used in this assessment can be found in the following technical appendices:

- Technical Appendix 7.3 A (Marine Mammals: Environmental Impact Assessment);
- Technical Appendix 7.3 B (Framework for assessing the impacts of pile-driving noise from offshore wind farm construction on Moray Firth harbour seal populations);
- Technical Appendix 7.3 C (SAFESIMM impact assessment for seals and cetaceans);
- Technical Appendix 7.3 D (A comparison of behavioural responses by harbour porpoise and bottlenose dolphins to noise);
- Technical Appendix 7.3 E (Identification of appropriate noise exposure criteria for assessing auditory injury for Pinnipeds using offshore wind farm sites);
- Technical Appendix 7.3 F (Noise propagation and SAFESIMM model outputs);
- Technical Appendix 7.3 G (Habitat Regulations Appraisal: Marine Mammals - Two SAC's listing marine mammals as qualifying features can be found within the Moray Firth. For the purpose of Appropriate Assessment, an appraisal under the Habitats Regulation is presented within this appendix); and
- Technical Appendix 7.3 H (EPS Assessment: Supplementary Information - All cetaceans present within the Moray Firth are European Protected Species (EPS). MORL recognises that an EPS license may be required during the construction phase of the developments. A preliminary assessment is presented, which will be revised once construction parameters have been finalised).

7.3.2.3 Additional supporting information on underwater noise modelling activities can be found in Chapter 3.6 and Technical Appendix 3.6 A (Underwater Noise).

7.3.2.4 The marine mammal assessment interacts with assessments for the following receptors and receptors and linkages have been made where relevant.

- Chapters 4.2 and 7.1 (Benthic Ecology);
- Chapters 4.3 and 7.2 (Fish and Shellfish Ecology); and
- Chapters 5.2 and 8.2 (Shipping and Navigation).

7.3.2.5 The aim of this assessment is to describe the significance of effect that specific activities associated with offshore wind farm development within the proposed development sites (Telford, Stevenson and MacColl) may have on the marine mammal populations of the Moray Firth. Key effects on marine mammals under discussion are summarised in Table 7.3-2 below.

Table 7.3-2 Summary of the Key Risks for Marine Mammals Addressed in this Assessment, and their Associated Activities

Risk	Associated Activity	Effect
Permanent Hearing Damage	Increased noise levels, in particular from piling	Reduction in ability to find prey, avoid predators and socially interact
Temporary Disturbance / Displacement	Increase vessel movement Elevated construction noise	Restricted access to food sources, breeding grounds or migration routes leading to reduced fitness
Collision	Vessel movement, including those with ducted propellers	Physical injury and reduced viability
Long Term Avoidance	Foundation footprints Increased operation and maintenance related vessel movement	Habitat disturbance leading to reduction in prey source; Restricted access to food sources, breeding grounds or migration routes leading to reduced fitness
Reduction in Prey	Secondary effect resulting from increased noise and / or vibration (including electromagnetic fields), habitat disturbance or habitat loss due to the physical presence of the turbines	Reduction in fitness
Stranding	Electromagnetic fields from operational cables	Disruption of navigation mechanism, possibly resulting in stranding (and death)
Toxic / Non-toxic Contamination	General construction activities leading to increased sediment Sacrificial anodes and antifouling paints	Habitat disturbance leading to reduction in foraging ability and prey resources leading to reduced fitness. Contamination of food chain leading to reduced fitness

7.3.2.6 Temporary Threshold Shift (TTS) has not been considered within this impact assessment. It is considered a short term change in the sensitivity of hearing due to exposure to excessive noise. For example: studies of TTS in bottlenose dolphins showed that for TTS of about 3 to 4 dB (exposure SELs of 195 to 199 dB re 1 Pa^2 s), recovery was nearly complete (i.e. TTS was no longer measurable) by 10 min post-exposure (Finneran *et al.,* 2005). For exposure SELs of 201 and 203 dB re 1 Pa^2 s, TTS was larger (4 to 5 dB) and full recovery was not complete by 10 min (Finneran *et al.*, 2005). However, in all cases, recovery to within the normal range of pre-exposure thresholds was complete by the following day (when the dolphins were re-tested). As individuals experiencing TTS demonstrate full recovery of their hearing abilities it is generally assumed to be innocuous (Mooney *et al.*, 2009). Given these relatively short term effects, and given the highly precautionary assumptions we make with regard to the biological effects of PTS and behavioural responses (see Table 7.3-11 below), MORL did not consider TTS in assessment.

7.3.3 Rochdale Envelope Parameters Considered in the Assessment

7.3.3.1 Key components of the Project design relevant for impact assessment for marine mammals are:

- Duration and timing of construction activities;
- Vessel activity;
- Number of turbines and type of foundation structures; and
- Extent of array and layout.

7.3.3.2 This assessment has focussed on key activities within the Rochdale Envelope that may have an effect on marine mammal species during the life cycle of the development. The parameters from the Rochdale Envelope used for this assessment are described in Table 7.3-3 below. The rationale for pile diameter and soil province chosen for the modelling is provided in paragraphs 3.6.5.23 to 3.6.5.29 of Chapter 3.6 (Underwater Noise). A full review of potential effects on marine mammals and the methodologies used in this assessment can be found in Technical Appendix 7.3 A.

Table 7.3-3 Rochdale Envelope Parameter relevant to the Marine Mammal Impact Assessment

Type of Effect	Rochdale Envelope Scenario Assessed
Construction & Decommissioning	
Permanent Threshold Shift (PTS – hearing damage)	Greatest potential cause of auditory damage will be from piling noise during construction. Worst case (as modelled): • Wind farms: 1,356 x 2.5 m diameter pin piles over five, three or two year construction phases. Based on 339 turbines, four piles per turbine; and • Met mast: single mast with monopole foundation of 4.5 m diameter.
Disturbance / Displacement	Greatest potential cause of disturbance / displacement will be increased noise, in particular from piling, created during construction. The parameters assessed are associated with worst case scenario (as modelled): • Wind farms: 1,356 x 2.5 m diameter pin piles over five, three or two year construction phases. Based on 339 turbines, four piles per turbine; and • Met mast: single mast with monopole foundation of 4.5 m diameter. Increased vessel movement based on predicted number of transects between construction sites and onshore construction port.
Collision Risk	An assessment has been undertaken based on predicted increases in vessel movements within and around the site, taking account of the presence of standard vessel routes which will localise effects. A separate study on ducted propeller related injury from vessel movement near haul-out sites has been undertaken as part of the impact assessment described below. Cognisance has been taken of consultation responses by Marine Scotland to the (consented) MORL met mast application. Worst case scenario assumes the use of vessels with ducted propellers.
Reduction in Prey Sources	Secondary effects as a result of changes in prey distribution or density. Worst case likely to be gravity base foundations (maximum 339 turbines plus one met mast, sea bed take of 65 m x 65 m) and associated loss of habitat. The effects of piling noise on prey viability are also considered (refer to Chapter 7.1 and 7.2 for details).
Reduction in Foraging Ability	Secondary effect due to increased suspended sediment associated with construction activities. Refer to Chapter 6.2 for details.

Type of Effect	Rochdale Envelope Scenario Assessed
Operation	
Collision Risk from Maintenance Vessels	An assessment has been undertaken based on predicted increases in vessel movements within and around the site during operation. A separate study on ducted propeller related injury from vessel movement near haul-out sites has been undertaken as part of the impact assessment described below. Cognisance has been taken of consultation responses by Marine Scotland to the (consented) MORL met mast application. Worst case scenario assumes the use of vessels with ducted propellers.
Barrier to Movement / Displacement	Physical barrier: worst case, minimum spacing between turbines for sites 1, 2 and 3 (840 x 600 m). Displacement potentially caused by operational turbine noise. Assessment has been based on published noise levels (i.e. Thomsen *et al*., 2006). Worst case scenario, 7 MW turbines.
Electromagnetic Fields	33 to 66 kV AC cable for inter-array cables; 220 kV AC cable for inter-platform cables; 320 kV DC cable for export.
Long Term Reduction in Prey Availability	Secondary effects due to changes in prey distribution or density as a result of loss of habitat (refer to chapters 7.1 and 7.2 for details) or avoidance of operational noise.
Toxic Contamination	Sacrificial anodes & anti-fouling coatings

7.3.4 EIA Methodology

7.3.4.1 The assessment process used for marine mammals is based on methodologies recommended by the Institute of Ecology and Environmental Management (IEEM, 2010). Some additional definitions are provided by Wilhelmsson *et al*., (2010) in a review of potential effects of offshore wind developments.

7.3.4.2 The basic assessment steps are as follows:

- Identification of potential receptors and description of baseline conditions;
- Prediction of activities during the different stages of the development that may result in potential effects;
- Characterisation of potential effects including likelihood of occurrence;
- Assessment of whether effects are ecologically significant and the geographical scale at which they may occur;
- Proposed mitigation if applicable;
- Assessment of whether residual effects (after mitigation) are ecologically significant; and
- Assessment of cumulative / in-combination effects.

7.3.4.3 A list of defining terms used in this assessment can be found in Table 7.3-4 below.

7.3.4.4 An ecologically significant effect (in the context of EIA regulations) is defined as having an effect on the integrity of the site or ecosystem. The geographical scale at which the ecological significance of a potential effect may occur is defined as:

- **Local**: receptors of local importance;
- **Regional**: receptors of regional importance;
- **National**: receptors are a feature of a UK designated site, i.e. Site of Special

Scientific Interest (SSSI), UK Biodiversity Action Plan (UK BAP) species or Marine Protected Areas[3]; and

- **International**: receptors are a feature of European designated sites, i.e. Special Area of Conservation (SAC).

7.3.4.5 Certainties in predictions for this assessment follow the criteria described below in Table 7.3-5, based on IEEM guidance (IEEM, 2010).

7.3.4.6 Given the level of legal protection afforded all of the marine mammals likely to be encountered within the Moray Firth, all species of marine mammal are considered to be of high sensitivity in this assessment.

Table 7.3-4 Definition of Terms Used in Assessment

Term	Definition
Magnitude	Size of potential effect (e.g. number of individuals predicted to be affected). For the purposes of this impact assessment, low has been termed as < 10 % of the population considered, medium as between 10 to 20 %, and high as over 20 % of the population considered.
Extent	Area over which effect predicted to occur. For this assessment, the extent has been considered as the Moray Firth.
Duration	Time period over which effect predicted to occur. For example: short term (occur over days or weeks within construction phase); medium term (occur over complete construction phase); or long term (detectable after 25 years).
Reversibility	Potential effect predicted to be reversed (either though natural processes or mitigation).
Timing	Period of the year that activity would need to occur to result in potential effect. It has been assumed for this assessment that construction activities occur throughout the year and do not exhibit seasonality.
Frequency	Frequency of activity leading to potential effect.
Risk	Likelihood potential effect will occur.

Table 7.3-5 Criteria Used for Predicting Certainty in Predictions during the Assessment

Term	Definition
Certain	Interactions are well understood and documented, i.e. receptor sensitivity investigated in relation to potential effect, data have comprehensive spatial coverage / resolution and predictions relating to effect magnitude modelled and / or quantified. Probability estimated at > 95 %.
Probable	Interactions are understood using some documented evidence, i.e. receptor sensitivity is derived from sources that consider the likely effects of the potential effect, data have a relatively moderate spatial coverage / resolution, and predictions relating to effect magnitude have been modelled but not validated. Probability estimated at 50 to 95 %.
Uncertain	Interactions are poorly understood and not documented, i.e. predictions relating to effect magnitude have not been modelled and are based on expert interpretation using little or no quantitative data. Probability estimated at < 50 %.

[3] MORL are aware that Marine Scotland is leading the Scottish Marine Protected Area Project for Scottish Waters. SNH and JNCC are providing guidance and scientific advice on the selection of Nature Conservation MPAs and development of an ecologically coherent network. No draft MPAs are available for inclusion within this impact assessment at present.

7.3.4.7 A magnitude and resulting significance scale (see Table 7.3-6 below) was determined through consultation with scientific experts, and guided by comparison of predicted changes in population size against likely baseline trends. This also considered whether predicted change could be detected in these marine systems. A high magnitude change in distribution or population size should be measurable within the Moray Firth given the robust baseline information for this area. Medium or low magnitude change may remain undetected due to high levels of background variation and sampling variability. The duration of effect described has been agreed through consultation with Marine Scotland, SNH and JNCC.

Table 7.3-6 Criteria Used for Predicting Significance from Magnitude of Effect and Duration

	Duration		
Magnitude	**Short Term (days)**	**Medium Term (construction years)**	**Long Term (25 yrs)**
High (> 20 %) of Population	Major significance	Major significance	Major significance
Medium (> 10 %)	Minor significance	Medium significance	Medium significance
Low (< 10 %)	Negligible significance	Minor significance	Minor significance

7.3.4.8 Technical Appendix 7.3 B provides the rationale for using a 25 year period to predict the long term consequences of these construction activities. In summary, the assessments of Favourable Conservation Status (FCS) must consider whether or not protected populations are maintaining themselves in the long term (Annex II, EU 2010). In this context, it is suggested that "long term" be considered to be a 25 year time-scale. First, this is the time-scale typically considered by the International Union for Conservation of Nature (IUCN) when assessing conservation status. Second, it is equivalent to approximately 1 to 2 times the generation time for key marine mammal receptors, and thus seems an appropriate period for assessing longer term population change. See Chapter 4.4 (Marine Mammals) for a summary of the consultation responses to this proposal.

7.3.5 Habitats Regulations Appraisal Methods

7.3.5.1 As part of the Habitat Regulations, the likely significant effects from the proposed developments on SACs will be assessed by the competent authority through consideration of each SAC's conservation objectives (see Technical Appendix 7.3 A). Full details of this appraisal can be found in Technical Appendix 7.3 G (HRA).

7.3.5.2 The two SACs under consideration in this assessment are the Moray Firth SAC (qualifying feature: bottlenose dolphin) and the Dornoch Firth and Morrich More SAC (qualifying feature: harbour seal).

7.3.5.3 The assessment by the competent authority is based on whether the following will occur due to the development of the three proposed wind farm sites:

1. Changes in the distribution or extent of the habitats supporting the species;
2. Changes in the structure, function and supporting processes of habitats supporting the species;
3. Significant disturbance to the qualifying species;

4. Changes in the distribution of the species within the site; and
5. The species being maintained as a viable component of the site in the long term, and therefore the integrity of the site.

7.3.5.4 Terminology used with the HRA assessment is based on that suggested by the Intergovernmental Panel on Climate Change (IPCC). Definitions provided by the IPCC for levels of confidence in an assessment can be found in Technical Appendix 7.3 A.

7.3.6 Noise Impact Modelling

7.3.6.1 Simple Propagation Estimator and Ranking (SPEAR) modelling was conducted by Subacoustech Environmental Ltd to demonstrate the level of noise produced by different construction activities. The SPEAR model was run using a value of 90 dB_{ht}, a level which is predicted to cause strong avoidance in virtually all individuals, and 75 dB_{ht}, a level predicted to cause milder reactions by a lower proportion of individuals (Nedwell *et al*., 2007) for four species; harbour porpoises, bottlenose dolphins, harbour seals and minke whales. Background noise levels experienced by marine mammals within the Moray Firth are in the range of 30-55 dB_{ht}, depending on species and sea state. Underwater measurements of background noise taken within the Moray Firth suggest that levels of background noise within the Moray Firth are typical for UK waters (see Section 7 of Technical Appendix 3.6 A: Underwater Noise for details).

7.3.6.2 For the purpose of this analysis and based on available information, harbour seal is considered an appropriate proxy for grey seals. For the minke whale, an audiogram was developed based on data for the humpback whale (see Section 4.2.2.2 of Technical Appendix 7.3 A for more details).

7.3.6.3 In order to investigate the potential effects of noise from piling further, the University of Aberdeen, SMRU Ltd, Natural Power Consultants and Subacoustech Environmental Ltd have developed in consultation with SNH, JNCC and Marine Scotland a framework for assessing the effects of piling noise on seals and other marine mammal species (see Technical Appendix 7.3 B: Seal Assessment Framework). This document formed the basis of the impact assessment of piling noise (see Technical Appendix 7.3 A and 7.3 B for criteria definitions and more details). A brief outline of the Framework process is described below:

- *Phase 1*: Predicted noise propagation from piling was modelled using the Impulse Noise Sound Propagation and Impact Range Estimator (INSPIRE) model by Subacoustech Environmental Ltd. Blow energies and durations required for the installation of the pin piles in the proposed Telford, Stevenson and MacColl sites are provided within Section 6.4 of Technical Appendix 3.6 A (Underwater Noise). Ramping up of power (i.e. soft start with subsequent increases in blow energy in a step-wise manner to reach full blow energies) is included in the model parameters.

  For behavioural response predictions, this model was then used to predict received noise levels (dB_{ht} by the receptor) in different parts of the Moray Firth. The dB_{ht} contours were generated at 5 dB_{ht} increments between 25 and 130 dB_{ht}.

  The dB_{ht} contours were then used to calculate the maximum perceived level of noise in 4 x 4 km grid squares for which species density estimates are available (see Phase 2 below). Representations of these outputs can be found in Technical Appendix 7.3 F.

To make predictions of auditory injury (PTS), M-Weighted Sound Exposure Level (SEL) (Southall *et al.,* 2007) was also modelled. The numbers of animals experiencing PTS were predicted using an animal movement model (SAFESIMM) together with the modelled SELs (see Technical Appendix 7.3 C for details). The resulting model outputs (which utilise the density estimates described in Phase 2 below) provide predicted numbers of individuals of each species that would be exposed to SELs sufficient to induce the onset of PTS;

- *Phase 2*: The distribution of different receptor species was modelled using best available data in habitat association models - presented in 4.4.9 of Chapter 4.4 (Marine Mammals) and corresponding Technical Appendix 4.4 A. These studies provided density estimates per 4 x 4 km grid square across the Moray Firth for all species considered within this assessment;
- *Phase 3*: Publicly available data, such as the porpoise behavioural studies in response to piling noise at Horns Rev II (Brandt *et al*., 2011), enabled the generation of a dose-response relationship between received noise levels and the probability of avoidance / displacement. The best fit response curve to the data described above from Horns Rev II was generated using the predicted coefficients from logistic regression and the lower fit uses the lower standard error of those coefficients. The upper level is based on the precautionary fit to the data assuming complete displacement from areas receiving 90 dB_{ht} or greater perceived noise levels. The details of this relationship and how it is has been used to model displacement are presented as Technical Appendix 7.3 B (Seal Assessment Framework); and
- *Phase 4*: This phase combines the predicted noise levels within each 4 x 4 km grid square, the number of individual marine mammals of each species within each grid square, the proposed dose-response relationship described above in Phase 3 and the number of individuals predicted to experience the onset of PTS by SAFESIMM. For harbour seal and bottlenose dolphin, these data were then used within population models to assess how different construction scenarios might affect long term population growth in comparison to baseline scenarios with no construction (see Section 4.2.2 Technical Appendix 7.3 A and 7.3 B for full methodology). For grey seal, harbour porpoise and minke whale the predicted number of individuals impacted were related to regional population sizes to assess the magnitude of effects.

7.3.6.4 The above methodology (described in detail in Technical Appendix 7.3 B) makes the assumption that porpoise responses to piling noise (displacement) can be used as proxy for behaviour for other species including harbour seals and bottlenose dolphins. Technical Appendix 7.3 D (a comparison of behavioural responses by harbour porpoises and bottlenose dolphins to noise) provides a comparison of the best-fit relationships between noise level and response level for harbour porpoises and bottlenose dolphins. The analysis of available data indicates higher level responses by harbour porpoises than bottlenose dolphins to similar noise levels. From a risk assessment perspective, these results indicate that the use of a harbour porpoise behavioural dose / response is likely to lead to a highly precautionary approach to predicting bottlenose dolphins' responses that will potentially over-estimate effects for this species; the results of the bottlenose dolphin behavioural response predictions should therefore be viewed in this context.

7.3.6.5 As described in Technical Appendix 7.3 E and Table 7.3-11 below, the scientific advisors working with MORL reviewed the available literature for the rationale supporting the 186 dB SEL criteria for PTS onset for seals. They concluded that the evidence did not support the differential sensitivity of seals over cetaceans, and proposed a common criterion (198 dB SEL) for all species assessed. Peer and stakeholder consultation on this approach concluded that while there was general agreement that the 186 dB SEL criteria was likely to be overly conservative, there was little evidence to support reducing the criteria to 198 dB SEL for seals. It was generally agreed that the likely criteria for the noise exposure and duration to induce PTS onset would be somewhere between the 198 and 186 dB SEL level. As a consequence, the 186 dB SEL for seals has been used here as a conservative modelling scenario (recognising that there is likely to be an over estimation of numbers of seals modelled to experience the onset of PTS).

7.3.6.6 For the purpose of the wind farms assessment, three different piling scenarios were modelled (see Table 7.3-7 below for details). These scenarios reflect the proposed build out scenarios that may be undertaken by MORL during the construction of the three proposed wind farm sites. For the location of modelled piling locations, refer to Figure 01 in Technical Appendix 7.3 F.

Table 7.3-7 Details of the Scenarios Used for Predicting the Effects of Piling Noise on Marine Mammals

Scenario A	One piling vessel to build all three schemes. The vessel would remain within the Moray Firth for up to five years, building each wind farm in succession (build duration 2016 to 2020). Modelling based on a 2.5 m diameter pile at location 1, due to it being closest to the inner Firth.
Scenario B	Two piling vessels to build all three schemes. For this scenario, the build programme would be envisaged to take up to three years (build duration 2016 to 2018). It is likely that the vessel spread at any one time would be relatively small. However, for the purposes of this assessment, worst case, the modelled locations have been chosen to reflect the largest vessel spread possible and so cumulative noise extent. Modelling based on a 2.5 m diameter pile at locations 1 and 5.
Scenario C	Six piling vessels to build all three schemes (two vessels within each site) within a two year construction phase (build duration 2016 to 2017). While six piling vessels are unlikely to require a full two year continuous construction period, there may be some time within this period in which all six vessels would be on site and operational together. Modelling based on a 2.5 m diameter pile at locations 1, 2, 3, 4, 5 and 6.

7.3.6.7 The predicted SELs are modelled assuming a level of noise, and so exposure to this noise, produced within a 24 hour period. As such, installation of one, two or up to four pin piles in a 24 hour window will affect the SEL and therefore the PTS predictions. It is likely that the Telford, Stevenson and MacColl construction programmes will involve between two and four pile installations per 24 hour window on each construction vessel.

7.3.6.8 Modelling using INSPIRE to predict SELs from pile driving multiple, consecutive 2.5 m diameter pin piles into the stiff soil type of the Moray Firth in one 24 hour period showed that due to the logarithmic nature of the SEL equation, the majority of the noise exposure for animals that led to modelled onset of PTS occurred during the first piling event (see Technical Appendix 7.3 A for modelling outputs). As piling of two pin piles per 24 hour period is considered to be most representative of likely construction activity on the MORL site (the majority of currently available construction vessels would drive two piles from one location and then be required to mobilise and reposition in order to pile the remaining two pin piles of each foundation), the modelled scenarios undertaken for the impact assessment process described above in Table 7.3-7 (and all other PTS onset modelling presented here) have been carried out using the example of two pin piles being installed consecutively per 24 hour window. Furthermore, it is considered that animals are likely to flee in response to piling (see Section 4.2.2.1 of Appendix 7.3 A) and in relative terms, the predicted probability of PTS from the piling of two piles consecutively in any one 24 hour is considered to be representative of four consecutive piles.

Meteorological Mast

7.3.6.9 A Marine Licence has been granted for the installation of an offshore meteorological mast (met-mast) which MORL intends to install in 2012. A second mast is planned at some stage through the construction period (see 2.2.8 in Chapter 2.2: Project Description for details). There are four types of foundation that could be used:

- Single monopole with a diameter of 4.5 m;
- Steel jacket substructure with pin-piles similar to those used for wind turbines;
- Gravel-bed, gravity foundation; and
- Floating foundation.

7.3.6.10 SPEAR modelling was repeated, based on the installation of a 4.5 m pile as this is considered the worst case in terms of the production of underwater noise from piling activity (see Technical Appendix 7.3 A for more details).

7.3.7 Primary Impact Assessment: Three Proposed Wind Farm Sites

7.3.7.1 All marine mammal species that may be encountered in the vicinity of the three proposed wind farm sites are considered target species due to the fact that all cetaceans are listed under Annex IV of the Habitats Directive and the bottlenose dolphin, harbour porpoise, harbour seal and grey seal are listed on Annex II. This assessment will concentrate on the key species highlighted in Chapter 4.4 (Marine Mammals) and associated Technical Appendix 4.4 A. Conclusions are also applied to less frequently observed species. The key species assessed in this chapter are:

- Grey seal;
- Harbour seal;
- Harbour porpoise;
- Bottlenose dolphin; and
- Minke whale.

Construction

7.3.7.2 The primary potential effects during the construction phase of the developments will be:

- Disturbance /displacement and physical injury from increased anthropogenic noise, in particular piling; and
- Collision risk from construction vessels.

7.3.7.3 There is also the potential for a secondary effect of:

- Reduction in prey due to noise from construction activities; and
- Increased suspended sediment leading to reduced prey availability and foraging ability.

Anthropogenic Noise (Non-Piling Activities)

7.3.7.4 It is considered that the greatest effect on marine mammals during construction will be from increased levels of underwater anthropogenic noise. Effects from increased noise levels can be divided into two broad categories: disturbance / displacement and, physical injury (see Section 4 of Technical Appendix 7.3 A for more details).

7.3.7.5 Plate 7.3-1 below illustrates the range (distance in m) predicted by SPEAR modelling at which noise from different construction related activities reaches 90 dB_{ht} for harbour porpoise. SPEAR modelling for other marine mammal species (shown in detail in Section 4.1.2 of Technical Appendix 7.3 A: Impact Assessment, and summarised below in Table 7.3-8) show a similar pattern of impact ranges from the modelled construction activities to those of harbour porpoises.

7.3.7.6 The 90 dB_{ht} radii for noise during pin pile installation (based on worst case scenario of 2.5 m diameter piles) is nearly two orders of magnitude higher than those for other construction activities (Plate 7.3-1). Plate 7.3-2 below illustrates the same construction activities with piling noise removed from analysis.

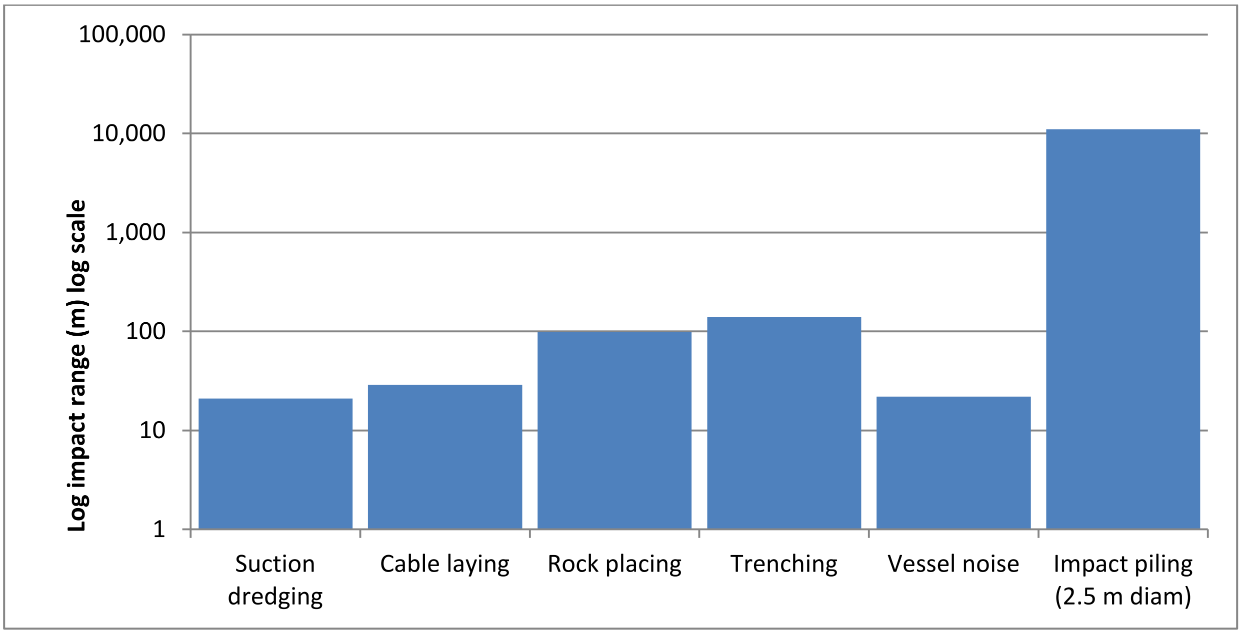

Plate 7.3-1 Spatial Extent of 90 dB_{ht} Effect of Various Construction Related Activities on Harbour Porpoise. For a Complete set of Results across all Species, see Section 4.1.2 of Technical Appendix 7.3 A. Note: Y-axis Log Scale.

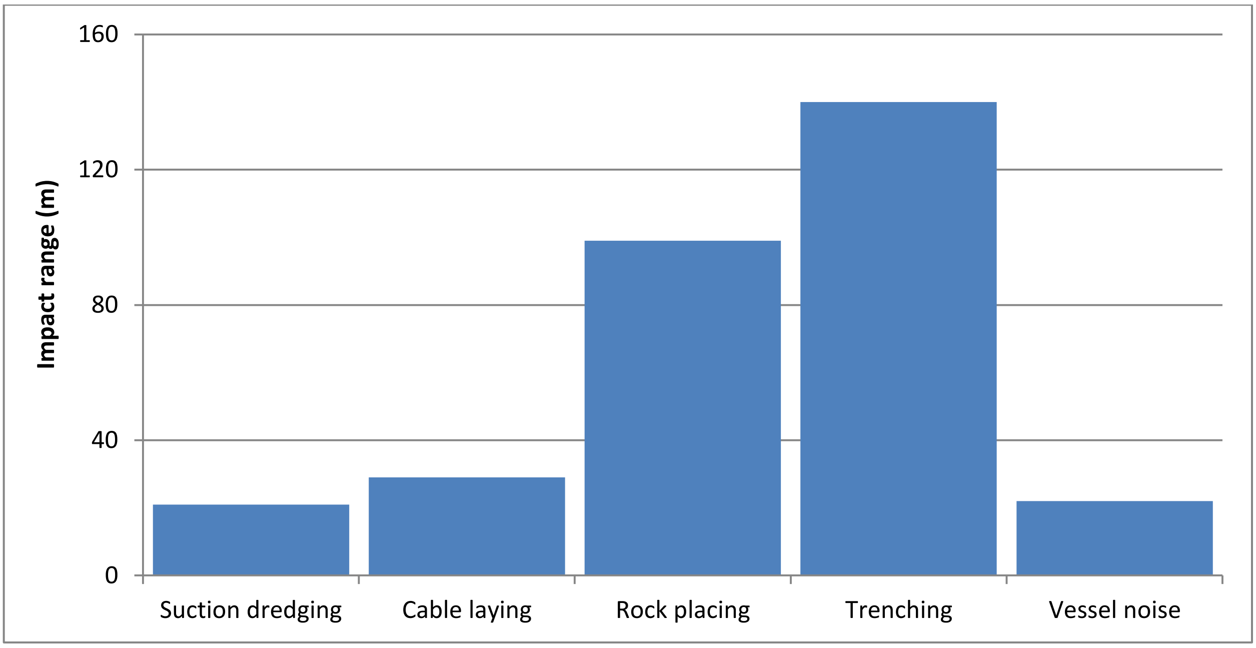

Plate 7.3-2 Spatial Extent of 90 dB$_{ht}$ Effect of Various Construction Related Activities (excluding piling) on Harbour Porpoises. For a complete set of Results across all Species, see Table 7.3-8 below and Section 4.1.2 of Technical Appendix 7.3 A for Graphs.

Table 7.3-8 Numerical Output from SPEARS Model Predicting and Comparing the Modelled Noise Effects of Different Construction Activities on Marine Mammals

Construction Activity	Impact Range (m)							
	Minke Whale		Bottlenose Dolphin		Harbour Porpoise		Harbour Seal	
	90 dB$_{ht}$	75 dB$_{ht}$	90 dB$_{ht}$	75 dB$_{ht}$	90 dB$_{ht}$	75 dB$_{ht}$	90 dB$_{ht}$	75 dB$_{ht}$
Suction Dredging	16	180	21	72	21	200	2	26
Cable Laying	18	180	9	75	29	220	2	29
Rock Placing	70	390	31	170	99	550	17	99
Trenching	59	390	81	350	140	640	12	87
Vessel Noise	6	130	12	110	22	200	< 1	11
Impact Piling (2.5m diameter)	11,000	23,000	7,300	15,000	11,000	21,000	5,100	13,000

7.3.7.7 The results of this study showed that the primary source of noise during construction (and therefore exerting the greatest potential effect on marine mammals) will be from piling. Piling noise is discussed in greater detail below, and while occurring, it is considered that the effects of piling are of more significance than those effects related to other construction activities.

7.3.7.8 When piling is not occurring, marine mammals may become sensitive to other sources of anthropogenic noise. Such noise sources include:

- Vessel noise;

- Suction dredging;
- Cable laying;
- Rock placing; and
- Trenching.

7.3.7.9 Based on the SPEAR model outputs above, it was concluded that the effects of these additional construction activities would be minimal due to their local influence and the fact that more distant effect would be masked by the noise produced from piling. During periods when no piling is occurring, strong reactions to the activities modelled are unlikely to occur at distances of greater than 140 m (Table 7.3-8) from the source and so any effects would be of low magnitude, of medium duration, temporary in nature and of minor significance.

Anthropogenic noise – piling

7.3.7.10 The SPEAR model confirmed the greatest source of noise during the construction period will be from piling (based on the blow energies required to install a 2.5 m pile diameter pin).

7.3.7.11 Full details of the model process are provided within Section 4.2 of Technical Appendix 7.3 A in conjunction with Technical Appendix 7.3 B (Seal Assessment Framework) and Technical Appendix 3.6 A (Underwater noise). Visual outputs (i.e. noise contours) from the models can be found in Technical Appendix 7.3 F. Table 7.3-9 below provides the numbers of individuals of each species that are predicted to be either displaced, or have the potential to experience the onset of PTS[4], per year of construction. The details of the population estimates and distributions for each species that have been used in this modelling can be found in Chapter 4.4 (Marine Mammals). The population of minke whales potentially subject to the effects of the construction phase of the Project was taken to be 1,462, based upon SCANS II model estimates for block J (which includes the Moray Firth).

7.3.7.12 For the purposes of this impact assessment process, it is assumed that this first year of predicted effects will be extended through subsequent years of construction, although this is considered to be highly precautionary as it assumes no habituation to low level noise. For example: if 72 % of the harbour seal population is predicted to be displaced from favoured feeding grounds during the first year of piling, these individuals have been modelled to be displaced from these feeding grounds for the full duration of the construction phase. The modelling also assumes that displaced animals will not return to these favoured foraging grounds between piling events and so are displaced for the full construction period (see Table 7.3-11 below for a list of assumptions made during the modelling undertaken for marine mammals).

[4] It is recognised that the potential to induce PTS would require an EPS licence. Details of the preliminary EPS risk assessment can be found in Technical Appendix 7.3 H. This risk assessment will be up-dated as the construction parameters have been finalised prior to construction.

Table 7.3-9 Predicted Number (and proportion of modelled baseline population) of Individuals Affected by Piling Noise in Year One of Construction. It has been Assumed that these Figures Equate to the Additional Yearly Effects from Subsequent Piling Years.

	Scenario A		Scenario B		Scenario C	
	Number	%	Number	%	Number	%
Harbour Seal						
PTS: 186 dB	121	10.2	198	16.7	305	25.8
PTS: 198 dB[5]	26	2.2	47	3.9	89	7.5
Behavioural Displacement: High	731	61.8	823	69.6	853	72.1
Behavioural Displacement: Best fit	522	44.1	629	56.4	667	66
Behavioural Displacement: Low	42	3.5	66	5.6	92	7.7
Grey Seal						
PTS: 186 dB	170	5.4	301	9.5	478	15.1
PTS:198 dB[6]	35	1.1	65	2.1	119	3.8
Behavioural Displacement: High	1,159	32.2	1,656	46	1,753	48.7
Behavioural Displacement: Best Fit	739	20.5	1,184	32.9	1,285	35.7
Behavioural Displacement: Low	45	1.3	94	2.6	123	3.4
Harbour Porpoise						
PTS: 198 dB	6.4	0.1	10.2	0.2	21.9	0.4
Behavioural Displacement: High	4,015	65.6	4,056	73.7	5,149	84.2
Behavioural Displacement: Best Fit	2,933	47.9	3,442	56.3	4,208	68.8
Behavioural Displacement: Low	263	4.3	367	6	629	10.3
Bottlenose Dolphin						
PTS: 198 dB	0.06	< 0.1	0.07	< 0.1	0.12	0.1
Behavioural Displacement: High	31	15.7	33	16.8	36	18.5

[5] Provided for information to show the difference in seal numbers calculated to experience the potential onset of PTS using the 186 and 198 dB criteria. The 186 dB criteria is used within the assessment of effect described below.

[6] Provided for information to show the difference in seal numbers calculated to experience the potential onset of PTS using the 186 and 198 dB criteria. The 186 dB criteria is used within the assessment of effect described below.

	Scenario A		Scenario B		Scenario C	
	Number	%	Number	%	Number	%
Behavioural Displacement: Best Fit	17	8.9	19	9.7	21	11
Behavioural Displacement: Low	0	0.2	1	0.3	1	0.4
Minke Whale						
PTS: 198 dB	12.3	0. 8	10.7	0. 8	9.9	0. 7
Behavioural Displacement: High	206	14.1	218	14.9	222	15.2
Behavioural Displacement: Best Fit	168	11.5	185	12.7	191	13.1
Behavioural Displacement: Low	20	1.4	27	1.8	34	2.3

7.3.7.13 It can be seen that the increase in piling activity leads to an increase in modelled noise related displacement and the potential for individual animals to experience PTS onset.

7.3.7.14 Displacement of bottlenose dolphin is not expected to occur in key foraging locations within the Moray Firth SAC, but may occur within the corridor that links the Inner Moray Firth and Forth of Tay / Aberdeen. However, levels of noise expected to lead to complete displacement (> 90 dB_{ht}) were not predicted to occur even in these areas. Instead, noise levels were in the range in which partial displacement may occur. The temporal pattern of piling is an important consideration when assessing these effects. Rochdale Envelope calculations estimate that, if one vessel were constructing over a five year period, piling would be highly intermittent (For example: due to time spent relocating vessels between piling operations and periods of bad weather), with a total piling time of 13 % of the total construction phase. This would effectively enable passage between key dolphin areas even if there was any effect upon movements through this area during piling. For example: based on a swimming speed of 2 ms^{-1}, bottlenose dolphins would be able to move right through the affected area within approximately ten hours. If the number of piling vessels were greater than one, the number and duration of these windows may reduce, although weather considerations would still be likely to provide some longer periods between piling. Such a decrease in the duration of pile-free windows would be compensated by a reduced overall construction phase duration.

7.3.7.15 In addition to the above modelling of the number of individual animals estimated to be disturbed or to experience PTS onset, population modelling was conducted for the harbour seal and bottlenose dolphin populations. The results of this modelling can be found in Plates 7.3-4 and 7.3-5 below.

7.3.7.16 For harbour seals, a deterministic stage-based matrix model previously used to estimate the effects of shooting seals (PBR) was adapted (Thompson *et al*., 2007), enabling potential changes in reproductive output and mortality specific to certain age-classes or sex to be explored. The bottlenose dolphin model used a stochastic individual-based model previously used to compare different management strategies for the Moray Firth bottlenose dolphin population (Thompson *et al*., 2000). This uses available literature values for bottlenose dolphin demographic and life-history parameters in the programme VORTEX to produce a baseline model with a stable population growth rate (see Section 4.2.2 of Technical Appendix 7.3 A, and Technical Appendix 7.3 B: Seal Assessment Framework for full details on both methodologies).

7.3.7.17 Baseline models (see Plate 7.3-3 below) were run to compare with modelled impact scenarios over a 25 year period from 2011. The upper graph represents the harbour seal baseline population model which demonstrates that, without disturbance (but under current levels of licensed shooting), the harbour seal population of the Moray Firth is predicted to increase until the carrying capacity of the habitat (estimated at 2000) is reached.

7.3.7.18 The outputs for the bottlenose dolphin population model differ in appearance to those from the harbour seal model. The baseline bottlenose dolphin model was run 1,000 times to provide a frequency distribution of predicted population sizes after 25 years, which could then be compared with the distribution of final population sizes from different impact scenarios. Because the model was parameterised to give, on average, a stable population, the majority of baseline runs resulted in a population size of around 196 (Plate 7.3-3), the most recent estimate of population size (Cheney *et al*., 2012).

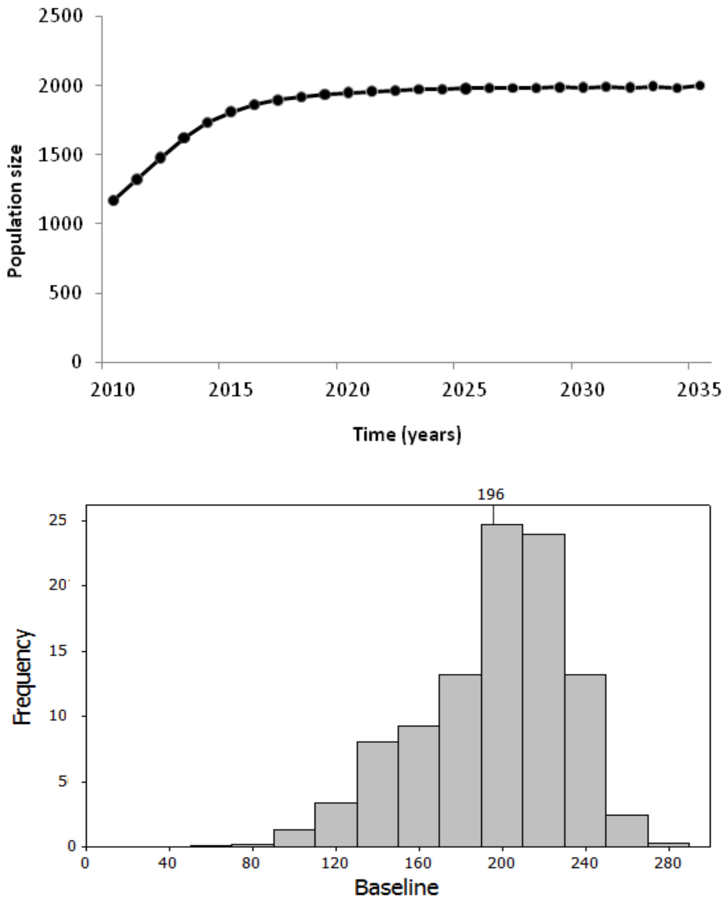

Plate 7.3-3 Baseline Models Against which Scenarios are Compared. Top = harbour seal; bottom = bottlenose dolphin.

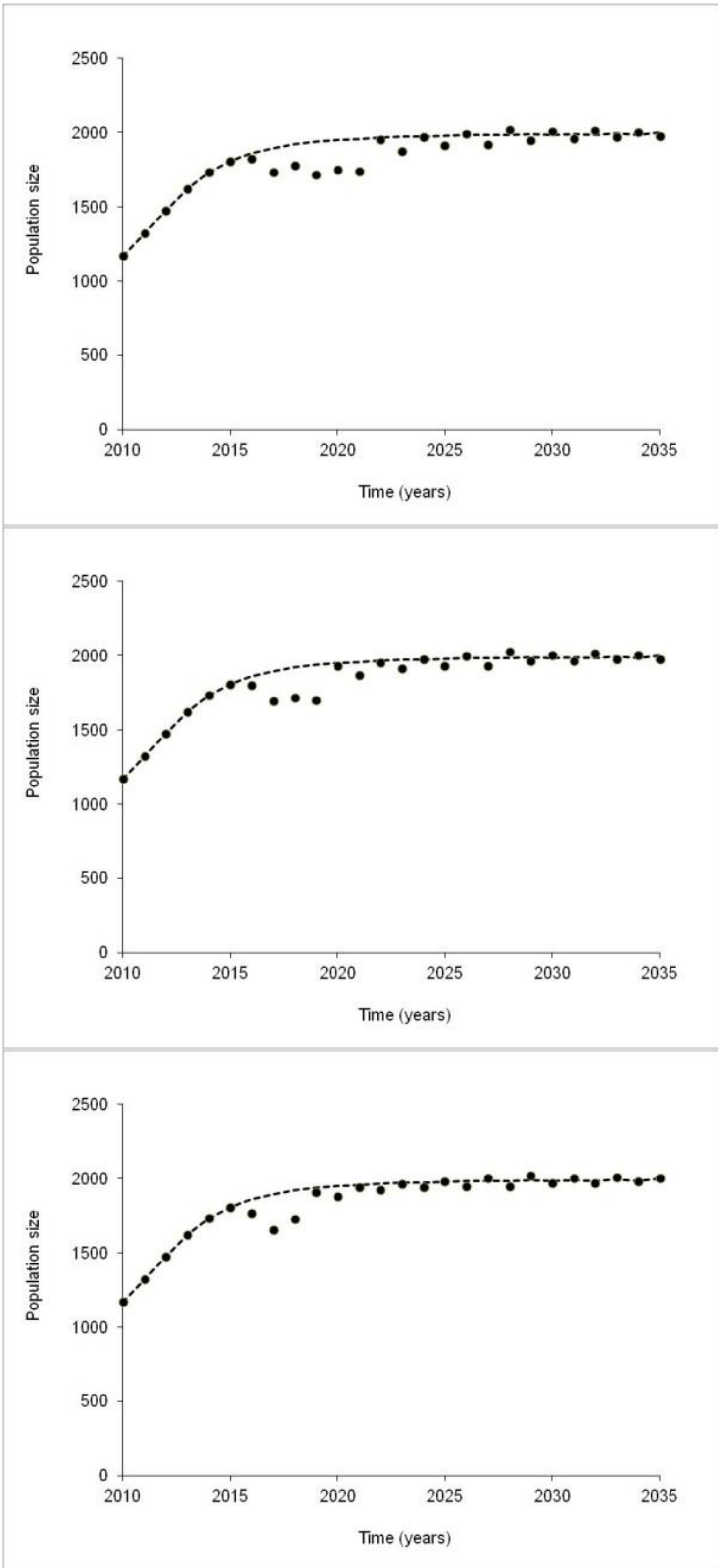

Plate 7.3-4 Population Modelling for the Harbour Seal Population in the Moray Firth. Data Based on 186 dB SAFESIMM Model Outputs and Conservative Relationship between Perceived Noise and Displacement. From top to bottom: Scenario A, B and C.

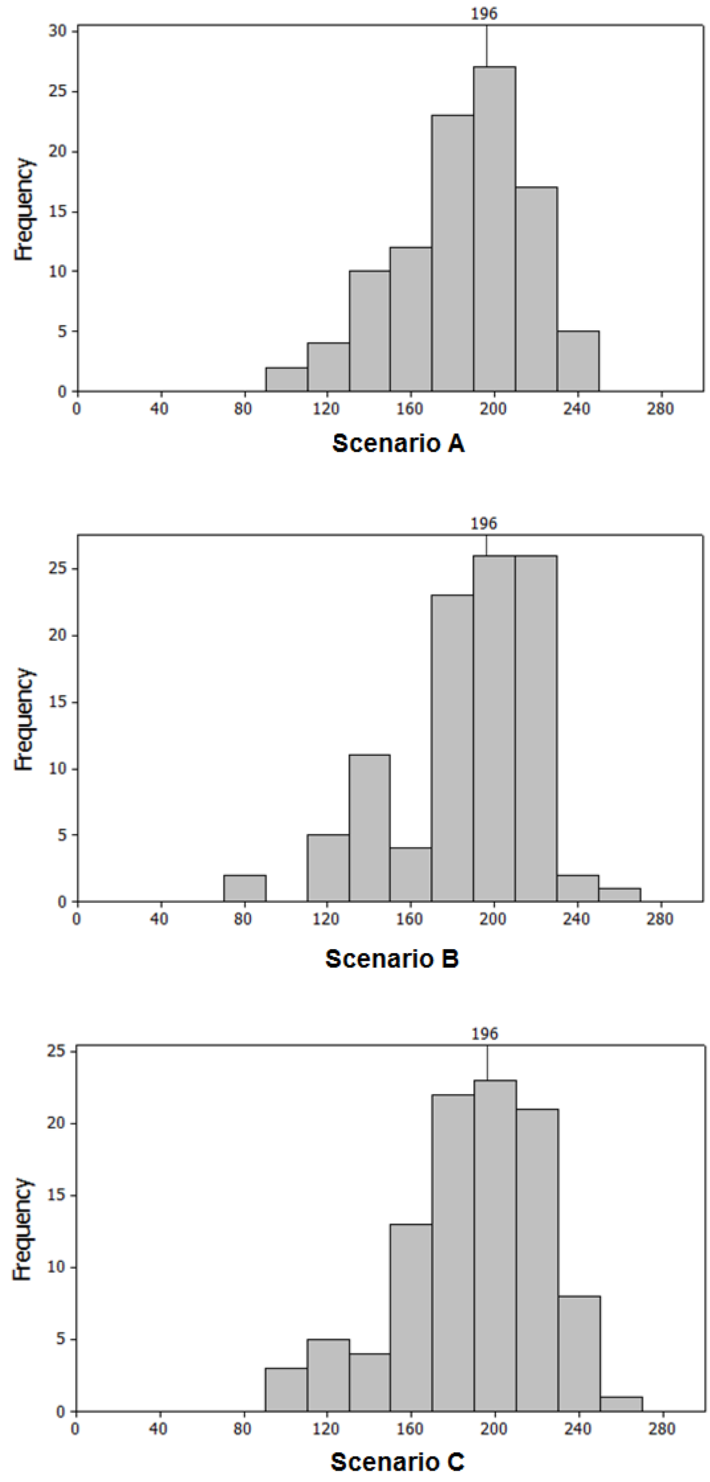

Plate 7.3-5 Population Modelling for the Bottlenose Dolphin Population in the Moray Firth. Data Based on 198 dB SAFESIMM Model Outputs and Conservative Relationship between Perceived Noise and Displacement. From top to bottom: Predicted Population Size in 2035 after Construction Scenarios A, B and C. Current Population is Estimated to be 196 Individuals (see Chapter 4.4: Marine Mammals for details).

7.3.7.19 The modelling above indicates that while there will clearly be medium term significant effects to the harbour seal (high magnitude, medium duration), these are not predicted to result in long term effects on population size. Thus the overall effect is considered to be of low magnitude (predicted population size within 10 % of that predicted as a baseline if population parameters do not change within the Moray Firth) and so **minor significance** for harbour seals.

7.3.7.20 Chapter 4.4 (Marine Mammals) describes how the bottlenose dolphin population are found almost exclusively within the coastal strip of the Moray Firth and very rarely frequent the waters over Smith Bank. It is therefore not unexpected that the modelling above predicts negligible numbers of individuals exposed to levels of noise sufficient to induce PTS, and a medium magnitude level for displacement. As described above, partial displacement has the potential to occur within the areas between the Inner Moray Firth and Forth of Tay / Aberdeen rather than within the Moray Firth SAC. However, gaps within the piling regime are thought to be sufficient to enable animals to continue to use these areas. The population modelling undertaken (which assumes displacement from foraging grounds and a similar sensitivity to noise to that of harbour porpoises, although this is recognised as a conservative assumption) indicates that there will be no long term effect upon the population size from the modelled construction activity from all three scenarios. The overall effect is considered to be of low magnitude (predicted population size within 10 % of that predicted as a baseline if population parameters do not change within the Moray Firth) and so **minor significance**.

7.3.7.21 A similar approach to the short, medium and long term effect upon grey seals, harbour porpoises and minke whales has been adopted. However, a lack of appropriate data means that population modelling has not been undertaken for these species.

7.3.7.22 Many of the grey seals observed within the Moray Firth are thought to have originated from breeding and haul-out sites outside the area (see Technical Appendix 4.4 A: Marine Mammals). While the modelling undertaken using the 186 dB criteria has predicted low (Scenario A and B) to medium (Scenario C) magnitude number of grey seals exposed to noise levels sufficient to induce PTS onset, these numbers are considered highly conservative and likely to represent a significant over-estimation (see Table 7.3-11 below, assumption 9 in particular). Given the results of population modelling for harbour seals in the Moray Firth, any effect upon the larger and increasing grey seal population is unlikely to have a significant long term effect at the population level. While the effects of behavioural displacement on grey seals within the Moray Firth are considered to be of short and medium term major significance, given that grey seals are not tied to specific breeding or feeding grounds within the Moray Firth it is suggested that the long term effect on this species at the population level will be of **minor significance**.

7.3.7.23 Both harbour porpoise and minke whales have widespread distributions and do not appear to be tied to specific feeding or breeding grounds. The modelled numbers of individuals of both species predicted to experience PTS are of low magnitude, while the disturbance effects from piling within the wind farm site on individuals within the Moray Firth are considered of short and medium term major significance. Given the wide distribution and abundance of both species, the long term effects at the population level will be of **minor significance**.

7.3.7.24 A summary of the predicted potential effects from piling noise based on this framework and results can be found in Table 7.3-10 below. Details of the assessment are provided within Section 4.2.3 of Technical Appendix 7.3 A.

Table 7.3-10 Summary of Potential Effects from Piling Noise During Construction on Relevant Marine Mammal Receptors

	Scenario A	**Scenario B**	**Scenario C**
Harbour Seal			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.
Grey Seal			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.
Harbour Porpoise			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.
Bottlenose Dolphin			
Predicted Effect	Medium significance over medium term for individuals during construction phase, with minor significance for long term effects on the population level.	Medium significance over medium term for individuals during construction phase, with minor significance for long term effects on the population level.	Medium significance over medium term for individuals during construction phase, with minor significance for long term effects on the population level.
Minke Whale			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.

Certainty in Predictions During the Assessment

7.3.7.25 As described above in 7.3.4 (EIA Methodology), the IEEM guidance (IEEM, 2010) provides criteria to be used when assigning certainty to predictions of potential effects. Due to the number of conservative assumptions that have been made during the impact assessment for marine mammals, consultation with scientific experts has resulted in an assignation of a probable degree of certainty of effects

(50 to 95 % probability). Further, if the IPCC guidelines were to be followed (see 7.3.1.4 at the end of this chapter), a likely degree of certainty (66 to 100 % probability) has been assigned to the predictions. The scientific experts involved in the development of the assessment methodology suggest that the conservative nature of all the assumptions taken result in a substantial cumulative over-prediction of effect. Table 7.3-11 below provides details on the assumptions that have been made during this impact assessment, and why they represent the most conservative approach possible in each case.

Table 7.3-11 Assumptions Made during the Impact Assessment on Marine Mammals and their Degree of Conservatism

Assumption		Conservatism
1	**Noise modelling used blow energies required to drive piles into the stiffest of the three soil types present on site throughout assessment**	The blow energy required to drive piles into stiffer soil types is greater than that required to drive them into softer soil types. As a consequence, higher noise levels are predicted from pin pile installation in the stiffest soil types. However, the degree of complexity required to model different blow energies in different regions of the sites, over an uncertain build duration, was prohibitive. As a consequence, worst case has been used throughout.
2	**INSPIRE noise propagation modelling is conservative over the 20 to 50 km range**	As shown in Technical Appendix 7.3 B, comparison of INSPIRE model predictions with published measured recordings from the Beatrice Demonstrator (Bailey *et al.*, 2010) indicate that the model predictions for unweighted peak levels provide a relatively good fit of the measured data. Modelled and measured noise levels correlate well at distances up to 20 km from the piling event, but provide a conservative prediction of sound levels across the wider Moray Firth (20 to 50 km).
3	**Noise modelling locations to represent indicative piling activity have always been chosen to be closest to sensitive receptors or produce the largest spatial extent of effect**	This approach introduces an inherent conservatism over the duration of the construction phase. For example: for Scenario A described above in Table 7.3-7, a single location closest to the sensitive receptors (bottlenose dolphin and harbour seal) has been chosen and effects modelled to occur for five years. This is an over-estimation of effect, as the majority of piling would be more distant than this most sensitive location. In a similar conservative manner, the two piling locations for Scenario B (Table 7.3-7) have been chosen to represent the largest possible noise footprint from piling operations. Effects from Scenario B have been modelled to take place for three years. In practice, if two piling vessels were used on site they would operate in relatively close proximity to each other reduce vessel spread and transit time of support vessels, thus producing a significantly reduced noise footprint.
4	**Allocation of perceived noise level to each 4x4 km grid square used for marine mammal displacement modelling always used the highest level predicted for each square**	Technical Appendix 7.3 F illustrates how the modelled perceived noise levels for each species under individual construction scenarios were allocated. A perceived noise level that equated to the highest dB_{ht} radii that touched the 4x4km grid square was assigned to each square, rather than allocating a dB_{ht} level that corresponded to the greatest proportion of the square.
5	**Degree of displacement from piling associated noise**	As described in Technical Appendix 7.3 B, a precautionary fit has been applied to the porpoise displacement data gathered during the foundation piling at Horns Rev II and used to generate a dose response curve for porpoise displacement against perceived noise levels within the Moray Firth. The use of this precautionary fit to generate the dose response curve results in a higher level of modelled displacement than the best fit curve to the data, and therefore represents a conservative assumption in the modelling that has been undertaken.

Assumption		Conservatism
6	**Harbour porpoise behaviour was used as a proxy for bottlenose dolphin in the modelled disturbance from piling noise**	As described in Technical Appendix 7.3 D, analysis of available data indicates higher level responses by harbour porpoises than bottlenose dolphins to similar noise levels. Thus, using harbour porpoise as a proxy for bottlenose dolphin is likely to produce an overestimation of associated effect upon the bottlenose dolphin population.
7	**Modelled avoidance of areas predicted to experience high piling related noise for the full duration of the construction period (i.e. animals modelled to not return in between periods of piling)**	No data are currently available on the period of time that will elapse between the cessation of piling activity and the return of animals displaced from Smith Bank. Animals have therefore been modelled to remain excluded for the full duration of the construction period (i.e. a number of years). It is considered likely that animals will return between some piling events, especially during breaks in construction activity (e.g. due to bad weather). Assuming displacement for the entire construction period therefore represents a highly conservative assumption.
8	**Effect of displacement upon reproduction rates of harbour seal and bottlenose dolphins**	Population modelling has been undertaken to assess the population consequences of effects experienced by individual harbour seals and bottlenose dolphins. Animals modelled as being displaced for the full construction period have been assumed to either fail to produce young or for the young produced to not survive. This is considered to be a conservative assumption, at least in part due to the considerations described above (that the animals are displaced for the entire duration of the construction phase, and do not return to favoured feeding grounds in periods of no construction activity such as that induced by bad weather).
9	**The 186 dB SEL criteria was used for modelling the number of individual seals exposed to noise of sufficient volume and duration to induce PTS onset**	As described above and in Technical Appendix 7.3 E, the scientific advisors working with MORL reviewed the available literature for the rationale supporting the 186 dB SEL criteria for seals. They concluded that the evidence did not support the differential sensitivity of seals over cetaceans, and proposed a common criterion (198 dB SEL) for all species assessed. Peer and stakeholder consultation on this approach concluded that while there was general agreement that the 186 dB SEL criteria was likely to be overly conservative, there was little evidence to support reducing the criteria to 198 dB SEL. It was generally agreed that the likely criteria for the noise exposure and duration to induce PTS onset would be somewhere between the 198 and 186 dB SEL level (see values provided in Table 7.3-9). As a result of this consultation the 186 dB SEL has been used here as a conservative modelling scenario (recognising that there is likely to be an over estimation of numbers of seals modelled to experience the onset of PTS).
10	**SAFESIMM was used to model the number of individual animals which would experience noise levels sufficient to induce PTS onset**	As described in Technical Appendix 7.3 B, SAFESIMM estimates for the number of individual seals experiencing PTS from piling noise are of an order of magnitude higher than those calculated using INSPIRE generated SEL radii. While both models use the same impact criteria (dB SEL levels), this difference is likely to be a consequence of the way INSPIRE and SAFESIMM model the fleeing behaviour of animals. In the INSPIRE model, the animal flees at a speed of 1.5 m / s away from the noise source. In the SAFESIMM model, animals make 'directed random walk' movements away from the noise source, and take significantly longer to leave the area affected by noise of sufficient volume to induce PTS. Furthermore, seals in SAFESIMM continue to receive a noise dose regardless of whether they were diving or at the surface, when in reality animals (seals) at the surface will have their heads above the water and therefore not receive this dose. The use of SAFESIMM to estimate the number of individuals exposed to sufficient noise to induce PTS therefore represents a conservative element of the impact assessment methodology.

Assumption		Conservatism
11	**Consequence of PTS is a 25 % risk of mortality**	The PTS onset criteria proposed by Southall *et al.,* (2007) represents an estimate of the noise levels at which a reduction in hearing acuity may start to occur. There are no empirical data on actual levels of PTS in marine mammals, or on whether such hearing impairment may affect their survival Based upon discussions with scientists and other stakeholders, the 25 % mortality risk used in these models is considered highly conservative, but has been used due to the degree of uncertainty surrounding the consequences of these criteria.

7.3.7.26 MORL intends to install a met mast on a 4.5 m monopile foundation within the Stevenson site during a period of two weeks in 2012, and will take the opportunity to participate in surveys designed to refine some of the assumptions made above.

7.3.7.27 MORL will deploy equipment to measure underwater noise propagated through the water column from the piling event at locations both near to the met mast installation (750 m) and further afield (up to 50 km). These will be correlated with the detailed records of the blow energies required to install the met mast foundation, and used to quantity any over-conservative predictions of perceived noise at distant locations from the piling events. The aim of this study is to validate noise estimates in assumption 2 in Table 7.3-11 above.

7.3.7.28 DECC have funded the deployment of up to 50 C-PODs by the University of Aberdeen that will be located in two linear arrays between 750 m and 25 km from the met mast location in the Moray Firth. The results from the analysis of the data collected from these C-PODs before, during and after the met mast construction will be used in conjunction with the noise measurement described above to refine the noise dose response curve for harbour porpoises to the received noise from piling of the monopile foundation. The C-PODS will be deployed up to three weeks prior to piling activity and left in situ for up to three weeks after piling has ceased. This up to seven week deployment will establish the distribution of harbour porpoise before, during and after the piling event, and thus provide information to aid, refine and validate assumptions 5 and 7 in Table 7.3-11 above.

7.3.7.29 In addition to the above survey work, MORL also intend to commission aerial photography along a linear transect route to provide data on the noise dose response for seals to piling noise. Unlike harbour porpoises, seals do not constantly vocalise and so their presence or absence will not be detected by C-PODs. Aerial photograph will record seals on, or near to, the surface of the sea along the transect route immediately before, during and after the piling event. It is hoped that this will provide information upon baseline use of the transect route, displacement due to perceived noise levels and an indication of the length of time needed for the seals to return to the vicinity of the piling site. While the results of this study will be qualitative rather than quantitative, they will go some way towards providing confidence to reduce the conservative assumption 7 in Table 7.3-11 above. A caveat to this proposed study is that it requires a good weather window during the piling of the monopile. Should wind and wave conditions allow piling to take place, but the cloud cover be low to prevent aerial photography, piling will take place in the absence of aerial photography.

7.3.7.30 It is also hoped that information to be made available from the DECC funded, SMRU harbour seal tagging study within the Wash will provide information on how harbour seals react to anthropogenic noise sources associated to the construction of offshore wind farms (including piling) and thus provide information to inform assumption 7 in the Table 7.3-11 above.

Reduction in Prey Due to Noise from Construction Activities

7.3.7.31 Noise modelling was conducted to predict impact ranges from piling noise produced by the Project on key fish species (see Chapters 7.2: Fish and Shellfish Ecology and 3.6: Underwater Noise). Impact ranges were found to be similar to those derived from the worst case scenarios for the three proposed wind farm sites.

7.3.7.32 The effects from noise during construction on potential marine mammal prey species are therefore considered to be of low magnitude for a medium duration and therefore of minor significance.

Collision Risk and Use of Ducted Propellers

7.3.7.33 Section 4.3 of Technical Appendix 7.3 A provides the detailed methodology and assessment for the collision risk to marine mammals during the construction of the three sites.

7.3.7.34 The precise number and type of vessels to be used during construction is yet to be confirmed, but as reported in Chapter 11.2 (Shipping and Navigation), it was concluded that any vessel traffic would be slow moving in a predictable manner (along a predefined corridor). As a result, the effects of increased vessel traffic on marine mammals (all species) was considered probable in the immediate vicinity of the vessel but overall, effects would be of low magnitude, medium duration and **minor significance**.

7.3.7.35 Recently, concern has been raised by Statutory Nature Conservation Agencies on the potential effect upon seals from vessels fitted with ducted propellers. Since 2008, a number of carcasses have been found in south east Scotland, the north Norfolk coast and around Strangford Lough (Northern Ireland), with a characteristic single smooth edge cut spirally the length of the body (Thompson *et al*., 2010). It was concluded that these injuries were consistent with the animals being pulled through a ducted propeller common to a wide range of vessels including tugs, self-propelled barges, rigs, offshore support vessels and research boats (Thompson *et al*., 2010). As part of Chapter 5.2 (Shipping and Navigation), a variety of offshore support vessels, fishing vessels, cargo vessels and tankers that currently operate within the Moray Firth were tracked every day. It can be assumed that a significant proportion of these vessels were equipped with (and utilising) dynamic positioning capabilities that utilise ducted propellers. An even larger proportion would have had some type of ducted propellers and have been travelling at low speeds or were maintaining position.

7.3.7.36 Based on previous stranding data (Thompson *et al*., 2010), breeding females are seen as being at the greatest risk due to the numbers of females being found with injuries potentially caused by ducted propellers. Although the construction port has yet to be identified for the three proposed wind farm sites, much of the vessel movement will be offshore and within pre-defined vessel corridors. The greatest use of ducted propellers for dynamic positioning is likely to be within the construction area, over 55 km (30 nm[7]) away from haul-out sites within the inner Firth (including the harbour seal SAC). Within the wind farm construction sites, the construction associated noise would act as a self-mitigating deterrent, with the noise encouraging seals to keep away from the area and therefore reducing opportunities for harm.

7.3.7.37 Considering the uncertainty of the potential for injury, the knowledge that local seal populations are recovering (refer to Chapter 4.4: Marine Mammals) and the small additional incremental risk when considered in the context of existing regional activities, the effect of ducted propellers is considered to be uncertain and of low magnitude, medium duration and therefore **minor significance**.

Reduction in Foraging Ability (Increased Suspended Sediment)

7.3.7.38 Increases in turbidity (suspended sediment) as a result of construction activities could affect foraging or social interactions of marine mammals. Chapter 6.2 (Sedimentary and Coastal Processes) considers the effect construction of the three proposed wind farms (Telford, MacColl and Stevenson) will have on local sedimentary processes. Increased suspended sediment concentration is predicted to be of minor significance to mobile fish species (Chapter 7.2: Fish and Shellfish Ecology) and therefore the secondary effects to marine mammals are also considered to be unlikely, of low magnitude, short duration (at a local level) and of **negligible significance**.

Operation

7.3.7.39 The primary effects during the operational phase of the three proposed wind farms will potentially be:

- Displacement or disturbance due to turbine operating noise;
- Habitat loss due presence of turbines;
- Collision risk from maintenance vessels;
- Disturbance from electromagnetic fields produced by inter-array cables; and
- Toxic contamination of prey from sacrificial anodes and antifouling paints.

7.3.7.40 For more details on the predicted effects to marine mammals during operation, see sections of Technical Appendix 7.3 A (Impact Assessment). Publicly available information was reviewed with respect to the potential effects that operational wind farms may have on marine mammals. SPEAR modelling was also conducted to enable an assessment for effects of operating noise on marine mammals.

Displacement or Disturbance due to Turbine Operating Noise

7.3.7.41 Any behavioural reactions that may occur will do so in the immediate vicinity of the foundations. Harbour porpoise have relatively poor hearing in the frequency ranges recorded to date from wind turbines (Tougaard *et al.,* 2009), while seals have better hearing in these frequencies. A review of publicly available information highlighted that the potential effects of turbine operating noise on marine mammals are uncertain. Taking into account published data and the output of SPEAR modelling which predicts a 75 dB_{ht} radii of less than 1 m from the turbine foundation (see

[7] This distance of 30 nm is advised as being of low risk for cork screw injuries in the recently released SNCA internal 'Guidance for staff advising on the potential risk of seal corkscrew injuries April 2012' document.

Section 5.1 of Technical Appendix 7.3 A), any effects are considered to be of a very local nature. It is also predicted that marine mammals will quickly habituate to the presence of turbines in the water and that there will be sufficient distance between turbines to allow movement between foundations (see Technical Appendix 7.3 A for more details). The effects of turbine presence on behaviour are therefore predicted to be of low magnitude for all species, only affecting those in very close proximity to the turbines, of long term duration and **minor significance**.

Habitat Loss

7.3.7.42 The direct effects of habitat loss on fish species is discussed in detail in Chapter 7.2 (Fish and shellfish Ecology). In general, the effects on fish species were predicted to be minor to moderate. Effects on sandeels, a common marine mammal prey species, are predicted to be low. As a result, the indirect effects of habitat loss (leading to a reduction in available prey species) upon marine mammals are considered to be of low magnitude, of long term duration and therefore **minor significance.**

Collision Risk from Maintenance Vessels

7.3.7.43 Given the predicted level of additional vessel traffic will be small compared to existing levels of traffic passing through the Moray Firth (see Technical Appendix 7.3 A, Section 5.3.3 for detailed assessment), the effect of increased vessel traffic during the operational phase on marine mammals is considered to be of low (negligible) magnitude, long duration and **minor significance**.

Electromagnetic Fields

7.3.7.44 A review of publicly available information (see Section 5.4 of Technical Appendix 7.3 A for details) highlighted that the potential effects of electromagnetic fields generated by inter-array cabling on marine mammals is uncertain and suggests effects would be unlikely. As a result, potential effects are considered to be of low magnitude, long term duration for all species and of **minor significance**.

Toxic Contamination

7.3.7.45 Leaching of compounds (in particular heavy metals) from sacrificial anodes or antifouling paints has the potential to contaminate marine mammals and their food supply. Given that such systems are likely to be present on most (if not all) shipping vessels already present within the Moray Firth and taking into account the tidal regime around the proposed sites (see Chapter 6.1: Hydrodynamics – Wave Climate and Tidal Regime), it is not considered there will be any detectable increase in metal concentrations within the Moray Firth should these systems be applied. As a result, effects on marine mammals are considered to be unlikely and of **minor significance**.

Decommissioning

7.3.7.46 The preliminary decommissioning programme has not yet been finalised and will be dependent on the choice of turbine structure. As a consequence, a detailed assessment is not possible at this stage. The decommissioning of an offshore wind farm may involve the use of cutting tools and / or other methodologies yet to be identified.

7.3.7.47 Current cutting techniques include mechanical and abrasive cutting, both of which would generate noise near the turbine foundation. No data are available at this time on noise levels produced by cutting mechanisms underwater, but it would be expected to be substantially lower than noise levels created during the construction phase, in particular from piling. There may also be disturbance from vessels associated with the decommissioning but as with the construction phase; the associated effects are considered to be of low magnitude. The duration and phasing of any decommissioning is also unknown at this stage, but it is assumed for the purposes of this assessment that it would be of medium duration and of **minor significance** to the marine mammals within the Moray Firth at the time.

Meteorological Mast

7.3.7.48 Based on SPEAR modelling results for a 4.5 m pile, it was concluded that the effect of such a pile taken in isolation would be predicted as being of a major significance for a short duration (days) and of **negligible significance** to the population in the long term. Given the level of construction that will be occurring simultaneously to the installation of this second met-mast, it is considered that the effects of this single construction activity will be masked and therefore indistinguishable from activities occurring around it (see Section 4.2.3.4 of Technical Appendix 7.3 A for full discussion).

7.3.8 Proposed Monitoring and Mitigation

7.3.8.1 The information below summarises potential mitigation and management measures which are proposed to be applied during the different stages of the three proposed wind farms.

Construction

7.3.8.2 The primary effect on marine mammals during the construction phase of the three proposed wind farm developments is predicted to be from piling noise. MORL is working with The Crown Estate and other developers to investigate and develop best practice mitigation measures to reduce either the level of noise at the source or noise propagation. These investigations have shown that while such mitigation measures (such as bubble curtains and piling sleeves) have been relatively successful in the low-tidal regimes of the German waters in depths of 8.5 m, they are either unviable in deeper, tidal conditions of the Moray Firth (bubble curtains) or at the concept design or early prototype testing stage for deeper water (piling sleeves and other designs), and thus not commercially viable for large scale deployment at present.

7.3.8.3 Existing Joint Nature Conservation Committee (JNCC) guidelines require the presence of a marine mammal observer prior to piling commencing and the instigation of a "soft start" procedure once piling starts. Typically this involves a 30 minute visual watch being conducted prior to all piling operations along with a 30 minute acoustic survey. If a marine mammal is observed (visually or acoustically) within 500 m of the piling vessel during this period, piling is delayed until the animal has moved away from the area (outside of the 500 m buffer) or has not been sighted for 20 minutes.

7.3.8.4 Recent developments in passive acoustic monitoring technology promises to improve the potential to detect cetaceans in low light or poor weather conditions. Similarly, more effective acoustic deterrents are being developed to exclude seals from potential impact areas. It is anticipated that these developments may lead to more effective mitigation procedures within the life-time of this project. The use of alternative approaches will be investigated prior to construction commencing and their use decided upon after consultation with regulatory bodies.

7.3.8.5 Typical response distances from pile driving activity range from 10 m for lethal injury (240 dB) and 60 m for non-auditory physical injury (220 dB) for marine mammal species (see Chapter 3.6: Underwater Noise). Given the small radii predicted to cause physical injury to marine mammals, mitigation will focus on ensuring that marine mammals are outside a 500 m buffer zone to reduce such impacts. Once piling begins, the power will be ramped up in stages thus giving the majority of marine mammals outside of this area the opportunity to move away from the area prior to the piling hammer reaching full power (and maximum noise generation).

7.3.8.6 The soft start procedure will involve the ramping up of power over a 20 minute period until the hammer reaches optimal force. This procedure has already been factored into the noise propagation models discussed in Chapter 3.6 (Underwater Noise) and utilised within the assessment presented here. Therefore residual effects after the consideration of these mitigation measures have already been included in the impact assessment.

7.3.8.7 The risk to marine mammals of collision with construction vessels is predicted to be negligible and of low significance. Although mitigation is not considered a necessity, the designation of a navigational route for construction vessel traffic will aid marine mammals to predict vessel movement and reduce potential effects.

Pre-Construction

7.3.8.8 MORL intends to install a met mast on a 4.5 m monopile foundation within the Stevenson site over a two week period in 2012, and will take the opportunity to participate in surveys designed to refine and validate some of the assumptions detailed above in Table 7.3-11. These surveys are summarised below.

7.3.8.9 MORL also recognise that the robust baseline data available to themselves and BOWL for the undertaking of the impact assessment described above utilises data sources funded through a variety of studies and initiatives. These studies, and the funding bodies responsible for them, are identified within Section 4.2.2.5 of Technical Appendix 7.3 A and summarised below.

7.3.8.10 **Bottlenose dolphins** - Annual photo-identification surveys have provided information on changes in bottlenose dolphin abundance since 1990. Initiated as a collaboration between Aberdeen University and SMRU, this project has since involved a wide range of regional and international partners.

7.3.8.11 These surveys have allowed individual dolphins to be monitored for over 20 years, providing information on reproductive rates, survival and movement patterns between the Moray Firth and other parts of their range, including the Firth of Forth.

7.3.8.12 Since 2005, these studies have been complemented by passive acoustic monitoring, providing fine-scale data on changes in the occurrence of both dolphins and harbour porpoises at a series of core-sites within and outside the Moray Firth.

7.3.8.13 **Harbour seals -** Since 1987, annual counts have been made at harbour seal haul-out sites during both the pupping season and moult, providing detailed information on trends in abundance and changes in distribution. The first 20 years of this time-series were based upon land-based surveys, carried out by Aberdeen University. Since 2006, annual data have been collected through aerial survey as part of SMRUs national seal monitoring programme.

7.3.8.14 Following the development of a new pupping site in Loch Fleet NNR, photo-identification studies of individually recognisable harbour seals were initiated in 2005. Detailed annual surveys have now monitored the reproductive success and survival of over 60 different females. Information on variation in the timing of pupping, lactation duration and pup survival provide important indicators of environmental changes that would be impossible to collect at most other sites in the world.

7.3.8.15 In some years, this information is complemented by tracking data on foraging distribution. New developments in GPS tag technology mean this work can be built upon with increasingly high resolution data. For example: to assess individual responses to construction noise. Such tracking data will be especially valuable because they can be integrated with information on these individual's previous reproductive history and subsequent survival.

7.3.8.16 Maintaining this survey effort through the pre-construction, construction and post construction phases (2012 to 2020) would enable robust assessment of the population consequences of the construction phases of both the MORL and BOWL offshore wind farm projects on bottlenose dolphins and harbour seals. However, the above datasets represent a huge survey effort and cost, and it is not considered appropriate that this maintenance of survey effort should fall to any one Developer or funding body. MORL are currently exploring the potential for developing such studies in collaboration with other Developers, Government and other funding bodies.

7.3.8.17 Through the studies identified above, MORL would seek to inform the population parameters made within the existing framework used for modelling the construction effects upon marine mammals within the Moray Firth (Technical Appendix 7.3 B) and refine the assumptions detailed in Table 7.3-11 above.

Operation

7.3.8.18 The risk to marine mammals of collision with operational and maintenance vessels is predicted to be negligible and of low significance. Although mitigation is not considered a necessity, the designation of a navigational route for construction vessel traffic will aid marine mammals to predict vessel movement and reduce potential effects.

Decommissioning

7.3.8.19 The preliminary decommissioning programme has not yet been finalised and will be dependent on the choice of turbine structure, therefore mitigation plans are not possible at this stage. The most likely scenario would involve the use of cutting equipment and is predicted to be of low significance to marine mammals. Once the decommissioning programme has been decided upon, a review of mitigation requirements will be undertaken and instigated as required based on the best available procedures at the time.

7.3.9 Residual Effects – Primary Impact Assessment

7.3.9.1 Much of the mitigation and management measures described above are standard procedure for such developments. For example: the use of a soft start procedure has already been incorporated into the noise modelling. The marine mammal observer/ PAM mitigation (and subsequent soft start) is designed to ensure that no marine mammals are within a certain radius of the piling event thus reducing the potential for physical injury.

7.3.9.2 The use of designated navigational routes, although primarily a management tool, will also help reduce risks to marine mammals from collision and is therefore an indirect form of mitigation. This has already been incorporated into impact assessments presented here and therefore included in residual effects.

7.3.10 Secondary Assessment: Individual Wind Farm Sites

7.3.10.1 The previous assessments have highlighted that the greatest potential effects on marine mammals during the construction of an offshore wind farm is through increased noise levels associated with piling. In order to provide an assessment of each of the three proposed wind farms individually, the noise modelling described previously was repeated based on piling occurring within each of the three proposed sites independently. Details of the model scenarios performed can be found in Table 7.3-12 below.

Table 7.3-12 Details of the Scenarios Used for Predicting the Effects of Piling Noise on Marine Mammals from Individual Wind Farm Sites. For the Location of Modelled Piling Locations, refer to Figure 01 in Technical Appendix 7.3 F.

Scenario 1	Two piling vessels on MacColl, piling 2.5 m piles at locations 1 and 2 for two years (2016 to 2017)
Scenario 2	Two piling vessels on Stevenson, piling 2.5 m piles at locations 4 and 6 for two years (2016 to 2017)
Scenario 3	Two piling vessels on Telford, piling 2.5 m piles at locations 3a and 5a for two years (2016 to 2017)

7.3.10.2 Further details of this assessment can be found in Section 4.2.3.3 of Technical Report 7.3 A with visual outputs from this modelling in Technical Appendix 7.3 F. Locations for representative piling locations were chosen to be closest to the sensitive receptors (harbour seals and bottlenose dolphins). Table 7.3-13 below provides the number of each species that is predicted to be either displaced, or have the potential to experience the onset of PTS, per year of the construction phase of each scenario. As before, the modelling assumes that displaced animals will not return to favoured habitat in between piling events and so are displaced for the full construction phase.

Table 7.3-13 Predicted Number of Individuals and Proportion of Modelled Baseline Population Affected by Piling Noise in Year One of Construction for each of the Three Proposed Sites if Constructed at Separate Times

	Scenario 1: MacColl		Scenario 2: Stevenson		Scenario 3: Telford	
	Number	%	Number	%	Number	%
Harbour Seal						
PTS: 186 dB	180	15.2	172	14.5	175	14.8
Behavioural Displacement: High	806	68.1	707	59.8	691	58.4
Behavioural Displacement: Best Fit	602	50.9	514	43.5	511	43.2
Behavioural Displacement: Low	57	4.8	52	4.4	55	4.7
Grey Seal						
PTS: 186 dB	269	8.5	243	7.7	263	8.3
Behavioural Displacement: High	1,463	40.7	1,313	36.5	1,438	40
Behavioural Displacement: Best Fit	988	27.5	865	24.1	991	27.5
Behavioural Displacement: Low	72	2	55	1.5	70	2
Harbour Porpoise						
PTS: 198 dB	10	0.2	8.9	0.2	9	0.2
Behavioural Displacement: High	4,537	74.7	5,131	83.9	4,098	67
Behavioural Displacement: Best Fit	3,452	56.4	4,171	68.2	3,007	49.2
Behavioural Displacement: Low	357	5.8	545	8.9	305	5
Bottlenose Dolphin						
PTS: 198 dB	0.08	< 0.1	0.06	< 0.1	0.06	< 0.1
Behavioural Displacement: High	34	17.5	25	12.7	23	11.7
Behavioural Displacement: Best Fit	20	10.1	14	7.2	13	6.6
Behavioural Displacement: Low	1	0.3	0	0.2	0	0.2
Minke Whale						
PTS: 198 dB	8.9	0.6	9.6	0.7	9.2	0.6
Behavioural Displacement: High	218	14.9	208	14.2	209	14.3
Behavioural Displacement: Best Fit	185	12.7	171	11.7	174	11.9
Behavioural Displacement: Low	27	1.8	22	1.5	24	1.6

7.3.10.3 The table above illustrates that the effects upon individual marine mammal species associated with the development of each site in isolation are similar, and thus that the potential effects from piling activities within each site are considered of equal magnitude and so significance to each other.

7.3.10.4 As above, population modelling was conducted for the harbour seal and bottlenose dolphin populations to explore the potential population level effects of the predicted potential PTS onset and displacement numbers. Details of this methodology can be found in Section 4.2.2 of Technical Appendix 7.3 A and Technical Appendix 7.3 C (Seal Assessment Framework). The results of this modelling can be found in Plates 7.3-6 and 7.3-7 below, and show the potential effects at population levels from two years of piling on each of the three sites are not distinguishable from each other.

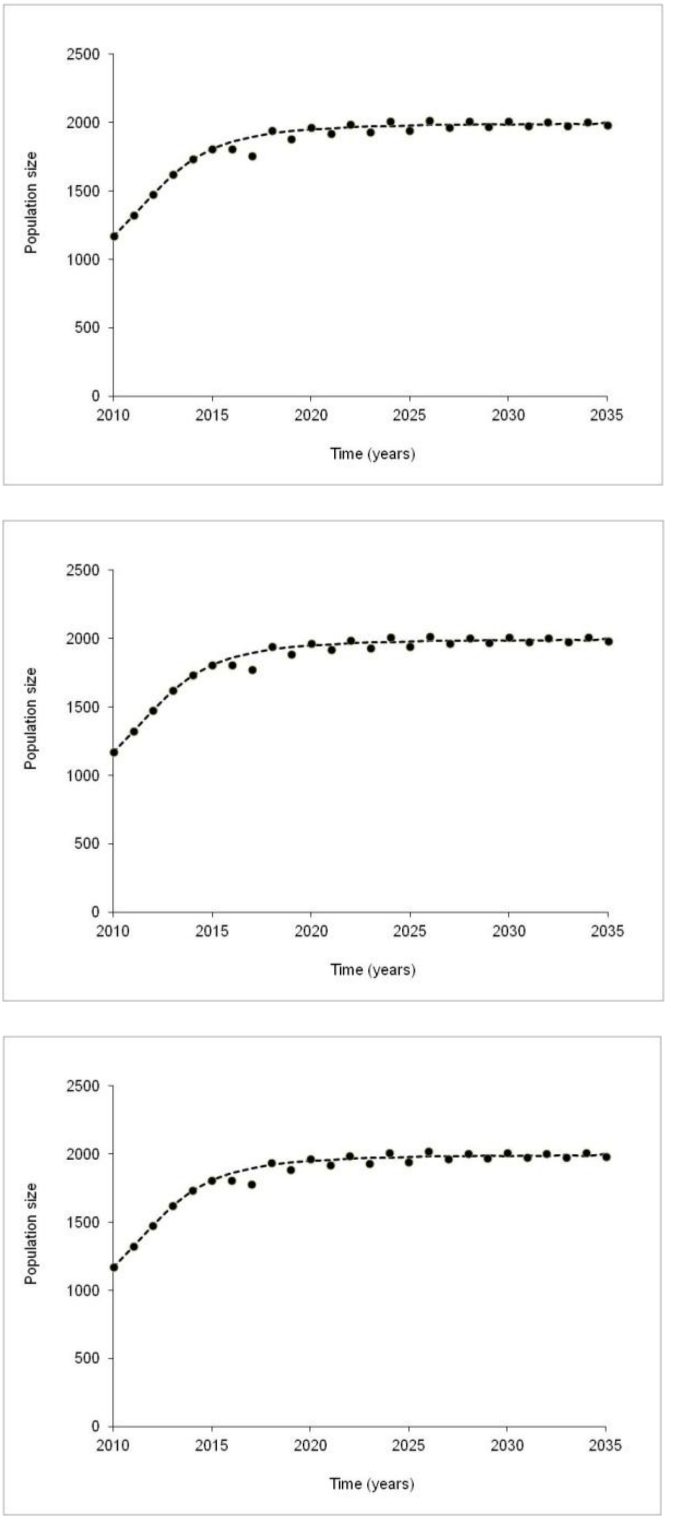

Plate 7.3-6 Modelling for the Harbour Seal Population in the Moray Firth. Data Based on 186 dB SAFESIMM Model Outputs and Conservative Relationship between Perceived Noise and Displacement. From top to bottom: Scenario 1 (MacColl), 2 (Stevenson) and 3 (Telford).

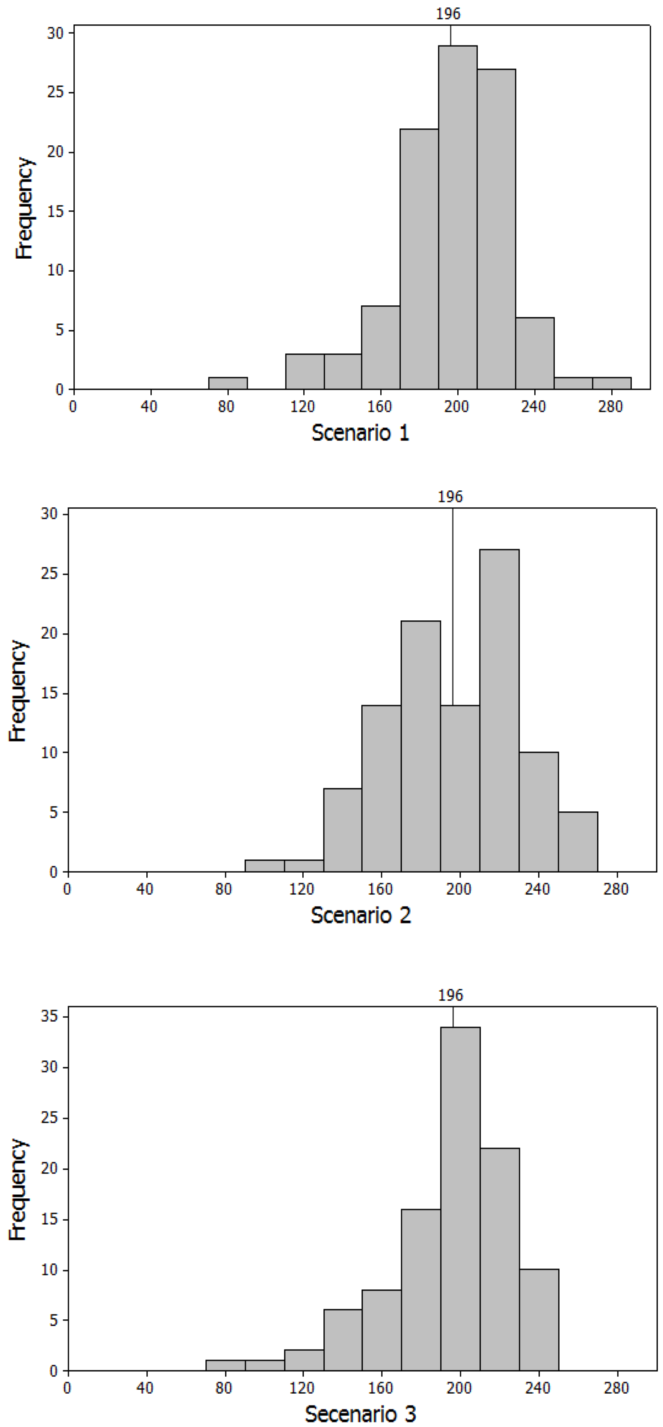

Plate 7.3-7 Population Modelling for the Bottlenose Dolphin Population in the Moray Firth. Data Based on 198 dB SAFESIMM Model Outputs and Conservative Relationship between Perceived Noise and Displacement. From top to bottom: Predicted Population Size in 2035 after Construction Scenarios 1 (MacColl), 2 (Stevenson) and 3 (Telford). Current Population is Estimated to be 196 Individuals (see Chapter 4.4: Marine Mammals for details).

7.3.10.5 As above, this modelling indicates that there will be medium term high significance of effect for harbour seal and bottlenose populations (high magnitude, medium duration). However, these effects are (a) not long term and (b) not significantly different from each other with regards to site specific characterisation.

7.3.10.6 In summary, it can be seen from the maps presented in Technical Appendix 7.3 F that the dB_{ht} contours for both harbour seals are similar for all three scenarios. This is also true when considering the dB_{ht} contours for bottlenose dolphins, as also shown in Technical Appendix 7.3 F. Table 7.3-13 above provides similar figures for displacement and potential onset of PTS across all three scenarios. Thus the effect of each site is considered to be of long term low magnitude (predicted population size within 10 % of that predicted as a baseline if population parameters to not change within the Moray Firth) and so **minor significance** in the long term for both harbour seals and bottlenose dolphins.

7.3.10.7 This lack of difference is also apparent in the effect upon grey seals, harbour porpoises and minke whales, although population modelling has not been undertaken for these species. A summary of the predicted potential effects from piling noise based on this framework and results can be found in Table 7.3-14. Details of the assessment are provided within Section 4.2.3.3 of Technical Appendix 7.3 A.

Table 7.3-14 Secondary Assessment Summary

	MacColl	Stevenson	Telford
Harbour Seal			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.
Grey Seal			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.
Harbour Porpoise			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.
Bottlenose Dolphin			
Predicted Effect	Medium significance over medium term for individuals during construction phase, with minor significance for long term effects on the population level.	Medium significance over medium term for individuals during construction phase, with minor significance for long term effects on the population level.	Medium significance over medium term for individuals during construction phase, with minor significance for long term effects on the population level.
Minke Whale			
Predicted Effect	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.	Major significance over medium term for individuals during construction phase with minor significance long term effects on the population.

7.3.11 Sensitivity Assessment

7.3.11.1 As described above, a sensitivity assessment for piling noise has been undertaken as to the relative effects upon the marine mammals of the Moray Firth of different combinations of the individual sites. Modelling of impacts from piling related noise in site specific locations has shown there to be little to differentiate between the development of the three proposed wind farm sites.

7.3.11.2 Other construction related activities (e.g. vessel noise, suction dredging, cable laying, rock placement and trenching) are considered to have localised effects which will not extend outside of the wind farm boundaries. Marine traffic from construction and local ports will utilise defined, common corridors when transiting to each of the three sites and, therefore, will not present an increased sensitivity over the other two. Therefore, there are no changes in the assessments for each permutation of the three proposed wind farms.

7.3.12 Proposed Monitoring and Mitigation: Secondary Assessment

7.3.12.1 All mitigation procedures will be as described for the primary assessment.

7.3.13 Residual Effects: Secondary

7.3.13.1 Residual effects will be as described for the primary assessment. If all the assumptions detailed in Table 7.3-11 are confirmed, the assessments presented above are assessed as likely significant effects.

7.3.14 Habitats Regulations Appraisal

7.3.14.1 As part of the Habitats Regulations, the likely significant effects from the Project on SACs will be assessed by the competent authority through consideration of each SAC's conservation objectives (see Technical Appendix 7.3 G). The two SACs under consideration in this assessment are the Moray Firth SAC (qualifying feature: bottlenose dolphin) and the Dornoch Firth and Morrich More SAC (qualifying feature: harbour seal).

7.3.14.2 The assessment is based on whether the following will occur due to the development of the three proposed wind farm sites:

1. Changes in the distribution or extent of the habitats supporting the species;
2. Changes in the structure, function and supporting processes of habitats supporting the species;
3. Significant disturbance to the qualifying species;
4. Changes in the distribution of the species within the site; and
5. The species being maintained as a viable component of the site in the long term, and therefore the integrity of the site.

7.3.14.3 Terminology used is based on that suggested by the Intergovernmental Panel on Climate Change (IPCC). Definitions provided by the IPCC for levels of confidence in an assessment can be found in Technical Appendix 7.3 G. As part of the EIA for designated sites and to provide information to the competent authority, the following tables summarises the effects the proposed developments are predicted to have on Moray Firth (Table 7.3-15) and Dornoch Firth SACs (Table 7.3-16) in respect each of the five criteria listed above.

7.3.14.4 As detailed in the impact assessment above, the risk to designated species through construction activities such as risk of:

- Collision with vessels and ducted propellers;
- Long term avoidance resulting from operation and maintenance activity;
- Secondary effects associated with changes to prey availability;
- Risk of stranding associated with electromagnetic field (EMF) emissions; and
- Impacts of non-toxic and toxic contamination.

7.3.14.5 These are predicted to be of minor or negligible significance to harbour seal and bottlenose dolphin. These effects are therefore not considered further within this HRA, and the HRA concentrates upon potential impacts from piling activities.

Table 7.3-15 Assessment of the Moray Firth SAC per Conservation Objectives. Confidence Levels Based on Conservative Assumptions Proposed in Seal Framework Assessment (Technical Appendix 7.3 B) and Detailed in Table 7.3-11 above, in Addition to Desk Top Comparison of Behavioural Responses by Harbour Porpoise and Bottlenose Dolphins to Noise (Technical Appendix 7.3 D).

Criterion	Assessment
1: Change in Habitat Distribution	The footprint of the proposed wind farms do not overlap with the Moray Firth SAC. Bottlenose dolphins are primarily encountered within the coastal regions and are not expected to occur within the wind farm area. Chapter 7.1 predicts negligible to minor impacts on benthic habitats within the footprints of the Telford, Stevenson and MacColl farms. Taking into account predictions made in this ES and the fact that the SAC does not fall within the boundaries of the proposed developments, changes to habitat distribution as a result of construction activities are considered to be exceptionally unlikely and **not significant** on the Moray Firth SAC. **Confidence level: very high.**
2: Change in Habitat Structure	Chapter 7.2 predicts minor effects for the impacts of piling noise or habitat loss from gravity foundations on fish species from the proposed MORL developments. Taking into account predictions made in this ES and the fact that the SAC does not fall within the boundaries of the proposed developments, changes to habitat structure are considered to be exceptionally unlikely and **not significant** on the Moray Firth SAC. **Confidence level: very high.**
3: Significant Disturbance to Species	The primary disturbance to bottlenose dolphins from the proposed developments is increased noise from piling during the construction phase. This disturbance has the potential to cause partial displacement from habitats currently frequented by bottlenose dolphins within the Moray Firth. Levels of displacement predicted by the most precautionary models presented above and in Technical Appendix 7.3 A suggest that for all scenarios investigated for the construction of MacCall, Stevenson and Telford wind farms, less than 12 % of dolphins present in the Moray Firth will suffer behavioural displacement (based on the model of best fit) and 19 % for the most precautionary fit. Noise propagation models (see Technical Appendix 7.3 F) suggest that sound levels from piling at parts of the southern Moray Firth (which is commonly used by bottlenose dolphins) will be approximately 70 dB_{ht}. Using the noise dose response curve from harbour propose behaviour described above and in detailed within Technical Appendix 7.3 A as a proxy for bottlenose dolphin, 70 dB_{ht} equates to between 20 % (best fit) and 40 % (conservative fit) displacement . Noise levels in the inner Moray Firth will be even lower. As described in Technical Appendix 7.3 D, analysis of available data indicates higher level responses by harbour porpoises than bottlenose dolphins to similar noise levels. Thus, using harbour porpoise as a proxy for bottlenose dolphin is likely to produce an overestimation of associated effect upon the bottlenose dolphin population. The modelling presented in Technical Appendix 7.3 A and summarised above assumes piling will occur consistently across the construction period. In practice there will be gaps in piling operations, either from operational constraints (i.e. when re-positioning vessels) or during periods of bad weather, thus providing periods without the risk of disturbance. Taking all of this into account, it is considered that any disturbance from piling noise on the bottlenose dolphin population will be likely but temporary in nature (i.e. only for the duration of the piling activities) and of **minor significance** in the long term. **Confidence level: high**

Criterion	Assessment
4: Change in Species Distribution	Many of the foraging areas used by the bottlenose dolphin population occur outside of the boundaries of the SAC and research has confirmed that individuals regularly leave the Moray Firth and spend time in other areas along the eastern coast (see Technical Appendix 9.4 A: Marine Mammals). Noise propagation and impact modelling presented in Technical Appendix 7.3 A, along with the comparison of behavioural responses by harbour porpoises and bottlenose dolphin to noise presented in Technical Appendix 7.3 D, suggests that while noise levels in coastal waters from piling activities within the three proposed wind farm sites are predicted to elicit a response, and may lead to low levels of displacement, they will not prevent movement by bottlenose dolphins along the southern coast of the Moray Firth. It is therefore considered that changes in species distribution are unlikely and if they were to occur, would be temporary in nature (i.e. only for the duration of piling activities). The overall impact of piling noise on species distribution is considered to be of **minor significance** in the long term. **Confidence level: high**
5: Species Maintained as Viable Component	The population modelling described in Technical Appendix 7.3 A predicts the abundance of bottlenose dolphins within the Moray Firth over a 25 year period, including years of presumed disturbance. Outputs from the most precautionary models for the scenario in which most noise is generated[8], indicate that the final distribution of population sizes is similar to baseline scenarios, even with a period of disturbance. Therefore it is predicted that the long term viability of the bottlenose dolphin population will not be affected by construction activities and the potential effects from piling noise on the population as a viable component of the SAC are unlikely and of **minor significance**. **Confidence level: high**

Table 7.3-16 Assessment of the Dornoch Firth and Morrich More SAC per Conservation Objectives. Confidence Levels Based on Conservative Assumptions Proposed Seal Framework Assessment (Technical Appendix 7.3 B) and detailed in Table 7.3-11.

Criterion	Assessment
1: Change in Habitat Distribution	Chapter 7.1 predicts negligible to minor impacts on benthic habitats within the footprints of the proposed Telford, Stevenson and MacColl wind farms. The footprint of the three proposed wind farms do not overlap with the SAC, but do represent part of the harbour seal foraging range. Taking into account predictions made in this ES, changes to habitat distribution (either within the SAC or in preferred foraging areas within the Moray Firth) as a result of piling activities are considered to be unlikely and **not significant** for the Dornoch Firth and Morrich More SAC. **Confidence level: high.**
2: Change in Habitat Structure	Chapter 7.2 predicts minor effects for the cumulative impacts of piling noise or habitat loss from gravity foundations on fish species from the proposed MORL developments. The footprint of the proposed wind farms do not overlap with the SAC but do represent part of the harbour seal foraging range. Taking into account predictions made in this ES, changes to habitat structure as a result of piling noise (either within the SAC or in preferred foraging areas within the Moray Firth) are considered to be unlikely and **not significant** for harbour seal. **Confidence level: high.**
3: Significant Disturbance to Species	The primary disturbance to harbour seals from the proposed developments is considered to be increased noise from piling during the construction phase. This disturbance has the potential to cause displacement from habitats currently frequented by harbour seals within the Moray Firth. Noise propagation modelling suggests that noise levels from piling will be low in the inner Moray Firth and the Dornoch Firth and Morrich More SAC. Given the distance between the proposed

[8] Model C: six piling vessels working simultaneously over a two year period; two vessels within each of the proposed MORL sites (Telford, Stevenson and MacColl).

Criterion	Assessment
3: Significant Disturbance to Species (continued)	developments and haul-out sites within the SAC (> 50 km), disturbance to seals hauled-out are considered to be unlikely. As shown in Chapter 4.4, the footprint of the proposed wind farms represents part of the harbour seal foraging range and it is here that the greatest level of disturbance has the potential to occur. Modelling presented in Technical Appendix 7.3 A, and summarised above, predict that between 44 to 66 % of the population may be displaced as a result of piling noise based on the models of best fit. This proportion rises to 62 to 72 % if the most precautionary data fit from the porpoise noise dose response curve is used. The modelling presented in Technical Appendix 7.3 A assumes piling will occur consistently across the construction period. In practice it is expected there will be gaps in piling operations, either from operational constraints (i.e. when re-positioning vessels) or during periods of bad weather, which will provide periods during which seals can forage within the wind farms footprints. Modelling the proportion of the population to be excluded for the full duration of the construction period therefore represents a very precautionary approach. It is considered that some harbour seals from this population are likely to experience major significant disturbance while foraging during the piling operations. This impact is not expected to extend for prolonged periods once piling temporarily ceases. The effects of this disturbance are considered to be temporary (i.e. the duration of piling activities) and of **minor significance** to the population long term. **Confidence level: high**.
4: Change in Species Distribution	Annual haul-out surveys over the last 25 years have demonstrated that there have been natural changes in the distribution of harbour seals at different haul-out sites across the Moray Firth (Thompson *et al.*, 1996), including changes in the relative importance of sites within the SAC (Cordes *et al.*, 2011) . Tagging studies have also shown that foraging areas for harbour seals from Moray Firth haul-out sites are not within the boundaries of the SAC (Cordes *et al.*, 2011). The footprint of the proposed wind farms covers part of the harbour seals' potential foraging area (Smith Bank), and the most precautionary models presented in Technical Appendix 7.3 A predict that between 62 to 72 % of the population may be displaced as a result of piling noise. The duration of this displacement is unknown, but it is expected to be temporary by scientific experts, and forthcoming data from DECC funded studies in the Wash can be used to test these assumptions. Displaced seals are likely to use alternative foraging areas within the Moray Firth where there are lower levels of disturbance. This would represent a potential temporary change in their distribution within the waters of the Moray Firth. As seen during periods of natural changes in prey availability, these changes may also lead to temporary changes in the use of different Moray Firth haul-out sites (Thompson *et al.*, 1996). Given the distance between the proposed developments and haul-out sites within the SAC (> 50 km), it is considered unlikely that haul-out sites will be directly disturbed from piling noise and therefore changes in haul-out distribution as a direct result of piling noise are considered unlikely, although indirect changes linked with changes in foraging patterns may occur. Population modelling (described in Technical Appendices 7.3 A, 7.3 B and summarised in above) suggests while population levels may decrease during the construction period, the population is predicted to recover once construction is completed. Taking all of this into account, it is suggested that changes in distribution of harbour seals associated with piling noise within the Moray Firth are likely but temporary in nature (i.e. duration of piling activities) and of **minor significance**. **Confidence level: high**
5: Species Maintained as Viable Component of SAC	The population modelling described in Technical Appendix 7.3 A, and summarised above, predicts the abundance of harbour seals within the Moray Firth for each year over a 25 year period, including those years in which disturbance is predicted to occur. These projections indicate that population levels will decrease by less than 10 %, even for the most precautionary models and the scenario in which disturbance is greatest[9]. All scenarios suggest that the population will recover quickly over subsequent years, and there will be no long term difference between impact and baseline scenarios. It is predicted that the long term viability of the harbour seal population will not be affected by construction activities, and potential effects from piling noise on the population as a viable component of the SAC are unlikely and of **minor significance** in the long term. **Confidence level: high**

[9] Model C: six piling vessels working simultaneously over a two year period; two vessels within each of the proposed MORL sites (Telford, Stevenson and MacColl).

7.3.15 References

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7.4 Ornithology

7.4.1 Summary of Effects and Mitigation

7.4.1.1 This chapter presents an assessment of the likely significant effects of the construction, operation and decommissioning of the three proposed wind farm sites on ornithological receptors. The short–listed ornithological receptors for EIA were pink–footed goose, greylag goose, fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, and puffin. Short–listing was undertaken based on numbers of species recorded on the site (see Technical Appendix 4.5 A).

7.4.1.2 Information supporting this assessment has been collected from desk–based studies and contemporary surveys (2009 to 2012) as explained in Chapter 4.5 (Ornithology).

Summary of Effects

7.4.1.3 The effects on ornithology receptors that were assessed for the three proposed wind farm sites include:

- Disturbance caused by increased vessel traffic, especially during construction and decommissioning, but also during the operation phase;
- Displacement caused by the presence of the turbines, including indirect effects due to changes in prey availability associated with presence of turbines;
- Collision with turbines whilst in flight; and
- Barrier effects caused by turbines, resulting in changes to flight routes (e.g. to feeding areas or on migration).

Proposed Mitigation Measures and Residual Effects

7.4.1.4 Primary mitigation includes best–practice in terms of setting standard wind farm vessel corridors in order to minimise any potential disturbance. Operational monitoring requirements will be agreed with regulators and Statutory Nature Conservation Agencies (SNCAs).

7.4.1.5 A summary of the effects is provided in Table 7.4-1 below.

Table 7.4-1 Impact Assessment Summary

Effect	Receptor	Pre–Mitigation Effect	Mitigation	Post–Mitigation Effect
Construction / Decommissioning				
Disturbance	Pink–footed goose	Disturbance (direct and indirect) – no risk (certain) **No significant effect predicted**	None	**Not significant**
	Greylag goose	Disturbance (direct and indirect) – no risk (certain) **No significant effect predicted**	None	**Not significant**
	Fulmar	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**

CHAPTER 7.4

Effect	Receptor	Pre–Mitigation Effect	Mitigation	Post–Mitigation Effect
Disturbance (Continued)	Gannet	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**
	Kittiwake	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**
	Herring gull	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**
	Great black–backed gull	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**
	Guillemot	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**
	Razorbill	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**
	Puffin	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary) **No significant effect predicted**	Wind farm vessel corridors	**Not significant**
Operation				
Disturbance / Displacement **Collision Risk** **Barrier Effects**	Pink–footed goose	Disturbance / displacement (direct and indirect) – no risk (certain) Collision – minor risk (probable; medium–term, temporary) Barrier effects – minor risk (probable; medium–term, temporary) **No significant effect predicted**	None	**Not significant**
	Greylag goose	Disturbance / displacement (direct and indirect) – no risk (certain) Collision – minor risk (probable; medium–term, temporary) Barrier effects – minor risk (probable; medium–term, temporary) **No significant effect predicted**	None	**Not significant**

Effect	Receptor	Pre–Mitigation Effect	Mitigation	Post–Mitigation Effect
Disturbance / Displacement **Collision Risk** **Barrier Effects** **(continued)**	Fulmar	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – negligible risk (certain; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – < 0.1 % increase in likelihood of 10 % population reduction).	Wind farm vessel corridors	**Not significant**
	Gannet	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – moderate risk (probable; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – < 5 % increase in likelihood of 20 % population reduction).	Wind farm vessel corridors	**Not significant**
	Kittiwake	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – minor risk (probable; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – < 1 % increase in likelihood of 10 % population reduction).	Wind farm vessel corridors	**Not significant**
	Herring gull	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – moderate risk (probable; medium–term, temporary). Barrier effects – negligible risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – 10 % increase in likelihood of 10 % population reduction).	Wind farm vessel corridors	**Not significant**
	Great black–backed gull	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – minor risk (certain; medium–term, temporary). Barrier effects – negligible risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – < 1 % increase in likelihood of 10 % population reduction).	Wind farm vessel corridors	**Not significant**

Effect	Receptor	Pre–Mitigation Effect	Mitigation	Post–Mitigation Effect
	Guillemot	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – negligible risk (certain). Barrier effects – minor risk (certain; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – < 0.1 % increase in likelihood of 10 % population reduction).	Wind farm vessel corridors	**Not significant**
	Razorbill	Disturbance / displacement (direct and indirect) – minor risk (probable; medium–term, temporary). Collision – negligible risk (certain). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – < 0.1 % increase in likelihood of 10 % population reduction).	Wind farm vessel corridors	**Not significant**
	Puffin	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – negligible risk (certain). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis – < 0.1 % increase in likelihood of 10 % population reduction).	Wind farm vessel corridors	**Not significant**

7.4.2 Introduction

7.4.2.1 This chapter addresses the likely significant effects associated with the Telford, Stevenson and MacColl wind farms on ornithological receptors. The data collected during the baseline studies, along with available information on the effects of existing offshore wind farms, have been used to identify and evaluate these likely significant effects.

7.4.2.2 The following technical reports support this chapter:

- Technical Appendix 4.5 A (Ornithology Baseline and Impact Assessment);
- Technical Appendix 4.5 B (Aerial Ornithology Surveys for the Moray Firth Zone, Summer 2011); and
- Technical Appendix 4.5 C (Seabird Tracking and Modelling Report).

7.4.2.3 The ornithology assessment interacts with assessments for the following receptors and where relevant linkages have been made within the assessment:

- Chapters 4.2 and 7.1 (Benthic Ecology); and
- Chapters 4.3 and 7.2 (Fish and Shellfish Ecology).

7.4.2.4 Full details of the Rochdale Envelope for the three proposed wind farm sites are provided in Chapter 2.2 (Project Description). The key components of the Project design for this ornithological impact assessment are the:

- Number of turbines proposed;
- Turbine design in terms of blade length, maximum blade height, and rotor speed;
- Extent of the array and proposed layout;
- Duration and timing of construction / decommissioning activity;
- Project lifespan; and
- Operation and maintenance (O&M) strategy.

7.4.3 Rochdale Envelope Parameters Considered in the Assessment

7.4.3.1 The Rochdale Envelope parameters that have been considered in this assessment vary with the effect being assessed; these are summarised in Table 7.4-2 below.

Table 7.4-2 Rochdale Envelope Parameter Relevant to the Ornithology Impact Assessment

Potential Effect	Rochdale Envelope Scenario Assessed
Construction & Decommissioning	
Disturbance	The area of the three proposed wind farms as shown in Figure 1.1-2, Volume 6 b. As recommended by JNCC / SNH the disturbance analysis is based on the area of the three proposed wind farms rather than an approach based on the number of turbines. The analysis includes O&M traffic (vessels and helicopters)
Operation	
Disturbance / Displacement including Indirect Effects on Fish Species by O&M Traffic (vessels and helicopters).	A site extent as shown in Figure 1.1-2, Volume 6 b. As recommended by JNCC / SNH the disturbance / displacement analysis is based on the area of the three proposed wind farms rather than an approach based on the number of turbines. The analysis includes O&M traffic (vessels and helicopters)
Collision Risk	Site 1: 139 x 3.6 MW turbines (130 m rotor diameter, 4.2 m maximum blade width, and maximum rotation speed of 13.36 rpm). Site 2: 72 x 7 MW turbines (172 m rotor diameter, 5.8 m maximum blade width, and maximum rotation speed of 12.8 rpm). Site 3: 72 x 7 MW turbines (172 m rotor diameter, 5.8 m maximum blade width, and maximum rotation speed of 12.8 rpm). The above is based on assessing all turbine scenarios in the collision risk model to identify the worst–case scenario. Note that this does not represent the maximum potential number of turbines on the sites as impact is related to both rotor size and turbine number.
Barrier Effects	A site extent as shown in Figure 4.5-1, Volume 6 b.

7.4.3.2 Sites 1, 2 and 3 represent the order of construction for the three proposed wind farms. It is not known which of Telford, Stevenson or MacColl will be built first.

7.4.4 EIA Methodology

7.4.4.1 The impact assessment process used for ornithology is that recommended by IEEM (Institute of Ecology and Environmental Management) for marine and coastal developments (IEEM, 2010), whilst also using some further definitions provided by a review of potential biodiversity effects of offshore wind farm developments (Wilhelmsson *et al*., 2010). Further details are provided in Technical Appendix 4.5 A.

7.4.4.2 The basis of this assessment process is the following steps (some relevant definitions are provided in Table 7.4-3):

- Identification of the activities associated with the development of the three sites that may result in effects on ornithological receptors;
- Identification of potential ornithological receptors / designated sites;
- Identification of likely significant effects on ornithological receptors / designated sites, during the construction, operation and decommissioning stages of the development;
- Description of development activity in terms of whether the effect is likely to be positive or negative, along with its magnitude, extent, duration, reversibility, timing and frequency;
- Characterisation of effect, including the risk / likelihood of its occurrence;
- Assessment of whether the likely (pre–mitigation) effects are ecologically significant and the geographical scale at which they are predicted to occur, including an indication of certainty in the predictions made;
- Provision of details of proposed mitigation (if applicable);
- Assessment of whether the residual (with mitigation) effects are ecologically significant and the geographical scale at which they are predicted to occur, including an indication of certainty in the predictions made; and
- Assessment of cumulative effects (with mitigation) reported in Chapter 14.4 (Ornithology).

Table 7.4-3 Definition of Terms

Term	Definition
Magnitude	The size of the effect, e.g. the number of individuals predicted to be affected.
Extent	The area over which the effect is predicted to occur.
Duration	The period of time over which the effect is predicted to occur: short–term for those which occur for up to 1 year (e.g. within the construction phase); medium–term lasting for up to 5 years (e.g. due to habituation); long term for those lasting for the whole operational phase, and permanent for those that are predicted to still be detectable after decommissioning (Wilhelmsson *et al.,* 2010).
Reversibility	Whether the effect is predicted to be reversed, either through natural processes or mitigation.
Timing	The period of the year during which the activity would need to occur in order for the effect to occur.
Frequency	The frequency of the activity leading to the effect.
Risk	The likelihood that a particular effect will occur.

7.4.4.3 Ecological significance, in the context of the EIA Regulations, is used to describe the relative importance of a potential effect on a feature of importance. An ecologically significant effect is an effect that has an effect on the integrity of the site or ecosystem.

7.4.4.4 The geographic scale at which the ecological significance of an effect operates is defined as:

- International – ornithological receptors subject to the potential effect are features of European–designated sites, i.e. SPAs (Special Protection Areas) or RAMSAR sites;
- National – ornithological receptors subject to the potential effect are features of UK–designated sites, i.e. SSSIs (Sites of Special Scientific Interest), UK BAP (Biodiversity Action Plan) species;
- Regional – ornithological receptors subject to the potential effect are of regional (Moray Firth) importance; and
- Local – ornithological receptors subject to the potential effect are of local (site) importance.

7.4.4.5 Certainty in predictions will use the following criteria (based on IEEM Guidance probabilities, with further justification of definitions):

- Certain (probability estimated at > 95 %) – interactions are well understood and documented, i.e. receptor sensitivity has been investigated in relation to the potential impact, data have a comprehensive spatial coverage / resolution, and predictions relating to effect magnitude have been modelled and / or quantified;
- Probable (probability estimated at 50 to 95 %) – interactions are understood using some documented evidence, i.e. receptor sensitivity is derived from sources that consider the likely effects, data have a relatively moderate spatial coverage / resolution, and predictions relating to effect magnitude have been modelled but not validated; and
- Uncertain (probability estimated at < 50 %) – interactions are poorly understood and not documented, i.e. predictions relating to effect magnitude have not been modelled and are based on expert interpretation using little or no quantitative data.

7.4.4.6 The species to be considered for the impact assessment have been determined based on the likelihood of the potential risks occurring. The definitions for the threat levels are as follows:

- Negligible – threat will have no effect on the species;
- Minor – threat will have a small but acceptable threat on the species;
- Moderate – threat will affect the species to the extent that some mitigation may be necessary; and
- Major –threat will have an unacceptable effect on the species.

7.4.5 *Habitats Regulations Appraisal Methods*

7.4.5.1 As part of the Conservation (Natural Habitats &c) Regulations 1994 as amended (Habitats Regulations), the likely significant effects on Special Protected Areas (SPAs) have been assessed through consideration of each site's conservation objectives (Table 7.4-16 to 7.4-35), and whether there will be an effect on the integrity of the site. Site integrity is defined, with particular reference to sites protected by the Habitats Directive (Council Directive 92/43/EEC), in Scottish Government guidance (Scottish Executive, 2000):

"as the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and / or the levels of populations of the species for which it was classified".

7.4.5.2 In terms of the Habitats Regulations, the conservation objectives for the SPA sites are:

- To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained; and
- To ensure for the qualifying species that the following are maintained in the long term:
  - Population of the species as a viable component of the site;
  - Distribution of the species within site;
  - Distribution and extent of habitats supporting the species;
  - Structure, function and supporting processes of habitats supporting the species; and
  - No significant disturbance of the species.

7.4.5.3 Therefore, an assessment has been made on whether the following will occur due to the development of the three proposed wind farm sites:

- Changes in the distribution or extent of the habitats supporting the species;
- Changes in the structure, function and supporting processes of habitats supporting the species;
- Significant disturbance to the qualifying species;
- Changes in the distribution of the species within the sites; and
- The species being maintained as a viable component of the sites in the long term, and therefore the integrity of the sites.

7.4.6 *Key Potential Risks to Ornithological Sensitive Receptors*

Disturbance

7.4.6.1 Disturbance effects could operate by deterring ornithological receptors from using suitable or preferred habitat. During construction disturbance has the potential to arise as a result of the presence of vessels and construction works.

7.4.6.2 Different species show differing sensitivities to disturbance. Assessment of birds' sensitivity to disturbance was based upon: the number of each species on the three proposed wind farm sites, the estimated proportion of the colony–population within the sites, their estimated sensitivities to vessel presence (Garthe & Huppop 2004), whether their distribution over the wider area was highly localised or widespread, their reliance on specific habitat types, and any known rates of habituation. This displacement effect was then assessed using the analyses provided below.

7.4.6.3 The direct effects of construction noise on birds have been removed from this assessment through consultation with JNCC / SNH. There is also the potential for disturbance effects to continue into the operation phase due to operation / maintenance activities.

Collision Risk

7.4.6.4 There is the potential for birds flying through the wind farms to collide with the rotating turbines, which would then be predicted to result in mortality (Drewitt & Langston, 2006). The risk of a bird colliding with a turbine depends on several factors:

- The height of the turbines, area of air swept by the rotors, the speed of the rotating blades, and the overall number of turbines;
- Effects from specific developments are influenced further by the suite of species that occur on or pass through the sites: the number of birds of each species flying through the risk zone can be predicted by the number observed flying through the sites at the relevant heights during baseline surveys, but also the avoidance behaviour of the species is key to determine the true effect; and
- The probability that a bird flying through the rotor–swept area will be at risk also varies dependent on flight speed and bird size (length and wingspan).

7.4.6.5 Assessment of collision risk follows protocols set out by Band (2011) in a revised model produced specifically for offshore wind farms, based on the original model designed by SNH (2000).

7.4.6.6 A key component of collision risk modelling is the inclusion of a parameter to describe avoidance behaviour. Different species are expected to avoid wind farms to differing degrees (Pendlebury 1996, Cook *et al*., 2011), and this avoidance behaviour can be described as either:

- Avoidance of the wind farm completely (macro–avoidance); or
- Avoidance of an individual turbine (micro–avoidance).

7.4.6.7 Total avoidance behaviour is therefore made up of a combination of these two avoidance rates:

Total Avoidance = 1 – [(1 – macro–avoidance) x (1 – micro–avoidance)];
E.g. 99.5 % = 1 – [(1–90 %) x (1–95 %)

7.4.6.8 An avoidance rate of 98 % was recommended by JNCC / SNH as a precautionary starting point for seabirds and whooper swan; a rate of 99 % was recommended for geese. Reviews of avoidance rates for seabirds have been undertaken by the British Trust for Ornithology (BTO) (Cook *et al*., 2011 and Maclean *et al*., 2009). Of the recommendations made by MacLean et al., 2009 for total avoidance rates the relevant species for the Moray Firth sites are 99.5 % avoidance for gulls and gannet.

7.4.6.9 Collating data from studies at other developments has allowed for species–specific or group–specific avoidance rates to be estimated.

7.4.6.10 A radar study of pink–footed geese has been undertaken off the Lincolnshire coast for the Lynn and Inner Dowsing Offshore Wind Farms, between 2007 and 2010 (Plonczkier pers. comm.). During the study 979 skeins were detected, of which 43,249 in 630 skeins were identified as pink–footed geese. No geese were recorded colliding with turbines. The proportion of geese flying through the turbine arrays has changed through the study, with 48 % recorded in 2007 (pre / during construction), 26 % in 2008, 38 % in 2009, and 19 % in 2010 (latter three years were post–construction). This implies that there has been macro–avoidance of the turbine arrays by geese (note that the estimates do not include micro–avoidance so are a conservative estimate of overall avoidance).

7.4.6.11 A radar study in Denmark was used to record flight–lines of migrating geese / ducks through Nysted Offshore Wind Farm. No collisions were detected despite the site being within a major migration route (Kahlert *et al*., 2004), and over 99 % of birds were found to make detours around the site (Desholm & Kahlert, 2005).

7.4.6.12 Studies carried out using radar in Swedish waters between 1999 and 2003 tracked over 1.5 million wildfowl flight tracks, noting only one collision. All other birds avoided the turbines, even in conditions of low light or poor visibility (Pettersen, 2005).

7.4.6.13 A post–construction study at the Egmond aan Zee, off the Netherlands was undertaken in 2007 to 2009, using visual observations and radar to estimate macro and micro–avoidance rates (Krijgsveld *et al*., 2011). Comparing the observed proportion of flights within the wind farm with the expected proportion, reductions of birds recorded within the wind farm for gannet, small gulls and large gulls were 88 %, 56 % and 24 %, respectively. A measure of macro–avoidance can be obtained by using the deflection rates (where a bird flying towards the wind farm changes direction away from it): 89 % for gannet, and 40 % for gulls. A combination of visual and radar studies were also used to estimate a generic micro–avoidance rate of 97.6 %. Combining the macro and micro–avoidance rates this gives total avoidance rate estimates for gannet and gulls of 99.7 % and 98.6 %, respectively.

7.4.6.14 A calculation of gull micro–avoidance rates for six onshore wind farm sites in Belgium (Everaert & Kuijken 2007), following the process used by Pendlebury (2006), gives mean rates of 97.7 % and 98.5 %, for large and small gulls respectively. Further details of this are provided in Section 2.1.5 of Technical Appendix 4.5 A.

7.4.6.15 A calculation of large gull micro–avoidance rate, also following the process used by Pendlebury (2006), was undertaken for the Blyth Harbour wind farm by Dewar (2011). This analysis was based on a study undertaken 1991 and 2001. The macro–avoidance rate calculated for large gulls was 99.1 %.

7.4.6.16 The above avoidance rates are summarised in Table 7.4-4 below. The total avoidance rate estimate of 99.7 % for gannet is based on the Egmond aan Zee study. The mean micro–avoidance estimate given for large gulls from the Dutch studies (97.7 %) is similar to the generic estimate from Egmond aan Zee (97.6 %), meaning the total avoidance rate estimates are the same (98.6 %). For small gulls, using the mean micro–avoidance rate from the Dutch studies (98.5 %) and the macro–avoidance rate from Egmond aan Zee (40 %), gives a total avoidance rate estimate of 99.0 %.

Table 7.4-4 Summary of Avoidance Rates from JNCC / SNH and BTO Reviews

Species	JNCC / SNH Current Guidance	MacLean *et al.*, 2009	Summary of Mean Avoidance Rates		
			Macro	Micro	Combined
Gannet	98 %	99.5 %	89 %	97.6 %	99.7 %
Large Gulls	98 %	99.5 %	40 %	97.7 %	98.6 %
Small Gulls	98 %	99.5 %	40 %	98.5 %	99.0 %

7.4.6.17 Based on these data, total (combined) appropriate rates to use would therefore be 99.5 % for gannet, 98.5 % for large gulls (herring and great black–backed gull), and 99 % for small gulls (kittiwake).

7.4.6.18 Since the turbines will have lighting there is a potential that nocturnal–migrating species may be attracted towards the structures. There is no evidence either way for this to occur. In terms of the key species that collision risk analysis has been undertaken for, this factor will not be relevant since they are active only infrequently during the night. Passerines are the most likely species group for which this risk is a potential issue, but given that all these species tend to migrate on a broad migration front (Technical Appendix 4.5 A), this is unlikely to be a significant effect.

Displacement

7.4.6.19 Displacement affects bird populations by denying them access to a habitat on a long term basis, as a result of the presence of the turbine structures having an impact on prey distribution / abundance (indirect effects). A summary (based on Chapter 7.2: Fish and Shellfish Ecology) is provided in Table 7.4-5 below. The effect that displacement has on a population depends on the species' dependence on specific habitats and the availability of viable alternatives to the area from which the birds have been displaced. Short–listing species of birds sensitive to displacement was based upon the same criteria used to shortlist birds susceptible to disturbance (see paragraph 7.4.6.2 above). Further details are provided in Technical Appendix 4.5 A.

Table 7.4-5 Summary of Potential for Effects on Prey Species

Prey Species	Relevant Bird Species	Construction and Decommissioning	Operation
Fish (including Plaice, Salmon, Sea Trout, Cod, Whiting, Herring, Glass Eels, Elasmobranchs, River Lamprey, Sea Lamprey, European Eel)	Fulmar, gannet, herring gull, great black–backed gull	Minor (probable)	Minor (probable)
Shellfish (including Edible Crab, King Scallops, Nephrops)	Fulmar, herring gull, great black–backed gull	Minor (probable)	Minor (probable)
Sandeels	Shag, Arctic skua, great skua, kittiwake, Arctic tern, guillemot, razorbill, puffin	Minor (probable)	Minor (probable)

7.4.6.20 Studies of bird displacement by offshore wind farms by Kahlert *et al*., (2004) and Cristensen (2004) have not shown any conclusive results regarding displacement, but showed no significant effects as a result of disturbance. Studies of Egmond aan Zee Offshore Wind Farm off Netherlands have found that auks did not show a marked avoidance (Lindeboom *et al*., 2011).

7.4.6.21 A recent analysis of data from Robin Rigg Offshore Wind Farm in the Solway Firth, comparing five pre–construction years with the construction year and one post–construction year, has estimated displacement rates of 50 % for gannet, 10 % for gulls, and 30 % for auks (Shenton & Walls, 2011). These rates are considered to be precautionary estimates of displacement due to this being based on the first year after construction only, so therefore does not include any habituation over time.

Barrier Effects

7.4.6.22 Barrier effects may arise when birds incur extra energetic costs as a result of avoiding a wind farm. Species passing through an area infrequently, such as birds traversing the sites as part of a longer biannual migration flight, would incur much less impact than a species breeding near the development that needed to avoid it on a daily basis as part of its foraging routine. Effects upon birds simply passing through an area will be negligible (although possibly contributing to cumulative effects where other barriers exist on a migration route), whereas those making frequent flights across the sites may do so to the detriment of their condition, or reproductive success. Speakman (2009) predicted that a deviation of 30 km for a migrating bird would use < 2 % of a bird's fat reserves. Birds regularly crossing an area to forage will incur greater energetic costs, with 15 km extra per day equating to an increase in energy demands of 4.8 to 6.0 %.

7.4.6.23 As well as the regularity of flights across the three proposed wind farm sites, the efficiency of the species flight has been taken into account based on the review undertaken by Masden (2010). Birds employing a fast flapping flight will expend more energy than those species that glide. Also, those with high body mass in relation to a small wing area will expend more energy than others.

7.4.6.24 Short–listing species for barrier effect considerations was based upon: the number of each species recorded on the sites, the likelihood of locally breeding individuals foraging on the sites (based on maximum mean foraging ranges, from BirdLife and a recent review by Thaxter *et al*., [2012), the frequency of foraging flights made by each species (from Masden 2010), the efficiency of each species flight and wing loading, and known macro–avoidance rates (from Cook *et al*., 2011).

7.4.7 Primary Impact Assessment: Three Proposed Wind Farm Sites

7.4.7.1 A list of the relevant ornithological receptors for consideration in the impact assessment, along with their legislative statuses, is provided in Table 7.4-6 below. This shortlist of species for inclusion in the impact assessment has been determined based on numbers recorded meeting either a threshold of an on–the–sea density of 3 km^2, or > 40 individuals recorded in flight at potential collision height. A list of the designated sites that will be assessed within this chapter is provided in Table 4.1-1 of Chapter 4.1 (Designated Sites).

Table 7.4-6 Summary of Legislative Statuses for Relevant Ornithological Receptors

Species	Legislative status	Distribution	Importance
Pink–Footed Goose	SPA feature	Winters in UK, with large concentrations in several areas including north east Scotland	International
Greylag Goose	SPA feature	Winters in UK, with majority wintering in western Scotland and Orkney.	International
Fulmar	SPA feature	Common and widespread UK breeder, except around south east coast.	International
Gannet	SPA feature	Breeds in large colonies around UK, most numerous in Scotland.	International
Kittiwake	SPA feature	Common and widespread UK breeder, particularly around north eastern areas.	International
Herring Gull	SPA feature	Common and widespread breeder around UK, though less abundant around south east coast.	International
Great Black–Backed Gull	SPA feature	Common breeder around north and west Scotland, less common elsewhere and largely absent from south east coast.	International
Guillemot	SPA feature	Common and widespread UK breeder, except around south east coast.	International
Razorbill	SPA feature	Locally common, widespread UK breeder, except around south west coast.	International
Puffin	SPA feature	Locally common breeder around Scotland, less common elsewhere and not breeding around south east coast.	International

Displacement / Disturbance

7.4.7.2 Two analyses were undertaken for relevant seabird species (geese were excluded given displacement / disturbance from the site will be nill): one using parameters currently recommended by JNCC / SNH (worst–case scenario; WCS); and another using parameters considered to be precautionary but realistic, based on information collated for Technical Appendix 4.5 A (realistic scenario; RS). The analysis, which is summarised in Table 7.4-7 below, used the following approach:

- The mean breeding season population estimates (the period when distributions are most constrained) of birds using the sea for the three proposed wind farm sites combined were used, and divided between the three most local SPAs (East Caithness Cliffs SPA, North Caithness Cliffs SPA, and Troup, Pennan and Lion's Heads SPA) according to the findings of the flight direction analyses (the latter using a precautionary approach since flights to all three SPAs sum to > 100 %: see Section 3.1.5 in Technical Appendix 4.5 A);
- The proportion of the bird population that is breeding was estimated (50 %) based on guidance from JNCC / SNH;
- Displacement rates were applied to these using: the higher rates from JNCC / SNH guidance (Table 4.5-2 in Chapter 4.5: Ornithology) for the WCS model; or realistic scenario (RS) rates from the Robin Rigg Offshore Wind Farm analysis (Shenton & Walls, 2011 – 50 % for gannet, 10 % for gulls, and 30 % for auks (all but

the latter within the rates recommended by JNCC / SNH prior to release of the Robin Rigg analysis). The figures for disturbance take into account indirect effects resulting from effects on fish species;

- Failure rates (the proportion of birds predicted to have failed breeding attempts as a result of displacement / disturbance) were then applied. These were 100 % in both the 'WCS' and 'RS' scenarios for all species, apart from fulmar and gannet which were modelled with failure rates of 50 % under the 'RS' scenario due to the greater spatial flexibility afforded to them by their larger foraging range (see Table 4.5-3 in Chapter 4.5: Ornithology); and
- The percentage of the number affected compared to the most recent population estimate (see Table 2 in Technical Appendix 4.5 A) for each relevant SPA was then calculated. Significance of these numbers was assessed through reference to population viability analysis (see below).

Table 7.4-7 Numbers of Displaced or Disturbed Birds from Relevant SPAs

Species	Approach	Total	East Caithness Cliffs	North Caithness Cliffs	Troup, Pennan and Lion's Heads
Fulmar			14,202 bp.	14,168 bp.	1,795 bp.
	WCS	391	352 (1.2 %)	98 (0.3 %)	98 (2.7 %)
	RS	97	88 (0.3 %)	24 (0.1 %)	24 (0.7 %)
Gannet	SPA population		Not a feature	Not a feature	1,547bp.
	WCS	50	N / A	N / A	50 (1.6 %)
	RS	13	N / A	N / A	13 (0.4 %)
Kittiwake	SPA population		40,410 bp.	10,147 bp.	17,171 bp.
	WCS	491	368 (0.5 %)	147 (0.7 %)	123 (0.4 %)
	RS	98	74 (0.1 %)	29 (0.1 %)	25 (0.1 %)
Herring Gull	SPA population		6,786 ind.	Not a feature	3,374 ind.
	WCS	3	1 (0 %)	N / A	1 (0 %)
	RS	0	0 (0 %)	N / A	0 (0 %)
Great Black–Backed Gull	SPA population		180 bp.	Not a feature	Not a feature
	WCS	17	34 (9.44 %)	N / A	N / A
	RS	4	7 (1.9 %)	N / A	N / A
Guillemot	SPA population		158,985 ind.	70,584 ind.	17,598 ind.
	WCS	3,513	2,020 (1.3 %)	1,683 (1.2 %)	168 (1.0 %)
	RS	1,683	1,010 (0.6 %)	842 (0.6 %)	84 (0.5 %)

Species	Approach	Total	East Caithness Cliffs	North Caithness Cliffs	Troup, Pennan and Lion's Heads
Razorbill	SPA population		17,830 ind.	2,463 ind.	3,001 ind.
	WCS	899	623 (3.5 %)	332 (13.5 %)	42 (1.4 %)
	RS	415	311 (1.7 %)	166 (6.7 %)	21 (0.7 %)
Puffin	SPA population		274 bp.	7,405 bp.	Not a listed feature
	WCS	958	240 (43.7 %)	814 (5.8 %)	N / A
	RS	479	120 (21.9 %)	407 (2.9 %)	N / A

Key: bp – breeding pairs; ind – individuals. Due to the precautionary approach of the flight direction analysis (the proportion flying to the three SPAs combined is > 100 %), summing the estimates of numbers displaced from the three individual SPAs will be greater than the total displacement estimate for the three SPAs combined.

Collision Risk Analysis

7.4.7.3 In order to assess collisions, the number of birds flying through the area at potential collision height (PCH) must be assessed. The numbers of birds flying in the area are calculated using densities of birds recorded in the air (from boat–based survey data) or by scaling up numbers recorded from vantage point observations to cover the spring and autumn migration periods. These numbers are then multiplied by the proportion observed flying at PCH. Collision risk analysis was not undertaken for fulmar, guillemot, razorbill or puffin due to numbers flying at PCH being very low.

7.4.7.4 These numbers then feed into the revised Band (2011) model that takes into account the dimensions and flight speeds of the birds, as well as structural aspects of the turbines such as blade length, turbine number, and the maximum revolution speed (see Table 7.4-2 above). Avoidance rates for each species or group of species (using those based on the literature and those recommended by JNCC / SNH) are also taken into account. Outputs of the analyses are summarised below in Tables 7.4-8 and 7.4-9. For geese / swans, a flight was judged as ‘probably’ flying through the proposed wind farm sites if extrapolation of the linear flight direction from the coastal vantage point intersected with one of the sites. A flight was judged as ‘possibly’ flying through the proposed wind farm sites if this extrapolated flight route was within 2 km of one of the sites. Significance of these numbers was assessed through reference to population viability analysis (see below).

Table 7.4-8 Annual Collisions Predicted for Relevant Species with Sufficient Data, using a Range of Avoidance Rates

Avoidance	99.50 %			99.0 %	98.5 %	98.0 %
Species	**Breeding Season**	**Non–Breeding Season**	**Total**	**Total**	**Total**	**Total**
Gannet	31	26	57	113	170	227
Kittiwake	27	10	37	75	112	150
Herring Gull	5	47	52	104	156	208
Great Black–Backed Gull	9	26	35	70	105	139

Table 7.4-9 Estimates of Annual Swans / Geese Collisions, Based on Migration Surveys

	Predicted Annual Mortality		
Species	**Possible**	**Probable**	**Total**
Whooper Swan	0.0	0.1	0.1
Pink–Footed Goose	4.3	15.5	19.8
Greylag Goose	0.2	2.6	2.8
Barnacle Goose	0.1	0.0	0.1

Population Viability Analysis

7.4.7.5 Population viability analysis (PVA) was undertaken to assess the effects of displacement / disturbance and collision risk. PVAs assess the capability of a population to cope with a reduction in numbers or productivity, by modelling various demographic parameters (for details on parameters used, please see Section 2.1.9 in Technical Appendix 4.5 A). Outputs of the analyses are summarised in Table 7.4-10 below. PVAs for geese and swans were not undertaken, as it was agreed with JNCC / SNH that the effects were minor.

7.4.7.6 An effect has been assessed as minor if there is a < 10 % increase in the likelihood of a 10 % population reduction. An effect has been assessed as moderate if there is a > 10 % increase in the likelihood of a 10 % population reduction, but a < 5 % increase in the likelihood of a 20 % population reduction. An effect has been assessed as moderate–high if there is > 5 % increase in the likelihood of a 20 % population reduction, but a < 2 % increase in the likelihood of a 50 % population reduction.

Table 7.4-10 Results of Population Viability Analysis – Increase in Likelihood (%) of Population Reduction

SPA	**Model**	**% Reduction from Baseline**		
		50 %	**20 %**	**10 %**
Fulmar				
East Caithness Cliffs	Displacement (RA)	0.2 %	0.1 %	0.0 %
North Caithness Cliffs	Displacement (RA)	0.1 %	0.1 %	0.0 %
Troup, Pennan and Lion's Heads	Displacement (RA)	0.5 %	0.3 %	0.0 %
Gannet				
Troup, Pennan and Lion's Heads	Displacement (RA)	0.0 %	0.0 %	0.0 %
	Collision (99.5 %)	0.0 %	3.7 %	43.5 %
	Displacement + collision	0.0 %	4.38 %	47.14 %

SPA	Model	% Reduction from Baseline		
		50 %	20 %	10 %
Kittiwake				
East Caithness Cliffs	Displacement (RA)	0.1 %	0.0 %	0.1 %
	Collision (98 %)	2.4 %	1.0 %	0.4 %
	Displacement + collision	2.6 %	1.2 %	0.4 %
North Caithness Cliffs	Displacement (RA)	0.2 %	0.1 %	0.1 %
	Collision (98 %)	4.1 %	1.6 %	0.5 %
	Displacement + collision	4.3 %	1.8 %	0.6 %
Troup, Pennan and Lion's Heads	Displacement (RA)	0.0 %	0.0 %	0.1 %
	Collision (98 %)	1.9 %	0.9 %	0.3 %
	Displacement + collision	1.9 %	0.9 %	0.5 %
Herring Gull				
East Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %
	Collision (98 %)	0.4 %	5.1 %	5.4 %
	Displacement + collision	0.6 %	5.9 %	5.1 %
Troup, Pennan and Lion's Heads	Displacement (RA)	0.0 %	0.0 %	0.0 %
	Collision (98 %)	1.3 %	10.8 %	9.9 %
	Displacement + collision	1.2 %	11.0 %	10.5 %
Great Black–Backed Gull				
East Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %
	Collision (98 %)	0.0 %	0.0 %	0.4 %
	Displacement + collision	0.0 %	0.0 %	0.9 %
Guillemot				
East Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %
North Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %
Troup, Pennan and Lion's Heads	Displacement (RA)	0.0 %	0.0 %	0.0 %

SPA	Model	% Reduction from Baseline		
		50 %	20 %	10 %
Razorbill				
East Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %
North Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %
Troup, Pennan and Lion's Heads	Displacement (RA)	0.0 %	0.0 %	0.0 %
Puffin				
East Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %
North Caithness Cliffs	Displacement (RA)	0.0 %	0.0 %	0.0 %

Baseline Conditions and Primary Impact Assessments

Operation

7.4.7.7 A summary of each relevant ornithological receptor, based on Chapter 4.5 (Ornithology) and the above analysis for the primary impact assessments, is provided in Table 7.4-11 below. Full details are provided in the Species Accounts in Sections 4 and 5 of Technical Appendix 4.5 A.

Table 7.4-11 Summary of Baseline Conditions and Primary Impact Assessments of Relevant Ornithological Receptors

Species	Summary
Pink–Footed Goose	**Seasonality**: present in the region between mid–September and mid–May. **Distribution**: migrants through the sites. **Migration estimate**: 23,907 annually. **Displacement / disturbance risk estimate**: no effect. **Collision risk estimate**: up to 19.8 per year (99 % avoidance rate); minor effect. **Barrier effects summary**: minor effect.
Greylag Goose	**Seasonality**: present in the region between mid–September and mid–May. **Distribution**: migrants through the sites. **Migration estimate**: 3,255 annually. **Displacement / disturbance risk estimate**: no effect. **Collision risk estimate**: up to 2.8 per year (99 % avoidance rate); minor effect. **Barrier effects summary**: minor effect.

Species	Summary
Fulmar	**Seasonality**: present all months; highest numbers in spring. **Distribution**: throughout the three sites; highest densities in Stevenson, south–west corner of MacColl, and adjacent buffer zone; site within area of medium density of breeding SPA individuals (University of Plymouth models, Technical Appendix 4.5 C); 95.9 % of individuals recorded in wider Moray Firth aerial survey area were outwith the proposed wind farm sites (Technical Appendix 4.5 B). **Mean monthly site estimates**: 782 in breeding season; 197 in non–breeding season. **Displacement / disturbance risk estimate**: mean of 97 birds during the breeding season; minor effect (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: negligible effect (low % flights at risk height). **Barrier effects summary**: minor effect.
Gannet	**Seasonality**: present all months; highest numbers in spring. **Distribution**: throughout the three sites; highest densities in western MacColl, south–west Stevenson, and adjacent buffer zone. **Mean monthly site estimates**: 100 in breeding season; 23 in non–breeding season. **Displacement / disturbance risk estimate**: mean of 13 birds during the breeding season; minor effect (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: 31 and 26 collisions predicted (using 99.5 % avoidance) during breeding and non–breeding seasons respectively; moderate effect (based on PVA analysis; < 5 % increase in the likelihood of a 20 % population reduction). **Barrier effects summary**: minor effect.
Kittiwake	**Seasonality**: peak in summer; present in small numbers during winter. **Distribution**: throughout the three sites; highest densities in the buffer zone west of Stevenson, central Telford, and western MacColl – matching sandeel distribution (see Figure 4.3-13, Volume 6 b); site within area of low–medium density of breeding SPA individuals (University of Plymouth models, Technical Appendix 4.5 C); 97.4 % of individuals recorded in wider Moray Firth aerial survey area were outwith the proposed wind farm sites (Technical Appendix 4.5 B). **Mean monthly site estimates**: 1,963 in breeding season; 261 in non–breeding season **Displacement / disturbance risk estimate**: mean of 98 birds during the breeding season; minor effect (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: 75 to 150 total collisions predicted annually, using 99 % and 98 % avoidance rates respectively; minor effect (based on PVA analysis; < 1 % increase in likelihood of 10 % population reduction at 98 to 99 % avoidance rates). **Barrier effects summary**: minor effect.
Herring Gull	**Seasonality**: present in all months; increase in numbers during winter. **Distribution**: similar densities throughout the three sites. **Mean monthly site estimates**: 7 in the breeding season; 41 in the non–breeding season. **Displacement / disturbance risk estimate**: minor effect (low numbers present; based on PVA population predictions; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: 156 to 208 total collisions predicted annually, using 98.5 % and 98.0 % avoidance rates respectively; moderate effect (based on PVA analysis; < 10 % increase in likelihood of 10 % population reduction at 98 % avoidance rate). **Barrier effects summary**: negligible effect.

Species	Summary
Great Black–Backed Gull	**Seasonality**: present in all months. **Distribution**: similar densities throughout the three sites. **Mean monthly site estimates**: 271 in breeding season; 106 in non–breeding season. **Displacement / disturbance risk estimate**: mean of 14 birds during the breeding season; minor effect (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: 105 to 139 total collisions predicted annually, using 98.5 % and 98.0 % avoidance rates respectively; minor effect (based on PVA analysis; < 1 % increase in likelihood of 10 % population reduction at 98 % avoidance rate). **Barrier effects summary**: negligible effect.
Guillemot	**Seasonality**: present in all months with peaks in early summer. **Distribution**: throughout the three sites; highest densities in western Stevenson and MacColl and adjacent buffer zone, and central Telford – matching sandeel distribution (Figure 4.3-13, Volume 6 b); site within area of low density of breeding SPA individuals (University of Plymouth models, Technical Appendix 4.5 C); 90.2 % of individuals recorded in wider Moray Firth aerial survey area were outwith the proposed wind farm sites (Technical Appendix 4.5 B). **Mean monthly site estimates**: 6,732 in breeding season; 990 in non–breeding season. **Displacement / disturbance risk estimate**: mean of 1,683 birds during the breeding season; minor effect (based on PVA population predictions; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: negligible effect (low % flights at risk height). **Barrier effects summary**: minor effect.
Razorbill	**Seasonality**: present in all months with peaks in late spring / early summer. **Distribution**: throughout the three sites; highest densities in western MacColl, southern Stevenson, and adjacent parts of the buffer zone; site within area of low density of breeding SPA individuals (University of Plymouth models, Technical Appendix 4.5 C); 95.8 % of individuals recorded in wider Moray Firth aerial survey area were outwith the proposed wind farm sites (Technical Appendix 4.5 B). **Mean monthly site estimates**: 1,661 in breeding season; 892 in non–breeding season. **Displacement / disturbance risk estimate**: mean of 415 birds during the breeding season; minor effect (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: negligible effect (low % flights at risk height). **Barrier effects summary**: minor effect.
Puffin	**Seasonality**: present in all months, with peaks in spring and summer. **Distribution**: throughout the three sites; highest densities in central MacColl, Stevenson, and adjacent parts of the buffer zone; 95.4 % of individuals recorded in wider Moray Firth aerial survey area were outwith the proposed wind farm sites (Technical Appendix 4.5 B). **Mean monthly site estimates**: 1,916 in breeding season; 450 in non–breeding season. **Displacement / disturbance risk estimate**: mean of 479 birds during the breeding season; minor effect (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction). **Collision risk estimate**: negligible effect (low % flights at risk height). **Barrier effects summary**: minor effect

Construction and Decommissioning

7.4.7.8 During construction and decommissioning, effects are predicted to be limited to disturbance (arising from turbine installation / removal and associated vessel traffic) and the indirect effects on prey species (Table 7.4-12 below). These are expected to be of short–term duration and reversible.

Table 7.4-12 Summary of Likely Significant Effects during Construction / Decommissioning on each Relevant Ornithological Receptor

Species	Likely Significant Effects
Pink–Footed Goose	Disturbance (direct and indirect) – no risk (certain). **No significant effect predicted.**
Greylag Goose	Disturbance (direct and indirect) – no risk (certain). **No significant effect predicted.**
Fulmar	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**
Gannet	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**
Kittiwake	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**
Herring Gull	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**
Great Black–Backed Gull	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**
Guillemot	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**
Razorbill	Disturbance(direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**
Puffin	Disturbance (direct and indirect) – minor risk (certain; short–term, temporary). **No significant effect predicted.**

Operation

7.4.7.9 During operation, the two key likely significant effects on species populations are predicted to be collision risk and disturbance / displacement (Table 7.4-13 below). These are expected to be of long–term duration but reversible. The magnitude of the effects will vary during the year due to seasonal variation in site numbers.

Table 7.4-13 Summary of Likely Significant Effects during Operation on each Relevant Ornithological Receptor

Species	Likely Significant Effects
Pink–Footed Goose	Disturbance / displacement (direct and indirect) – no risk (certain). Collision – minor risk (probable; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted**.
Greylag Goose	Disturbance / displacement (direct and indirect) – no risk (certain). Collision – minor risk (probable; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted**.
Fulmar	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – negligible risk (certain; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction).
Gannet	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – moderate risk (probable; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; < 4.4 % increase in likelihood of 20 % population reduction).
Kittiwake	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – minor risk (probable; medium–term, temporary). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; < 1 % increase in likelihood of 10 % population reduction).
Herring Gull	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – moderate risk (probable; medium–term, temporary). Barrier effects – negligible risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; 10 % increase in likelihood of 10 % population reduction).
Great Black–Backed Gull	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – minor risk (certain; medium–term, temporary). Barrier effects – negligible risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; < 1 % increase in likelihood of 10 % population reduction).
Guillemot	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – negligible risk (certain). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction).

Species	Likely Significant Effects
Razorbill	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – negligible risk (certain). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction).
Puffin	Disturbance / displacement (direct and indirect) – minor risk (certain; medium–term, temporary). Collision – negligible risk (certain). Barrier effects – minor risk (probable; medium–term, temporary). **No significant effect predicted** (based on PVA analysis; < 0.1 % increase in likelihood of 10 % population reduction).

7.4.8 Proposed Monitoring and Mitigation

7.4.8.1 During all phases, vessel traffic will be along set routes; thus reducing the area of disturbance and increasing the likelihood of habituation to disturbance. Operational monitoring requirements will be agreed with regulators and SNCAs.

7.4.9 Residual Effects – Primary Impact Assessment

7.4.9.1 Given the minor / moderate risk of effects predicted for all ornithological receptors (no significant effect) there is also a minor / moderate risk of effects predicted post–mitigation (Table 7.4-1 above).

7.4.10 Secondary Assessment: Individual Wind Farm Sites

7.4.10.1 Secondary assessments have been carried out for each of the three proposed wind farm sites, using disturbance / displacement and collision risk analysis, and through reference to the PVAs. All details are provided in the Technical Appendix 4.5 A. A summary of these secondary assessments is provided in Table 7.4-14 below. For each of the individual proposed wind farm sites, displacement and collision risk analysis was undertaken. Displacement effects were determined based on extents of the three sites. Collision risk estimates were determined based on the worst case scenario for the individual sites – 72 x 7 MW turbines in each site. For most species the predicted impacts are similar between each of the three sites due to relatively uniform distributions for these species. The predicted collision effects on gannet during operation are minor for Telford and Stevenson, and moderate for MacColl. The predicted collision effects on herring gull during operation are minor for all three sites when considered alone.

Table 7.4-14 Secondary Assessment Summary

Effect	Telford	Stevenson	MacColl
Construction and Decommissioning			
Disturbance	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**
Operation			
Disturbance / Displacement	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**
Collision	No effect on fulmar, guillemot, razorbill, puffin. Minor effect on pink–footed goose, greylag goose, gannet, kittiwake, great black–backed gull, herring gull. **No significant effects.**	No effect on fulmar, guillemot, razorbill, puffin. Minor effect on pink–footed goose, greylag goose, gannet, kittiwake, great black–backed gull, herring gull. **No significant effects.**	No effect on fulmar, guillemot, razorbill, puffin. Minor effect on pink–footed goose, greylag goose, gannet, kittiwake, great black–backed gull, herring gull. **No significant effects.**
Barrier Effects	Negligible – minor effect on all species. **No significant effects.**	Negligible – minor effect on all species. **No significant effects.**	Negligible – minor effect on all species. **No significant effects.**

7.4.11 Sensitivity Assessment

7.4.11.1 Sensitivity assessments have been carried out for each permutation of the three proposed wind farm sites, using disturbance / displacement and collision risk analysis, and through reference to the PVAs. All details are provided in the Technical Appendix 4.5 A. A summary of these sensitivity assessments is provided in Table 7.4-15. The displacement and collision risk analysis undertaken for the secondary assessment was also used for the sensitivity assessment. The predicted collision effects on gannet during operation are minor for Telford / Stevenson combined, and moderate for combinations involving MacColl.

Table 7.4-15 Sensitivity Assessment Summary

Effect	Telford and Stevenson	Telford and MacColl	Stevenson and MacColl
Construction and Decommissioning			
Disturbance	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**
Operation			
Disturbance / Displacement	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**	No effect on pink–footed goose, greylag goose. Minor effect on fulmar, gannet, kittiwake, herring gull, great black–backed gull, guillemot, razorbill, puffin. **No significant effects.**
Collision	No effect on fulmar, guillemot, razorbill, puffin. Minor effect on pink–footed goose, greylag goose, gannet, kittiwake, great black–backed gull, herring gull. **No significant effects.**	No effect on fulmar, guillemot, razorbill, puffin. Minor effect on pink–footed goose, greylag goose, kittiwake, great black–backed gull, herring gull. Moderate effect on gannet. **No significant effects.**	No effect on fulmar, guillemot, razorbill, puffin. Minor effect on pink–footed goose, greylag goose, kittiwake, great black–backed gull, herring gull. Moderate effect on gannet. **No significant effects.**
Barrier Effects	Negligible – minor effect on all species. **No significant effects.**	Negligible – minor effect on all species. **No significant effects.**	Negligible – minor effect on all species. **No significant effects.**

7.4.12 Proposed Monitoring and Mitigation: Secondary / Sensitivity Assessment

7.4.12.1 As per the monitoring and mitigation outlined in 7.4.8 of this chapter.

7.4.13 Residual Effects: Secondary / Sensitivity Assessment

7.4.13.1 Given the minor / moderate risk of effects predicted for all ornithological receptors (no significant effect) there is also a minor / moderate risk of effects predicted post–mitigation.

7.4.14 Habitats Regulations Appraisal

7.4.14.1 For each short–listed SPAs, the effects on each short–listed qualifying species were assessed based on the following five criteria:

1 Changes in the distribution or extent of the habitats supporting the species;

2 Changes in the structure, function and supporting processes of habitats supporting the species;

3 Significant disturbance to the qualifying species;

4 Changes in the distribution of the species within the sites; and

5 The species being maintained as a viable component of the sites in the long–term, and therefore the integrity of the sites.

7.4.14.2 These assessments are provided below in Tables 7.4-16 to 7.4-35. Further details on the selection process of short-listed SPAs are provided in Technical Appendix 4.5 A.

Table 7.4-16 Assessment of East Caithness Cliffs SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on prey species to be minor during construction / decommissioning, and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
Shag	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) due to low numbers on sites.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability.
Cormorant	1	No effects on habitat – not recorded on site.
	2	No effects on habitat – not recorded on site.
	3	Risk of disturbance assessed as negligible (certainty – probable) due to none recorded on the sites (coastal species).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability.
Peregrine	1	No effects on habitat – not an offshore species.
	2	No effects on habitat – not an offshore species.
	3	Risk of disturbance assessed as negligible (certainty – probable) due to being an onshore species.

Species	Criterion	Assessment
Peregrine (continued)	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability.
Kittiwake	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 1 % increase in likelihood of 10 % reduction.
Herring Gull	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on prey species to be minor during construction / decommissioning, and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a 10 % increase in likelihood of 10 % reduction.
Great Black-Backed Gull	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on prey species to be minor during construction / decommissioning, and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a 1 % increase in likelihood of 10 % reduction.
Guillemot	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.

Species	Criterion	Assessment
Guillemot (continued)	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
Razorbill	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
Puffin	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 20 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.

Table 7.4-17 Assessment of North Caithness Cliffs SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 33 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
Peregrine	1	No effects on habitat – not an offshore species.
	2	No effects on habitat – not an offshore species.
	3	Risk of disturbance assessed as negligible (certainty – probable) due to being an onshore species.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 33 km from the SPA.
	5	No effect on species viability.
Kittiwake	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 33 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 1 % increase in likelihood of 10 % reduction.
Guillemot	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 33 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.

Species	Criterion	Assessment
Razorbill	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 33 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
Puffin	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 33 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.

Table 7.4-18 Assessment of Troup, Pennan and Lion's Heads SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 49 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
Kittiwake	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 49 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 1 % increase in likelihood of 10 % reduction.

Species	Criterion	Assessment
Herring Gull	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on prey species to be minor during construction / decommissioning and during operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 49 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a 10 % increase in likelihood of 10 % reduction.
Guillemot	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 49 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
Razorbill	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 49 km from the SPA.
	5	No effect on species viability – the effect on the SPA population is predicted to be a < 0.1 % increase in likelihood of 10 % reduction.

Table 7.4-19 Assessment of Pentland Firth Islands SPA per Conservation Objectives

Species	Criterion	Assessment
Arctic Tern	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic tern prey species to be minor during construction / decommissioning and operation.
	3	Peak of 592 recorded during migration – even if foraging was excluded from the proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 42 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-20 Assessment of Hoy SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on fulmar prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 58 km from the SPA.
	5	No effect on species viability found from the population viability analysis carried out for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4-16 to 18); no effect (certain) therefore also predicted here.
Great Skua	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on great skua prey species to be minor during construction / decommissioning and operation.
	3	Peak abundance of 100 was estimated during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 58 km from the SPA.
	5	No collision risk (low flight height) and minor disturbance / displacement effect; no effect on species viability.
Arctic Skua	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic skua prey species to be minor during construction / decommissioning and operation.
	3	Peak of 41 recorded during migration – even if foraging was excluded from the three proposed wind farm sites effect is predicted to be minor (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 58 km from the SPA.
	5	No collision risk (low flight height) and minor disturbance / displacement effect; no effect on species viability.
Kittiwake	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (probable) for nearer SPAs; effect therefore predicted to be minor at worst (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 58 km from the SPA.
	5	No effect on species viability for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4-16 to 18); no effect (certain) therefore also predicted here.

Species	Criterion	Assessment
Great Black-Backed Gull	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on great black–backed gull prey species to be minor during construction / decommissioning and operation (see criteria 3).
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 58 km from the SPA.
	5	No effect on species viability for the SPAs nearest to the three proposed wind farm sites (Table 7.4-16); no effect (certain) therefore also predicted here.
Guillemot	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 58 km from the SPA.
	5	No effect on species viability for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4.16 to 18; no effect (certain) therefore also predicted here.
Puffin	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 58 km from the SPA.
	5	No effect on species viability for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4-16 to 18); no effect (certain) therefore also predicted here.

Table 7.4-21 Assessment of Copinsay SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on fulmar prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 61 km from the SPA.
	5	No effect on species viability for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4.16 to 18); no effect (certain) therefore also predicted here.
Kittiwake	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on sandeels to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (probable) for nearer SPAs; effect therefore predicted to be minor at worst (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 61 km from the SPA.
	5	No effect on species viability for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4-16 to 18); no effect (certain) therefore also predicted here.

Table 7.4-22 Assessment of Loch of Strathbeg SPA per Conservation Objectives

Species	Criterion	Assessment
Pink-Footed Goose	1	Habitats supporting geese will not be affected.
	2	Habitats supporting geese will not be affected.
	3	There will be no potential for disturbance / displacement.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 68 km from the SPA.
	5	A maximum collision rate of 20 is predicted; a minor effect (probable).
Whooper Swan	1	Habitats supporting whooper swan will not be affected.
	2	Habitats supporting whooper swan will not be affected.
	3	There will be no potential for disturbance / displacement.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 68 km from the SPA.
	5	A maximum collision rate of 0.1 is predicted; a minor effect (probable).

Table 7.4-23 Assessment of Auskerry SPA per Conservation Objectives

Species	Criterion	Assessment
Arctic Tern	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic tern prey species to be minor during construction / decommissioning and operation.
	3	Peak of 592 recorded during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 79 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-24 Assessment of Calf of Eday SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on fulmar prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 99 km from the SPA.
	5	No effect on species viability for nearer SPAs; no effect (certain) therefore also predicted.

Table 7.4-25 Assessment of Rousay SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on fulmar prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 99 km from the SPA.
	5	No effect on species viability for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4-16 –18); no effect (certain) therefore also predicted here.
Arctic Skua	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic skua prey species to be minor during construction / decommissioning and operation.

Species	Criterion	Assessment
Arctic Skua (continued)	3	Peak of 41 recorded during migration – even if foraging was excluded from the three proposed wind farm sites, effects are predicted to be minor (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 99 km from the SPA.
	5	No collision risk (minor flight height) and minor disturbance / displacement effect; no effect on species viability.
Arctic Tern	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic tern prey species to be minor during construction / decommissioning and operation.
	3	Peak of 592 recorded during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 99 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-26 Assessment of West Westray SPA per Conservation Objectives

Species	Criterion	Assessment
Fulmar	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on fulmar prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 108 km from the SPA.
	5	No effect on species viability for the three SPAs nearest to the three proposed wind farm sites (Tables 7.4-16 to 18); no effect (certain) therefore also predicted here.
Arctic Skua	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic skua prey species to be minor during construction / decommissioning and operation.
	3	Peak of 41 recorded during migration – even if foraging was excluded from the three proposed wind farm sites effect is predicted to be minor (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 108 km from the SPA.
	5	No collision risk (low flight height) and minor disturbance / displacement effect; no effect on species viability.

Species	Criterion	Assessment
Arctic Tern	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic tern prey species to be minor during construction / decommissioning and operation.
	3	Peak of 592 recorded during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 108 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-27 Assessment of Papa Westray SPA per Conservation Objectives

Species	Criterion	Assessment
Arctic Tern	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic tern prey species to be minor during construction / decommissioning and operation.
	3	Peak of 592 recorded during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 129 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-28 Assessment of Sule Skerry and Sule Stack SPA per Conservation Objectives

Species	Criterion	Assessment
Gannet	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on gannet prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 131 km from the SPA.
	5	No effect on species viability for the Troup Head colony (Table 7.4-18); no effect (certain) therefore also predicted here.

Table 7.4-29 Assessment of Fair Isle SPA per Conservation Objectives

Species	Criterion	Assessment
Gannet	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on gannet prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 143 km from the SPA.
	5	No effect on species viability for the Troup Head colony (Table 7.4-18); no effect (certain) therefore also predicted here.
Arctic Skua	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic skua prey species to be minor during construction / decommissioning and operation.
	3	Peak of 41 recorded during migration – even if foraging was excluded from the three proposed wind farm sites effect is predicted to be minor (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 143 km from the SPA.
	5	No collision risk (low flight height) and minor disturbance / displacement effect; no effect on species viability.
Arctic Tern	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Arctic tern prey species to be minor during construction / decommissioning and operation.
	3	Peak of 592 recorded during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 143 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-30 Assessment of North Rona and Sula Sgier SPA per Conservation Objectives

Species	Criterion	Assessment
Gannet	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on gannet prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 205 km from the SPA.
	5	No effect on species viability for the Troup Head colony (Table 7.4-18); no effect (certain) therefore also predicted here.

Table 7.4-31 Assessment of Noss SPA per Conservation Objectives

Species	Criterion	Assessment
Gannet	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on gannet prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 222 km from the SPA.
	5	No effect on species viability for the Troup Head colony (Table 7.4-18); no effect (certain) therefore also predicted here.
Great Skua	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on great skua prey species to be minor during construction / decommissioning and operation.
	3	Peak abundance of 100 was estimated during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 222 km from the SPA.
	5	No collision risk (low flight height) and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-32 Assessment of Firth of Forth Islands SPA per Conservation Objectives

Species	Criterion	Assessment
Gannet	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on gannet prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 237 km from the SPA.
	5	No effect on species viability for the Troup Head colony (Table 7.4-18); no effect (certain) therefore also predicted here.

Table 7.4-33 Assessment of Hermaness, Saxa Vord and Vala Field SPA per Conservation Objectives

Species	Criterion	Assessment
Gannet	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on gannet prey species to be minor during construction / decommissioning and operation.
	3	Risk of disturbance assessed as minor (certain) for nearer SPAs; effect therefore predicted to be minor at worst (certain).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 298 km from the SPA.
	5	No effect on species viability for the Troup Head colony (Table 7.4-18); no effect (certain) therefore also predicted here.
Great Skua	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on great skua prey species to be minor during construction / decommissioning and operation.
	3	Peak abundance of 100 was estimated during migration – even if foraging was excluded from the three proposed wind farm sites, effect is predicted to be minor (probable) due to use of site being limited to migratory period.
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 298 km from the SPA.
	5	No collision risk (low flight height) and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-34 Assessment of Rum SPA per Conservation Objectives

Species	Criterion	Assessment
Manx Shearwater	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Manx shearwater prey species to be minor during construction / decommissioning and operation.
	3	Peak of 32 recorded during migration – even if foraging was excluded from the three proposed wind farm sites effect is predicted to be minor (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 366 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

Table 7.4-35 Assessment of St Kilda SPA per Conservation Objectives

Species	Criterion	Assessment
Manx Shearwater	1	Chapter 7.1 predicts negligible to minor effects on benthic habitats.
	2	Chapter 7.2 predicts effects on Manx shearwater prey species to be minor during construction / decommissioning and operation.
	3	Peak of 32 recorded during migration – even if foraging was excluded from the three proposed wind farm sites effect is predicted to be minor (probable).
	4	No effect on distribution within SPA due to the three proposed wind farm sites being 376 km from the SPA.
	5	No collision risk and minor disturbance / displacement effect; no effect on species viability.

7.4.14.3 The above assessments on each of the short–listed SPAs have determined no effects on the Conservation Objectives, and therefore no change to population viability of the designated species.

7.4.15 References

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