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Glossary

Anadromous	The term used to describe marine fish that migrate from sea to rivers to spawn.
Barrier effects	The effect seen when a disturbance restricts the free movement, breeding and mingling or populations of a species.
Benthic	Communities of organisms present on the sea bed.
Benthic grab	A sampling method used to capture bottom sediment samples. The grab comprises a pair of hinged jaws and a lever system with a release catch that allows the jaws to close on the bottom capturing the organisms and sediment within.
B-fields	Magnetic fields produced by an electric current close to a cable.
Bycatch	Unwanted marine species captured in nets whilst targeting other species.
dB_{ht}	The dB_{ht}(*Species*) metric (Nedwell *et al.*, 2007) has been developed as a means for quantifying the potential for a behavioural impact of a sound on a species in the underwater environment. It uses a species' audiogram in its calculation. The dB_{ht}(*Species*) metric can be understood as the level above the minimum audible sound (threshold of hearing) which a species can hear. A level of 0 dB_{ht}(*Species*) represents the minimum audible sound.
Demersal	Marine species living close to the seabed.
Diadromous	The term used to describe migration of a species between fresh water and the sea.
E-fields	Electric fields produced by an electric current close to a cable.
Elasmobranch	Cartilaginous fish which comprises sharks, rays and skates.
Electromagnetic Field (EMF)	The coupled electric (iE) and magnetic (B) fields that are generated by time-varying currents and accelerated charges from, for example, subsea cables.
Epibenthic trawl	A device which trawls across the bottom of the seabed capturing organisms in a net.
Fish Aggregating Device (FAD)	A permanent, semi-permanent, or temporary structure or device made from any material which has the effect of attracting fish.
Glochidial	The larvae of a freshwater mussel which lives parasitically in the gills or other external parts of fish.
Grilse	A salmon which has returned to fresh water after a single winter at sea.
iE-fields	Secondary electric field which is induced by B-fields (see also B-fields) close to a cable.
Invertebrate	Animals lacking a backbone.

Kelt	A salmon which has recently spawned.
Keystone species	A species whose presence and role within an ecosystem is of major importance to other organisms within the system due to its function and dependencies.
Natal	The place of birth.
Nursery grounds	Any grounds where juvenile fish are found.
Otolith	Small calcareous structures in the inner ear of fishes (vertebrates) involved in movement and hearing.
Otter trawl	A device which is pulled along the seabed with large rectangular boards called "otter boards" either side of the mouth that keep the net open.
Pelagic	Marine species inhabiting the mid and upper layers of the open sea.
Piscivorous	Species which exclusively feed on fish.
SACFOR Scale	A commonly used scale to measure abundance of species (Super Abundant, Abundant, Common, Frequent, Occasional, Rare).
Salmonids	Fish from the salmon family including Sea Trout and Salmon.
Smolt	A young salmon (or trout) after the parr stage, when it becomes silvery and migrates to the sea for the first time.
Southern Bight	The southern extent of the North Sea bounded by the coasts of the Netherlands, Belgium, France and Great Britain.
SPEAR Modelling	SPEAR (Sound Propagation Estimation and Ranking) model and provides an indication of the typical levels of underwater noise generated by wind farm related activities. The model allows the significance of a wide range of sources of underwater noise to be rank-ordered for a wide range of marine animals.
Sub Adult	An individual that has passed through the juvenile period but not yet attained typical adult characteristics.
Swimbladder	An internal gas filled organ which enables a fish to regulate hydrostatic pressure and maintain buoyancy.
Teleost	A fish which possesses a large bony skeleton such as cod, herring, and plaice.

Abbreviations and Acronyms

AA	Appropriate Assessment
ASFB	Association Salmon Fisheries Boards
Cefas	Centre for Environment, Fisheries and Aquaculture Science
DDV	Drop Down Video
EMF	Electromagnetic Field
FAD	Fish Aggregating Device
FTOWDG	Forth and Tay Offshore Wind Developer Group
FWPM	Freshwater Pearl Mussels
GBS	Gravity Base Substructures
HAWG	Herring Assessment Working Group
HRA	Habitat Regulations Appraisal
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Sea
ICOL	Inch Cape Offshore Limited
IHLS	International Herring Larvae Survey
IPCC	Intergovernmental Panel on Climate Change
JNCC	Joint Nature Conservation Committee
LSE	Likely Significant Effects
MLS	Minimum Landing Size
MSS	Marine Scotland Science
NPC	Natural Power Consultants
O&M	Operations and Maintenance
OfTW	Offshore Transmission Works
OSP	Offshore Platform
PMF	Priority Marine Feature
PSA	Particle Size Analysis

SAC	Special Area of Conservation
SMP	Survey Monitoring Plan
SNH	Scottish Natural Heritage
SSC	Suspended Sediment Concentrations
TAC	Total Allowable Catch
UKBAP	UK Biodiversity Action Plan
WTG	Wind Turbine Generator

Units

V	Volts
kV	Kilovolts
mV	Millivolts
µV	Microvolts
A	Amps
V/m	Volts per m
µV/m	Microvolts per metre (used to measure electric E and iE fields)
T	Tesla (unit used to measure magnetic fields)
µT	Micro Tesla
dB	Decibel
1 µPa	micropascal, an SI unit of pressure and stress
Pa	Pascal SI unit of pressure and stress

13 Natural Fish and Shellfish

13.1 Introduction

1 This chapter describes the natural fish and shellfish resource within and around the Development Area and Offshore Export Cable Corridor. This chapter presents an assessment of the predicted impacts of the construction, operation and decommissioning phases of the Wind Farm and associated Offshore Transmission Works (OfTW) on natural fish and shellfish.

2 The predicted impacts of the proposals on relevant Special Areas of Conservation (SACs), which are designated for migratory fish, have also been assessed within a Habitats Regulations Appraisal (HRA) (see *Section 13.13*). Details of mitigation are also presented to avoid, offset or reduce impacts of the proposals on natural fish and shellfish.

3 This chapter is supported by the following appendices:

- *Appendix 13A: Natural Fish and Shellfish Survey Report*;
- *Appendix 13B: Sandeel Habitat Mapping*;
- *Appendix 13C: Electromagnetic Field Assessment*; and
- *Appendix 13D: Herring Spawning Study*.

4 This chapter also shares direct linkages with the following chapters and makes reference to their content where relevant:

- *Chapter 10: Metocean and Coastal Processes*;
- *Chapter 11: Underwater Noise*;
- *Chapter 12: Benthic Ecology*;
- *Chapter 14: Marine Mammals*;
- *Chapter 15: Ornithology*; and
- *Chapter 18: Commercial Fisheries*.

13.2 Consultation

5 This section summarises the scoping responses of statutory and non-statutory consultees in relation to the assessment of effects of the Project on fish and shellfish. Consultation with Scottish Natural Heritage (SNH) and commercial fishing representatives aided the identification of the receptors to be assessed within this chapter. The scoping responses are summarised in Table 13.1.

Table 13.1: Consultation Responses and Actions

Consultees	Consultation Response	Project Response
SNH	Impacts to elasmobranches to be assessed, especially in relation to Electro Magnetic Fields (EMF).	Assessed – see *Section 13.6 to Section 13.9*.
	Impacts to migrating species, including Atlantic salmon (*Salmo salar*), lamprey species (*Petromyzon marinus*, *Lampetra fluviatilis* and *Lampetra planeri*), European eel (*Anguila angiula*), shad species (*Alosa* spp.), sea trout (*Salmo trutta*) and sparling (*Osmerus eperlanus*) to be assessed, specifically barrier effects, noise and EMF.	Assessed – see *Section 13.6 to Section 13.9*.
	Impacts on Atlantic salmon and lamprey species of the Rivers Tay, Teith and South Esk SACs to be assessed, in particular the effects of construction and operational noise/vibration.	Assessed – see *Section 13.6 to Section 13.9* and within the HRA (*Section 13.13*).
	Impacts on the fresh water pearl mussel (*Margaritifera margaritifera*) due to impacts on Salmon populations.	Assessed within *Section 13.6 to Section 13.9* and HRA (*Section 13.13*).
Marine Scotland	Impacts on diadromous fish of freshwater fisheries interest including Atlantic salmon, anadromous brown trout (sea trout) and European eel to be assessed.	Assessed – see *Section 13.6 to Section 13.9*.
	Impacts on diadromous fish of conservation interest including Atlantic salmon to be assessed specifically barrier effects, noise and EMF.	Assessed – see *Section 13.6 to Section 13.9*.
	Impacts to Nephrops *(Nephrops norvegicus)* on muddy sediments to be assessed.	Assessed – see *Section 13.6 to Section 13.9*.
	Impacts to scallops (*Pectinidae*) on sand and gravel substrates to be assessed.	Assessed – see *Section 13.6 to Section 13.9*.
	Impacts to skates and rays to be assessed, specifically EMF.	Assessed – see *Section 13.6 to Section 13.9*.
	Impacts to sandeel populations to be assessed.	Assessed – see *Section 13.6 to Section 13.9* and in specific sandeel mapping study commissioned by Inch Cape Offshore Limited (ICOL) – see *Appendix 13B.*

Consultees	Consultation Response	Project Response
	Impacts on Marine Mammal prey species should be assessed (Marine Mammal scoping response with links to fish).	Assessed – see *Section 13.6* to *Section 13.9*.
Marine Scotland Science (MSS) (via Marine Scotland) comments on Survey monitoring plan (SMP)	Baseline information should present data on all fish and shellfish species, regardless of their commercial value.	Species of non commercial importance have been assessed throughout surveys and impact assessment – see *Section 13.4* and *13.6* to *13.9*.
	Impacts on species on the draft Priority Marine Feature (PMF) list to be assessed.	Assessed – see *Section 13.6 to Section 13.9*.
	A wider area for assessment should be applied to fish and shellfish than one tidal excursion.	The study area for assessment is defined in *Section 13.4.1* and shown in Figure 13.1 and is larger than one tidal excursion.
	Concerns that the sandeel abundance/presence could be under represented by fish survey methodologies.	Accepted, therefore sandeel habitat mapping using Greenstreet *et al.,* 2010 methodology was undertaken (*Appendix 13B)* and sandeel data in the wider Study Area provided by MSS as described in *Section 13.5.*
	The use of the drop-down video (DDV) and stills, in combination with fishing industry consultation, may yield some useful information on king scallops.	DDV stills as well as catch data from the fishing industry have been used to provide information on scallops in the natural fish and shellfish baseline in *Section 13.4.3*.
	Impacts on 'Electro-sensitive species' should include fish and shellfish species which are sensitive to EMF, i.e. not just elasmobranchs.	All key receptors as identified in *Section 13.4.4* have been assessed for impacts from EMF- see *Section 13.6 to Section 13.9*.

Consultees	Consultation Response	Project Response
Association of Salmon Fishery Boards (ASFB) and the following District Salmon Fishery Boards (DSFB); Tweed Commission/DSFB Tweed, Tay DSFB, Esk DSFB, Dee (DSFB) and Usan Salmon Fishing Ltd.	Forth and Tay Offshore Wind Developers Group (FTOWDG) District Salmon Fishery Boards Stakeholder Meeting (13 January 2012)	
	Are the developers carrying out studies into the effects of EMF on Salmon?	MSS are carrying out studies on the impact of EMF on salmon, at a strategic level. For this project an EMF report was produced which identified electro/ magneto-sensitive species which may be present at the Development Area and/or Offshore Export Cable Corridor (*Appendix 13C*), and an assessment has been carried out based on the conservative assumption that salmon will be present in the Development Area and Offshore Export Cable Corridor – see *Section 13.6 to 13.9.*
	What work will be done to assess salmon and sea trout migration routes?	There are recognised gaps in the understanding of salmon and sea trout migration in their offshore phases. Studies on migration routes are not viable and therefore this assessment has been carried out using a conservative assumption that these species will be present in the Development Area and/or Offshore Export Cable Corridor. See *Section 13.6 to Section 13.9*.
	EMF impacts to be assessed.	Assessed - see *Section 13.6 to Section 13.9* and *Appendix 13C.*
	Concerns over barriers to migration routes.	Assessed - see *Section 13.6 to Section 13.9* and HRA (*Section 13.13*).
Tay DSFB	Noise/vibration impacts to be assessed on migratory fish.	Assessed – see *Section 13.6 to Section 13.9*.
Forth DSFB	Concerns over indirect habitat loss and displacement from feeding areas as a consequence of disturbance or due to displacement of prey during the construction phase.	Assessed - see *Section 13.6 to Section 13.9* and in specific sandeel mapping study commissioned by ICOL – see *Appendix 13B.*
Tweed DSFB	Disturbance to nursery/spawning grounds during the construction phase.	Assessed - see *Section 13.6 to Section 13.9*.

Consultees	Consultation Response	Project Response
	Disturbance or physical injury associated with construction noise.	Assessed - see *Section 13.6 to Section 13.9*.
	Changes to the ecosystem, e.g. a decrease in water quality due to sediment disturbance during the construction phase.	Assessed - see *Section 13.6 to Section 13.9*.
	Disturbance at or displacement from, migration routes during the construction phase.	Assessed - see *Section 13.6 to Section 13.9*.
	The creation of EMF associated with inter-array and export cabling of the operational wind farm.	Assessed - see *Section 13.6* to *Section 13.9* and *Appendix 13C.*
	Changes in biodiversity due to habitat changes associated with cable and scour protection of the operational wind farm.	Assessed - see *Section 13.6 to Section 13.9* and HRA (*Section 13.13*).
	Changes to the foraging areas of fish predators (birds, mammals) due to the habitat changes.	Assessed - see *Section 13.6 to Section 13.9*.
	Impacts on fish that are resident in the site, those that undertake part of their life cycle within the site, and those that have regular migration routes that takes them through it.	Assessed - see *Section 13.6 to Section 13.9* and HRA (*Section 13.13*).
RSPB	Impacts on prey species (sandeel and sprat) should be assessed.	Assessed - see *Section 13.6 to Section 13.9*.

6 In addition to the formal Scoping Opinion, Table 13.1 includes further informal consultation which has been undertaken in relation to the assessment of the impacts of the Wind Farm and OfTW with relevant stakeholders. Further information on salmon and sea trout fisheries consultation, which is ongoing, is provided in *Section 18.2.2*.

7 The information received through this consultation, along with the formal Scoping Opinion and recognised best practice, has informed the methodology and scope for the assessment of the impacts on natural fish and shellfish presented in this chapter.

13.3 Design Envelope and Embedded Mitigation

8 The potential development parameters and scenarios are defined as a Design Envelope and presented in *Chapter 7: Description of Development*. The assessment of potential impacts on natural fish and shellfish is based upon the worst case scenario as identified from this Design Envelope, and is specific to the potential impacts assessed in this chapter.

9 Key parameters for the worst case scenario for each potential impact are detailed in Tables 13.2 and 13.3 below. For this assessment these include consideration of the design, construction and operation of: Wind Turbine Generators (WTGs), meteorological masts (met masts), foundation and substructures, Offshore Substation Platforms (OSPs), inter-array cables and Offshore Export Cables.

Table 13.2: Worst Case Scenario Definition - Development Area

Potential Impact	Design Envelope Scenario Assessed
Construction (and Decommissioning) Phase	
Direct temporary habitat disturbance.	**Total seabed area disturbed is 5.54 km^2, equating to 3.69% of the Development Area resulting from:** • Seabed preparation for 213 WTGs with gravity base substructures (GBS) selected as having the largest disturbance footprint (125 m dredger affected diameter); • Seabed preparation for five OSPs with GBS selected as having the largest area disturbance footprint (300 m dredger affected diameter); • Seabed preparation for three met masts with GBS selected as having the largest area disturbance footprint (125 m dredge effected diameter); • 353 km inter-array cable installation with a cable corridor disturbed width of six metres as the widest possible area of disturbance; • jack up vessel with disturbance footprint per vessel of 600 m^2 and three visits per foundation installation/decommissioning required for WTGs, OSPs and met masts; and • Vessel anchorage disturbance = 5.0 m^2 footprint, six anchors deployed per 500 m along inter-array cable.
Indirect disturbance as a result of sediment deposition and temporary increases in suspended sediment concentrations (SSC).	Model outputs of anticipated SSC, deposition and sediment transportation from energetic means (cable) and dredging (foundations) from *Chapter 10,* which includes; • Suspended sediments arising from seabed preparations and installations for 213 WTGs, five OSPs and three met masts with GBS substructure/foundation types; and • Suspended sediments arising from inter-array cable burial using energetic means (excavated trench 353 km long, one metre wide and two metres depth) as recognised as representing the worst case as described in *Section 10.1.3*. Note that the actual range of cable burial depths is zero to three metres, with protection where burial is not feasible; the target depth is one metre. Two metres was chosen as being sufficiently conservative to represent the macro impacts of SSC from burial across the Development Area.

Potential Impact	Design Envelope Scenario Assessed
Barrier effects, disturbance or physical injury associated with construction noise (piling).	Construction noise from seabed preparations and installations for 213 WTGs (four legged Jacket structure, driven piles), five OSP (with eight driven piles per structure) and three met masts. Up to two piling vessels may operate simultaneously. Piling operations will take place over a two year construction period. However, only 11% - 23% of this time will be spent physically piling. Model outputs for Piling Noise from *Chapter 11*.
Operational Phase	
Long term loss of original habitat.	**Total loss of original habitat is 1.87 km^2, equating to 1.25% of the Development Area resulting from:** • Seabed preparation for 213 WTGs with GBS selected as having the largest footprint (95 m diameter including scour protection); • Seabed preparation for five OSPs with GBS selected as having the largest footprint (180 m diameter including scour protection); • Seabed preparation for three met masts with GBS selected as having the largest footprint (95 m diameter including scour protection); and • Maximum 10% protection on the 353 km inter-array cable installation with protection width of six metres as the widest possible area of disturbance.
Creation of new habitat due to presence of Project infrastructure.	Introduction of new substrate available for colonisation from 213 WTGs, five OSPs and three met masts (GBS as greatest area), scour protection and inter-array cable protection (10% of cable length) as per loss of original habitat above.
Effect on fish and shellfish resources due to reduced fishing pressure within the site.	Qualitative assessment based on worst case recognised as the minimum potential loss of fishing grounds.
Behavioural responses to EMF associated with cabling.	Total inter-array cable length (353 km). Cables will be suitably buried or will be protected by other means when burial is not practicable. The AC option is identified as having the greatest potential for EMF impacts and will be used for the inter-array cables.
Disturbance or physical injury associated with operational noise.	Operational noise from the works in the Development Area, taken from evidence base, resulting from WTG operation and maintenance vessels.

Potential Impact	Design Envelope Scenario Assessed
Temporary habitat disturbance from operations and maintenance (O&M) activities.	**Area of seabed disturbed annually is 0.14 km^2, equating to 0.09% of the Development Area resulting from:** • Jack up vessel with disturbance footprint per vessel of 600 m^2 and one visit per foundation (WTGs, OSPs and met masts); • Vessel anchorage with 5.0 m^2 footprint, six anchors deployed per 500 m along Export Cable; and • Inter-array cable reburial assuming maximum of 10% reburial during operation of total 353 km, with a disturbed footprint of six metres as the widest possible area of disturbance.

Table 13.3: Worst Case Scenario Definition - Offshore Export Cable Corridor

Potential Impact	Design Envelope Scenario Assessed
Construction (and Decommissioning) Phase	
Direct temporary habitat disturbance.	**Area of seabed disturbed is 3.02 km^2 across Offshore Export Cable Corridor:** • AC as largest number (six) of Export Cables**;** • Export Cable length = 83 km (multiplied by six); • Each Export Cable in a separate trench; • Offshore Export Cable trench affected width = six metres (for each of six Export Cables); and • Anchoring disturbance from vessels.
Indirect disturbance as a result of sediment deposition and temporary increases in SSC.	Model outputs of anticipated SSC, deposition and sediment transportation from installation of the cable by energetic means (*Chapter 10*).
Operational Phase	
Long term loss of original habitat.	**Total area of long term original habitat loss = 0.60 km^2** • Protection of maximum 20% of each of the six, 83 km long Export Cables; and • Protection material six metres wide.
Creation of new habitat due to presence of Project infrastructure.	Introduction of new substrate available for colonisation from Export Cable protection (maximum 20% of Export Cable length on an approximately 83 km length and 6 cables with protection width of 6 m) = 0.60 km^2.

Potential Impact	Design Envelope Scenario Assessed
Behavioural responses to electromagnetic fields associated with cabling.	Total Export Cable length of 83 km. Cables will be suitably buried or will be protected by other means when burial is not practicable. The AC option is identified as having the greatest potential for EMF impacts. Qualitative assessment based on interaction of fish species along total Export Cable length informed by the assessment in *Appendix 13C*.
Temporary habitat disturbance from O&M activities.	Annual disturbance is 0.007 km^2 assuming reburial of 10% of total length of Export Cables (six) 83.3 km during operation.

Embedded Mitigation

10 A range of Embedded Mitigation measures to minimise environmental effects are captured within the Design Envelope (see *Section 4.4.1*). The assessment of effects on natural fish and shellfish has taken account of the following Embedded Mitigation measures:

- Piling operations will incorporate a soft start procedure as detailed in *Chapter 11* which will reduce the potential for noise related fatality as described in *Section 13.6.1*;
- Cables will be suitably buried or will be protected by other means when burial is not practicable as considered in *Section 7.8 and 7.9* which will reduce the potential for impacts relating to EMF as described in *Section 13.6.2* and *13.7.2*; and
- Cables will be specified to reduce EMF emissions as per industry standards and best practice such as the relevant IEC (International Electrotechnical Commission) specifications.

11 These measures would be delivered as part of the Project (see *Appendix 7A: Draft Environmental Management Plan*).

13.4 Baseline Environment

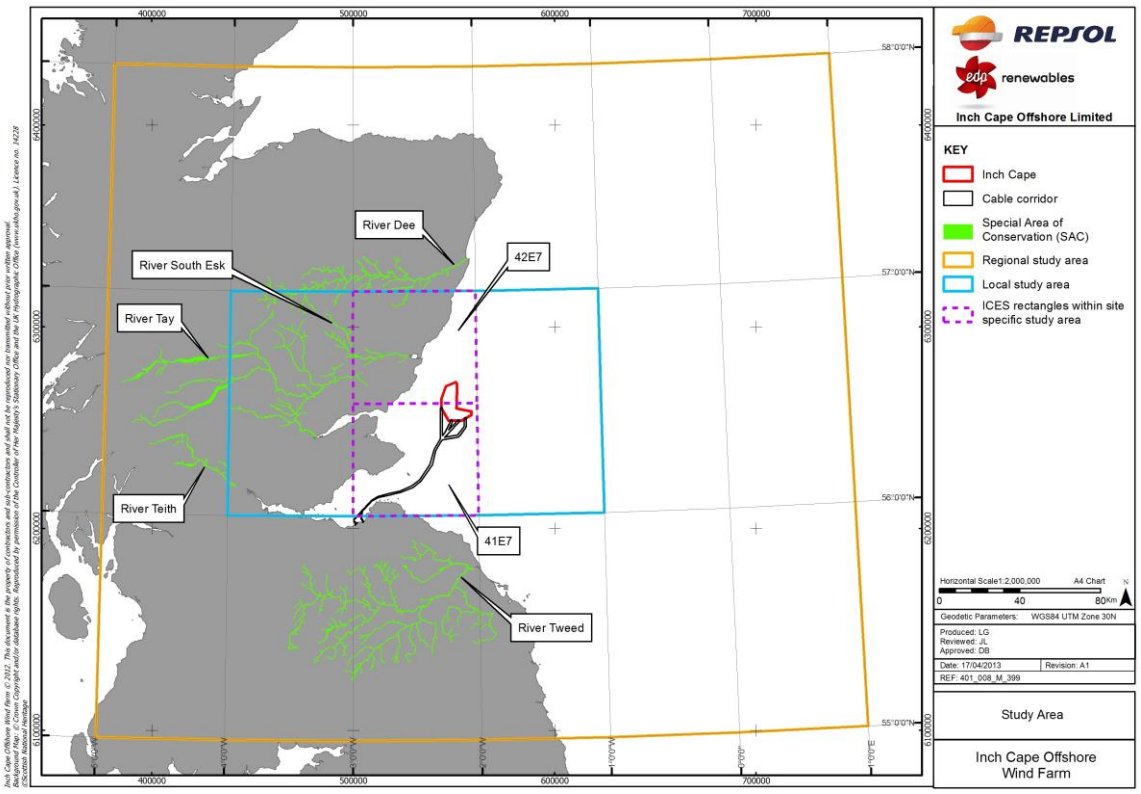
12 The baseline environment of the Development Area and Offshore Export Cable Corridor is fully described in *Appendices 13A to 13D* and summarised below. As many of the species relevant to this chapter are highly mobile and widely distributed over both the Development Area and the Offshore Export Cable Corridor an overview of the fish and shellfish species found in the vicinity of the Project has been presented. From this overview key receptors have been identified and information on their distribution within the Development Area and Offshore Export Cable Corridor are extrapolated in order to assess the baseline conditions of these areas.

13.4.1 Definition of Study Area

13 In line with the Commercial Fisheries Assessment (*Chapter 18*, Figure 18.1), the study areas used for this assessment correspond to relevant International Council for the Exploration of the Sea (ICES) Rectangles (Figure 13.1).

14 The Site Specific Study Area comprises rectangles 42E7 and 41E7 which encompass the Development Area, the Offshore Export Cable Corridor and stations surveyed during Environmental Impact Assessment (EIA) characterisation fish surveys (Figure 13.2). Rectangles 42E7 and 41E7 are, therefore, the focus of the study. In addition, where relevant, the baseline is described in wider geographical contexts of a Local Study Area and Regional Study Area (Figure 13.1). The Local Study Area encompasses the salmon fishery districts in closest proximity to the Project, namely the Tay, Forth, Esk (Bervie, North Esk and South Esk) and the ICES squares 42E8, 42E9; while the Regional Study Area encompasses the Dee and Tweed fisheries regions. Information relating to commercial fisheries data is also presented at Local and Regional Study Area level in order to give context to the distribution of species in relation to the Project. In addition, given the migratory behaviour of some species and the wide distribution of spawning areas, information at the national level and international level has also been presented where relevant.

Figure 13.1: Study Area

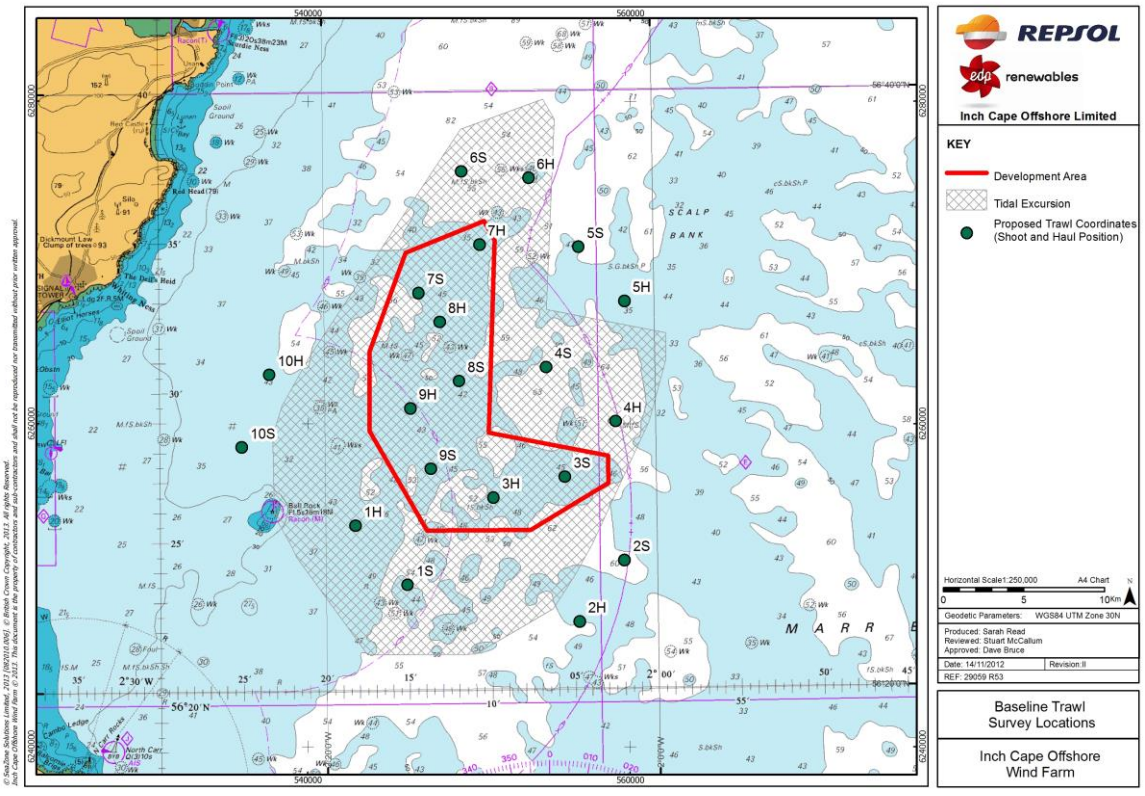


13.4.2 Data Sources

Site Specific Surveys

15 Between January 2012 and October 2012 a series of surveys were undertaken to determine the type and distribution of fish and shellfish species in and around the Development Area (*Appendix 13A*). Otter trawl surveys using commercial gear were conducted within each maritime season (winter, spring, summer and autumn) at 10 stations (Figure 13.2) to gain seasonal information on fish distribution (full methodology is provided in *Section 13A.2*). This method of trawling, whereby a net is pulled along the seabed with large rectangular "otter boards", either side of the mouth, keeping the net open and 'hearding' individuals into the net. This method is used commercially to target demersal fish and shellfish such as Norwegian lobsters (*Nephrops norvegicus* – from here on referred to as *Nephrops*); however other benthic invertebrates and pelagic fish may also be captured as bycatch. Marine Scotland Science (MSS) was consulted and approved the trawl survey scope and methodology prior to its commencement. Additionally, data gathered during baseline surveys of the benthic ecology (*Appendix 12A: Benthic Ecology Baseline Development Area, Section 12A.3*) pertinent to fish and shellfish, including epibenthic beam trawl, benthic grab samples and drop down video (DDV) surveys, have also incorporated into this assessment (full methodology and survey details *Section 12A.2*). For all surveys, all species of fish and shellfish (of both commercial and non-commercial importance) were identified to species level and enumerated.

Figure 13.2: Baseline Otter Trawl Locations for Site Specific Surveys



16 Due to the importance of sandeels as a prey item baseline characterisation, work for fish ecology also included analysis of potential sandeel habitat in and around the Development Area and Offshore Export Cable Corridor (*Appendix 13B*). Sandeels have been shown to have a preference for clean coarse sands with a low proportion of silt (Greenstreet *et al*., 2010), and as such, sediment composition data can be used to indicate areas of suitable habitat for this species. In order to do this, Particle Size Analysis (PSA) of 158 benthic grab samples (of which 113 (from 97 sampling stations) were taken from the Development Area and 45 from the Offshore Export Cable Corridor) (Figure 12.2 and 12.6); along with visual assessment of sediment proportions from DDV analysis at 35 sites in and around the Development Area (Figure 12A.15), were assessed in order to assign categories of suitability to areas of the seabed (Prime, Subprime, Suitable and Unsuitable).

Desk Based Studies

17 Desk based reviews have been coupled with the site specific survey data in order to inform a number of assessments made within this chapter. This has included reviewing landings data and literature on the life history and biological sensitivities of fish and shellfish species present.

18 In addition an Electromagnetic Field (EMF) study was conducted, specifically in relation to the potential EMF effects on fish populations in the area of the Project *(Appendix 13C*), and a review of the distribution of nursery and spawning areas (Ellis *et al*., 2012 and Coull *et al*., 1998) informed the assessment of potential impacts to those spawning and nursery areas in close proximity to the Development Area and Offshore Export Cable Corridor.

19 Given the hearing sensitivity of herring to piling noise a specific Herring Spawning Study was also undertaken (*Appendix 13D*), in which the potential impact of noise disturbance was examined on herring spawning areas through the examination of the International Herring Larvae Survey (IHLS) data (ICES, last updated 2012), International Bottom Trawl Survey (IBTS) data (ICES, last updated 2013) and herring landings data (ICES).

20 These and other key data sources used for the baseline assessment are summarised in Table 13.4.

Table 13.4: Data Sources for Fish and Shellfish Baseline and Impact Assessment

Data Source	Area of Research
External/Pre-existing Data	
Marine Scotland Science	Salmon Migration routes (Malcolm *et al*., 2010). Landings data (2007-2011) (Marine Scotland Science, 2012). Bycatch data (2010). Marine Scotland Science all demersal gear survey data (1927 – 2010). Sandeel habitat preference methodology (Greenstreet *et al*., 2010 – *Appendix 13B*).

Data Source	Area of Research
ICES (DATRAS)	IBTS Data (ICES, last updated 2013). IHLS Data (ICES, last updated 2012). Landings data (ICES, 2011).
Cefas	Fish sensitivity maps (Coull *et al.,* 1998; Ellis *et al.,* 2012). Nursery and Spawning data (Coull *et al.,* 1998; Ellis *et al.,* 2012).
Published literature	Academic peer reviewed papers on relevant topics including EMF and noise impacts on fish. These are referenced where appropriate in this chapter.
ICOL Commissioned Surveys and Studies	
AMEC Environment & Infrastructure Limited	Inch Cape quarterly fishing surveys (*Appendix 13A*). ICOL epibenthic beam trawl survey (*Chapter 12 Section 12.5*). ICOL DDV survey (*Chapter 12 Section 12.5*) ICOL benthic grab survey (*Chapter 12 Section 12.5*).
Envision Mapping Ltd	Sandeel Habitat Mapping (*Appendix 13B*).
Fugro EMU Ltd	2010 data collection. 2012 DDV and data analysis.
Subacoustech Ltd	Noise modelling study (*Chapter 11 and Appendix 11A: Underwater Noise*).
Intertek METOC Ltd	Metocean and coastal process modelling study (*Chapter 10*).
The Natural Power Consultants Limited	EMF study *(Appendix 13C).* Herring Spawning Study *(Appendix 13D).*

13.4.3 Overview of Fish and Shellfish Resources in the Study Area

Commercial Fisheries Data

21 Commercial fisheries data provides an insight into the range of species found within the region of the Project. Examination of landings data taken from the Site Specific Study Area (ICES rectangles 41E7 and 42E7) highlights the dominance of shellfish over white fish in commercial landings, with *Nephrops* and king scallop (*Pecten maximus)* dominating landings by weight (Figure 13.3 and Figure 13.4). Other shellfish species landed between 2007 and 2011 include the edible crab (*Cancer pagurus*), the common lobster (*Homarus gammarus*), European squid (*Loligo forbesii*), whelks (*Buccinum undatum*), velvet swimming crabs (*Necora puber*), clams (*Mya arenaria*), surf clams and razor clams (unspecified species) (Figure 13.3 and Figure 13.4). In addition to the shellfish shown in Figure 13.3 and Figure 13.4, smaller quantities of queen scallops (*Aequipecten opercularis*), green crab (*Carcinus*

maenas), cockles (*Cerastoderma edule*) and brown shrimps (*Crangon crangon*) have also been landed over the past five years.

Figure 13.3: Landings of Invertebrates by Weight from ICES Rectangle 41E7 (2007-2011)

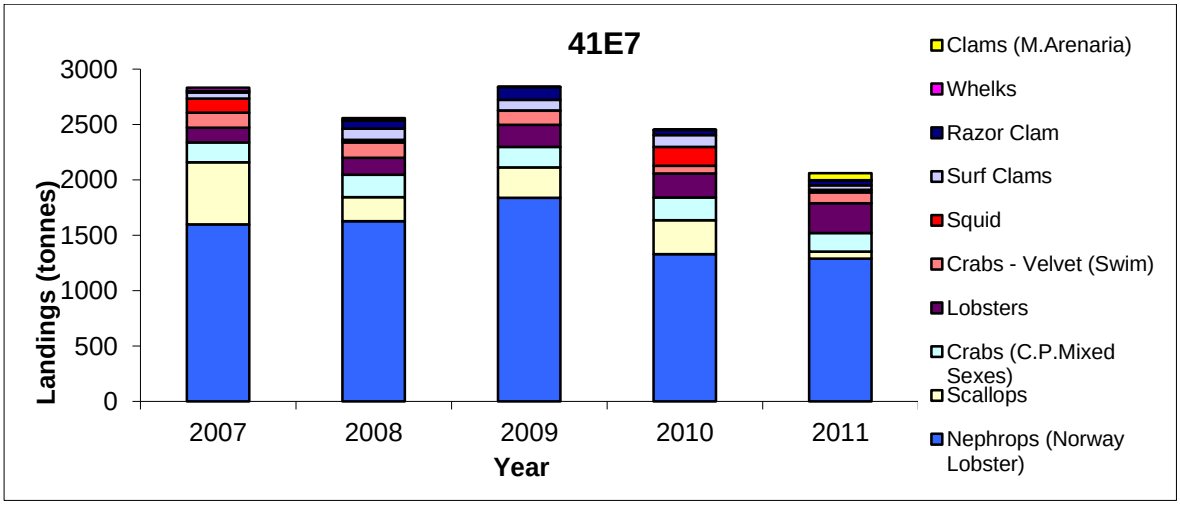
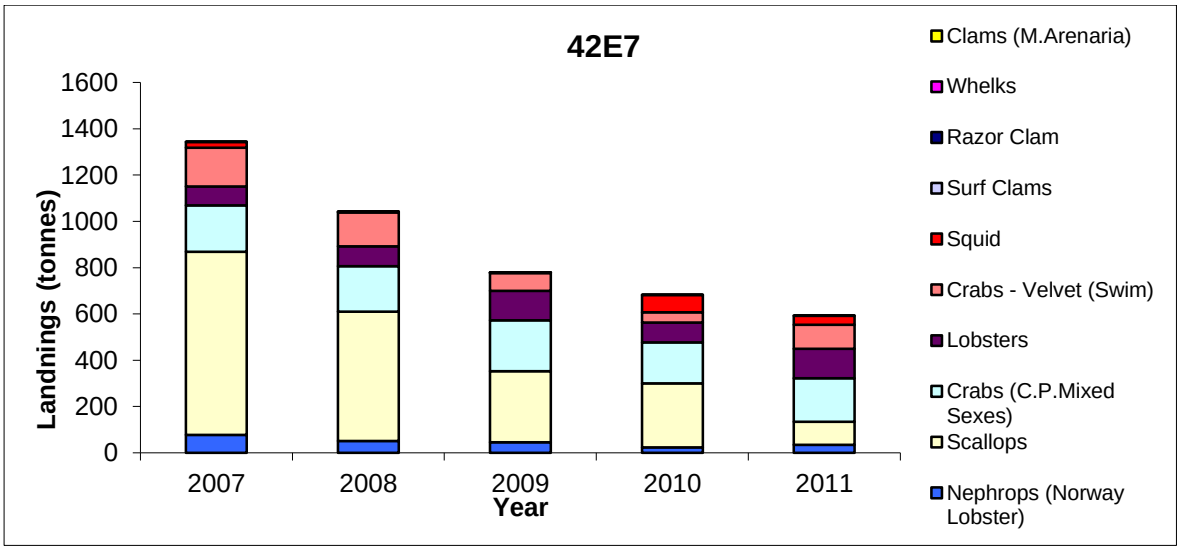


Figure 13.4: Landings of Invertebrates by Weight from ICES Rectangle 42E7 (2007-2011)



22 Of the fish landed from within the Site Specific Study Area, mackerel (*Scomber scombrus*), haddock (*Melanogrammus aeglefinus*) and cod (*Gadus morhua*) were the dominant species by weight between 2007 and 2011, with mackerel contributing increasingly both in terms of overall weight and proportion of landings over the past five years. Plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangus*), lemon sole (*Microstomus kitt*), saithe (*Pollachius virens*), halibut (*Hippoglossus hippoglossus*) and monkfish (*Lophius piscatorius*), were also commonly landed between 2007 and 2011 (Figure 13.5, Figure 13.6, Table 13.5).

Figure 13.5: Landings of Fish Species by Weight from ICES Rectangle 41E7 (2007-2011)

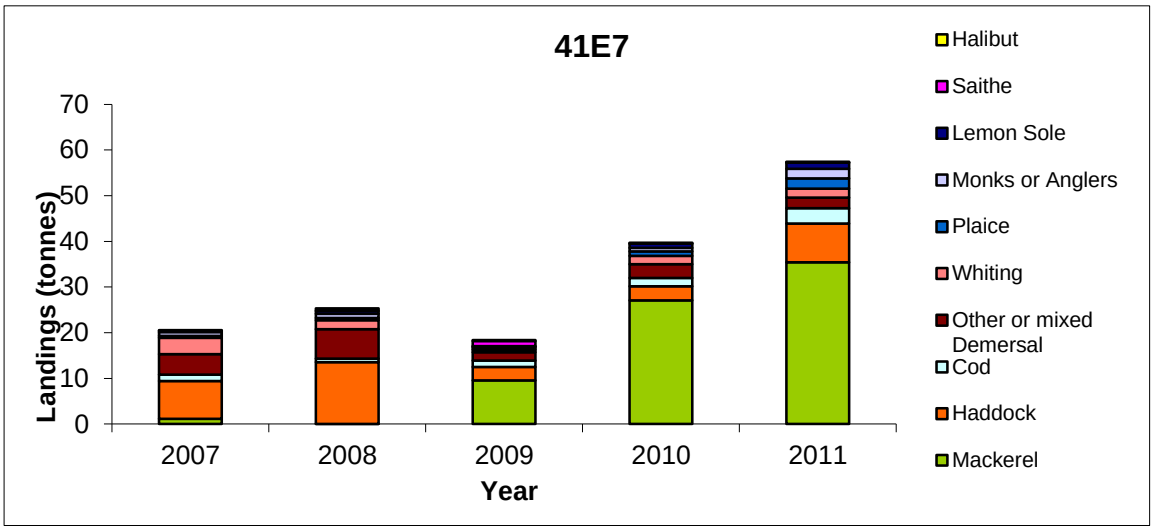


Figure 13.6: Landings of Fish Species by Weight from ICES rectangle 42E7 (2007-2011)

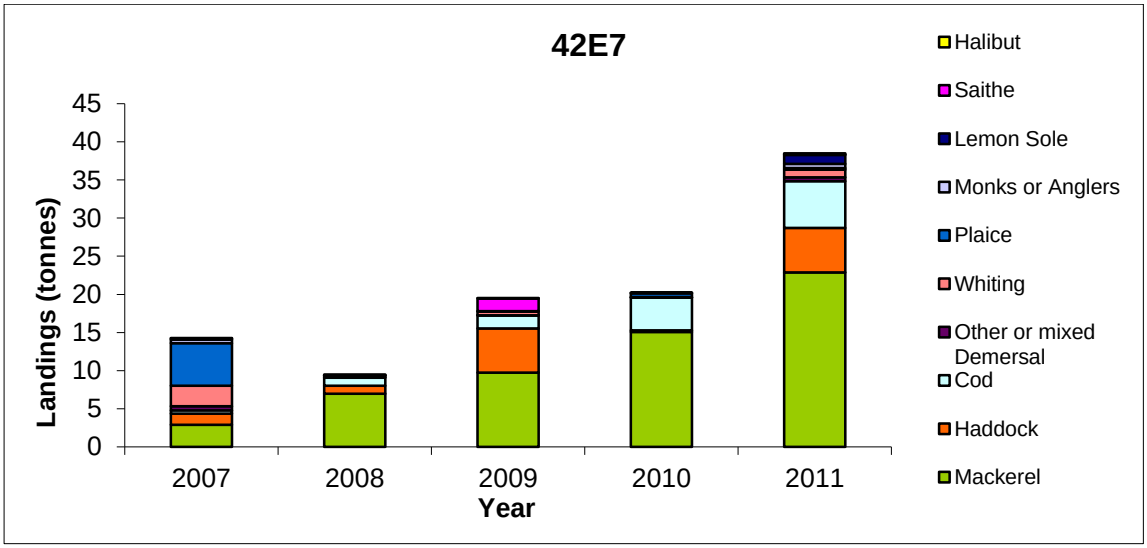


Table 13.5: Commercial Fish Species which Contributed to Catches from ICES Rectangles within the Site Specific Survey Area between 2007-2011.

41E7	42E7
Mackerel (*Scomber scombrus*), haddock (*Melanogrammus aeglefinus*), cod (*Gadus morhua*), plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangus*), lemon sole (*Microstomus kitt*), saithe (*Pollachius virens*), halibut (*Hippoglossus hippoglossus*), monkfish (*Lophius piscatorius*), dab (*Limanda limanda*), witch (*Pleuronectes cynoglossus*), hake (*Merluccius merluccius*), pollack (*Pollachius pollachius*), skate and ray, other flatfish, sprat (*Sprattus sprattus*), ling (*Molva molva),* red	Mackerel (*Scomber scombrus*), haddock (*Melanogrammus aeglefinus*), cod (*Gadus morhua*) plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangus*), lemon sole (*Microstomus kitt*), saithe (*Pollachius virens*), halibut (*Hippoglossus hippoglossus*), monkfish (*Lophius piscatorius*), dab (*Limanda limanda*), witch (*Pleuronectes cynoglossus*), hake (*Merluccius merluccius*), pollack (*Pollachius pollachius*), skate and rays, other flatfish, ling (*Molva molva*), red gurnard (*Aspitrigla cuculus*),

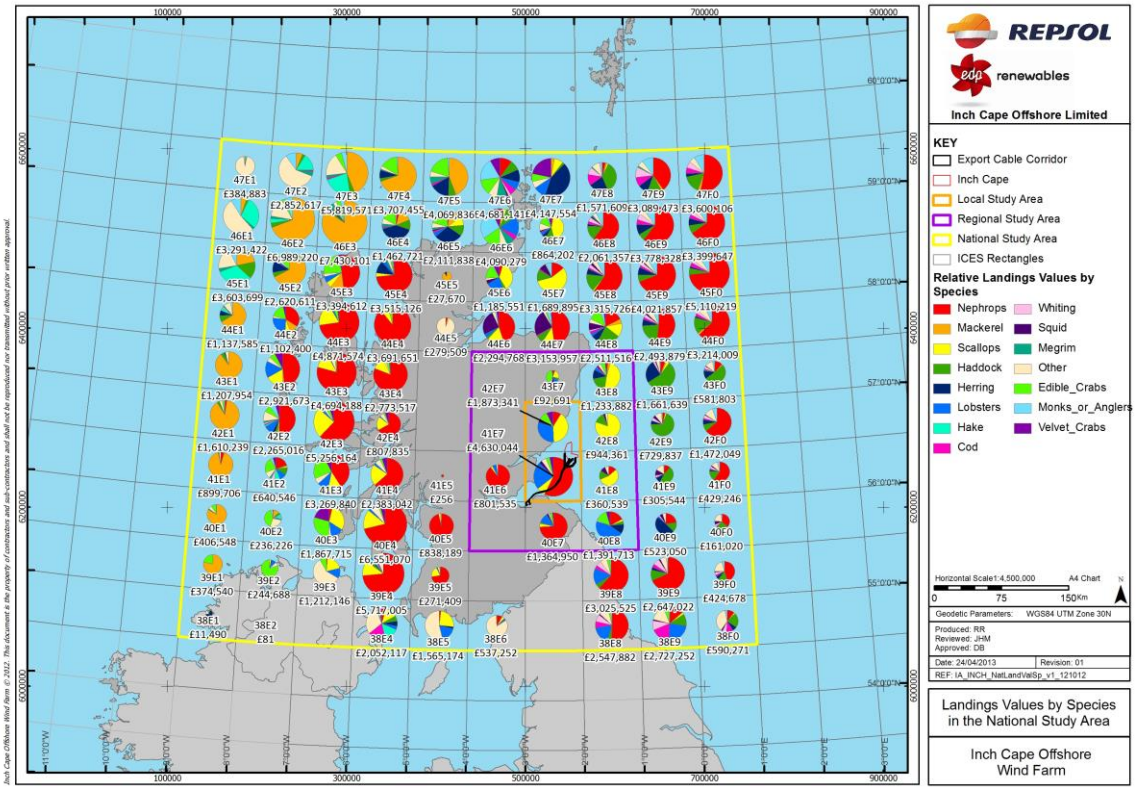
41E7	42E7
gurnard (*Aspitrigla cuculus*), turbot (*Scophthalmus maximus*), grey gurnard (*Eutrigla gurnardus*), gurnard and latchet, spurdog (*Squalus acanthius*), sole (*Solea solea*), megrim (*Lepidorhombus whiffiagonis*), shark, brill (*Scophthalmus rhombus*), red mullet (*Mullus surmuletus*), unidentified dogfish, conger eels (*Conger conger*), redfish, roes, shad, wrasse (*Labridae*), mullet – other, John dory (*Zeus faber*), bass (*Dicentrarchus labrax*).	turbot (*Scophthalmus maximus*), gurnard and latchet, sole (*Solea solea*), brill (*Scophthalmus rhombus*), red mullet (*Mullus surmuletus*), conger eel (*Conger conger*).

23 Further information on the range of species present in the Site Specific Study Area is available from bycatch (i.e. fish which are captured and then discharged) data. Despite their low commercial value these species represent a range of potentially important prey items for birds, mammals and larger fish. In addition to those species found to be dominant within commercial fisheries landings (Table 13.5), 2010 bycatch data from the Site Specific Study Area demonstrates the presence of cuckoo ray (*Leucoraja naevus*), dragonet (*Callionymus lyra*), flounder (*Platichthys flesus*), long rough dab (*Hippoglossoides platessoides*), sars wolf eel (*Lycenchelys sarsii*), Norway bullhead (*Taurulus liljeborgi*), Norway pout (*Trisopterus esmarki*), poor cod (*Trisopterus minutus*), bullrout (*Myoxocephalus scorpius*), four-bearded rockling (*Rhinonemus cimbrius*), herring (*Clupea harengus*), hooknose (*Agonus cataphractus*), John dory (*Zeus faber*), lesser spotted dogfish (*Scyliorhinus canicula*), shore rockling (*Gaidropsarus mediterraneus*) and viviparous blenny (*Zoarces viviparous*).

24 The site specific surveys carried out in and around the Development Area (Figure 13.2, *Appendix 13A*) confirm the presence of many of these species identified in the Site Specific Survey Area. A total of 30 different species of fish and 20 species of macro-invertebrate were found during these surveys. Of the fish species, Norway pout, whiting, haddock, bib (*Trisopterus luscus*) and sprat were caught in the highest numbers. European squid, pink shrimp (*Pandalus montagui*) and common lobster were the most commonly captured invertebrates.

25 Examination of commercial landings data at at a national level allows the fish and shellfish resource within the Site Specific Study Area study to be put into context (Figure 13.7). Through examination of *Chapter 18, Section 18.4,* it is clear that in terms of value of the fishery, 41E7 is locally important in terms of *Nephrops* and lobster landings (comparable to north-east and west coast in terms of *Nephrops* landings), whereas 42E7 is locally important for scallop fishing and lobsters. Further east of the Site Specific Study Area, within the Local Study Area (ICES squares 42E8, 42E9) haddock and scallops dominated landings by weight over the period 2001-2010 (Figure 13.7).

Figure 13.7: Scottish Landings of Fish and Shellfish Species by Value (2001-2010)*



*The definitions of the study areas used in Figure 13.7 are derived from *Chapter 18* and boundaries differ from those used in this this assessment.

Spawning Grounds and Nursery Areas

26 A number of species of both natural fish and shellfish are known to spawn or have nursery grounds which overlap the Development Area and/or the Offshore Export Cable Corridor (Table 13.6; *Annex 13A.1*). These are spawning grounds of plaice, lemon sole, whiting, cod, sandeels and *Nephrops*; and nursery grounds for mackerel, sprat, herring, plaice, lemon sole, whiting, cod, sandeel (mixed species), spurdog (*Squalus acanthias*), tope (*Galeorhinus galeus),* common skate (*Dipturus batis* – complex), blue whiting (*Micromesistius poutassou*), European hake, ling, saithe, anglerfish and *Nephrops* (Ellis *et al.,* 2012 and Coull *et al.,* 1998). Beyond the boundaries of the Development Area and/or the Offshore Export Cable Corridor, but within the Local Study Area, spawning areas of herring and sprat are present (Ellis *et al*., 2012 and Coull *et al*., 1998). The locations of the spawning and nursery areas of the most relevant species are provided in *Annex 13A.1*) and impacts on these are assessed in *Sections 13.6* and *13.7.*

Table 13.6: Spawning and Nursery Grounds Present in the Site Specific Study Area and Distances to Nearest Spawning Area

Species	Spawning area location and spawning seasons (in brackets)	Nursery area location
Anglerfish	Irish Sea - off South Wales	Overlaps Project
Sandeel	Overlaps Project (November, December, January, February)	Overlaps Project
Spurdog	No data on spawning location	Overlaps Project
Mackerel	Irish Sea	Overlaps Project
Plaice	Overlaps Project (December, **January, February,** March)	Overlaps Project
Tope	No data on spawning location	Overlaps Project
Whiting	Overlaps Project (February – June)	Overlaps project
Common skate	No data on spawning location	Overlaps Development Area only
Spotted ray	No data on spawning location	3 km from Project
Blue whiting	Off Western Ireland - Atlantic	Overlaps Project
European hake	Irish Sea and North Atlantic	Overlaps Project
Ling	Irish Sea	Overlaps Project
Herring	4.5 km from the Project	Overlaps Project
Cod	Overlaps Project (January, **February**, **March,** April)	Overlaps Project
Saithe	375 km from the Project	Overlaps Project
Lemon sole	Overlaps Project (April – September)	Overlaps Project
Sprat	15 km from Project	Overlaps Project
Haddock	292 km from Project	44 km from Project
Nephrops	Overlaps Project (all year- **April - June**)	Overlaps Project

Key: purple cells = Present (Coull *et al.,* 1998); blue cells = Present at low intensity (Ellis *et al.,* 2012); red cells = Present at high intensity (Ellis *et al.*, 2012). **Bold** = peak spawning seasons

NB: Project definition is found in *Chapter 1: Introduction Section 1.3.2* and in this context refers to only the offshore elements of the Project

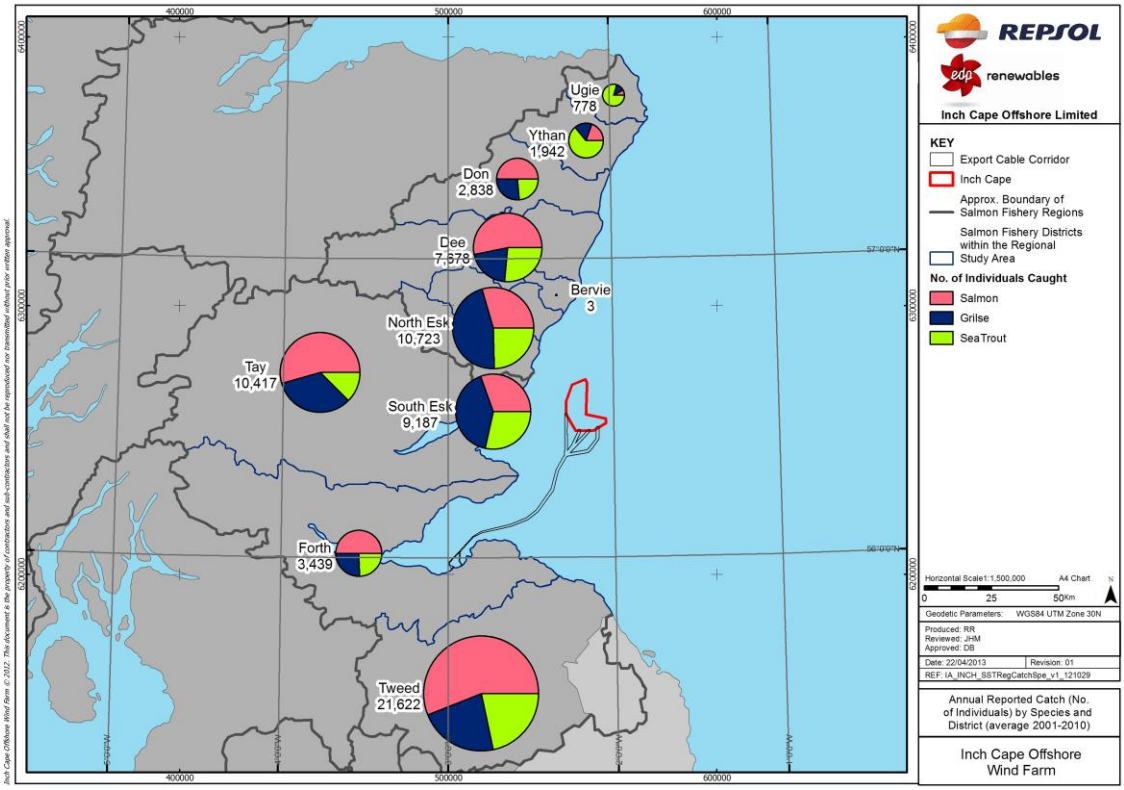
Species of Conservation Importance

27 As detailed in *Chapter 9: Designated Nature Conservation Sites* there are a number of SACs on the east coast of Scotland (Figure 13.1) which are designated for migratory fish. The River Tay, River Teith and River Tweed are designated for Atlantic salmon (*Salmo salar*) (also referred to as salmon), sea lamprey (*Petromyzon marinus)* and river lamprey (*Lampetra fluviatilis*), while the Rivers South Esk and Dee are designated for Atlantic salmon and fresh water pearl mussels (*Margaritifera margaritifera*) (from here on abbreviated to FWPM). These migratory fish enter and leave these SACs and may therefore pass through the Development Area and/or Offshore Export Cable Corridor during the marine phase of life. FWPM are found as adult mussels in riverine environments only, however they rely on migrating anadromous salmonids during the glochidial stage of their lifecycle when the larvae attach to the gills of passing fish as parasites.

28 In addition to these SAC qualifying species, there are a number of other migratory species found locally which are of conservation importance including Priority Marine Features (PMFs), species which are listed on the *Scottish Biodiversity List (Scottish Government, last updated 2013)* and OSPAR (2008) *List of Threatened and/or Declining Species and Habitats*, such as sea trout (*Salmo trutta*), the European eel (*Anguilla anguilla*), allis and twaite shad (*Alosa alosa* and *Alosa fallax*), and sparling (*Osmerus eperlanus*) (Atlantic salmon, river and sea lamprey are also PMFs). The ecology of these species and their designated status is discussed within *Appendix 13A*. Information on the distribution of these species within the Regional Study Area is somewhat limited, due to gaps in the knowledge of the offshore migratory phase of these species (Malcolm *et al.,* 2010; *Appendix 13A*). While it is recognised that these species are of conservation importance it should be noted that they do not necessarily have enhanced protection (no PMF falls within a proposed Marine Protected Area) and there is no requirement to undertake any additional assessment beyond the EIA Regulations.

29 Full detail on salmon and sea trout fisheries can be found in *Chapter 18, Section 18.4.2* and *Appendix 18C: Salmon and Sea Trout Baseline*. Atlantic salmon and sea trout are captured predominantly in rivers within the Regional Study Area. Salmon and grilse account for the majority of the catch in the Regional Study Area (Figure 13.8 taken from *Chapter 18*), with the exception of the Ythan and Ugie, where sea trout is the principal species caught. Highest salmon and sea trout catch numbers are recorded in the Tweed and Esk (including the North Esk, South Esk and Bervie) and, to a lesser extent, from the Tay and the Dee (Figure 13.8). The Forth and Teith (the River Teith is a tributary of the River Forth) have salmon and sea trout catch numbers less than a third of those recorded in the neighbouring Tay district. Salmon, grilse and sea trout catches have fluctuated during the ten year period, with no clear trends being apparent (Figure 18.33).

Figure 13.8: Annual Catch (No. of Individuals) by Species in Salmon Fishery Districts within the Regional Study Area (average 2001 - 2010) (Source: MSS)



30 There is a lack of detailed, evidence-based knowledge on the migration of Atlantic salmon smolt leaving Scottish east coast rivers, however they are likely to travel in a northerly and easterly direction en route to feeding grounds around Greenland (Malcolm *et al.*, 2010). Smolt are believed to leave the rivers in late spring. Malcolm *et al.*, (2010) found no evidence of coastal migration and it is assumed that smolt may migrate over a broad area unless there are areas of strong coastal currents. Adult Atlantic salmon returning to rivers on the east coast of Scotland are predominately multi sea winter adults and are believed to enter east coast Scottish rivers from the south (migrating up the coast from Northumberland between October and January; Malcolm *et al.*, 2010), although they are likely to migrate across a broad front. As no definitive migratory routes exist for Scottish east coast Atlantic salmon it must be assumed that some individuals migrate through the Project area enroute from or to their natal rivers.

31 Little is known about the distribution of sea lamprey during the adult (marine) phase of their lifecycle. They have been reported in shallow coastal waters and deep offshore waters suggesting they have a wide range and utilise a range of habitat types (Maitland, 2003).

32 No specific directions or routes have been identified and sea lampreys do not appear to return home to their natal streams, but instead are thought to be attracted to spawning areas by chemical cues released by conspecific larvae (Li *et al.*, 1995; Bjerselius *et al.*, 2000; Vrieze and Sorensen, 2001, cited in Watt, 2008). River lamprey migrate downstream to estuaries during the adult phase of the lifecycle and spend the majority of their adult life in

estuarine habitats with restricted movements to open sea (Maitland, 2003), rarely leaving estuarine habitats.

33 The allis and twaite shad spawn in riverine environments and use the coastal shelf for nursery grounds and migration. Information on the migratory behaviour of these species is limited, with the only known spawning sites found in rivers which flow into the Irish Sea (River Cree for allis shad, and the rivers flowing into the Severn estuary for twaite shad; Carstairs, 2000). Little is known about their offshore distribution; however they are known to be pelagic shoaling species. In relation to the Project, the database for the Atlas of Freshwater Fishes (Davies *et al*., 2004) shows two records of the twaite shad in the Tay in 1978 and one record of the allis shad off the coast of St Andrews (date unknown). Unspecified species of shad have occasionally been reported in bycatch data within the ICES rectangle which encompasses the Offshore Export Cable Corridor (41E7), however these totalled just 5.7 kg for the two years they were reported (2009 and 2011).

34 The uncertainties of distribution and migrational routes for these species also apply to that of sea trout, European eel and sparling.

35 In addition to these migratory species the presence of a number of marine fish of species of conservation importance was confirmed by the site specific surveys at the Development Area and review of commercial fisheries landings and bycatch data, and spawning/nursery areas (Table 13.7).

Table 13.7: Species of Conservation Importance found within the Site Specific Study Area and Data Source 41E7 and/or 42E7 (excluding migratory fish)

Species	Data Source	PMF	UK BAP Species Scottish Biodiversity List	OSPAR
Norway pout *(Trisopterus esmarkii)*	ICOL survey data, Bycatch data	Yes	-	-
Whiting *(Merlangius merlangus)*	ICOL survey data, ICES landings data , Spawning Ground, Nursery Area	Yes – juveniles	Yes	-
Sandeel *(Ammodytes tobianus)*	ICOL survey data, Bycatch data	Yes	-	-
Mackerel *(Scomber scombrus)*	ICOL survey data, ICES landings data	Yes	-	-
Herring *(Clupea harengus)*	ICOL survey data, Bycatch Data	Yes – juveniles and spawning adults	-	-

Species	Data Source	PMF	UK BAP Species Scottish Biodiversity List	OSPAR
Cod *(Gadus morhua)*	ICOL survey data, ICES landings data	Yes	Yes	Yes
Saithe *(Pollachius virens)*	ICOL survey data, ICES landings data	Yes	-	-
Ling *(Molva molva)*	ICOL survey data, ICES landings data	Yes	Yes	-
Spurdog (*Squalus acanthias*)	Bycatch data, Nursery area	Yes	-	Yes
Common skate (*Dipturus batis* – complex)	Bycatch data, Nursery Area	Yes	-	Yes
Angler/Monk fish *(Lophius piscatorius)*	Nursery Area	Yes - juveniles	-	-

Ecologically Important Species

36 All of the species captured or described previously have an ecological role; however particular attention must be paid to sandeel, which are defined as a keystone species for many marine food webs, constituting the principal prey of many top predators including birds (*Chapter 15*) and marine mammals, such as harbour porpoise (*Phocoena phocoena*) and minke whale (*Balaenoptera acutorostrata*) (*Chapter 14*).

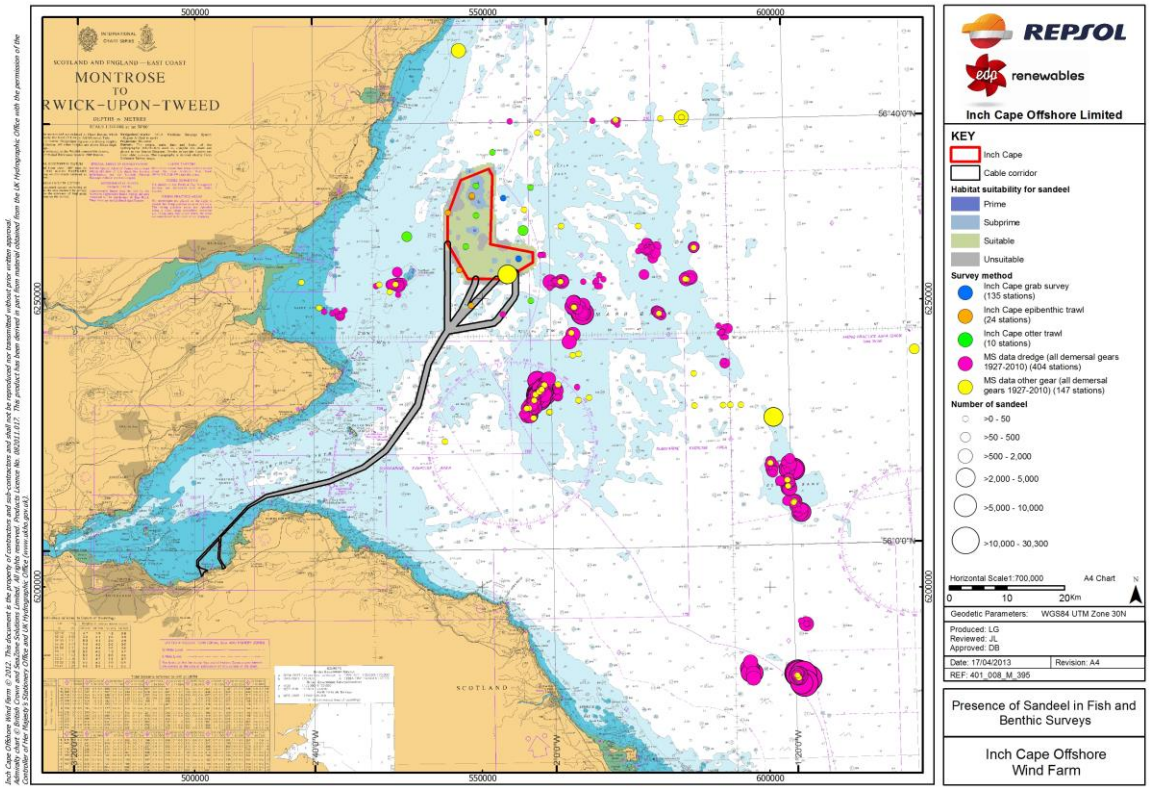
37 There are five species of sandeel in the North Sea, though the majority of commercial landings are of *Ammodytes marinus* (Cefas, 2001). Sandeel abundance within the Regional Study Area was provided by MSS (pers. com) which collates catch data from their surveys using all demersal gears (including dredge, grab and trawls) from 1927 to 2010 (from hereon referred to as MSS, all demersal gear survey data, 1927-2010). The highest catches of sandeels have been recorded on specific banks to the south east of the Development Area (Figure 13.9) where MSS undertook dredging surveys. This method which specifically targets sandeels was repeated over a number of years in these areas and recorded catches up to 30,300 in a single sample. The fact that sandeel surveys have been repeatedly carried out on these banks may indicate that these areas are known areas of sandeel concentration.

38 Noting the importance of sandeel, the baseline characterisation work for fish ecology included analysis of potential sandeel habitat in and around the Development Area and Offshore Export Cable Corridor (*Appendix 13B*). Sandeels have been shown to have a preference for clean coarse sands with a low proportion of silt (Greenstreet *et al.,* 2010), and as such sediment composition data can be used to indicate areas of suitable habitat for this

species. Habitat mapping of the Development Area and Offshore Export Cable Corridor indicates that large areas of the Development Area are suitable for sandeel, but with few areas of prime habitat, whereas the Offshore Export Cable Corridor was considered to be almost entirely unsuitable for sandeel (Figure 13.9).

39 MSS data (MSS, all demersal gear survey data, 1927 – 2010) and site specific survey data (benthic grabs, epibenthic trawls and otter trawls (Figure 13.9)) supports this conclusion, revealing that low densities of sandeels have been found in areas in and around the Development Area. The exception to this is one trawl sample taken from the south-east region of the Development Area in 1992 by MSS where a large number of sandeels were found, however this was located in subprime habitat and this result has not been repeated. Although it is acknowledged that the site specific surveys and trawl and grab MSS surveys were not specifically designed to catch sandeels, the spatial and temporal extent of the data does provide an indication of where high sandeel concentrations may be found, as in areas of high sandeel abundance high catches do occur. For example, in one MSS trawl survey (not within the Development Area or Offshore Export Cable Corridor area) over 7,000 sandeels were recorded in a single trawl tow. During site specific surveys the greatest number of sandeel caught within the Development Area in a single sample was 13 individuals, caught during the otter trawl survey (*Appendix 13A*). Sandeel were captured at only two of 113 grab sample stations, eight out of 10 otter trawl stations and five of 24 epibenthic trawl stations.

Figure 13.9: Sandeel Suitability of Seabed (Development Area and Offshore Export Cable Corridor) and Distribution in the Local Study Area



13.4.4 Consideration of Key Receptors

40 The overview of fish and shellfish resources, in conjunction with consultation with statutory and non-statutory consultees, has allowed the identification of specific fish and shellfish receptors against which detailed impact assessment can be undertaken. As it is not possible to assess every fish and shellfish species against every impact, fish and shellfish species have been grouped together in receptor groups in line with current IEEM (2010) guidelines. The receptors are grouped with reference to their life history characteristics, sensitivity, relative conservation and ecological importance (Table 13.8) and are assessed as such throughout this chapter.

Table 13.8: Key Fish and Shellfish Receptors

Receptor	Key Species
Mobile fish species	Whiting, plaice, haddock, plaice, mackerel, sea trout, European eel, sparling, squid, etc. (i.e. all species of fish not included in another specific receptor group).
Hearing specialists	Herring, sprat, allis shad, twaite shad and cod.
Prey species (specifically sandeel)	Sandeel.
Electro-sensitive elasmobranchs	Ray and skate species, dogfish, spurdog, tope.
SAC qualifying feature species	Salmon, sea lamprey, river lamprey, FWPM.
Shellfish	Scallop, crab, lobster, *Nephrops.*

41 Information is provided below on why they are grouped along with a summary of information relevant to the assessment of impact on these key receptors (Table 13.9). The assessment for each receptor group incorporates impacts on spawning success, where the Development Area or Offshore Export Cable Corridor overlap, or could affect, spawning grounds. This includes the impact of effects on spawning aggregations of adult fish at spawning areas, and effects on larvae and eggs.

42 With the receptor group approach, it is important to remember that, although there may be differences in the species within groups, in terms of exact sensitivities to effects, variations in some stage of their life history, or in their conservation value, these variations fall within a relative range which allows them to be assessed as a group. Differences between species within groups are explored within the assessment.

43 Information on their presence and distribution within the Development Area and Offshore Export Cable Corridor is provided in *Sections 13.4.5* and *13.4.6*, respectively. The sensitivity of these receptor groups in terms of EIA methodology are defined in *Section 13.5*.1.

Table 13.9: Information on Grouping and Sensitivities/Vulnerabilities of Receptor Groups

Species Included/Reason for Inclusion or Exclusion from Group	Summary of Sensitivity/Vulnerability to Effects
Mobile fish species	
This receptor group includes both demersal and pelagic fish species that have similar sensitivities to effects, as well as similar conservation value and ecological importance. This group includes squid (*Loligo forbesii*) which although technically not a fish is highly mobile and of a similar sensitivity. This group also includes migratory fish such as sea trout, sparling, and European eel that are not qualifying features of SACs. SAC qualifying species (i.e. salmon and lamprey) are not included in this group due to their high level of conservation importance as Annex II species and are dealt with as a separate receptor (**SAC species**). Fish whose swim bladders are connected to the inner ear, such as the clupeids (herring, sprat and shad) are considered to be hearing specialists and are considered as a separate receptor group. Cod are also regarded as having a moderate sensitivity to noise of a scale similar to herring, therefore cod are excluded as a mobile fish species receptor and included as a **Hearing specialist.** This group does not include species with specific sediment type requirements, such as sandeel as they are particularly vulnerable to sedimentation change and therefore, although they are mobile fish species, they have been treated as a separate receptors (see **Prey species** sections below). This group also does not include certain elasmobranchs that are able to detect EMF. These species are dealt with in their own receptor group **Electro-sensitive elasmobranchs.**	Mobile fish species (both pelagic and demersal) may be sensitive and/or vulnerable to effects arising from construction, operation and maintenance of the Project including, changes in SSC levels and associated deposition, noise, EMF and habitat loss. An increased SSC can result in avoidance behaviour and even a change in shoaling behaviour in some fish species. The vulnerability of mobile fish species to sedimentation is species specific, arising as a result of differences in tolerance, recoverability and adaptability of different species. Adult stocks of demersal fish are considered to be less vulnerable than juveniles to habitat loss, due to greater mobility and generalist feeding behaviour, the exception to this are sandeels which are dealt with as a distinct receptor group (**Prey species**) due to their importance as a prey item to many species of birds, marine mammals and fish. Vulnerability of fish to noise is dependent on whether the fish is a hearing generalist or specialist (**Hearing Specialists** are identified as a specific receptor group). Species that lack a swim bladder including flatfish and elasmobranchs, as well as species whose swim bladder is well removed from the inner ear such as salmon, tend to have low sensitivity to noise and are termed hearing generalists. Although there is variation in the exact hearing ranges between species, all the species within this group can be regarded as "hearing generalist". Hearing generalists generally hear over relatively narrow frequency ranges (from approximately 50 Hz to frequencies of up to 1,500 Hz) with a hearing sensitivity which is often not very good. The majority of marine fish are pelagic spawners, i.e. release their eggs into the water column. Pelagic spawners are less vulnerable to habitat loss/disturbance and SSC as they are not dependent on the bottom type for spawning success compared to demersal spawners. Increases in SSC can cause pelagic fish eggs (such as those laid by plaice) to sink and experience higher mortality rates (e.g. greater than 100 mgl^{-1} for cod eggs), and lethal and sub-lethal effects on fish larvae through reduced sight and therefore feeding have been recorded (Engell-Sørensen and Skyt, 2003). Some of the fish in this group are migratory fish that spawn in riverine habitats and as such spawning success is vulnerable indirectly through barrier effects to migration rather than direct impacts on spawning within rivers.

Species Included/Reason for Inclusion or Exclusion from Group	Summary of Sensitivity/Vulnerability to Effects
Hearing specialists	
Herring, sprat, shad and cod make up the receptor group **Hearing specialists** for this assessment. They form a distinct receptor group due to their enhanced sensitivity to noise, which means they must be assessed separately. In herring, shad and sprat, the diverticula of the swim bladder extends into the skull and is connected to the inner ear by otic bullae, this aids transmission of acoustic vibrations from the swim bladder to the ear thus increasing the hearing capabilities of the species (Allen *et al.,* 1976). Therefore these species are considered a hearing specialist (Enger *et al.,* 1993; Kastelein *et al.,* 2008; Blaxter *et al.,* 1981; Nedwell, 2004). As cod do not have a connection between the swim bladder and the inner ear, they may be classed as a hearing generalist. However, it is considered to be more sensitive to noise than other generalists, and as such has been assessed within the hearing specialist receptor group.	Fish species categorised as hearing specialists usually have improved sensitivity at the same frequencies ranges as hearing generalists and sensitivity to sound at higher frequencies (extending above 3,000 Hz). Hearing specialists also may be vulnerable to habitat loss and disturbance, SSC and EMF. These impacts are assessed for this receptor group throughout the assessment. Herring are demersal spawners i.e. they lay their eggs on the seabed. Herring spawning distribution is therefore strongly related to substratum type, specifically well-sorted, coarse sand or fine gravel (>50% gravel content), with little or no silt content (Maravelias, 2001). This can make herring particularly vulnerable to impacts which could affect the physical make up of their spawning grounds. This includes habitat loss, habitat disturbance as well as increased levels of SSC and deposition which could lead to a change in the grain size of the seabed. The potential impact on spawning success is dependent on whether it falls within the geographical area considered to be affected. Shad species spawn in riverine environments, and cod and sprat release their eggs into the water column (pelagic spawners). These species are therefore less vulnerable to habitat loss/disturbance in the marine environment.
Prey species	
Many of the species identified in the baseline will represent important prey items for birds, marine mammals and larger fish, however sandeels (various species) represents one of the most important prey species for many bird, fish and marine mammal species and as such are defined as a keystone species for many marine food webs. Noting the importance of this species, it has been identified as a specific receptor against which the various impacts from this development have been assessed.	Sandeels have highly specific habitat requirements, whereby they inhabit shallow turbulent sandy areas with a high percentage of medium to coarse grained sand (particle size 0.25-2.0 mm) (Greenstreet *et al.,* 2010). Sandeels do not maintain permanent burrow opening, and instead ventilate their gills with interstitial water, hence fine sediment particles could clog their gills and inhibit respiration (Holland *et al.,* 2005). For this reason increased SSC and subsequent sedimentation may have an impact on sandeel populations. The highly specific habitat requirements of sandeels mean that they are also sensitive to habitat loss, as other suitable areas may not be available. In addition, sandeels may be vulnerable to other effects in the same way as other demersal species.

Species Included/Reason for Inclusion or Exclusion from Group	Summary of Sensitivity/Vulnerability to Effects
	Sandeels deposit their eggs on the seabed (demersal spawners) which, combined with their very specific habitat preferences, can make sandeel particularly vulnerable to impacts which could affect the physical make up of their spawning grounds. This includes habitat loss, habitat disturbance as well as increased levels of SSC and deposition which could lead to a change in the grain size of the seabed. The potential impact on a spawning habitat is dependent on whether it falls within the geographical area considered to be affected.
Electro-sensitive elasmobranchs	
Certain species of marine organisms are able to detect EMF. Elasmobranches (sharks, skates and rays), and are considered to be particularly sensitive to this effect, therefore are assessed as a separate receptor group. In addition many species of elasmobranchs are considered of conservation importance, either as PMFs or under OSPAR. Other species of fish and shellfish are also sensitive to EMF (such as river lamprey, sea lamprey, cod, European eel, plaice, Atlantic salmon and even some shellfish species (Gill *et al.,* 2005; *Appendix 13C*), however the impact of EMF on these species is considered within their own receptors groups (i.e. Mobile fish species, SAC species, shellfish etc.).	Specific data on the way in which elasmobranchs species utilise this ability to detect magnetic fields is limited but it is predicted that detection of prey/predators and/or orientation, homing, and navigation may all benefit from this ability (Gill *et al.,* 2005; Normandeau *et al.,* 2011). A review of the EMF sensitive species within the Project area was undertaken (*Appendix 13C*), however it was concluded that despite continuing research attempting to address the effects of offshore electrical cabling there are still knowledge gaps resulting in uncertainty in risk determinations of marine species in response to EMF's generated from subsea infrastructure. For example, experimental studies have provided evidence that some elasmobranch species (i.e. the lesser spotted dogfish and the thornback ray) can respond to the presence of EMF that are of the type and intensity associated with the subsea cables anticipated (Gill *et al.,* 2009). The reaction, however, was unpredictable and did not always occur and appeared to be species specific and, in some cases, individual specific (Gill *et al.,* 2009). In order to address the uncertainty in the understanding of EMF effects, the results of a recent site specific modelling study conducted for an analogous wind farm in the Moray Firth have been utilised where applicable and conservative estimations of magnitude have been carried through the assessment. Electro-sensitive elasmobranchs may also be sensitive to habitat loss, habitat disturbance, noise and SSC in the same way as other mobile fish species are. These impacts are assessed for this receptor group throughout the assessment.

Species Included/Reason for Inclusion or Exclusion from Group	Summary of Sensitivity/Vulnerability to Effects
SAC qualifying feature species	
Atlantic salmon, sea lamprey, river lamprey and FWPM are known to occur in SACs on the east coast of Scotland (in the River Tay, River Teith, River South Esk, River Dee, and the River Tweed). These species form a distinct receptor group due high conservation status as Annex II species from designated sites. These species may pass through the Project area when either leaving or returning to natal rivers. Consultation with key stakeholders, including SNH, Marine Scotland and regional fisheries boards has also reiterated the need for a full assessment of impacts on these key SAC qualifying species within this chapter. Therefore, this specific receptor group has been identified and will be used as the basis for subsequent impact assessment. Information on the life histories and migratory routes of these species is provided in *Appendix 13A*. FWPM are found as adult mussels in riverine environments only, however as their larvae rely on migrating salmonids, impacts on salmonids could impact on their populations.	The migratory behavior of these SAC species means that they are likely to be vulnerable to certain effects associated with the Project, specifically SSC, noise generated during construction and operation and EMF generated by subsea cables. Significant increases in SSC could present a barrier to migratory pathways in these SAC species (Posford Duvivier Environment and Hill, 2001), although estuarine fish generally show tolerance to variations in suspended sediment loadings and turbidity as a result of natural adaptation to living in a dynamic and environmentally variable habitat, (ABPmer, 2005). SSC can only be a barrier to migration if the conditions extend across the entire width of the water body comprising the migration route at any given point (ABPmer, 2011), as fish can move around the adverse condition area, avoiding impacts. While salmon is relatively well studied less is known regarding lampreys, however, as partially estuarine species, they are likely to commonly tolerate increases in suspended sediments. The swim bladder of salmon plays no part in the hearing of the species, and Hawkins and Johnstone (1978) found salmon to show low sensitivity to noise. Salmon are used to relatively noisy riverine environments, providing for some pre-adaption to elevated noise levels (Hawkins and Johnstone, 1978; Thomsen *et al.,* 2006). Lampreys do not possess specialist sensory organs such as otoliths or a swim bladder suggesting that the species are hearing generalists. Salmonids are likely to utilise EMF for navigation purposes during long distance migrations, which occur at specific stages of their life cycle (Gill *et al.,* 2005). Marine Scotland are currently undertaking a research programme to improve the knowledge base. This research is due to report in 2013. However, as this report has not been published, this research cannot be taken into consideration in this chapter. Sea lamprey are reported as having a relatively low detection threshold to electric (iE fields) however, no evidence of response to B fields exists (Gill and Bartlett, 2010). A summary of EMF effect is provided in *Section 13.6.2* and detailed in *Appendix 13C*. Although these receptors spawn in riverine environments, indirect impacts such as barrier effects to migration may impact on spawning.

Species Included/Reason for Inclusion or Exclusion from Group	Summary of Sensitivity/Vulnerability to Effects
	There is little information on the impacts of effects on FWMP larvae, however as they will only come into contact with the offshore elements of the Project as parasites on salmon gills, impacts on the species are only considered in terms of their reproductive success. Therefore any impacts on salmon migration are directly applicable to FWPM populations.
Shellfish	
Shellfish have been identified as a specific receptor group for impact assessment as they are less mobile than many fish species and have similar sensitivities/vulnerabilities to pressure. Certain shellfish species (scallops, *Nephrops*, crab, lobster) also represent an important target resource for commercial fisheries that operate in this region. Squid are not included in this receptor group as, although they are an important commercial shellfish species, in the Site Specific Study Area, they are highly mobile and have therefore been assessed along with mobile fish.	Shellfish species are less mobile and they can be more susceptible to impacts of SSC and smothering. Increased SSC can damage the feeding apparatus of filter feeders such as scallops and reduce growth rates. The effect of impacts varies from species to species. Scallops, buried by less than five centimetres of sediment are considered to be able to lift themselves clear of deposited sediments, (Marshall and Wilson, 2009), however burial by sediment deeper than five centimetres is considered to be fatal. *Nephrops* are also tolerant to smothering and increased SSC (MarLIN, 2011). Crabs and lobsters have slightly higher mobility and are tolerant of increased suspended sediments (Neal and Wilson, 2008). Shellfish are not considered to be sensitive to noise. Various studies on scallops, mussels, and lobsters have shown no deleterious effect from exposure to noise or seismic activity (e.g. Harrington *et al.,* 2010; Kosheleva, 1992, in Parry and Gason, 2006; Payne *et al*., 2007). Some shellfish species e.g. brown shrimps and lobster are magneto-sensitive and therefore may be sensitive to the EMF generated from subsea cables (*Appendix 13C*). Boles and Lohman (2003) found European lobster navigate away from the source of the magnetic (B) fields; conversely brown shrimp were positively attracted to magnetic fields similar to those produced by offshore wind transmission cabling. In these experiments no effect, was found on the survival of the species exposed to magnetic fields (Bochert and Zettler, 2004). *Nephrops* spawning grounds have been identified within the offshore Project area. Although no scallop spawning grounds have been identified in the literature, scallops are low mobility species known to spawn where they live; hence the areas where scallops live are also their spawning grounds. Crabs and lobsters conversely are known to migrate further offshore to release their larvae; hence their spawning is to be affected less by the Project.

13.4.5 Development Area Baseline

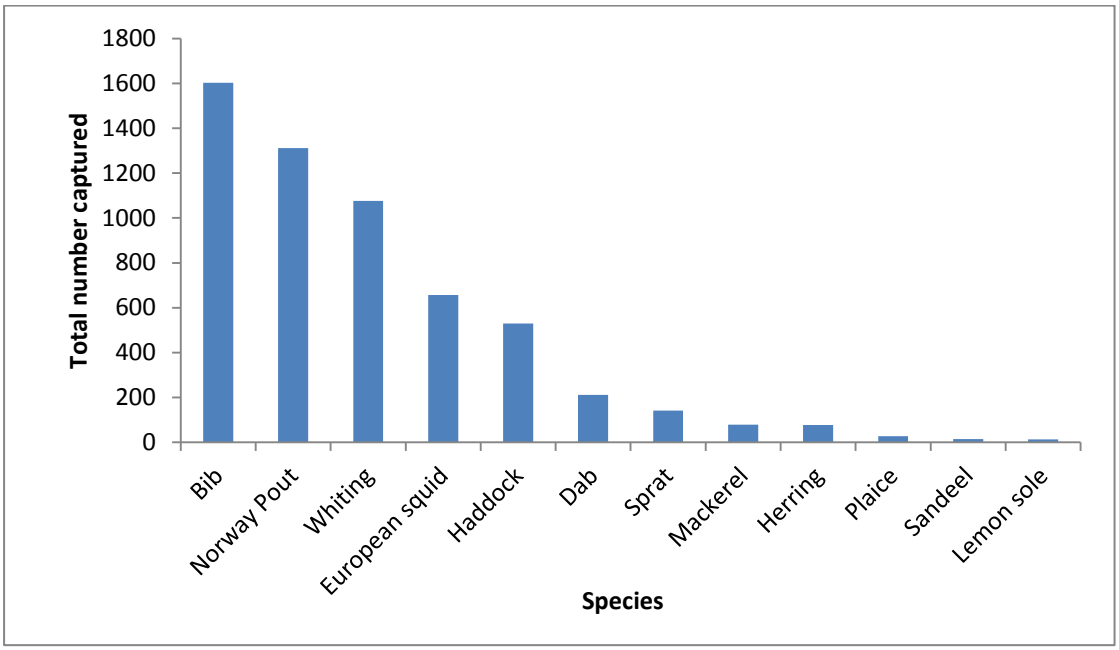
44 As a result of the mobile nature and wide distribution of many fish and shellfish species an overview of the baseline conditions in the study areas was presented in *Section 13.4.3* as many species are present in both the Development Area and Offshore Export Cable Corridor. This section presents baseline information summarising distribution of key receptors within the Development Area extrapolated from the overview and, in order to avoid repetition, where possible reference is made to information provided in *Section 13.4.3*.

Mobile Fish Species

45 The Development Area straddles two ICES rectangles: 41E7 covers the northern half of the Development Area while 42E7 covers the southern half and the Offshore Export Cable Corridor. Landings data for the period 2007 to 2011 for these rectangles indicate that the most abundant mobile fish species of commercial importance in this area is mackerel, followed by haddock, whiting and plaice (Figure 13.5 and Figure 13.6). In addition, the Development Area overlaps with identified spawning grounds of plaice, lemon sole, and whiting, and nursery grounds for mackerel, plaice, lemon sole, whiting, blue whiting, European hake, ling, saithe, and anglerfish (Table 13.6; see *Annex 13A.1*; Ellis *et al.,* 2012 and Coull *et al.,* 1998).

46 The presence of these species in the Development Area was demonstrated via the site specific otter trawl surveys (*Appendix 13A*) with whiting, haddock and mackerel being the dominant species of commercial importance captured (Figure 13.10). Other species of commercial importance captured during the otter trawl surveys were red and grey gurnard, lemon sole, cod, herring, John dory, ling and saithe. Analysis of the data revealed seasonal patterns of abundance and diversity with seasonal increases in Norway pout, bib and haddock (*Appendix 13A*).

Figure 13.10: Total Number of Most Abundant Fish Species Captured During the Site Specific Otter Trawl Surveys within the Development Area



47 Epibenthic beam trawl surveys carried out within the Development Area (*Appendix 12A*) identified additional mobile fish species, which were not recorded during otter trawl surveys. These were lesser weever (*Echiichthys vipera*), butterfish (*Pholis gunnellus*), sand goby (*Pomatoschistus minutus*) and topknot (*Zeugopterus puncatus*), and all were found in low abundance (i.e. 18 individuals or less).

Hearing Specialists

48 Herring, sprat and cod were captured in low numbers in the site specific surveys. Fisheries data also indicates that sprat and cod are present around the Development Area. It should be noted however, that no commercial landings of herring have been reported from the two ICES rectangles which cover the Development Area over the past five years (2007 to 2011), although herring are landed from other ICES rectangles within the Local and Regional Study Area (ICES squares 40E9, 42E8, 42E9; Figure 18.3). This indicates that although herring are present in the Development Area, they are either not judged to be worth landing by commercial fishermen or have not occurred in significant numbers in the period 2007 to 2011 and have therefore, not been captured and landed by commercial fishermen. Noting the fact that herring are a valuable commercial species and landed in relatively high quantities further offshore (ICES squares 40E9, 42E8, 42E9; Figure 18.3), it must be assumed that herring are not present in sufficient quantities to allow commercial exploitation within the Site Specific Study Area, rather than a lack of available market demand onshore.

49 No allis and twaite shad were found in the site specific surveys and records of these species in the Development Area are extremely scarce (see *Section 13.4.3*), being confined to one individual recorded off the coast of St Andrews (date unspecified) and 5.7 kg of bycatch in 2009 and 2011. The Development Area overlaps with identified spawning grounds of cod, and nursery grounds for sprat, herring and cod (Table 13.6; *Annex 13A.1*; Ellis *et al.*, 2012

and Coull *et al*., 1998). Sprat and herring spawning areas are also found beyond the boundaries of the Development Area (*Annex 13A.1*; Ellis *et al*., 2012 and Coull *et al*., 1998).

50 Although the Development Area does not coincide with potential herring spawning grounds as historically reported by Coull *et al.,* 1998 (Figure 13.11), there are reported grounds within proximity which are within the potential range of noise effects (*Section 13.6.1*). In addition, a review of spawning data by Ellis *et al.* (2012) suggested that herring could potentially spawn across a wider area although there was insufficient data to revise the historical spawning maps. In order to reduce uncertainties a Herring Spawning Study (*Appendix 13D*) was carried out to establish the extent of herring spawning in and around the Development Area. This included examination of IHLS data, IBTS data, site specific survey data and commercial fisheries data.

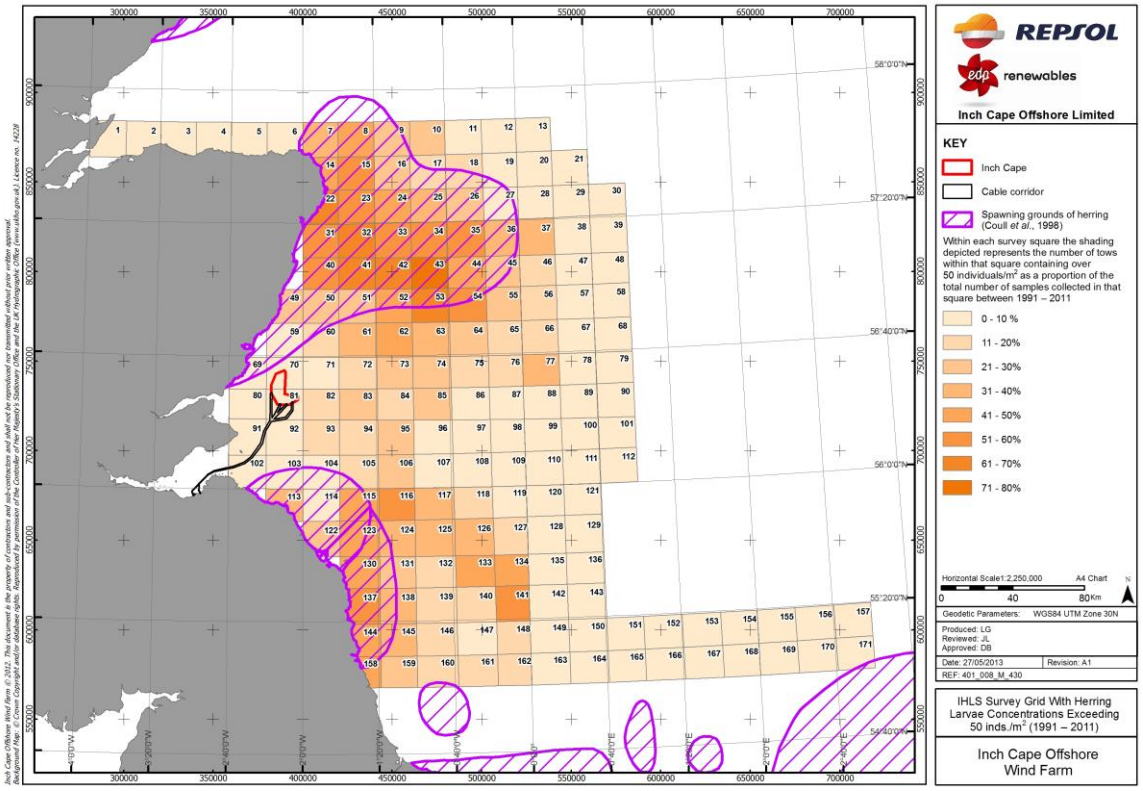
51 According to Coull *et al.* (1998) herring spawning grounds are located approximately 4.5 km to the north and 35.8 km to the south of the Development Area, although this report suggests that these may vary annually. To the north of the Development Area and off the north-east coasts of mainland Scotland and Shetland, herring of the Buchan/Shetland population spawn (Figure 13D.1), while to the south of the Development Area and off the north-east England coast (and in the central North Sea) herring from the Banks or Dogger herring population spawn. Adult herring migrate from offshore feeding grounds from mid-August peaking in September and lay eggs on gravel substrates at these spawning grounds. On hatching, the larvae move passively in a southerly direction on currents to coastal nursery areas along the east coast of the United Kingdom (UK).

52 Although the Development Area is considered homogeneous from a geomorphologic perspective (as noted in *Chapter 10*), the benthic surveys (*Appendix 12A*) revealed small differences in sediment characteristics which result in different benthic habitats for invertebrates and fish, therefore the Development Area is regarded as heterogenic mosaic of predominantly fine medium sands, with limited discrete areas of gravel and pebble and boulder habitats in terms of benthic ecology. Small discrete areas within the Development Area could potentially be suitable for herring spawning (i.e. they are gravelly); however these areas have limited spatial extent and are highly variable. Therefore, the Development Area is highly unlikely to represent an important spawning resource for adult herring. Otter trawl survey data from in and around the Development Area revealed that the majority of herring captured were under the minimum landing size (MLS) and therefore unlikely to be sexually mature. Although this survey methodology did not target herring specially, the fact that herring were captured indicates that they were present. In the autumn survey (during the spawning period) only 19 fish were recorded, of which, only one individual was over the MLS. Further evidence which suggests lack of herring spawning grounds within the Development Area is provided via data from the IHLS for the period 1991-2011, (*Appendix 13D*). These data indicate that high densities of herring larvae were not consistently recorded in and around the Development Area over this period. Significant concentrations (i.e. herring larvae densities exceeding 50 individuals per m^2) were recorded more commonly to the north-east and the south-east of the Project area (Figure 13.11). The IHLS data from

1991-2011 indicates clearly that the key spawning grounds to the north and south of the Development Area are still active and appear to be used year-on-year by spawning herring.

53 IBTS and commercial fishery data indicates that the greatest catch per unit effort of adult herring are also caught in this area confirming that important spawning grounds are likely to be present further to the north (*Appendix 13D*). It is, therefore, considered unlikely that the herring spawning grounds extend outside the current mapped areas (Coull *et al*., 1998) toward the Development Area. This observation appears to be confirmed by the lack of herring landings from ICES rectangle 42E7 in the period 2007 to 2011 and from the lack of suitable habitats found during the benthic surveys (*Appendix 12A*).

Figure 13.11: Herring Spawning Areas (Coull *et al.,* 1998) Overlain with the Proportion of Years When Herring Larval Concentration Exceeded 50 Individuals/m^2 (1991-2011) (taken from IHLS data)

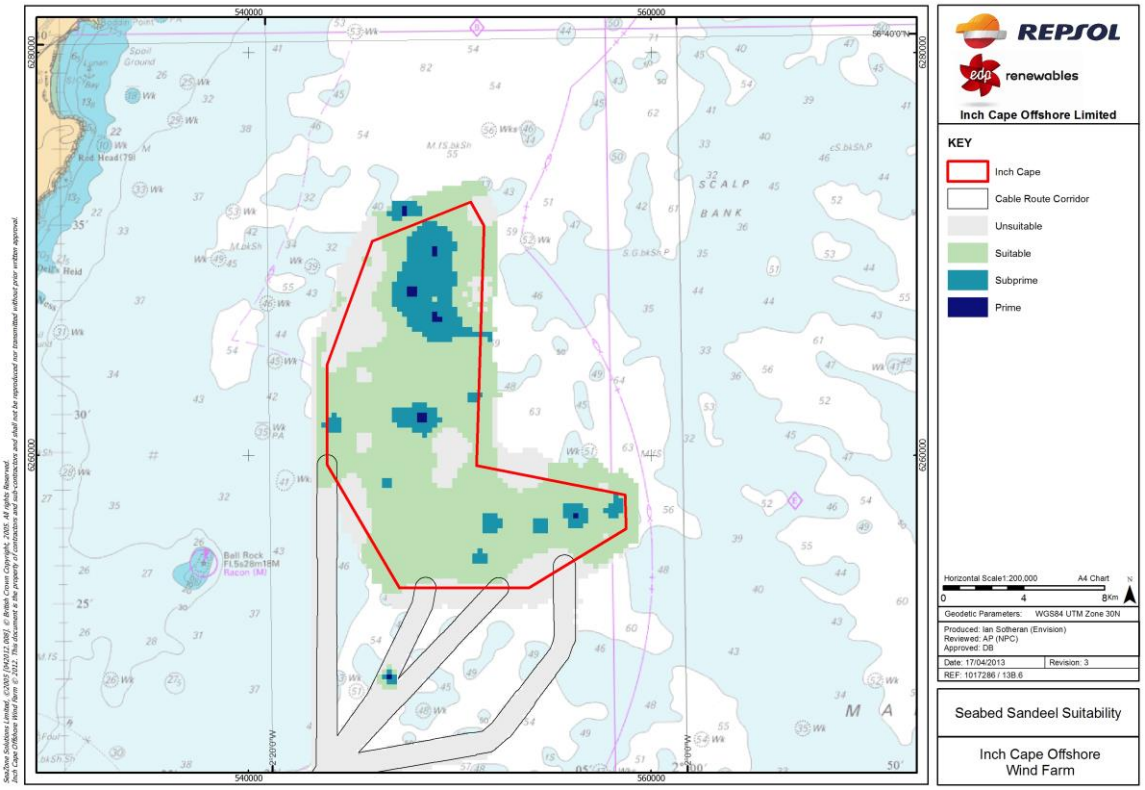


Prey Species

54 According to Ellis *et al.* (2012) and Coull *et al.* (1998) the Development Area overlaps with identified spawning and nursery grounds of sandeels (mixed species) (Table 13.6; Figure 13A.1.10). As sandeels spawn where they live this indicates that they may be in the Development Area. In order to investigate this, maps of sandeel habitat preference for the Development Area were produced based on analysis of the distribution of sediment types present across the Development Area (*Appendix 13B*). This analysis shows the Development Area to have areas of seabed habitat which could be suitable for sandeels (Figure 13.12). However very little habitat is identified as being of prime suitability, with distinct areas,

especially in the north of the Development Area, identified as subprime habitat. Furthermore, relatively few sandeel were recorded within the Development Area during the Natural Fish and Shellfish (*Appendix 13A*) and Benthic Ecology (*Appendix 12A*) baseline surveys, with relatively small numbers being recorded within prime habitat (Figure 13.9). It should be noted that the benthic grab and epibenthic trawl surveys were not specifically designed to assess sandeel, however, the high abundance of sandeels found at one site outside the Development Area indicates that their low abundance within the Development Area is not an artefact of survey technique. Data from MSS (all demersal gear survey data, 1927-2010) indicates that the sandeels populations are concentrated on specific banks to the south east of the Development Area (Figure 13.9).

Figure 13.12: Seabed Sandeel Suitability at the Development Area



Electro-sensitive Elasmobranchs

55 Five species of elasmobranch were identified through this study as potentially being present at the Development Area (Table 13.10). These were identified through the EMF assessment (*Appendix 13C*), which also acknowledged the potential for presence of a wider range of electro and magneto sensitive species within the Development Area. This assessment examined spawning and nursery areas, site-specific surveys data, as well as landing data and bycatch data. The Development Area overlaps with identified nursery grounds for spurdog, tope and common skate (Table 13.6; Figure 13A.1.11; Ellis *et al.,* 2012 and Coull *et al.,* 1998). No spawning areas for any of these species are known to occur in the vicinity of the Project. (NB – This study also identified other electro and magneto sensitive species (e.g. lobsters,

mackerel, river lamprey, Atlantic salmon, European eel, sea lamprey, plaice and cod etc.), however, EMF effects on these species is considered within their own receptor group in the assessment below).

Table 13.10: Electro-sensitive Elasmobranchs Species Potentially Present in the Development Area

Common Name	Possible Interaction with Development Area
Lesser spotted dogfish (*Scyliorhinus canicula*)	Recorded in low numbers during summer trawl survey.
Cuckoo ray (*Raja naevus*)	Recorded in low numbers during winter trawl survey.
Spurdog (*Squalus acanthias*)	Not recorded during site-specific survey work. Recorded regionally during North Sea groundfish surveys. Nursery areas identified in the vicinity of the Development Area (Ellis *et al.*, 2012).
Tope (*Galeorhinus galeus*)	Not recorded during site-specific survey work. Recorded regionally during North Sea groundfish surveys. Nursery areas identified in the vicinity of the Development Area (Ellis *et al.*, 2012).
Common skate (*Dipturus batis* – complex)	Not recorded during site-specific survey work. Recorded regionally during North Sea groundfish surveys. Nursery areas identified in the vicinity of the Development Area (Ellis *et al.*, 2012).

SAC Qualifying Feature Species

56 The scoping response from Marine Scotland and SNH identified three species of European protected migratory fish that could potentially be present in the Site Specific Study Area; Atlantic salmon, sea lamprey, and river lamprey, all of which are qualifying features of SACs on the Scottish east coast, namely the River Tay, River Teith, River South Esk, River Dee, and the River Tweed (Figure 13.1). River lamprey is not expected to interact with the Development Area, due to the estuarine limits of its migration. No Atlantic salmon or sea lamprey were recorded during site specific surveys, however as these species are rarely captured at sea through trawling, this is not an indication that they do not migrate through the Development Area. As the migrational routes of these salmon and sea lamprey are not fully established, the assumption, must therefore be made, that these SAC qualifying species may pass through the Development Area during migrations to and from natal rivers (see *Section 13.4.3* for more details on migration patterns), however it must be acknowledged there are other migratory paths available to them.

Shellfish

57 Shellfish are of particular commercial importance within the Development Area and account for a greater proportion of landings (by weight) than fish. King scallops are of particular commercial importance with over 2,000 tonnes of this species landed from ICES rectangle 42E7 in period 2007 to 2011.

58 Rectangles 42E7 and 41E7 (the border between which dissects the Development Area) record the second and fourth highest scallop landings in the Commercial Fisheries Regional Study Area, respectively. Scallop activity, as illustrated by Marine Scotland data (Figure 18.4) indicates that scallop dredging (by vessels over-15 m only) is distributed across the Development Area, and extends up the east coast of Scotland. Data for 2009 showed that the Development Area is located in the vicinity of the highest intensity fishing grounds in the Commercial Fisheries Regional Study Area (Figure 18.4); however, annual fluctuations in activity due to the cyclical nature of the fishery should be noted. Although no scallop spawning grounds have been identified in the literature, scallops are a low mobility species that are known to spawn where they live; hence the areas where scallops live are also their spawning grounds.

59 Brown crab and lobster do occur across the Development Area but the habitat present across the Development Area is not considered optimum habitat for mobile crustaceans (crabs and lobster) which are concentrated in the rocky areas inshore and around Bell Rock. Although the Development Area overlaps with identified spawning and nursery grounds of *Nephrops* (Table 13.6; Figure 13A.1.9; Ellis *et al*., 2012 and Coull *et al*., 1998), ICES landings data indicates the Development Area is not of particular importance to *Nephrops* (see *Section 13.4.3 Commercial Fisheries Data*); a finding that was supported during site specific trawl surveys (Table 13.11). This species appears to be more abundant within the Offshore Export Cable Corridor, where seabed substrates had higher mud content (i.e. more suitable *Nephrops* habitat). Shellfish species of commercial importance identified during site specific surveys are provided in Table 13.11.

Table 13.11: Shellfish of Commercial Importance Captured During the Site Specific Surveys within the Development Area (Otter Trawl, Epibenthic Beam Trawl and Benthic Grab Surveys)

Shellfish	Number Captured			Total
	Otter Trawl	Epibenthic Beam trawl	Benthic Grab	
Pink shrimp *(Pandalus montagui)*	39	361	0	400
Brown shrimp *(Crangon crangon)*	1	0	1	2
Lobster *(Homarus gammarus)*	19	1	0	20
Sea urchin *(Echinus esculentus)*	7	6	0	13
Queen Scallop (*Aequipecten opercularis)*	8	20	0	28

60 In addition to the species of commercial importance found during site specific trawl and grab surveys other species of note were harbour crabs (*Liocarcinus depurator, Liocarcinus pusillus*), hermit crabs (*Pagurus bernhardus, Pagurus prideauxi, Anapagurus laevis*), long clawed crabs (*Pisidia longicornis*), spider crabs (*Maja squinado, Hyas araneus, Macropodia sp., Macropodia rostrata, Macropodia tenuristris*), squat lobsters (*Galathea sp., Galathea dispersa, Galathea strigosa, Munida rugosa, Galathea intermedia*), and shrimp (*Crangon allmanni*).

61 DDV surveys recorded the abundance of conspicuous species captured on the image stills on the SACFOR scale. Shellfish species recorded within the Development Area were queen scallops (identified as rare at two stations), harbour crab (*Liocarcinus depurator*), squat lobster (*Munida rugosa*) and hermit crabs (*Pagurus bernhardus*). For full details see *Appendix 12A, Annex 12A.3: Video Faunal Data.*

13.4.6 Offshore Export Cable Corridor Baseline

62 This section presents baseline information summarising distribution of key receptors within the Offshore Export Cable Corridor. No site specific surveys were undertaken along the Offshore Export Cable Corridor, as it was felt that that due to the temporary nature of habitat disturbance the existing sources of data were sufficient to allow adequate assessment of the impacts. Therefore, information has been gathered through desk based study and extrapolation of data on the Development Area that is relevant to the Offshore Export Cable Corridor. In order to avoid repetition, where possible reference is made to information provided in *Section 13.4.3 and 13.4.5*.

Mobile Fish Species

63 The Offshore Export Cable Corridor runs from the south of the Development Area, to its landfall within the Firth of Forth, passing through ICES rectangle 41E7. Landings data from ICES rectangle 41E7 (2007 to 2011) reveal that the most abundant mobile fish species of commercial importance in this area were mackerel, haddock and whiting. Catch diversity is greater in ICES rectangle 41E7, with a total of 38 species of fish being landed from this area compared to 27 in the rectangle to the north (42E7 – which encompasses the northern half of the Development Area). This increased diversity is indicative of the range of habitats covered by the ICES rectangle which encompasses both the Firth of Forth and Tay Estuaries. Bycatch records for 41E7 also demonstrate the greater diversity of this rectangle with the following mobile fish species recorded at this rectangle and not 42E7; angler (monk) fish, bullrout, four-bearded rockling, hooknose, John dory, shore rockling and viviparous blenny.

64 The site specific surveys carried out to the south of the Development Area provide data on the mobile fish species present at the most northerly extent of the Offshore Export Cable Corridor. The only additional fish species, not already found in commercial fisheries data or bycatch data, was butterfish, found in the epibenthic surveys.

65 The Offshore Export Cable Corridor is identified as a spawning ground for plaice, lemon sole and whiting. Nursery areas of mackerel, plaice, lemon sole, whiting, blue whiting, European

hake, ling, saithe and anglerfish also cover the Offshore Export Cable Corridor (*Appendix 13A, Annex 13A.1*; Ellis *et al*., 2012 and Coull *et al*., 1998).

Hearing Specialists

66 No commercial landings of herring have been reported from the ICES rectangle 41E7, although herring have been recorded as a bycatch species. This indicates that although herring may be present in the Offshore Export Cable Corridor they are not present in sufficient quantities to allow commercial exploitation.

67 The Offshore Export Cable Corridor is a spawning ground for cod. Nursery areas for sprat, herring and cod also cover the Offshore Export Cable Corridor (*Appendix 13A, Annex 13A.1*; Ellis *et al.,* 2012 and Coull *et al*., 1998). Beyond the boundaries of the Offshore Export Cable Corridor spawning areas for herring and sprat are also found (*Appendix 13A, Annex 13A.*1; Ellis *et al*., 2012 and Coull *et al*., 1998). As stated previously, the only known Scottish spawning ground of shad is found on the west coast.

68 Extant data collected as part of the IHLS recorded higher densities of early stage larvae to the north of the Development Area off the Aberdeenshire coast and to the south-east of the Offshore Export Cable Corridor off the Berwickshire coast. This coincides with increased herring abundance recorded during semi pelagic trawl surveys sampled as part of the IBTS programme. Commercial herring catch data also confirms that, during the spawning season, the herring fishery focuses effort in a similar area whilst there is no catch data reported around the Offshore Export Cable Corridor. This substantiates Coull *et al*.'s (1998) conclusion on the location of the spawning grounds. Therefore, it is concluded that herring spawning grounds do not overlap with the Offshore Export Cable Corridor.

Prey Species

69 Like the Development Area, the Offshore Export Cable Corridor is recognised as a spawning ground and nursery area for sandeels by Ellis *et al.,* 2012 and Coull *et al.,* 1998 (Table 13.6; *Appendix 13A, Annex 13A*.1). Sandeel habitat suitability mapping, however, revealed that most of the Offshore Export Cable Corridor is unsuitable for sandeel as sediments are predominantly muddy sand (Figure 13.9). The exception to this was one small area located close to the Development Area. During site specific surveys only one epibenthic trawl station, which fell within the Offshore Export Cable Corridor, recorded low numbers of sandeel. In addition MSS data (Marine Scotland Science all demersal gear survey data, 1927 – 2010) revealed that sandeel were only found at one location close to the Development Area, also in low numbers (Figure 13.9).

Electro-sensitive Elasmobranchs

70 Three species of elasmobranchs were identified as being potentially present near the Offshore Export Cable Corridor by examining spawning and nursery areas (Coull *et al.,* 1998 and Ellis *et al.,* 2012), as well as landing data and bycatch data (Table 13.12; *Appendix 13C*). Nursery areas that cover the Development Area also cover the Offshore Export Cable Corridor (*Appendix 13A, Annex 13A.1*; Ellis *et al.,* 2012 and Coull *et al.,* 1998), with the only

exception - common skate which does not have a nursery area around the Offshore Export Cable Corridor (*Appendix 13A, Annex 13A.1*). No information is available on spawning areas of elasmobranchs in the vicinity of the Project areas.

Table 13.12: Electromagnetic-sensitive Species Potentially Present in the Offshore Export Cable Corridor

Common Name	Possible Interaction with Offshore Export Cable Corridor
Lesser spotted dogfish (*Scyliorhinus canicula*)	Recorded in low numbers during summer bycatch surveys.
Spurdog (*Squalus acanthias*)	Nursery areas identified in the vicinity of the Offshore Export Cable Corridor (Ellis *et al.*, 2012).
Tope (*Galeorhinus galeus*)	Nursery areas identified in the vicinity of the Offshore Export Cable Corridor (Ellis *et al*, 2012).

SAC Qualifying Feature Species

71 Atlantic salmon, sea lamprey and river lamprey, are found in the Scottish east coast, namely the River Tay, River Teith, River South Esk, River Dee, and the River Tweed (Figure 13.1). As the migration routes of these three species are not fully established, the precautionary assumption must therefore be that they may pass through the Offshore Export Cable Corridor during migrations to and from natal rivers (see *Section 13.4.3* for more details on migration patterns).

Shellfish

72 Catch data from ICES rectangle 41E7 highlights the dominance of shellfish over white fish. *Nephrops* dominate landings from the Offshore Export Cable Corridor, in contrast to the Development Area where scallops dominate landings. According to fisheries statistics, *Nephrops* are heavily targeted in rectangle 41E7, through which the Offshore Export Cable Corridor passes. Scallop fishing is focused along the northern section of the Offshore Export Cable Corridor (*Figure 18.5*), in proximity to the Development Area, with the greater proportion of grounds extending northwards.

73 Other commercially important invertebrate species in the area include lobster, velvet swimming crabs, edible crabs, scallops (*Pectin* sp., *Aequipecten* sp.), surf clams (*Spisula solida*), and razor clams (*Ensis ensis*). Site specific surveys carried out to the south of the Development Area provide data on the shellfish species present at the northerly most extent of the Offshore Export Cable Corridor. Pink shrimp were recorded during epibenthic beam trawls, however no other shellfish species of commercial importance were found during surveys in this location, with hermit crabs, squat lobsters and spider crabs recorded. For full catch data see *Appendix 12A.*

74 The Offshore Export Cable Corridor overlaps spawning and nursery grounds of *Nephrops* (Table 13.6; Figure 13A.1.9), however no information is provided by CEFAS on the locations where edible crabs and lobsters release their larvae (Ellis *et al*., 2012 and Coull *et al*., 1998). In the North Sea, berried females of both these species migrate offshore to release larvae (Nichols *et al*., 1982; Hayward *et al*., 1996). Hence the Offshore Export Cable Corridor is not predicted to overlap with these areas.

13.4.7 Baseline without the Project

75 In the event of the Project not being developed, no change in the baseline conditions would be expected beyond those resulting from climatic factors (such as temperature change and subsequent impacts of species' ranges), or anthropogenic activities such as changes in fishing activities. Commercial fishing is subject to numerous factors which may cause fish and shellfish populations to differ in the future from the baseline provided. This could be as a result of, for example, changes in fisheries management policies and legislation, alterations in species distribution and abundance, the introduction of marine conservation areas, increases in running costs such as fuel prices, etc. An assessment of the potential scale of an effect over a long period is difficult to predict because trends in climate, and anthropogenic activities, such as fishing, are not possible to accurately predict. The baseline conditions reported in this chapter are considered to be representative of those which could be expected in the short to medium term.

13.5 Assessment Methodology

76 This section summarises the methodology adopted in the impact assessment of effects on natural fish and shellfish. The assessment follows the standard methodology as presented in *Chapter 4: Process and Methodology*, with further chapter specific assessment parameters detailed below.

77 Potential impacts from the construction, operation and decommissioning of the Project are identified and their significance assessed with regard to the sensitivity of receptors and the magnitude of the impact.

13.5.1 Sensitivity of Receptor

78 For this assessment the sensitivity of receptors has been assigned in Table 13.13 and Table 13.14.

Table 13.13: Criteria for Classifying Sensitivity of Receptor

Receptor Sensitivity	Receptor Characteristics
High	Receptor of high conservation importance (international). Or provides a key ecological function. Or receptors considered to be rare in abundance.
Moderate	Receptors of high conservation importance (international), yet with either a low ecological value or high abundances. Or, receptors of low conservation importance, yet with high ecological value or low abundances.
Low	Receptors of medium conservation importance (national), yet with low ecological importance or high abundances. Or, receptors of low conservation importance, with low ecological importance or high abundances.

Table 13.14: Assessment of the Sensitivity of Fish and Shellfish Receptors

Receptor	Key species	Sensitivity	Justification
Mobile fish species	Whiting, haddock, plaice, mackerel, squid, etc.; non- Annex II migratory fish species (sea trout, European eel, and sparling); and squid.	Low	Generally low conservation value and high abundances throughout study areas; or of national conservation importance but with high abundance or low occurrence in the study areas.
Hearing specialists	Herring, sprat, allis shad, twaite shad and cod.	Moderate	Species classed as moderate sensitivity due to ecological or conservation importance and also wider status of stocks.
Prey species (specifically sandeel)	Sandeel.	Moderate	Sandeel listed as Scottish PMF and also high ecological importance as prey item (keystone species) but at comparatively low abundance in the Project Areas *(see Figure 13.9 for comparative abundances*).
Electro-sensitive elasmobranchs	Ray and skate species, dogfish, spurdog, tope.	Low	Elasmobranch species either of low conservation value and high abundance, or of national conservation importance but low occurrence within the study areas.
SAC qualifying feature species	Atlantic salmon, sea lamprey, river lamprey.	High	These species are listed as Annex II species on the *EU Habitats Directive* (92/43/EEC) and form qualifying features of freshwater SACs within the wider region.
Shellfish	Scallops, crab, lobster, *Nephrops*.	Low	Low conservation value and high abundances throughout study area.

13.5.2 Magnitude of Effect

79 Impacts to natural fish and shellfish were identified during the scoping phase of the Project, and refined through consultation via Scoping Opinion documents to ensure all key aspects, and those of concern to stakeholders were addressed. The magnitude of an effect has been assessed according to its spatial extent, duration, frequency and severity (Table 13.15). While all criteria and their definitions have been considered throughout all assessments, they have been coupled with expert judgement with respect to final assignation of magnitude, and therefore should not be considered absolute.

Table 13.15: Classification of Magnitude of Effect

Magnitude of Effect	Categories	Definition
High	Spatial extent	Apparent beyond boundary of Development Area/Offshore Export Cable Corridor.
	Duration	Effects persist beyond the operational and decommissioning phases and receptor exhibits low recoverability.
	Frequency	Effects persist beyond the operational and decommissioning phases.
	Severity	Effect could significantly influence size or structure of stock generally, or for particular species, as receptor is intolerant of effect.
Moderate	Spatial extent	Detectable throughout the Development Area/Offshore Export Cable Corridor.
	Duration	Occurs throughout operation and receptor exhibits moderate recoverability.
	Frequency	Occurs throughout operation.
	Severity	Effect could moderately influence species stock generally, or for particular species, as receptor is moderately tolerant of effect.
Low	Spatial extent	Detectable in discreet areas within the Development Area/Offshore Export Cable Corridor.
	Duration	Occurs through construction phase and receptor exhibits high recoverability.
	Frequency	Occurs through construction phase.
	Severity	Potential to have small effect on size or structure of stock as receptor is tolerant of effect.
Negligible	Spatial extent	Detectable within 10 m from source.
	Duration	Intermittent through construction or operation phase and receptor exhibits high recoverability.
	Frequency	Intermittent through construction or operation phase.
	Severity	Should not influence or have very small effect on size or structure of stock as receptor is highly tolerant of effect.
No impact	No change from baseline conditions	

13.5.3 Method for Assigning Significance of Impacts

80 Following the EIA methodology outlined in *Chapter 4 Section 4.4*, the Sensitivity and Magnitude criteria were then combined as per the significance matrix (Table 13.16). For the purposes of the assessment only those residual impacts indicated as Major and Moderate/Major are regarded as being significant.

Table 13.16: Significance Matrix

Magnitude of Effect	Sensitivity of resource/receptor		
	Low	**Moderate**	**High**
No Impact	No Impact	No Impact	No Impact
Negligible	Negligible/Minor	Minor	Minor/Moderate
Low	Minor	Minor/Moderate	Moderate
Moderate	Minor/Moderate	Moderate	Moderate/Major
High	Moderate	Moderate/Major	Major

81 Where uncertainty exists, the precautionary principle is adopted and appropriate conservative assumptions incorporated into assessment of magnitude. As a consequence, the assigned significance builds uncertainty into the assessment. This adoption of the precautionary principle provides a high degree of confidence that the assessment conclusions are robust.

13.6 Impact Assessment - Development Area

82 Impacts assessed within this Development Area assessment are outlined below relative to each receptor group for each development phase (Table 13.17, and Table 13.18).

Table 13.17: Effects Assessed during Construction (and Decommissioning)

Receptor Group	Direct temporary habitat disturbance	Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Barrier effects, disturbance or physical injury associated with construction noise
Mobile Fish Species	Assessed	Assessed	Assessed
Hearing specialists	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.	Assessed
Prey species	Assessed	Assessed	Assessed
Electro-sensitive elasmobranchs	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.	Magnitude scores assigned based on Mobile fish species.
SAC qualifying feature species	Assessed	Assessed	Assessed
Shellfish	Assessed	Assessed	Assessed

Table 13.18: Effects Assessed during Operation and Maintenance

Receptor Group	Long term loss of original habitat	Behavioural responses to EMF associated with cabling	Disturbance associated with operational noise	Reduced fishing activity within Development Area	Creation of new habitat due to presence of project infrastructure	Temporary habitat disturbance from O&M activities
Mobile Fish Species	Assessed	Assessed	Assessed	Receptor groups assessed under single assessment.	Assessed	Assessed
Hearing specialists	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.	Assessed		Assessed	Assessed
Prey species	Assessed	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions, and justification as per mobile fish species.		Assessed	Assessed
Electro-sensitive elasmobranchs	Magnitude, conclusions and justification as per mobile fish species.	Assessed	Magnitude, conclusions and justification as per mobile fish species.		Magnitude score for Mobile Fish Species receptor group applied.	Magnitude score for Mobile Fish Species receptor group applied.
SAC qualifying feature species	Assessed	Assessed	Assessed.		Receptor group not sensitive to effect.	Assessed
Shellfish	Assessed	Assessed	Magnitude, conclusions and justification as per mobile fish species.		Assessed	Assessed

13.6.1 Effects of Construction

Direct Temporary Habitat Disturbance

83 Installation of WTG, OSP and met mast foundations and associated inter-array cabling at the Development Area will result in direct, temporary habitat disturbances via the works associated with seabed preparation, jacking-up of vessels to install foundations and inter-array cable installation. In total, the area disturbed by construction related activities, and thus subject to temporary habitat disturbance will be 5.54 km^2, which represents 3.69 per cent of the Development Area. Similar habitats to those likely to be affected by temporary disturbance (sand and coarse sediments – see *Chapter 12*) extend across a large area of the north North Sea (EUSeaMap, 2012).

84 Temporary disturbance to the seabed within the Development Area will affect many of the receptors identified in the baseline *Section 13.4* and the potential significance of this impact for all receptors is discussed below in relation to the magnitude of the effect and the specific sensitivity of the receptor (summarised in Table 13.16).

Mobile Fish Species

85 A wide range of mobile fish species are known to occur within the Development Area, including pelagic species such as mackerel and demersal species such as haddock, whiting and plaice. All of these species will, to varying degrees, utilise the existing seabed habitats in this area for feeding and foraging. The Development Area has been noted to overlap with spawning areas for whiting, lemon sole, and plaice. Although the Development Area overlaps with these spawning areas, it is important to note that these species are not demersal spawners and do not rely on specific seabed characteristics to spawn. The total area of temporary habitat loss from the construction phase is very small (3.69 per cent of the Development Area), and the disturbance will be of a short duration. Furthermore, the area affected by temporary disturbance represents a very small proportion of the total spawning areas for the species listed above which are widespread in the north North Sea and not locally constrained.

86 Based on the definitions presented in Table 13.15, the temporary disturbance described above during construction will result in an effect of negligible magnitude as the effect will be localised to the source of the impact (seabed preparation, jacking up etc.), will be intermittent through construction and will not affect the wider stocks of any of these mobile fish species, as these species will be able to avoid the area of effect. Similar areas of seabed habitats also exist throughout the wider region so any temporary disturbance to existing habitats will not lead to a significant reduction in the overall habitat in the wider region. The sensitivity of this receptor group is defined as Low (as per definitions in Table 13.13), therefore, combined with a negligible magnitude, a negligible/minor impact is predicted via temporary habitat disturbance on mobile fish species.

Hearing Specialists

87 The same magnitude conclusions with respect to mobile fish species apply for the adult fish within this receptor group.

88 The Development Area does not overlap with recorded herring spawning grounds (as defined by Coull *et al.,* 1998) as these are located approximately 4.5 km to the north and 35.8 km to the south of the Development Area. Data from the IHLS survey over the period 1991 to 2011 does indicate low levels of herring larvae recorded within the Development Area, but this dataset also clearly demonstrates that the main focus of herring spawning in the wider region is located to the north and south of the Development Area, which tallies with Coull *et al.* (1998). For example, significant densities of herring larvae have been recorded consistently to the north of the Development Area over the past 20 years, whereas densities within the Development Area are generally far lower in abundance and highly inconsistent (*Appendix 13D*, Figure 13D.5). In addition, benthic survey data (*Appendix 12A*) revealed the Development Area to comprise predominantly of fine to medium sands, with a few discrete areas of gravel and is therefore unlikely to support a significant proportion of autumn spawning herring associated with the Shetland/Buchan component of the North Sea herring stock. Therefore, there is no scope for direct temporary habitat disturbance on herring spawning grounds.

89 The spawning habitats to the north east of the Aberdeenshire coast and around Shetland support a consistently high level of spawning activity. Furthermore, herring populations have been recorded to adapt spawning ground usage year on year, and so peripheral areas of suitable spawning habitats adjacent to highly used grounds are likely to be of little importance. As a result of the small area of overlap between potential spawning grounds and areas of direct physical disturbance, and the ubiquitous distribution of active spawning grounds to the north of the Development Area, the Project will result in minimal impact to the sub population of herring in the region.

90 The Development Area overlaps with spawning areas for cod, however as cod are not demersal spawners they do not rely on specific seabed characteristics to spawn and have wide ranging spawning areas in the north North Sea. Hence the area affected by temporary disturbance represents a very small proportion of the total spawning areas for the cod. Sprat spawning grounds have been identified as being 15 km from the Development Area, and shad species spawn in riverine environments on the west coast. Therefore, there is no scope for direct temporary habitat disturbance on sprat or shad spawning grounds.

91 The same magnitude conclusions with respect to mobile fish species apply for this hearing specialist receptor group. However, due to the increased sensitivity (moderate) assigned to this receptor, the combination of negligible magnitude of effect and moderate sensitivity results in a minor impact.

Prey Species

92 The key prey species considered with respect to this potential impact is sandeel. Analysis of potential sandeel habitat within the Development Area was undertaken as part of baseline

studies (*Appendix 13B*), and this concluded that although parts of the Development Area were classed as suitable habitats for sandeels, very small amounts were defined as being of prime suitability (as defined by Greenstreet *et al*., 2010).

93 The temporary habitat disturbance described above may create an impact on sandeels via both a direct impact on sandeels themselves (through injury or death of those that may be in the sediment that is disturbed) and/or the change in existing seabed characteristics which will arise due to the construction works (see next impact assessment in this section for more details on this). Sandeels lay their eggs on the same ground in which they live therefore, these factors may in turn also affect spawning success.

94 Only a small proportion of the overall Development Area (3.69 per cent) will be affected by temporary disturbance, and this effect is not expected to have any other than a very small impact on the size or structure of sandeel stocks in the wider region. Post construction surveys and analysis at the Horns Rev Offshore Wind Farm showed a short term increase in sandeel populations one year after installation, and predicted that no long term effects were likely with populations stabilising after this short term fluctuation (Leonhard *et al.,* 2011).

95 According to Ellis *et al.* (2012), sandeel spawning habitat does occur within the Development Area, therefore scope exists for an impact on this habitat. However, there is little prime ground for them on the Development Area (*Appendix 13B*), and this coupled with little evidence of sandeels living in the Development Area (from MSS and site specific surveys) suggests sandeel spawning ground on the Development Area is limited. Furthermore, high density sandeel spawning areas represent one of the more geographically constrained spawning areas in the North Sea, totalling approximately 37,000 km^2 (Coull *et al.,* 1998 and Ellis *et al.,* 2012).

96 The magnitude of this effect is therefore judged to be low as temporary habitat disturbance of the scale and extent predicted will not impact on the overall stock of sandeels in the wider region. When low magnitude is combined with a moderate sensitivity, a minor/moderate impact is predicted on prey species (sandeels) as a result of temporary habitat disturbance.

Electro-sensitive Elasmobranchs

97 The same magnitude conclusions with respect to mobile fish species apply for this specific receptor. The sensitivity of this receptor group is defined as low; therefore combined with a negligible magnitude, a negligible/minor impact is predicted via temporary habitat disturbance.

SAC Qualifying Feature Species

98 The SAC qualifying species identified in the baseline (*Section 13.4*) may potentially use the Development Area for foraging, however none will be reliant on seabed habitats within the Development Area as feeding grounds, as this will be a small proportion of the overall available resource on their migratory route. None will use the Development Area as nursery or spawning grounds. Therefore, while there is scope for salmon to be impacted by temporary habitat disturbance it is considered to be negligible in magnitude. Sea lamprey

will not forage on the seabed as they are parasites on other fish, hence will not be affected by this impact.

99 FWPM are found as adult mussels in riverine environments only, they will only come into contact with the offshore elements of the Project infrastructure as larval parasites on salmon gills. There is little information on the impacts of effects on FWMP larvae, however as their lifecycle relies on migrating salmonids any impacts on salmonids could impact FWPM populations. Therefore, any impacts (from construction and operation) on salmon migration are directly applicable to FWPM populations. This applies to all assessment on SAC species in this chapter.

100 Using a negligible magnitude, combined with high sensitivity, an impact of minor/moderate is predicted.

Shellfish

101 Shellfish such as scallops, *Nephrops*, brown crab and lobster, which have less mobility and greater site fidelity than most mobile fish species, are likely to be affected to a greater degree by temporary habitat disturbance than mobile fish species. Data from ICES rectangle 42E7 (within which the majority of the Development Area lies) for the period 2007 to 2011 indicated the importance of scallops to commercial landings in this area, suggesting that this species is widespread in this region (see *Chapter 18*). ICES data also illustrated the fact that crabs, lobsters and to a lesser degree *Nephrops* (which is more prevalent along the Offshore Export Cable Corridor) will be located within the Development Area. The presence of these species was confirmed by site specific surveys (*Appendix 13A*).

102 These species will be subject to temporary habitat disturbance, with a resultant loss of individuals due to direct impacts/removal. The magnitude of this effect is judged to be negligible as any effect will be relatively localised and intermittent, and the receptors are expected to exhibit high recoverability with no major impacts on the overall stock levels of these resources. This means that future recruitment to the area can be expected, with populations likely to return to non-impacted levels after two to three years (Marshall and Wilson, 2009).

103 The sensitivity of this receptor is judged to be low as none of the shellfish species present in the Development Area have a high conservation value and the abundances of these species is judged to be high. Therefore, when combined with a negligible magnitude, a negligible/minor impact is predicted on this receptor via temporary habitat disturbance. A summary of impacts significance can be found below.

Table 13.19: Impact Summary of Direct Temporary Habitat Disturbance

Impact	Receptor	Magnitude	Sensitivity	Significance
Direct temporary habitat disturbance	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in Suspended Sediment Concentrations (SSC)

104 Construction activities within the Development Area such as dredging for seabed preparation of GBS, and cable laying will cause a temporary increase in SSC levels, and discharge of materials, discussed in detail in *Section 10.5.1*. In this assessment we consider the effects of increases in SSC in the water column and its associated deposition and direct release of materials as a result of dredging activities. Elevated SSC levels would also result from the development of scour pits around jacket leg structures, should this design option be used in preference to GBS. However, preparation of the seabed for GBS foundations is considered to be the worst case scenario for deposition and SSC impacts, and is thus the focus of this assessment.

105 The background SSC (during fair weather) recorded within the Development Area is considered to be 15 mg l^{-1}, with levels predicted to increase up to 80 mg l^{-1} during winter storms. For preparation of the seabed for GBS foundations very localised peaks of SSC up to 4000 mgl^{-1} above background levels are predicted to occur at, and very close to, the point of sediment release. These high levels will dissipate quickly, with >98 per cent of the sediments settling out within 10 to 20 minutes and the remainder settling out within one to two hours, travelling a maximum of 10 km from the release point (although only a small volume of the finest sediment will travel >3.5 km from release point (*Appendix 10A*).

106 The predicted deposition footprint from the discharge of dredged material at the Development Area (assessed as the worst case scenario), based on the assumed WTG layout, is shown in Figure 10.8. The sediment deposition footprint resulting from dredging for GBS foundations is likely to cover the Development Area with varying thickness, generally less than 3 cm, and with peaks between one metre and two metres around each WTG, OSP or met mast foundation (*Section 10.5.1*). Depositional thicknesses will be largest within the immediate vicinity of the release location, with this rapidly decreasing and the deposition of dredged material will remain within the vicinity of the Development Area. The benchmark

used by the marine life information network (MarLin) for assessing the impacts of smothering is a >5.0 cm depth of deposited sediment, which would cover a total area of 6.7 per cent or 10.09 km^2 of the Development Area.

107 The increased SSC levels and subsequent deposition described above will affect many of the receptors identified in the baseline (see *Section 13.4*) and the potential significance of this impact for all receptors is discussed below, in relation to the magnitude of the effect and the specific sensitivity of the receptor (summarised in Table 13.16).

Mobile Fish Species

108 Effects of suspended sediments on fish have been recorded at all life stages, with individual species showing differing levels of sensitivity (Whalberg and Westerberg, 2005). In general, demersal species are more tolerant of increased SSC than pelagic species with the gills of clupeids (e.g. sprat, shad and herring) particularly susceptible to clogging. Young fish are also more sensitive to physical damage due to decreased gill dimensions. Estuarine species are the most tolerant to high SSC due to the high sediment loads they experience within their natural environment.

109 Generally, avoidance reactions in mobile fish are generated by sediment levels of tens of milligrams per litre (mgl^{-1}) with lethal concentrations reported in the thousands of mgl^{-1} (Engell-Sørensen and Skyt, 2003). In reality however, particle size and exposure time will also affect the response and effects of fish species, as will their prior acclimatisation to short term increases in suspended sediments, e.g. from storm events, as would be expected in the Development Area. Avoidance of the area by mobile fish species, as predicted to occur due to increased SSC, will be of a short duration and SSC is likely to drop to 100 mg l^{-1} or less within about 100 m of the discharge point (*Section 10.5.1*). Therefore, the magnitude of effect of increased SSC and deposition on mobile fish species is judged to be negligible as this effect is predicted to be intermittent and not likely to affect the overall stock of any mobile fish species, which will simply avoid the area until levels return to acceptable levels.

110 The increased SSC levels and deposition has the potential to impact on the spawning habitats of species that are known to overlap with the Development Area. Increases in SSC can cause pelagic fish eggs (such as those laid by cod and plaice, which are known to spawn in this study area) to sink and experience higher mortality rates. For cod eggs these effects result from SSC of greater than 100 mgl^{-1}. Lethal and sub-lethal effects on fish larvae through reduced sight and therefore impacts on feeding have been recorded (Engell-Sørensen and Skyt, 2003). Lethal effects of suspended sediments to pelagic eggs are however predicted to be of low magnitude due to the highly localised extent and short duration of high SSC (peaks of up to 4,000 mgl^{-1} which typically drop to 100 mgl^{-1} or less within about 100 m of the discharge point *Section 10.5.1*). High suspended sediments also have the potential to exclude spawning adults from spawning areas, reducing the available habitat for this activity. A number of spawning grounds have been recorded as being present within the Development Area and reported threshold levels of fish to suspended sediments can be used to assess the effects of the Wind Farm and associated OfTW in the Development Area. As with non-spawning adults a number of factors, e.g. exposure time, particle size and prior

acclimation will lead to variations in tolerances, however in general, avoidance reactions are typical at sediment levels of tens of mgl^{-1} with lethal concentrations reported in the thousands of mgl^{-1} (Engell-Sørensen and Skyt, 2003).

111 Overall, the magnitude of this effect on mobile fish species is judged to be negligible when considered against the criteria in Table 13.15, as temporary increases in SSC and/or deposition from construction activities will only have a very small effect on the size or structure of mobile fish stocks in this region. Combined with a receptor sensitivity of low, this results in an impact prediction of negligible/minor for mobile fish species.

Hearing Specialists

112 In general, pelagic species, such as herring are less tolerant to increased SSC than demersal species with the gills of clupeids (e.g. herring, sprat and shad) particularly susceptible to clogging. Cod, as a demersal species, is more tolerant. However, as per mobile fish species avoidance of the area by hearing specialists, as predicted to occur due to increased SSC plumes, will be of a short duration and SSC are likely to drop to 100 mg l^{-1} or less within about 100 m of the discharge point (*Section 10.5.1*).

113 The Development Area does not overlap with recorded herring spawning grounds (the only marine demersal spawner within this receptor group) but these are located approximately 4.5 km to the north and 35.8 km to the south of the Development Area. If sediments released from the construction process were subsequently transported and deposited onto herring spawning grounds, with their discrete habitat characteristics, scope for an impact on this receptor would arise. However, the outputs of the sediment plume modelling indicate that the majority of SSC liberated via seabed works during construction will be re-deposited within 3.5 km of the release point, and discharged dredged material will remain within the vicinity of the Development Area (Figure 10.8). A key point to remember is that the sediment is being deposited from the Development Area itself and is therefore likely to have the same characteristics (PSA) as the receiving environment it is transported to. Therefore, large-scale changes in the sediment characteristics of adjacent herring spawning grounds via sediments released from the construction phase is not expected, and the magnitude of effect is judged to be negligible.

114 Overall, the same conclusions with respect to mobile fish species apply for this specific receptor. However, due to the increased sensitivity (moderate) assigned to this receptor, the combination of negligible magnitude of effect and moderate sensitivity results in a minor impact being predicted.

Prey Species

115 The key prey species considered with respect to this potential impact is sandeel. As sandeels spend a large proportion of their life cycle buried within the sediments, smothering following increased SSC has the potential to directly impact this species through physiological effects (gill clogging etc.). Noting the specific habitat preferences for this species, sediment deposition also has the potential to alter the dominant particle size distribution in an area,

thus rendering the habitat less suitable for sandeels and therefore, creating another source of potential impact.

116 With respect to smothering of adult sandeels, little data exists for assessing the impact of smothering, however the effect to the sandeel population is likely to be minimal as only a small proportion of overall sandeel habitat in the wider region (i.e. that area subject to the greatest depositional depths), are likely to be lost to burial impacts. It is also assumed that sandeels have the ability to cope with temporary increases in SSC and subsequent deposition due to these effects happening naturally via winter storm events. However, from a precautionary standpoint, burial by sediment deeper than 5.0 cm (benchmark level assessed by MarLin) is considered to be fatal, and 6.7 per cent of the Development Area may be impacted to this degree. However, the baseline studies indicated that very little habitat within the Development Area was identified as being of prime suitability for sandeels. Furthermore, site specific surveys and MSS survey data indicate that sandeels are not present in large numbers within the Development Area, relative to the regional area.

117 In terms of the potential for sediment deposition to result in long-term changes in the existing seabed sediment characteristics, which could make this habitat unsuitable for sandeels (noting the discrete habitat preferences for this species), outputs of the physical modelling done for this EIA indicate that the sediment that will be re-deposited following mobilisation via construction activities will be the same as that which already exists in any affected areas (i.e. no “new” sediment will be deposited in this area – rather existing sediments will simply be mobilised into the water column and then settle out in the same vicinity). Therefore, whilst there may be some short-term change to the existing PSA distribution following deposition, it is predicted that residual tidal currents will act on any deposited sediments, such that the seabed sediment characteristics of the Development Area will return to those that existed pre-disturbance. Even if a change in PSA was to occur this is unlikely to affect sandeel stocks as sandeel habitat mapping (*Appendix 13B*) and site specific surveys revealed few sandeels to be present at the Development Area.

118 Increased sediment deposition on sandeel eggs deposited in spawning grounds on, or in, the sediment may lead to a reduction in hatching success due to a reduced oxygen uptake, although threshold levels have not been quantified. The effects of sediment deposition on areas of sandeel spawning habitat are however, likely to be minimal, as only a small proportion of the eggs (i.e. those subject to the greatest depositional depths), are likely to be lost to burial impacts.

119 In conclusion, it is accepted that there will be some effect on sandeels and their spawning habitats due to direct smothering effects via sediment deposition, however, the magnitude of this effect is judged to be low as this effect will be intermittent and will only have very small (if any) impacts on the overall size or structure of the wider sandeel stocks in this part of the North Sea. No long-term overall change in the sediment characteristics of the Development Area are predicted either via sediment deposition, therefore, the magnitude of this effect is also judged to be low. Thus, with a receptor sensitivity of moderate, a minor/moderate impact is predicted.

Electro-sensitive Elasmobranchs

120 The same magnitude conclusions with respect to mobile fish species apply for this specific receptor, as temporary increases in SSC and/or deposition from construction activities are unlikely to have an effect on the size or structure of elasmobranchs populations in the region. The sensitivity of this receptor is low, therefore combined with the negligible magnitude of effect a negligible/minor impact is predicted.

SAC Qualifying Feature Species

121 In general, the mobile nature of fish species allows avoidance of areas of adverse conditions, which will be unlikely to significantly affect a population, provided such conditions are temporary. In the case of migratory fish species however, the significance of such occurrences is potentially heightened as a result of the potential for such conditions to constitute a barrier to the movement of fish along specified migration routes (ABPmer, 2011). All of the Annex II fish species in the *Habitats Directive* (92/43/EEC) undergo migrations between freshwater and the sea at some stages in their life cycles and therefore significant increases in SSC could present a barrier to migratory pathways (Posford Duvivier Environment and Hill, 2001).

122 Some delay in migration may result from avoidance, and this is of note, as delays have been reported as being potentially associated with reduced survival rates (ABPmer, 2011). Suspended sediment levels, and resulting increased turbidity, are reported to affect salmonids, with effects including avoidance predicted. However, estuarine fish generally show tolerance to variations in suspended sediment loadings and turbidity as a result of natural adaptation to living in a dynamic and environmentally variable habitat (ABPmer, 2005). The *Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters* report (ABPmer, 2011) provides a good basis for assessment and states the occurrence of increased SSC would only be significant should the conditions extend across the entire width of the water body comprising the migration route at any given point, otherwise fish will be expected to be able to move around the area of adverse conditions, avoiding impacts, and thus not inhibiting migration.

123 Threshold levels have also been identified to some degree with salmon avoiding levels above 100 mg kg^{-1} (exposure over one hour) and lethal effects seen in juvenile salmon between 1,000 and 49,000 mg kg^{-1} (exposure over four days) (Newcombe and MacDonald, 1991). Effects have also been noted for Pacific salmon and trout with juveniles surviving for three to four weeks in SSCs of 300 to 750 mgl^{-1}, which were increased to 2,300 to 6,500 mg l^{-1} for short periods (FARL, 1995). Sub-lethal pathological effects included increased mucus production over the body and gills, and at very high suspended sediments, evidence of abrasion and damage to the gill filaments was noted (FARL, 1995). Sea trout have been shown to tolerate similar levels of suspended sediment as salmon (Newcombe and MacDonald, 1991).

124 Overall, the magnitude of this effect is judged to be negligible due to the small proportion of the overall water column that would be subjected to increased suspended sediments and

the fact that any such plume effects would not be expected to impact the overall size or structure of Annex II fish populations. The Development Area does not encompass an estuary mouth and as such does not form an unbroken barrier to migration. All diadromous species spend time within the river and estuary environments where SSC levels are considerably higher than those present within the open sea, and as such they are likely to have an increased tolerance to suspended sediments. While some small scale and temporary avoidance may occur this is not at a scale where migration would be hindered significantly.

125 Due to their conservation importance (qualifying features on SACs), the sensitivity of this receptor group is defined as high. Therefore, combined with a negligible magnitude, a minor/moderate impact is predicted.

Shellfish

126 Key shellfish species known to occur within the Development Area and thus be at risk of effects of sediment deposition and increased suspended sediments include scallops and *Nephrops*, although the former species is more common in the Development Area (*Nephrops* are more associated with habitats along the Offshore Export Cable Corridor).

127 Increased sediment levels will have a negative impact on filter feeders such as scallops through damage to feeding apparatus, and subsequent reduction in growth rates (Bricelj and Shumway, 1991). It is however, considered that recoverability after the cessation of the impact (when magnitude of the effect is below MarLIN benchmark of an arbitrary short term, acute change in background SSCs e.g., a change of 100 mg l^{-1} for one month) is likely to be high (Marshall and Wilson, 2009).

128 Scallops buried by less than 5.0 cm of sediment are considered to be able to lift themselves clear of deposited sediments, and as such, outside of this area no impact of smothering is expected (Marshall and Wilson, 2009). Burial by sediment deeper than 5.0 cm (benchmark level assessed by MarLin) is thus considered to be fatal according to a precautionary standpoint, and a total area of 10.09 km^2 (or 6.7 per cent) of the Development Area will be impacted to this degree. This area is considered to be negligible in relation to the wider area in which scallops are predicted to exist (scallop grounds are located around the UK on the Scottish east and west coasts, in the Irish Sea and the English Channel (see Figure 18.7)), and as such the magnitude of the smothering effect on scallops is assessed as negligible.

129 For other shellfish species (crab and lobster) increased SSC and smothering effects are not predicted to be greater than negligible magnitude. These species are tolerant of increased suspended sediments, although some reduction in feeding efficiency may occur (Neal and Wilson, 2008). Furthermore, these species are mobile and can move outside of the affected area if necessary. Smothering may cause some temporary displacement of these mobile invertebrates if sedimentary conditions change markedly, however, due to their mobility and ability to burrow out of sediments, no mortality is predicted (Neal and Wilson, 2008).

130 As such, the magnitude of effect of increased suspended sediments and deposition on mobile macro-invertebrates is considered negligible. The sensitivity of these receptors is

considered low, and as such a negligible/minor impact is predicted. A summary of impacts significance can be found below.

Table 13.20: Impact summary of Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in SSC

Impact	Receptor	Magnitude	Sensitivity	Significance
Indirect disturbance as a result of sediment deposition and temporary increases in suspended sediment concentrations (SSC)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Barrier Effects, Disturbance or Mortality, Physical and Auditory Injury Associated with Construction Noise

131 The following impact assessment considers the potential for subsea noise generated by construction activities to impact fish and shellfish receptors. Outputs of a project-specific noise modelling study have been used to inform this assessment, with noise contours related to different responses (death, injury, avoidance) for selected reference species overlain onto spawning ground distribution maps, to show the potential for these noise levels to effect spawning activity of certain species. More details with respect to this approach are provided below.

132 A variety of sources of noise from construction activities, including drilling, rock placement, vessel traffic, piling and dredging may elevate noise levels at the Development Area and cause adverse effects on fish. The effects of piling have received particular attention because of concerns regarding the very high sound levels generated, at a relatively broad bandwidth (Nedwell and Howell, 2004).

133 Thresholds against which to assess effects on fish have been established and are summarised below (from Nedwell and Brooker, 2008) and detailed in *Chapter 11 Section 11.5*;

- Lethal effects: peak to peak levels exceed 240 dB re.1 µPa, or an impulse of 100 Pa.s;
- Physical injury, e.g. damage to swim bladders or other organs: occurs where peak to peak levels exceed 220 dB re.1 µPa, or an impulse of 35 Pa.s; and
- Traumatic hearing loss: predicted to occur with sound levels of 130 dB_{ht} (*see glossary and Section 11.5.4*).

134 Below these levels, behavioural and physiological responses are displayed which may affect important activities such as feeding, spawning and migration. For the purpose of this assessment, the dB_{ht} (species) perception unit has been used as the basis of the assessment. The dB_{ht} metric is a measure of perception, i.e. the amount a certain noise is above the hearing threshold (ht) of various species. By way of illustration, 0 dB_{ht} is the hearing threshold where sound begins to be perceived (heard) by a species. Species-specific dB_{ht} metrics have been developed via audiograms and these are used in this assessment for selected species. The use of this metric enables recognition of the fact that the same level of sound will have different effects on different species depending on their sensitivity to noise (which is in turn linked to physiological differences) that result in fish being defined as hearing specialists or hearing generalists (see below). Table 13.21 provides a summary of the dB_{ht} noise criteria adopted for this assessment.

Table 13.21: 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.

135 Effects of noise on fish, ranging from behavioural changes, avoidance and physical damage and death, are becoming more widely understood and have been assessed specifically for offshore wind farms (Nedwell and Howell, 2004). Effects are species specific and can be seen in all life stages, from eggs and larvae to mature adults. There is large variation in the anatomical, behavioural and physiological variation among fish which affect the way various species detect and process sound (Nedwell *et al*., 2004). Despite this variability, two general categories can be identified:

- Hearing generalists (without a swim bladder or it is poorly developed or not connected to the inner ear, e.g. dab or sandeels); and
- Hearing specialists (with a swim bladder connected to the inner ear, e.g. herring, shad or sprat. Cod are also included in the hearing specialist category as although their swim bladder is not connected to the inner ear, the anterior part of the swim bladder is in close proximity).

136 Recognition of this fact has been the basis of assigning a discrete receptor group titled “hearing specialists” to this entire fish and shellfish impact assessment process. It should be assumed that the description of noise impacts on hearing specialists in this assessment

relates to this specific receptor, all other receptor groups are therefore 'hearing generalists'. Further details on the hearing specialist receptor group are provided in *Section 13.4.4*.

137 For the Development Area, a specific underwater noise study was carried out (*Chapter 11 and Appendix 11A*), which highlights the significantly larger impact range during piling than all other construction activities. Considering up to two piling vessels would potentially be working at one time anywhere within the Development Area, the spatial extent of effect zones on selected species of fish have been calculated assuming piling taking place at two locations concurrently. Noise was modelled for two pile locations - one in the north-east and one at the south-west of the Development Area which were considered to be the worst case location for salmon and herring. *Section 11.3* details the rationale and piling scenarios used for the noise modelling undertaken to inform this chapter. The noise contours from the worst case piling durations (predicted to result from encountering harder ground conditions) have been used throughout this assessment. Effect zones, as determined by the underwater noise modelling for impact piling, for a number of species are displayed in Table 13.22 below. Where no overlap was shown for noise contours of the two modelled piling locations, impact areas have been summed.

138 Dab and sea trout were modelled as representatives for fish hearing generalists, with herring used to assess the impacts on fish hearing specialists, such as themselves, shad and sprat. Cod has also been modelled as although this species is defined broadly as a hearing generalist it is thought to be more sensitive to noise than other hearing generalists, although not as sensitive as specialists such as herring. Therefore, for the purpose of this assessment and in line with a precautionary approach, cod is defined as a hearing specialist alongside herring, shad and sprat. Potential impacts of subsea noise from piling on salmon has also been modelled due to the fact that this species is likely to undertake migrations through the Study Areas en route to rivers where they spawn and that this species represents a qualifying feature of several SACs in the wider region. Noise modelling data for sandeel (with sand lance (*Ammodytes spp.*) as a surrogate) are also presented (no audiograms exist for sandeel and sand lance are morphologically and physiologically similar to sandeel therefore can be used as a surrogate). No noise modelling was undertaken for shellfish as they are not considered sensitive to noise.

139 For consistency of approach with other impact assessments within this chapter, each species that has had noise modelling outputs generated has been assigned to one of the receptor groups defined in Table 13.14. It should be noted the electro-sensitive elasmobranchs and shellfish are considered hearing generalists for the purpose of this assessment. Due to the potential impact of noise on fish and their spawning aggregations, the noise contours produced through the modelling have been overlaid onto maps of known spawning grounds (Coull *et al.,* 1998 and Ellis *et al.,* 2012) in the wider region in order that the magnitude of the effect can be quantified.

Table 13.22: Impact Range Areas for Selected Species Assessed via Noise Modelling (assuming two piling vessels operating simultaneously)

Receptor	Species (or surrogate species)	Impact Range Areas (km^2) predicted to result from impact piling		
		130 dB_{ht}	90 dB_{ht}	75 dB_{ht}
Hearing specialist	Herring	0.20	2,472.94	9,222.56
	Cod	0.20	1,821.00	7,452.00
Mobile fish species	Dab	0.01	42.54	1,119.25
	Sea Trout	-	0.41	20.69
SAC qualifying feature species	Salmon	0.01	13.89	475.08
Prey species	Sand Lance (*Ammodytes* spp) - surrogate for sandeel	-	0.17	11.70

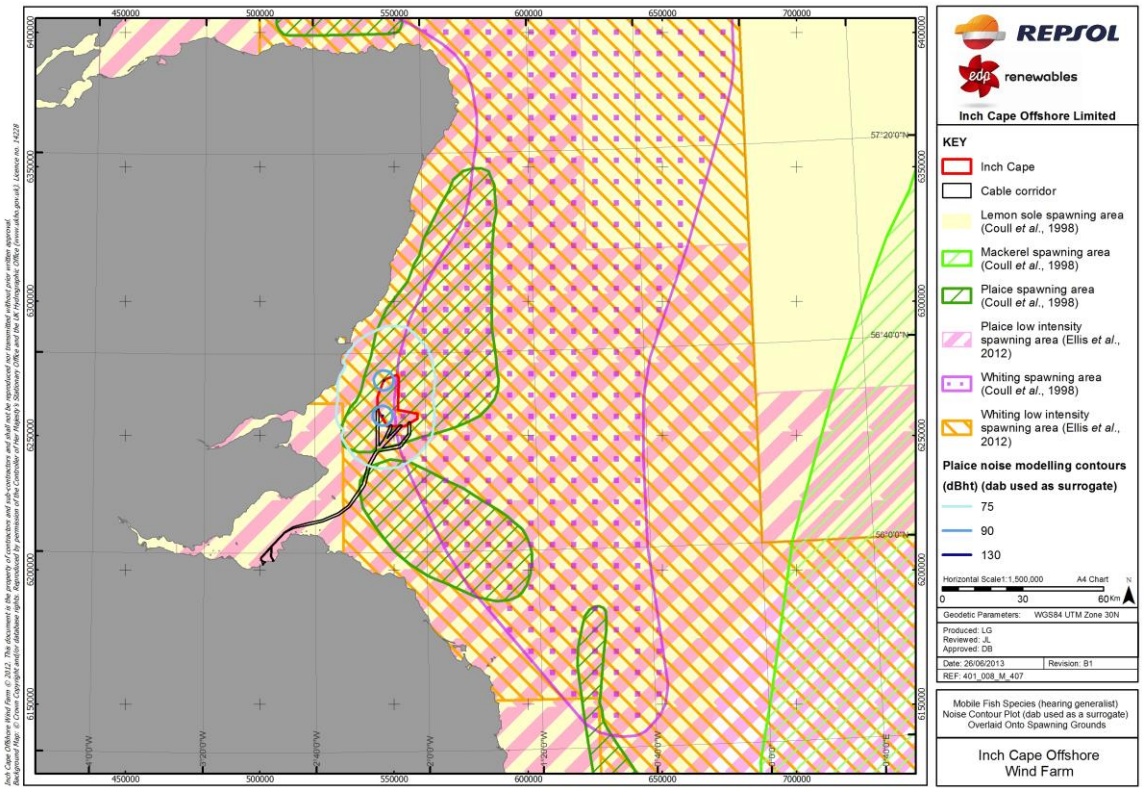
140 Complete installation for all piles will occur within a two year period during the construction phase, although piling will not be constant throughout this period (taking up only 11 to 23 per cent of the construction period). Over this period, due to the high levels of noise produced by piling, effects are predicted on a lethal, physical damage and behavioural scale. However soft start procedures will reduce the magnitude of the effect, allowing many fish to leave the area before suffering lethal effects and physical damage, and consequently minor behavioural effects are more likely.

Mobile Fish Species (Hearing Generalists)

Mortality, Physical and Auditory Injury

141 The noise modelling scenario is based on the assumption of two piling vessels working concurrently in the Development Area. The resultant area affected by noise levels that is likely to cause mortality, physical and auditory injury in dab (>130 dB_{ht}), is restricted to a maximum of 0.01 km^2 (0.015 per cent of the Development Area) (Figure 13.13). It should also be noted that the implementation of soft-start procedures will result in many fish being displaced from the area of effect before noise levels reach the levels that injury and mortality are predicted. The magnitude of this effect is judged to be negligible as any death or injury of fish species has little potential to create impacts on the size and structure of the overall stock. The sensitivity of this receptor is judged to be low, therefore, with respect to mortality, physical injury, and auditory injury due to piling noise, a negligible/minor impact is predicted on mobile fish species (hearing generalists).

Figure 13.13: Mobile Fish Species (hearing generalist) Noise Contour Plot for Simultaneous Piling in the Development Area (Dab Used as a Surrogate)



Behavioural Responses

142 With respect to behavioural responses on mobile fish species (hearing generalists), the spatial extent of areas affected by noise levels that will produce strong avoidance (90 dB_{ht} (dab)) and mild avoidance (75 dB_{ht} (dab)) responses exceeds the boundary of the Development Area. The sensitivity to noise impacts of hearing generalists is accounted for within the assignment of magnitude of effect, as noise levels are weighted for certain species to calculate areas of effect for differing response levels (the dB_{ht} metric – see Table 13.22). However, despite thresholds being set for certain broad ranging effects, within the avoidance and behavioural effects thresholds the actual physical response is still relatively uncertain and variable. Mueller-Blenkle (2010) highlights behavioural effects such as increased swimming speed and freezing responses in sole. However, the same author also identifies the variability of response to noise on an individual basis for the same species.

143 Avoidance and behavioural responses to subsea noise could result in decreased feeding activity, the potential avoidance of spawning grounds, and also potentially a barrier to migration. Whilst the former impact is unlikely to cause long term effects on wider fish populations, due to the widespread distribution of similar feeding grounds, behavioural responses such as avoidance, that impact on spawning and subsequent recruitment could have longer lasting consequences at a population/stock level. Thus there are concerns that piling noise can affect the behaviour of the fish that congregate on spawning grounds, which may in turn effect breeding success and therefore the stock as a whole. Therefore, the

impacts of noise on fish species is discussed in the context of the potential effects on adjacent spawning grounds. The same could also be said for any effect that causes a complete barrier to migration, in particular for species such as sea trout and sparling, all of which have been specifically identified by consultees (see *Section 13.2*) as species requiring assessment in relation to potential barriers to migration due to noise.

144 In addition to noise modelling of hearing generalists, using dab as the surrogate species, the noise modelling also considered potential impacts on sea trout (although it should be noted that this species does not form a qualifying feature of any SAC). The sensitivity of sea trout was investigated in respect to both pile driving and vibro piling in Southampton water (Gill and Bartlett, 2010). The results of this study showed no impact at a distance of 400 m from the noise source, however, the source levels were much smaller than those proposed for the Project. Project-specific noise modelling for sea trout undertaken for the piling within the Development Area indicated that levels of 75 db_{ht} (mild avoidance reaction) do not extend beyond 2 km from the source (Figure 11A.41). Therefore, impact areas for sea trout during piling at the Development Area are small, with strong avoidance (90 db_{ht}) predicted to occur less than 0.5 km from noise source and behavioural changes less than 2 km from the source. Detailed information on the migratory patterns of sea trout is relatively limited but, as per the conclusions with regard to salmon (see below), migration of this species to natal rivers is not predicted to be significantly impacted by piling noise as a complete barrier to migration will not be created.

145 Sparling are known to be present within the rivers Forth and Tay (SNH consultation, 2011). However, this species is not identified as a hearing specialist, and as they are predominantly estuarine species, only limited interactions with the Development Area are predicted and no barrier to their migration due to noise from piling is predicted.

146 In summary, for fish hearing generalists, including dab and sea trout, the noise impact areas that will produce behavioural responses (avoidance) as predicted by the noise modelling are small in proportion to the spatial extent of similar areas in the wider region, resulting in a low magnitude of effect using the criteria in Table 13.15. The sensitivity of the mobile fish receptor group is defined as low, therefore a minor impact is predicted on mobile fish (hearing generalists) due to subsea noise generated via piling in the construction phase.

Hearing Specialists

147 The following assessment presents the findings of the noise modelling on fish hearing specialists. Herring, shad and sprat are considered hearing specialists (Enger *et al.*, 1993; Kastelein *et al*., 2008; Blaxter *et al.,* 1981; Nedwell, 2004). Cod is also moderately sensitive to noise, hence for the point of view of this assessment, is considered a hearing specialist. As per above for hearing generalists, potential impacts via mortality and injury (physical and auditory) are discussed separately to potential behavioural responses.

148 As described above, noise itself will not affect spawning habitats; however there are concerns over the effects of piling noise on these species particularly in areas where greater densities congregate for spawning. Therefore, the effects of piling noise on adult fish

congregating on spawning grounds are discussed and then placed in the context of potential overlap of noise effects with adjacent spawning grounds. Herring spawning grounds are known to exist 4.5 km to the north (Buchan/Shetland population off the Aberdeen coast) and 35.8 km to the south of the Development Area (Banks population off the Berwickshire coast). No spawning grounds are noted to occur within the boundaries of the Development Area (Coull *et al.*, 1998).

149 The piling noise predicted could potentially impact herring from the Buchan population off the Aberdeenshire coast as well as the banks population along the Berwickshire coast. Adult herring migrate from offshore feeding grounds from mid-August peaking in September and lay eggs on gravel substrates at these spawning grounds. On hatching, the larvae moves passively in a southerly direction on currents to coastal nursery areas along the east coast of the UK. The potential for an interaction exists between adults migrating to spawning grounds at the Buchan and Banks spawning grounds. In addition, larvae moving to nursery grounds following hatching could potentially be exposed to elevated levels of noise during piling. Development of sensory hearing organs occurs in late stage larvae and so effects on the larval population from piling noise will be limited. Piling noise could evoke an avoidance response in adult and juvenile herring resulting in temporary avoidance by individuals during construction. Larvae from the spawning grounds further north around Orkney and Shetland also support some of the Buchan sub-population however ocean currents are assumed to carry larvae to nursery grounds in the Moray Firth and across the North Sea towards Denmark (Nichols, 1999), and will therefore not interact with the works in the Development Area (Figure 13D.2). Larvae from the Banks spawning areas will move south away from the Development Area.

150 Although Ellis *et al.,* (2012) suggested that herring could spawn over a much larger area, the Herring Spawning Study (*Appendix 13D*) concluded, after thorough review of IHLS (Figure 13.14), IBTS, commercial fishing and site specific fish and benthic data, that there was little evidence of significant spawning outwith the spawning areas defined by Coull *et al.* (1998) in the Regional Study Area. Therefore, for the purpose of this assessment, the established herring spawning grounds as presented by Coull *et al.* (1998) are used as the basis of the discussion of impacts of the various noise contours. This is however, judged to be a very precautionary approach as when larval data for the period 1991 to 2011 is analysed, it is clear that spawning activity (defined by consistent presence of >50 larvae/m^2) is not uniformly distributed across the Coull *et al.* (1998) spawning grounds, but rather concentrated in the northern part of this ground (off the north eastern Aberdeenshire coast) and also the southern spawning ground associated with the Banks component (south of the Development Area).

151 With respect to potential impacts on sprat spawning aggregation, sprat utilise coastal and offshore waters during spawning and release their eggs into the water column (Whitehead, 1986). As a result spawning grounds are widespread around the North Sea and not limited to specific benthic habitats.

152 Cod are also pelagic spawners that release eggs into the water column at all depths and are not dependant on specific benthic habitats. Cod spawning grounds are distributed all over

the North Sea but mainly in offshore waters particularly north west of the Dogger Bank (ICES, 2006).

153 With reference to shad, both allis shad and twaite shad are known to use the coastal shelf for migrations, however records of shad species in the nearby vicinity of the Development Area and the Offshore Export Cable Corridor are rare. Furthermore, the only known Scottish spawning area is found on the west coast in riverine environments, therefore interactions of shad species with both the Development Area and Offshore Export Cable Corridor is considered highly unlikely. Given the rarity of shad in the Study Areas they are not specifically assessed, however taking the precautionary principle the magnitudes of effect on sprat could be applied to shad if necessary.

Mortality, Physical Injury and Auditory Injury

154 The impact area for herring at 130 dB_{ht} (injury) is 0.2 km^2 (see Table 13.22). This represents a maximum of 0.27 per cent of the Development Area, if two piling vessels were working simultaneously. Data from the baseline surveys and also review of ICES landings data indicates that the distribution of herring within the Development Area is limited. Low numbers of adult herring were recorded in the site-specific surveys and the lack of landings of this species in the relevant ICES rectangle over the period 2007-2011 also illustrates this fact. Furthermore, IHLS data suggests spawning aggregations are greatest to the north of the Development Area. The limited spatial extent of noise levels resulting in mortality or injury (physical or auditory) is highly unlikely to overlap with aggregations of herring congregating on spawning grounds.

155 It is assumed that the impact area for injury to sprat will be the same based on similar acoustic sensory abilities. ICES report that sprat are abundant and widespread (ICES, 2006) and that nursery and spawning grounds are ubiquitous around the North Sea. The area around the Development Area does not have any particular importance to the North Sea sprat population, that would attract high densities to the Development Area. As the impact area for injury is spatially restricted to the immediate vicinity of the piling location there is no risk of a significant proportion of sprat populations being injured during piling operations.

156 Distributional data collected during IBTS and reported by ICES indicate that cod are widespread across the North Sea (ICES, 2006). Highest densities of adults have been recorded between Shetland and the North Sea and highest densities of sub adults have been reported in deeper waters further offshore in the North Sea. As a pelagic spawner, cod are not restricted to specific habitats during the spawning season. Spawning grounds for the species are therefore widespread across the North Sea (Ellis *et al.*, 2012). Although cod may be present around the Development Area, no substantial aggregations will be present that would pose a risk to the status of the stock. The area of mortality, physical injury and auditory injury will only occur within the immediate vicinity of the piling location and therefore does not pose a significant risk to the North Sea cod stock.

157 Therefore, the magnitude of this effect is judged to be negligible as the limited spatial extent of this effect should only have a small impact on the overall size or structure of wider

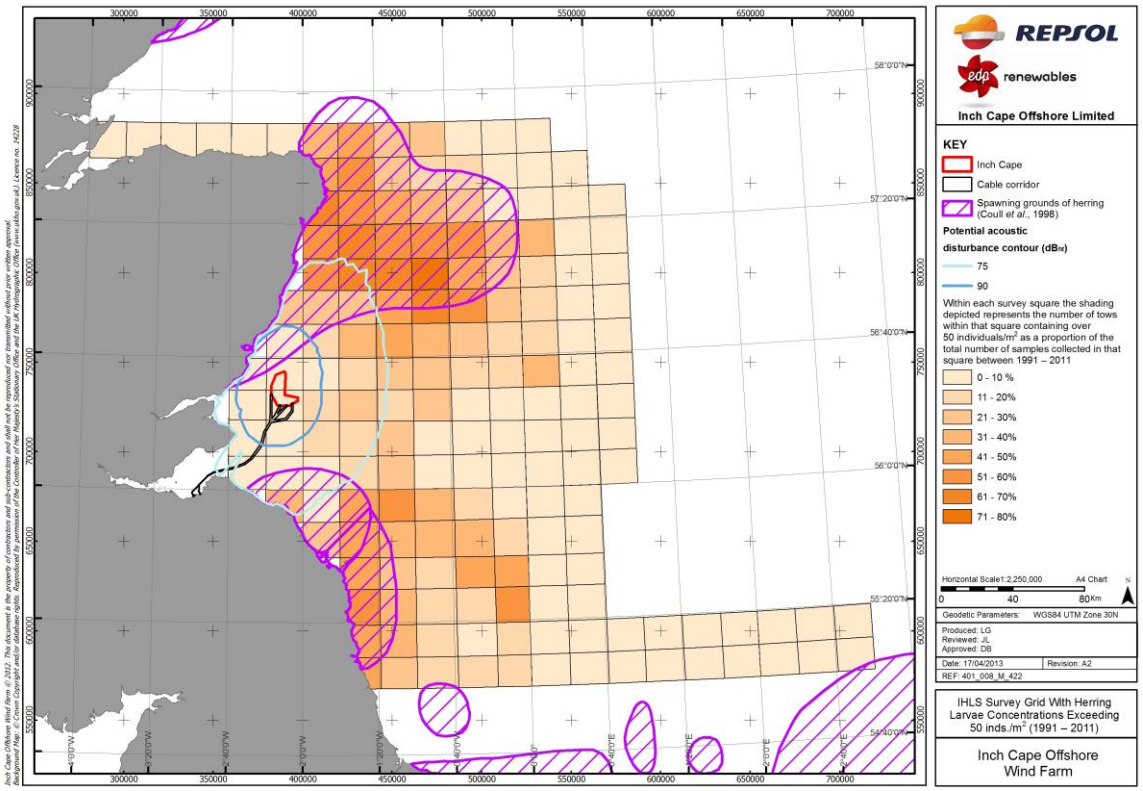
herring, sprat, and cod stocks in the region. The sensitivity of the hearing specialist receptor is judged to be moderate. Therefore a minor impact on hearing specialists via injury (physical and auditory) and mortality from piling noise is predicted.

Behavioural Responses

158 The impact areas for herring at 90 dB_{ht} and 75 dB_{ht} are 2,473 km^2 and 9,223 km^2 respectively (see Table 13.22). These 90 dB_{ht} (strong avoidance) and 75 dB_{ht} (mild avoidance) behavioural effect areas exceed the boundary of the Development Area and overlap with adjacent herring spawning grounds as defined by Coull *et al.* (1998). Therefore, scope exists for noise generated by piling to create behavioural responses (avoidance) in adult herring that may potentially deter them from congregating on these spawning grounds and therefore, lead to an adverse impact on spawning. Were this to occur, there could be knock-on effects on recruitment and the overall spawning stock biomass for this species.

159 The total area of herring spawning grounds (as defined by Coull *et al.,* 1998) that will be impacted by these strong avoidance (90 dB_{ht} (herring)) and mild avoidance (75 dB_{ht} (herring)) reaction noise levels is 542 km^2 and 3,008 km^2 respectively. This equates to 0.4 per cent and 2.5 per cent of the total UK spawning grounds (Figure 13.14; Coull *et al.,* 1998). Mild avoidance reaction noise effects (75 dB_{ht} (herring)) reach both Buchan and Banks spawning areas while the strong avoidance (90 dB_{ht} (herring)) impact area only interacts with the northern spawning area. To determine the effects on sub-populations of herring the area of overlap of noise contours has been calculated as a component of the spawning grounds that support the Shetland/Buchan and Banks sub-population separately. Spawning grounds to the north of the Development Area around the Aberdeenshire coast and around Orkney and Shetland are considered to support the Shetland/Buchan population. Spawning grounds to the south including those around the south-east of Scotland and Northumberland coastlines and the east Yorkshire coast down to the Humber and the Wash are considered to support the Banks spawning component. The 90 dB_{ht} (herring) and 75 dB_{ht} (herring) contour will coincide with 1.4 per cent and 5.6 per cent of the spawning grounds available to the Shetland/Buchan sub-population respectively. To the south the 90 dB_{ht} (herring) will not coincide with any spawning grounds associated with the Banks sub-population. However, the 75 dB_{ht} (herring) will coincide with 4.9 per cent of the Banks spawning sub-population.

Figure 13.14: Noise Contour Plot for Simultaneous Piling Superimposed onto Herring Spawning Grounds with IHLS Data



160 It is important again to reiterate that this assessment is judged to be highly precautionary as it assumes that the entire spawning grounds as defined by Coull *et al.* (1998) support a uniform level of spawning activity. The review of the IHLS data for the period 1991 to 2011 (Figure 13.14) indicates that spawning does not occur uniformly across these areas, but instead is focussed in more discrete areas. Therefore, the areas of actual spawning grounds where piling noise may cause a strong and/or behavioural responses to the aggregations of spawning adults are likely to be less than the areas presented here, meaning that the percentage of total UK spawning grounds predicted to be affected will also be less than presented. In addition the actual effects on herring spawning behaviour of such noise levels are relatively unknown, and while behavioural changes are predicted to occur within spawning grounds, following a study on overhead vessel traffic it is theorised that herring engaging strongly in spawning activity have higher reaction thresholds to threatening stimuli (including noise) than are normally found (Skaret *et al*., 2005).

161 Potential high intensity nursery grounds for herring have been reported along most of the east coast of the UK (Ellis *et al.*, 2012). Low intensity nursery grounds have been mapped across the entire western North Sea from Shetland to the Southern Bight. Displacement of juveniles from within the 90 and 75 dB_{ht} (herring) noise contour may result in temporary displacement. However, extensive alternative nursery resources exist to support the juvenile population. Therefore, any impacts on recruitment to the nursery stock as a result of disturbance from piling noise will be negligible.

162 Potential behavioural impacts on herring must be assessed based on the overall health of the stock and any potential exclusion effects that may result in reduced recruitment success and thus long term viability of the stock. The significance of any noise impacts would be greatly increased were it able to be demonstrated that the behavioural responses predicted to occur would impact spawning activity to a degree that the viability of the overall stock was compromised. However, for this particular assessment, whilst it is accepted that noise levels sufficient to result in both strong avoidance and mild avoidance reactions in herring will overlap with adjacent herring spawning grounds, the evidence available, in the form of up-to-date knowledge of the wider status of North Sea herring stocks and review of IHLS, IBTS and commercial fishery data, indicates that these impacts will not significantly influence the size or structure of the wider herring stocks in this region. Conclusions presented in the *ICES Herring Assessment Working Group (HAWG) report 2012* state that the North Sea herring stock is currently at full reproductive capacity and harvested sustainably with increases of over 95 per cent in the Total Allowable Catch (TAC) for 2012 (ICES, 2012). Any minor temporary displacement effects resulting from piling will not result in a significant increase in mortality that would be detrimental to the Shetland/Buchan sub-population or to the North Sea herring stock as a whole.

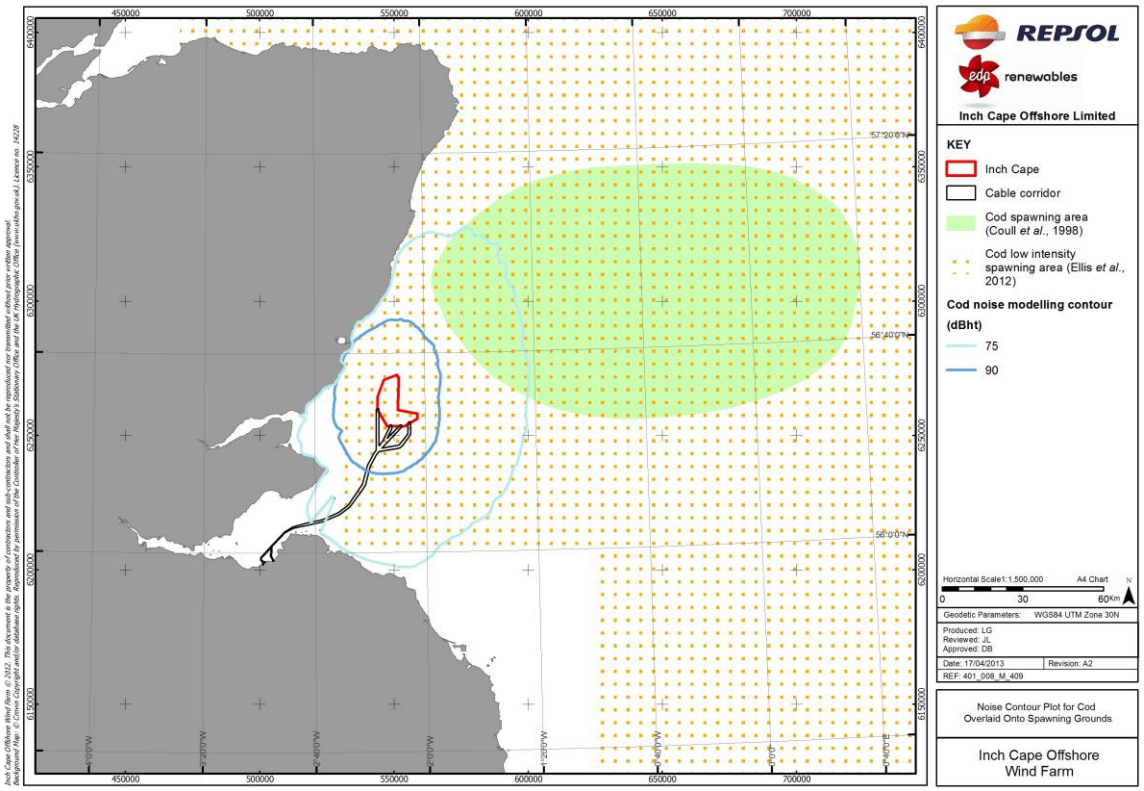
163 In conclusion, the area of overlap between the 75 and 90 dB_{ht} noise contours represent only a small area of the spawning grounds associated with both the Banks (4.9 per cent and 0 per cent respectively), and Shetland/Buchan (5.6 per cent and 1.4 per cent respectively) sub-populations which exhibit large variations in extent year on year. The spawning grounds affected lie on the periphery of much wider spawning areas, and IHLS and commercial catch data suggests that spawning intensity is greater further north than the 75 dB_{ht} (herring) noise contour. Furthermore, spawning activity is highly variable year on year, driven largely by environmental variables (Hufnagl and Peck, 2011). As herring (and sprat) are highly mobile species any avoidance of the noise contour area during piling will not result in exclusion of individuals from the wider available spawning locations. In addition, herring have been reported to shift to alternative spawning locations between generations (Schmidt *et al.* 2009). In the 1960's natural shifts in spawning ground usage were reported from areas around Buchan up to Shetland and then back again (Bainbridge and Forsyth, 1972). This ability to do so is hypothesised as a buffer against any environmental stressors acting on a population. However, it provides an indication of the ability of herring to adapt and use alternative suitable spawning grounds when necessary.

164 Consequently, the magnitude of this effect is judged to be moderate, based on the definitions in Table 13.15 and conservative assumptions made in the assessment. Coupled with a receptor sensitivity of moderate, a moderate impact is predicted as a result of piling noise causing behavioural impacts on herring that may congregate on local spawning grounds.

165 As cod (Figure 13.15) and sprat spawning grounds occur across much of the North Sea, displacement of adults during the respective spawning seasons will not affect the spawning success of these species. Nursery grounds for cod and sprat are common and widely distributed. Any juveniles displaced from nursery areas will not experience a significant

reduction in nursery resources that could affect recruitment to the spawning stock biomass. These species are considered to have a moderate sensitivity, and due to the distribution of each species the magnitude of this effect will be low. This results in an overall impact of minor/moderate.

Figure 13.15: Noise Contours Plot for Simultaneous Piling Superimposed onto Cod Spawning Grounds



Prey Species

166 In recognition of the importance of sandeels as a prey item for birds, marine mammals and larger fish in the Study Areas, the noise modelling described above included an assessment of noise impacts on the sand lance, which was used as a surrogate for sandeels.

Mortality Physical Injury and Auditory Injury

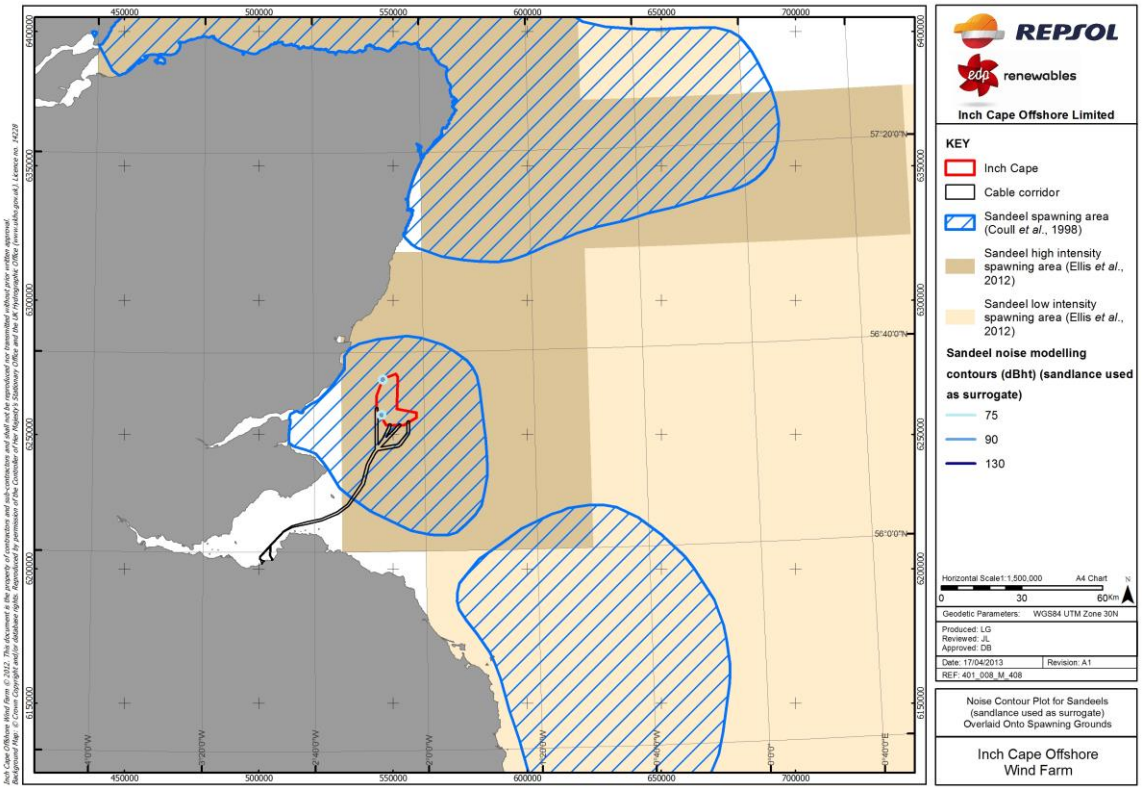
167 As a result of the low sensitivity of sandeels to subsea noise effects, the spatial extent of noise levels that would cause mortality and/or injury were too small to model (see Table 13.22), therefore an effect of negligible magnitude is predicted on sandeels via mortality and injury from noise effects. The sensitivity of this receptor has been defined as moderate; therefore a minor impact is predicted.

Behavioural Responses

168 The impact ranges for behavioural responses in sandeels are also limited compared to hearing specialists, with an area of 11.70 km^2 affected by the 75 dB_{ht}(sand lance), (mild

avoidance) contour (Figure 13.16) assuming two piling vessels operating simultaneously. This equates to a maximum of 7.7 per cent of the Development Area that will be affected at any one time. Seismic surveys of sandeels (*Ammodytes marinus*) has shown some behavioural reactions are likely to occur, with direct video observations showing increased tail motion, bending of the body and fleeing out of site during seismic shooting with a source level equivalent to 210 dB @ 1 mPa (Hassel *et al*., 2004). No observations of sandeels seeking refugia within the sediments were seen during seismic activity, and after the seismic shooting had ceased, normal behaviour was resumed (Hassel *et al*., 2004).

Figure 13.16: Noise Contour Plot for Simultaneous Piling Superimposed onto Sandeel Spawning Grounds (sand lance used as surrogate)



169 Furthermore, no increase in mortality or injurious effects were noted in treatment groups (exposed to seismic shooting) over control groups (not exposed to seismic activity), and no reduction in sandeel abundance in grab surveys was observed after the seismic activity had ceased (Hassel *et al*., 2004). The results of this survey indicate that effects on sandeels are short term, localised and constrained to behavioural level effects, with no longer term effects likely. As such, the effect of underwater noise on sandeels is considered of low magnitude in the context of behavioural responses. Due to the ecological and conservation status of sandeels, they are considered to be of moderate sensitivity, and as such, combined with a negligible magnitude, a minor/moderate impact is predicted.

Electro-sensitive Elasmobranchs

170 The same magnitude conclusions related to piling noise impacts reached for mobile fish species apply for this specific receptor as all electro-sensitive elasmobranchs are judged to be hearing generalists. The sensitivity of this receptor group is defined as low; therefore, combined with a negligible magnitude, a negligible/minor impact is predicted for mortality and injury, and combined with a low magnitude a minor impact is predicted for behavioural responses.

SAC Qualifying Species

171 Noise and vibration from construction activities (in particular piling) will result in increased levels of underwater noise which may act as a barrier to migration for species that are qualifying features of freshwater SACs located in the wider region. The potential for subsea noise to impact on migration of these species, which include Atlantic salmon, sea lamprey and river lamprey, has been highlighted through consultation with key stakeholders and as such, is assessed by individual species below.

Mortality and Auditory Injury

Salmon

172 The swim bladder of salmon plays no part in the hearing of the species, and Hawkins and Johnstone (1978) found salmon to show low sensitivity to noise; that particle motion, rather than sound pressure, proved to be more important. Furthermore salmon are also used to relatively noisy riverine environments and as such are acclimatised to elevated noise levels (Hawkins and Johnstone 1978, Thomsen *et al*., 2006). Their ability to respond to sound pressure is regarded as relatively poor with a narrow frequency span, a limited ability to discriminate between sounds, and a low overall sensitivity (Hawkins and Johnstone, 1978).

173 Noise modelling conducted for the Development Area (for impact pilling) indicates injurious effects are likely to occur less than 0.1 km from source (Figure 13.17). Therefore, the magnitude of this effect on salmon is judged to be negligible, as the effect will be intermittent and no wider effects on the size or structure of salmon stocks that represent qualifying features of local SACs is predicted. The sensitivity of this receptor is judged to be high due its designation as a qualifying feature for local SACs, therefore combined with a negligible magnitude, a minor/moderate impact is predicted.

Lamprey

174 River lamprey will not come into contact with the Development Area as they do not leave estuaries, and the noise contours do not extend to their range. Noise as a result of construction has the potential to impact on sea lampreys migrating to offshore waters. No audiogram exists for sea lamprey, however they do not possess specialist sensory organs such as otoliths or a swim bladder suggesting that the species are hearing generalists with low hearing thresholds. In the absence of detailed data on this species, and noting its likely status as a hearing generalist, the same conclusions with regard to magnitude of effect for potential mortality and/or injury effects as reached for other hearing generalist species

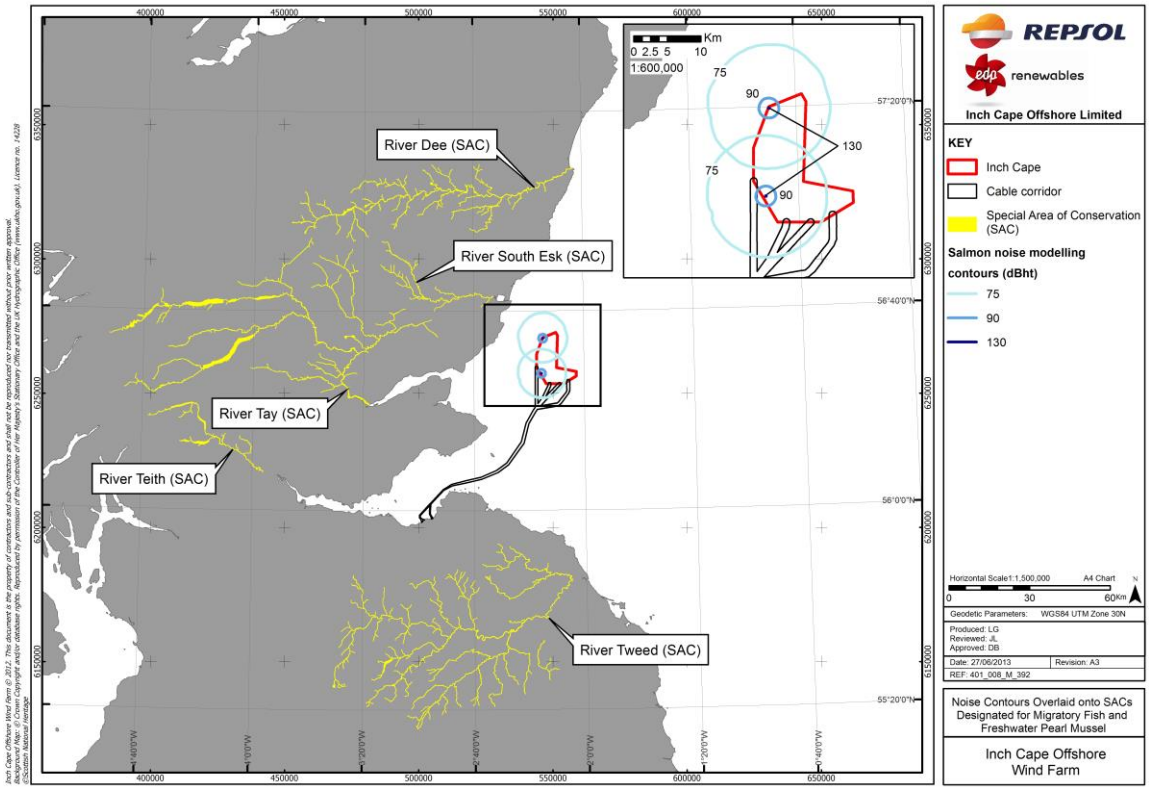
(such as salmon) is concluded for lamprey. Coupled with a receptor sensitivity of high (SAC qualifying feature), a minor/moderate impact is predicted.

Behavioural Responses

Salmon

175 Noise modelling conducted for the Development Area (for impact pilling) indicates an area of approximately 14 km^2 may be affected by noise levels that would create a strong avoidance reaction in salmon (90 dB_{ht}) and 475 km^2 affected by noise levels that would potentially create mild avoidance reactions (75 dB_{ht}) assuming two piling vessels operate simultaneously. To place these areas in context with the wider region, and to illustrate the amount of "sea area" still available for migration, Figure 13.17 presents the 90 dB_{ht} (salmon(and 75 dB_{ht} (salmon) contours alongside the Development Area and wider study areas, including the location of rivers designated as SACs which have salmon as a qualifying feature.

Figure 13.17: Noise Contour Plot for Simultaneous Piling Superimposed onto Salmon Designated Rivers.



176 The migratory patterns of salmon will determine the degree to which they may encounter piling noise from the Wind Farm. Both adult salmon migrating towards their natal rivers and smolt and kelt leaving rivers to enter coastal waters could be exposed to these noise impacts. However, it is important to note that these noise impacts will be intermittent and temporary over the two year construction period and there will be periods of time when no piling is taking place. Assuming 944 piles (213 WTGs, five OSPs and three met masts) the

proportion of the two year construction period when piling will take place will be between 11 to 23 per cent (with 4.2 and 2.1 hours considered to be the worst and most likely range for piling duration per pile).

177 Noting the distances between the estuaries of these SAC rivers and the Development Area (>20 km) and the fact that the maximum extent of noise effects have been predicted to be no more than 10 km (for a minor avoidance reaction), no barriers to migration as a result of subsea noise are predicted for adult salmon returning to any of the local rivers designated as SACs. Smolt leaving their natal rivers for the first time, are likely to travel in a northerly and easterly direction upon leaving these rivers and therefore may pass through the Development Area.

178 As with adult salmon migrating back to these rivers, the extent of the area affected by piling noise does not represent a complete barrier to this migration. As such the effect of piling noise on salmon (both returning adults and smolts/kelts leaving rivers) is considered to be of low magnitude as the behavioural responses that may arise via these noise levels are only predicted to result in small effects on the size or structure of salmon stocks in the wider region that form qualifying features of SACs and will not form a barrier to migration. With the sensitivity of this receptor being high combined with low magnitude, a moderate impact is predicted for behavioural responses to piling noise by migrating salmon.

Lamprey

179 The likely attenuation of construction noise in water may result in avoidance reaction of sea lamprey from the noise contours; however, this will be temporary in duration (two years, within which piling will be only an intermittent activity occurring 11 to 23 per cent of the time) and localised in extent representing a relatively small part of the species natural range. As such the effect on sea lampreys is considered to be of low magnitude as the behavioural responses that may arise via these noise levels are only predicted to result in small effects on the size or structure of sea lamprey stocks in the wider region that form qualifying features of SACs. With the sensitivity of this receptor being high, a moderate impact is predicted for behavioural responses to piling noise by sea lamprey.

Shellfish

Mortality and Auditory Injury and/or Behavioural Responses

180 The impact of piling noise on shellfish is likely to be negligible. Studies using lobsters have shown no effect on mortality, appendage loss or the ability of animals to regain normal posture after exposure to very high sound levels (>220 dB), although some avoidance behaviour can be expected (Payne *et al*., 2007). These reactions to noise and vibration should not interfere with the ecological functioning of the organisms with mobile species likely to return to the areas soon after cessation of the impacting activity. Results from studies on the impacts of seismic activity on scallops (*Pecten fumatus*) also indicate that no deleterious effects are likely (Harrington *et al.,* 2010). Studies have examined both lethal and sub-lethal (reduced growth, gonad condition, etc.) effects both immediately after seismic activity and after a duration of two months post seismic activity, and found no effects that

were detectable (Harrington *et al.,* 2010). Furthermore, other marine bivalves (e.g. mussels (*Mytilus edulis*) and periwinkles (*Littorina* spp.)) exposed to a single airgun at a distance of 0.5 m also have shown no effects after exposure (Kosheleva, 1992, in Parry and Gason, 2006). As such no impacts on sedentary macro-invertebrates are predicted.

181 The magnitude of the effect of underwater noise to mobile invertebrates is, therefore, considered to be negligible. The sensitivity of these species is considered to be low, and therefore a negligible/minor impact is predicted. A summary of impacts significance can be found below.

Table 13.23: Impact Summary of Barrier Effects, Disturbance, Auditory Injury, or Physical Injury Associated with Construction Noise

Impact	Receptor	Magnitude	Sensitivity	Significance
Barrier effects, disturbance or physical injury associated with construction noise.	Mobile fish species (hearing generalists)	(Mortality and injury) = Negligible (Behavioural responses) = Low	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	Hearing specialists	(Mortality and injury) = Negligible (Behavioural responses) Herring = Moderate Cod & sprat = Low	Moderate	(Mortality and injury) = Minor (Behavioural responses) Herring = Moderate Cod & sprat = Minor/Moderate
	Prey species	(Mortality and injury) = Negligible (Behavioural responses) = Low	Moderate	(Mortality and injury) = Minor (Behavioural responses) = Minor/Moderate
	Electro-sensitive elasmobranchs	(Mortality and injury) = Negligible (Behavioural responses) = Low	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	SAC qualifying feature species	(Mortality and injury) = Negligible (Behavioural responses) = Low	High	(Mortality and injury) = Minor/Moderate (Behavioural responses) = Moderate

Impact	Receptor	Magnitude	Sensitivity	Significance
	Shellfish	(Mortality and injury) = Negligible (Behavioural responses) = Negligible	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Negligible/Minor

13.6.2 Effects of Operation and Maintenance

Long Term Loss of Original Habitat

182 Long term loss of original habitat at the Development Area is associated with those areas beneath WTG foundations, OSPs, met masts, protection for cables and scour protection. The loss of habitat can impact fish and shellfish species in a number of ways, e.g. loss of feeding/refuge areas, changes in prey availability and loss of spawning/nursery grounds.

183 In total, the area of original habitat that will be subject to long term loss due to installation of infrastructure covers a maximum of 1.87 km^2, which represents 1.25 per cent of the Development Area. Similar habitat (sand and coarse sediments), including that containing known spawning and nursery areas, extends across a large area of the north North Sea (EUSeaMap, 2012; *Chapter 12*; Coull *et al.,* 1998; Ellis *et al.,* 2012), and therefore this amount of long term habitat loss represents a small and localised loss of this habitat type.

Mobile Fish Species

184 Most fish species have a wide geographic range and broad diet and are thus not constrained by a dependence on a particular prey item. As a result, any changes to the species composition or availability of prey are not predicted to cause any significant effects to adult fish populations in the area.

185 Direct use of the lost habitat is only relevant to a small number of demersal fish species (e.g. the flatfishes), however due to their high mobility and wide geographic ranges, these species will be able to utilise similar, adjacent habitats in the area.

186 Spawning habitats of several species overlap with the Development Area. The long term habitat loss defined above (1.87 km^2, 1.25 per cent of the Development Area) will create an adverse impact on these spawning habitats. However, the amount of any spawning habitat lost due to the Wind Farm and associated OfTW within the Development Area, as a proportion of similar habitats in the wider region, will be small. In terms of the magnitude of effect, any long term loss of spawning habitat will not create anything other than a small effect on the viability of any species that spawn in this area as the amount of available spawning habitat is not judged to be a limiting factor to overall stock size.

187 As a result, the effects of long term habitat loss to mobile fish species and their spawning area is of a negligible magnitude as this loss of habitat will not impact on the overall size or structure of any mobile fish species stocks in the wider region. This receptor is considered to be of low sensitivity, combined with negligible magnitude results in a negligible/minor impact being predicted for long term habitat loss for mobile fish species.

Hearing Specialists

188 The same magnitude conclusions with respect to mobile fish species apply for this specific receptor. No impact on herring spawning habitat is predicted via long term habitat loss as herring spawning grounds do not exist within the Development Area. However, the increased sensitivity of this receptor (moderate) combined with negligible magnitude, results in an impact of minor being predicted, due to long term loss of original habitat in the operational phase.

Prey Species

189 The long term loss of habitat within the Development Area will affect habitat defined by baseline studies as providing "suitable" sandeel habitat. The long term loss of this habitat is not predicted to lead to significant change in the sandeel population in the area as there are much more extensive areas of subprime and prime sandeel habitat available in the wider region and baseline studies also demonstrated that sandeel abundance within the Development Area was low. Therefore, although there will potentially be very localised impacts on sandeels, the impacts in the Regional and Local Study Areas to the wider sandeel population will be less significant. The magnitude of this effect on prey species, specifically sandeels is therefore judged to be low (based on criteria in Table 13.15) as this long-term habitat loss is not predicted to have anything more than a small effect on overall sandeel stocks in this region. The sensitivity of this receptor is moderate and therefore a minor/moderate impact is predicted on prey species as a result of the long term loss of habitat due to Project infrastructure.

190 Sandeel spawning grounds do overlap with the Development Area, therefore long term habitat loss will affect this resource. However, as outlined above, the small amount of permanent habitat loss (1.87 km^2, 1.25 per cent of the Development Area) will only represent a small proportion of similar sandeel spawning habitat across the Regional Study Area, therefore an effect of low magnitude is predicted. This conclusion of effect magnitude is also based on the observation that the Development Area contains very little prime habitat for sandeels and characterisation surveys also did not identify large numbers of sandeels at the Development Area. This receptor group is classed as having a moderate sensitivity; therefore, a minor/moderate impact is predicted.

Electro-sensitive Elasmobranchs

191 The same magnitude conclusions with respect to mobile fish species apply for this specific receptor i.e. negligible. The sensitivity of this receptor group is defined as low, therefore, combined with a negligible magnitude, a negligible/minor impact is predicted, due to long term loss of original habitat in the operational phase.

SAC Qualifying Feature Species

192 The long term loss of habitat within the Development Area will have a very limited impact on this receptor group as species such as salmon and lamprey are not thought to rely on the specific habitats within the Development Area for any particular ecological function, such as spawning or even feeding. Malcolm *et al.,* (2010) noted that analysis of gut contents of adult salmon indicated that these fish were feeding in coastal waters, particularly in those fish that arrived earlier in the year (in contrast to late-run fish). However, the seabed habitats of the Development Area are no more important in terms of prey resources than surrounding areas and in fact the lack of high abundances of sandeel in the Development Area actually suggests that the Development Area is less important than surrounding areas. Sea and river lamprey do not feed on the benthos (they live on migrating fish such as salmon). Therefore, loss of benthic habitat will only indirectly impact them and the same conclusions as for salmon can be drawn.

193 Overall, the magnitude of effect of long term habitat loss on SAC qualifying feature species is judged to be negligible as, based on criteria in Table 13.15, this effect is not predicted to influence the size or structure of stocks of SAC qualifying fish species in the wider region. The sensitivity of this receptor to all effects is high, therefore when combined with a negligible magnitude a minor/moderate impact is predicted.

Shellfish

194 Shellfish species present in the Development Area (scallops, edible crab, common lobster, *Nephrops*) will be displaced from any areas where permanent Project infrastructure is placed. These species will however be able to utilise similar, adjacent habitat and so will not be significantly affected at a population level. As such, effects to these species are considered to be of low magnitude based on the criteria in Table 13.15 as there will potentially be a small effect on the stock of some of these species. The shellfish receptor group is defined as having a low sensitivity; therefore a minor impact is predicted. A summary of impacts significance can be found below.

Table 13.24: Impact Summary of Long Term Loss of Original Habitat

Impact	Receptor	Magnitude	Sensitivity	Significance
Long term loss of original habitat	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Low	Low	Minor

Behavioural Responses to EMF Associated with Cabling

195 Many causes and sources of EMF occur in the marine environment as a result of natural and anthropogenic sources, ranging from the earth's magnetic field and movements of ocean currents through it, to infrastructure such as pipelines or communications and electrical cables. There are three types of EMF associated with subsea transmission cables:

- Electric fields are directly produced as a result of energy transmission and increase with increasing voltage. This is referred to as E-fields and is measured in kV/m^{-1}. Armouring around modern cabling is sufficient to shield the surrounding environment from E-fields, therefore effects of E-fields will not affect any fish species within the vicinity of the Development Area and is therefore not considered an issue with subsea cabling;
- Magnetic fields, referred to as a B-fields, are produced from DC or AC current passing through the cable and cannot be shielded by cable insulation (CMaCS, 2003). The B-field will radiate outwards and decrease rapidly as per the inverse square law and is measured in Tesla (T) or MicroTesla (µT, 1µT = 10^{-6} Tesla). The earth's background geomagnetic field in the North Sea is approximately 50 µT; and
- Induced electrical fields are known as iE-fields. They are secondary electric fields created in any nearby electrical conductors, i.e. sea water, or marine organisms by the magnetic B-field. iE fields are also measured in kV/m, or more usually µV/m as these induced electric fields are of a much smaller magnitude of strength compared to the electric current in cables. The strength of the iE field is site specific and varies with factors such as the configuration and orientation of the cables, the speed and the direction of water flow and the chemical composition of the seawater.

196 The Embedded Mitigation described in *Section 13.3* details mitigation relating to EMF impacts. Cables will be suitably buried or will be protected by other means when burial is not practicable. B-field propagation will not be diminished as a direct result of burial (i.e. the seabed will not act as a barrier to propagation), however increasing the distance for attenuation prior to contact with fish and shellfish receptors will reduce the maximum magnitude of EMF at the seabed/seawater interface. As such, the assessment considers values at the seabed and beyond, when considering impact on natural fish and shellfish species.

197 For the purposes of this assessment, AC has been identified as representing the worst case for EMF potential. It is anticipated that the inter-array cables will comprise of a maximum of 353 km of 66 kV AC cables. Modelling conducted in support of an application for an analogous wind farm in the Moray Firth indicated that B-fields from 66 kV (630 mm^2 at 715A) cables would be 15 µT at the seabed and dissipate to negligible levels at a few metres (the modelling was based on the assumption that the cable would be buried in one metre of sediment; MORL, 2012). This is well below the strength of the Earth's natural geomagnetic field which is assumed to be 50 µT around the central North Sea.

198 No modelling was done for MORL relating to the predicted strength of the induced iE fields, however information is available from a COWRIE funded study based on modelling from the Kentish Flats offshore wind farm on two 33 kV cables (carrying maximum loads of 530 A and

265 A) of the type commonly used for inter-array cabling (Gill *et al.,* 2005). This study indicated that there would be maximum iE field of circa 2.5 µV/m in seawater above the point of cable burial (assuming burial to 1.5 m) (Gill *et al*., 2005). Furthermore, the iE field within the seabed was modelled to dissipate rapidly to 1 or 2 µV/m within a distance of approximately 10 m from the 33 kV cable (Gill and Bartlett, 2010). As stated the strength of the iE-field is heavily dependent on site specific factors and it is therefore difficult to determine exact values of iE-fields to apply to the current assessment. However strengths within the inter-array cables are expected to be comparable in strength to those presented by Gill *et al.* (2005).

199 A literature review of the EMF impacts on natural fish and shellfish has been undertaken as part of an EMF study commissioned by ICOL (*Appendix 13C*). The review identified a number of species which are sensitive to EMF effects in the range likely to be encountered at the Development Area and Offshore Export Cable Corridor and which are likely to have some contact with the Project. Some species have been found to be sensitive to B-fields, some to iE fields and others to both. It should also be noted that, although many species have been found to be sensitive (i.e. can detect EMF), with some exhibiting behavioural responses, no negative impacts on survival have been reported in the literature.

Mobile Fish Species

200 Although it is recognised that certain species of fish exhibit specific electro-sensitive characteristics, i.e. elasmobranchs as they possess specialised electroreceptors, some other species of fish are also capable of detecting EMF, i.e. teleosts. According to Gill *et al.* (2005) other electro-sensitive fish are able to detect induced voltage gradients associated with water movement and geomagnetic emissions. The actual sensory mechanism of detection is not yet properly understood. It is likely that the E-fields that these species respond to is associated with peak tidal movements which can create fields in the range of 8-25 µV/m (Barber and Longuet-Higgins 1948; Pals *et al.,* 1982). EMF sensitivity has been identified in species such as plaice and mackerel, as well as migratory species such as sea trout and European eel and other non SAC migratory fish. Therefore, these species have the potential to be impacted by EMF emitted by the inter-array cabling, with studies around active cables showing behavioural responses to EMF (Gill *et al.,* 2005). While some species such as plaice and flounder may be able to detect EMF, there is little evidence of this affecting their behaviour or survival at the levels of EMF likely to be emitted from inter-array cables. For example Bochert and Zettler (2004) exposed flounder to continuous B-fields (of 3000 µT) for a period of three weeks and found no increase in mortality.

201 This receptor group has limited detection thresholds to iE fields (8-25 µV/m; Gill *et al*., 2005) and the levels emitted will be below this level of detection (assuming similar iE fields as predicted at Kentish Flats of 2.5 µV/m; Gill *et al*., 2005). In addition the level of B fields expected at the seabed of 15 µT will be lower than that of the earth background geomagnetic field (50 µT) and those studied by Bochart and Zettler (2004) (3000 µT). Therefore the magnitude of this effect is considered to be negligible. The sensitivity of this receptor group is low, therefore, a negligible/minor impact is predicted on mobile fish species from EMF effects from inter-array cables.

Hearing Specialists

202 Research was conducted on Baltic herring (*Clupea harengus membras* a subspecies of Atlantic herring) at the Danish Nysted offshore wind farm to identify effects of the 132 kV AC export cable. This concluded no effects on herring as a result of electric fields (Pedersen and Leonhard, 2006); therefore, inter-array cables of a lower voltage are unlikely to have any impacts on Atlantic herring or sprat. This research did however find cod to be receptive to EMF generated from 132 kV AC export cable, although no impact was found on their survival and no information is available on their behaviour in relation to lower voltage inter-array cables. Therefore, the same negligible magnitude conclusions with respect to effects of EMF on mobile fish species apply for this specific receptor. However, the increased sensitivity of this receptor (moderate) combined with a negligible magnitude results in a minor impact being predicted due to EMF effects in the operational phase.

Prey Species

203 The same magnitude conclusions with respect to effects of EMF on mobile fish species apply for this specific receptor. However, the increased sensitivity of this receptor (moderate) combined with a negligible magnitude, results in a minor impact being predicted, due to EMF effects in the operational phase.

Electro-sensitive Elasmobranchs

204 Elasmobranchs possess special electro-sensitive organs on their skin called Ampullae of Lorenzini (AoL), These pores can detect weak bioelectric currents in other animals which are produced through muscle contraction, respiratory movements, cardiac contraction and locomotion and from the electrochemical difference between an individual's internal environment and seawater (Gill *et al.*, 2001). Elasmobranchs use these weak electric fields to detect prey presence during feeding. Elasmobranchs have also exhibited an ability to detect magnetic fields in experimental studies conducted by Meyer *et al.,* (2004). Two species of shark, namely the sandbar shark (*Carcharhinus plumbeus*) and the scalloped hammerhead (*Sphyrna lewini*) showed behavioural changes in response to localised magnetic fields which ranged from 25 to 100 µT.

205 Elasmobranchs are known to occur in and around the Development Area including lesser spotted dogfish, common skate and cuckoo ray, spurdog and tope. Behaviour of the lesser spotted dogfish was measured for a range of electric fields surrounding a 3 phase 150 kV cable carrying 600 A (Gill and Taylor, 2001). This study showed that avoidance behaviour was only observed when field strengths reached 1,000 µV/cm (100,000 µV/m) and that this behaviour was elicited on average 10.4 cm from the source (Gill and Taylor, 2001). As this field strength far exceeds that of 2.5 µV/m, as predicted in the seawater above the 33 kV inter-array cable at Kentish Flats (buried to 1.5 m), coupled with the fact that these cables will be buried throughout their length to a target depth of one metre (or protected), no avoidance behaviours are predicted in the areas surrounding the cables.

206 Other responses to EMF by elasmobranches are variable (at both the species and individual level) but can range from attraction or avoidance of areas, to changes in swimming speed

and direction. Mesocosm research commissioned by COWRIE for example, highlights that behavioural reactions (changes in swimming speed and direction) can be predicted at much lower B and iE fields in the vicinity of subsea cables (8 µT and 2.5 µV/m respectively), however these reactions were variable according to individuals and species (Gill *et al.,* 2009). Any such response may lead to a reduction in the efficiency of feeding behaviours, or may add an additional energetic cost on to the animal. However, as this is variable within a single species it is unlikely to affect all individuals within the vicinity of the inter-array cable route. In addition, only small numbers of elasmobranch species were captured during the baseline surveys and data on nursery areas only indicates low intensity areas of wide ranging species in the vicinity of the Development Area (Ellis *et al.,* 2012). Therefore, interactions between sensitive species and iE fields will be limited and a magnitude of negligible has been ascribed to this effect.

207 The sensitivity of this receptor group is judged to be low; therefore a negligible/minor impact is predicted.

SAC Qualifying Feature Species

208 Salmon and lamprey, which represent this receptor group, exhibit distinct migratory phases as part of their life cycle. Of importance to salmon species is the magnetic (B) field produced by current carrying cables, which can disrupt the detection of the earth's magnetic field that is believed to be used by migrating species. Studies of the behavioural reactions to magnetic fields of migrating species have been inconclusive, and indicate that it is unlikely that magnetic cues are solely relied upon for navigation and that the use of other senses (e.g. olfactory, hearing, and hydrodynamic cues) are equally important (Lohmann *et al.,* 2008). Furthermore studies on chum salmon have indicated that although there may be small behavioural changes in swimming behaviour magnetic fields do not significantly affect migration patterns (Yano *et al.,* 1997).

209 With respect to salmon, electric fields are not considered to be a concern as salmon do not rely on electric fields of prey items when feeding. Concerns exist due to potential effects on migration routes from magnetic fields that may inhibit the ability of individuals to navigate. Due to their predominantly coastal migratory routes in the vicinity of the Firths of Forth and Tay, and generally wide ranging distribution at sea, the EMFs generated by the Wind Farm and OfTW in the Development Area are likely to represent only a very small proportion of the salmon's available habitat, and as such interactions with it are unlikely. Furthermore, salmon are reported to predominately swim in the upper 10 m of the water column (Malcolm *et al*., 2010), and it is considered that EMF impacts to salmon from subsea cables will not be present in water depths greater than 20 m due to the attenuation of EMF in seawater (Gill and Bartlett, 2010). Any interaction between migratory species and magnetic fields produced during energy transmission in inter-array cabling will be unlikely and is supported by modelling of subsea cables in the Moray Firth which indicates B fields will remain below that of the Earth's geomagnetic field at seabed level and reduce to negligible levels beyond. This assumption is supported by a review of salmon data from the Solway Firth in relation to the construction and operation of the Robin Rigg Offshore Wind Farm which concluded that the wind farm had no significant impact on the salmon populations of

the local river (Thorley, 2013). The magnitude of EMF effects to salmon from the inter-array cabling are considered to be negligible. With a high sensitivity of this receptor this results in a minor/moderate impact.

210 The sea lamprey migrates to sea for the adult phase of their lifecycle, although little is known of their distribution during this time. Records exist of sea lampreys in both shallow coastal and deep offshore waters, indicating that they have a wide ranging distribution once out of their natal rivers (Maitland, 2003). Sea lamprey are reported as having a low detection threshold to the iE fields generated from subsea cables. They are able to detect fields down to 10 $\mu V/m^{-1}$, however, no evidence of response to B-fields exists (Gill and Bartlett, 2010). Although information on the iE field for the inter-array cables has not been modelled, assuming similar values to the Kentish flats Offshore Wind Farm predicted of 2.5 µV/m in seawater above the point of cable burial (assuming burial to 1.5 m of 33 kV cables), this would be below that detectable to sea lamprey. Due to their detection thresholds (higher than the expected iE fields in the seawater above the point of cable burial), and the lack of evidence for any magneto-sensitive response, predicted effects on sea lampreys from the EMF emitted by the Wind Farm inter-array cabling, in the Development Area, will be negligible.

211 As described in *Section 13.4.5* river lamprey is not expected to interact with the Development Area, due to the estuarine limits of its migration and therefore isn't sensitive to this effect.

Shellfish

212 Although some species of shellfish (such as lobsters) can detect EMF no direct evidence of impacts to invertebrates from subsea cable EMF exists. For example, Bochert and Zettler (2004) conducted an experiment to determine the impacts of long term exposure to magnetic fields on the shrimp, *Crangon crangon*, the round crab *Rhithropanopeus harrisii* and the bivalve, *Mytilus edulis* and concluded that there was no effect on survival rate. The evidence for the sensitivity of invertebrates to EMF is based on selected studies of a small number of marine and aquatic species (Normandeau *et al*., 2011). As such, and considering the low abundances of the potentially sensitive species of shellfish (i.e. lobsters and brown shrimps, and that there is no evidence that scallops are sensitive to EMF) the magnitude of EMF effects on low mobility species is considered to be negligible, with a low sensitivity, resulting in a negligible/minor impact. A summary of impacts significance can be found below.

Table 13.25: Impact Summary of Behavioural Responses to EMF Associated with Cabling

Impact	Receptor	Magnitude	Sensitivity	Significance
Behavioural responses to EMF associated with cabling	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor

Impact	Receptor	Magnitude	Sensitivity	Significance
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Low

Disturbance Associated with Operational Noise

213 Sources of operational noise will include WTG vibration, the contact of waves on offshore structures, and maintenance vessel noise.

214 Operation and maintenance of an offshore wind farm may involve an increase in vessel traffic compared to baseline conditions (pre–construction) for the transportation of materials during maintenance activities (see *Chapter 19: Shipping and Navigation*). It is likely that during any maintenance activities, background noise and vibrations from vessel engines will increase in the surrounding environment, both within the Development Area and from commuting vessels travelling to and from the Development Area. An assessment of increase in vessel noise has been carried out using Sound Propagation Estimation And Ranking (SPEAR) modelling. The frequency and sound levels produced by an increase in vessel movement will be dependent on vessel size, type and speed of vessel movements, which may vary throughout the operational phase. General noise modelling (see *Chapter 11 and Appendix 11A*) has shown that for large vessels travelling at 10 knots, the impact range of underwater noise, at which significant displacement is predicted, will be no greater than one metre for any fish species.

215 Background levels of noise in coastal waters in the UK are commonly 130 dB re µPa (Nedwell *et al.,* 2003). Operational noise from offshore wind farms has been reported to be in the region of 2 dB noisier than the surrounding sea environment (Nedwell *et al.,* 2007). While these levels are not expected to have lethal effects, or cause physical damage to fish, behavioural effects may be displayed by some species. Increases to background noise have the potential to cause changes in behaviour, and could have masking effects on intra species communication or navigation. This could include the interference of fish spawning as some species, e.g. cod, have been reported to use noise to communicate when spawning (Nordeide and Kjellsby, 1999).

216 Measured noise levels of individual WTGs from operational offshore wind farms are not estimated to exceed 75 dB_{ht} (*Species*) at the point of emission at the WTG tower for any of the fish species. Although they are comparatively lower rated WTGs, it is not expected that the noise levels will significantly increase for higher rated WTGs, especially when considering the already low levels of noise produced.

Mobile Fish Species

217 Mobile fish species such as plaice, dab and mackerel are hearing generalists (Nedwell and Howell, 2004) and therefore operational noise will be audible for these species, and mild behavioural effects are possible. A review by Wahlberg and Westerberg (2005) concluded that no injurious effects would be seen in fish, even at close proximity to operating WTGs. A review of monitoring data from operational UK offshore wind farms (CEFAS, 2009) also indicated that there was no evidence from post-construction fish surveys that operational noise had resulted in significant impacts on fish populations, either in terms of changes to species composition or reductions in abundance. Furthermore, a number of recent reports on extensive campaigns of operation phase fish surveying in offshore wind farms have found no evidence of avoidance by mobile fish species (Leonhard *et al.,* 2011; Walls *et al.,* 2013). In addition a number of offshore wind farms have found increased numbers of fish living in the wind farm during the operational phase compared to the baseline, suggesting that operational noise is not having an adverse impact (Leonhard *et al.,* 2011). This strategic review also proposed that standard operational noise monitoring could be removed as a licence condition in Denmark due to the lack of risk associated with this effect on the marine environment.

218 From measured data on operational wind farms, operational WTG noise is not estimated to exceed 75 dB_{ht}(*Species)* at the point of emission at the WTG tower for any of the fish species modelled (*Chapter 11*). Therefore for the purposes of the assessment the avoidance area around each WTG will be considered to be less than one metre. This is a conservative figure based on evidence from the measured data.

219 Overall, the very small areas affected by avoidance noise levels result in the magnitude of this effect being classed as negligible. Sensitivity of mobile fish is defined as low, therefore, a negligible/minor impact is predicted.

Hearing Specialists

220 Fish with higher sensitivity of sound pressure, e.g. herring, sprat and cod, might detect the Wind Farm at a greater distance. A review by Wahlberg and Westerberg (2005) concluded that cod would be able to detect the operational underwater noise of a WTG at distances between 0.4 km and 25 km, although this distance is highly variable and will depend on wind speed, number and type of WTGs, water depth and substrate type. It was concluded that no injurious effects would be seen in fish, even at close proximity to operating WTGs, and that noise levels would only cause avoidance ranges of approximately four metres when operating at very high wind speeds (Wahlberg and Westerberg, 2005).

221 From measured data on operational wind farms, operational WTG noise is not estimated to exceed 75 dB_{ht}(*Species*) at the point of emission at the WTG tower for any of the fish species (*Chapter 11*). Therefore, the avoidance area around each WTG will be less than one metre. Large and medium vessels were also modelled and the model predicted that only herring will display behavioural avoidance at one metre from source (*Chapter 11*).

222 Therefore, the magnitude of this effect is judged to be negligible and with a sensitivity of moderate, a minor impact is predicted on hearing specialist fish, due to operational subsea noise.

Prey Species

223 The same general conclusions with respect to effects of operational noise on mobile fish species apply for this specific receptor with a negligible magnitude. However, the increased sensitivity of this receptor (moderate) results in a minor impact being predicted, due to operational noise impacts.

Electro-sensitive Elasmobranchs

224 The same magnitude conclusions with respect to mobile fish species apply for this specific receptor, resulting in a negligible magnitude. The sensitivity of this receptor group is defined as low therefore, combined with a negligible magnitude, a negligible/minor impact is predicted, due to subsea noise impacts on electro-sensitive species in the operational phase.

SAC Qualifying Feature Species

225 The review by Wahlberg and Westerberg (2005) concluded that operational noise from an offshore wind farm would be detectable out to 25 km from source for salmon, although avoidance reactions would only occur in the very near vicinity (approx. four metres) and only at very high wind speeds (13 ms^{-1}). The species specific noise modelling undertaken for the Development Area showed salmon to be the least sensitive of the fish species modelled for operational noise, and as for the other species, operational WTG noise is not estimated to exceed 75 dB_{ht}(*Species*) at the point of emission at the WTG tower and SPEAR modelling predicted an avoidance range of less than one metre from the WTGs. The very small areas potentially affected by avoidance noise levels results in the magnitude of this effect being classed as negligible. The sensitivity of SAC qualifying feature species is high, therefore a minor/moderate impact is predicted.

Shellfish

226 The same conclusions with respect to mobile fish species apply for this specific receptor. Therefore, a negligible/minor impact is predicted, due to subsea noise impacts on shellfish in the operational phase. A summary of impacts significance can be found below.

Table 13.26: Impact Summary of Disturbance or Physical Injury Associated with Operational Noise

Impact	Receptor	Magnitude	Sensitivity	Significance
Disturbance or physical injury associated with operational noise	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Reduced Fishing Activity within Development Area

227 During the operational phase, the potential reduction in fishing activity within the Development Area due to the presence of infrastructure may create a beneficial impact on existing fish and shellfish resources. Impacts on fishing activities are considered in *Chapter 18.* Due to uncertainties on how much, if at all, fishing pressure would be reduced the impact of reduction of fishing activity, and therefore benefits will be negligible/minor (positive) at best.

Creation of New Habitat due to Presence of Project Infrastructure

228 During the operational phase of the Project, the presence of subsea infrastructure, in the form of WTGs and substation foundations, scour protection and cable protection, has the potential to create new habitat for fish and shellfish. The potential impact of the presence of this infrastructure on the various fish and shellfish receptor groups is assessed below.

Mobile Fish Species

229 Studies of fish communities before and after wind farm installation (or other fish aggregating devices (FADs)) have shown it requires approximately five years for stable community changes to become observable, and that both small and large scale spatial changes in fish distributions and abundances can be expected (Jensen, 2002; Hille Ris Lambers and Ter Hifstede, 2009; Lindeboom *et al.,* 2011). Small scale changes are predominantly driven through aggregation of reef fishes (gobies, wrasse, etc.) and local changes in food resources, such as the epibenthic colonisers of tube dwelling amphipods and blue mussels, in place of benthic species (Leonhard *et al.,* 2011).

230 The increased abundances of reef fishes are thought to attract larger piscivorous fish, such as gadoids to the area, driving the observed larger scale changes in habitat use by pelagic and demersal species (Leonhard *et al.,* 2011). Studies have shown that species do not use

the impacted areas at the exclusion of other habitats, and still make seasonal and diurnal migrations to adjacent habitat types, suggesting that other habitats outside the wind farm areas are still required to provide a number of key functions, e.g. prey, refuge areas and spawning areas (Leonhard *et al.,* 2011).

231 The greatest area of seabed, above which habitat modification is possible, totals 1.87 km^2 or 1.25 per cent of the Development Area. Due to the large separation distances between WTGs, a significant change to the benthic ecology of the area, and subsequent reef effect, is not expected. This prediction also makes reference to operational phase fish surveys reported in the strategic review of offshore wind farms (Cefas, 2009), where no major changes in fish species composition were noted from any of the sites studies, indicating no major reef effects created by the presence of offshore wind farm infrastructure. This impact is therefore predicted to be of negligible magnitude and as this receptor group has a low sensitivity, the impact of the Project on the ecosystem in terms of creating new habitat for mobile fish species is predicted to be negligible/minor (positive).

Hearing Specialists

232 As well as being a hearing specialist, herring also exhibit discrete shoaling behaviour in open water therefore, the presence of large numbers of new subsea structures has the potential to adversely affect this activity, leading to impacts on this species. However, for the same reasons as outlined above in relation to mobile fish species, any effect on this receptor group of the Project infrastructure is judged to be of a negligible magnitude. The sensitivity of this receptor is moderate, therefore a minor impact is predicted.

Prey Species

233 Studies of sandeel populations in the operational phase of offshore wind farm projects have demonstrated no long term changes in populations of this important prey species (Leonhard *et al.,* 2011). However, the effect of increased predator density on populations has not yet been studied, and so there is the possibility that populations may fluctuate prior to reaching a new equilibrium (Leonard *et al.,* 2011). As a result, the effect to sandeel populations is considered to be of negligible magnitude, with this receptor group considered to have a moderate sensitivity due to their ecological and conservation importance. As such, this impact to prey items is minor.

Electro-sensitive Elasmobranchs

234 The same magnitude conclusions (negligible magnitude) with respect to mobile fish species apply for this specific receptor, and the sensitivity of this receptor group is defined as low, therefore, combined with a negligible magnitude, a negligible/minor (positive) impact is predicted due to the presence of Project infrastructure in the operational phase.

SAC Qualifying Feature Species

235 The creation of new habitat is not predicted to affect either salmon or lamprey, therefore no impact is predicted on this receptor group.

Shellfish

236 The introduction of foundations and any associated scour protection will provide additional key habitat for shellfish species such as the large mobile crustacea present in the Development Area (e.g. the edible crab and common lobster). The additional hard substrata will provide additional refugia and changes in food resources, e.g. the presence of blue mussels (Leonhard *et al.,* 2011). As a partial alteration to the baseline conditions to one of hard substrata, the magnitude of this effect is considered to be moderate. The shellfish receptor group is of low sensitivity and as such this impact is of minor/moderate (positive). A summary of impacts significance can be found below.

Table 13.27: Impact Summary of Creation of New Habitat due to Presence of Project Infrastructure

Impact	Receptor	Magnitude	Sensitivity	Significance
Creation of new habitat due to presence of Project infrastructure	Mobile fish species	Negligible	Low	Negligible/Minor (positive)
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor (positive)
	SAC qualifying feature species	No Impact	High	No Impact
	Shellfish	Moderate	Low	Minor/Moderate (positive)

Temporary Habitat Disturbance from Operations and Maintenance (O&M) Activities

237 During the operational phase of the Project, routine operational and maintenance (O&M) activities will take place, involving the temporary disturbance of habitats that may be of importance to fish and shellfish receptors. As detailed in Table 13.2, a total area of 0.14 km^2 (0.09 per cent) of seabed of the Development Area would be subject to temporary disturbance annually. This would result from placement of jack up vessels and vessel anchorage, and inter-array cable reburial. This compares to a total area of 5.54 km^2 of seabed habitat that would be subject to temporary habitat disturbance during the main construction phase. Therefore, it is assumed that the significance of impacts predicted on fish and shellfish receptors via temporary habitat disturbance via O&M activities would be no greater than those predicted from construction activities.

238 Table 13.28 below presents a summary of the impact significance predictions for the fish and shellfish receptors based on temporary habitat disturbance via construction. These impacts are predicted to be similar (or less) for any subsequent temporary habitat disturbance via O&M activities.

Table 13.28: Impact Summary of Temporary Habitat Disturbance via O&M Activities

Impact	Receptor	Magnitude	Sensitivity	Significance
Temporary habitat disturbance via O&M activities	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

13.6.3 Effects of Decommissioning

239 The potential effects of decommissioning are considered to be equivalent to, and potentially lower than, the worst case effects assessed for the construction phase. The approach to decommissioning is described in *Section 7.12*. A decommissioning plan will be prepared in accordance with the requirements of the *Energy Act 2004* (see *Section 3.2.5*) and will be subject to approval from Department of Energy and Climate Change prior to implementation.

240 It should be noted, however, that piling is not envisaged to be required during decommissioning and hence, effects associated with noise during this phase will likely be significantly smaller than those assessed for the construction phase above.

13.7 Impact Assessment - Offshore Export Cable Corridor

241 Impacts considered within this Offshore Export Cable Corridor assessment are listed below in Table 13.29 and 13.30.

Table 13.29: Effects Assessed During Construction (and Decommissioning)

Receptor Group	Direct temporary habitat disturbance via export cable installation	Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Disturbance or physical injury associated with construction noise
Mobile Fish Species	Assessed	Assessed	Assessed

Receptor Group	Direct temporary habitat disturbance via export cable installation	Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Disturbance or physical injury associated with construction noise
Hearing specialists	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.	Assessed
Prey species	Assessed	Assessed	Assessed
Electro-sensitive elasmobranchs	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.
SAC qualifying feature species	Assessed	Assessed	Assessed
Shellfish	Assessed	Assessed	Assessed

Table 13.30: Effects Assessed During Operation and Maintenance

Receptor Group	Long term loss of original habitat	Creation of new habitat due to presence of Project infrastructure	Behavioural responses to EMF associated with cabling.	Temporary habitat disturbance from O&M activities
Mobile Fish Species	Assessed	Assessed	Assessed	Referred to the assessment of Effects of Construction, from Direct Temporary Habitat Disturbance of the Offshore Export Cable Corridor
Prey species (specifically sandeel)	Assessed	Receptor group not sensitive to effect.	Receptor group not sensitive to effect.	
Shellfish	Assessed	Assessed	Assessed	
SAC qualifying feature species	Assessed	Assessed	Assessed	
Electro-sensitive elasmobranchs	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.	Magnitude, conclusions and justification as per mobile fish species.	
Hearing specialists	Magnitude, conclusions and justification as per mobile fish species.	Assessed	Assessed	

13.7.1 Effects of Construction

Direct Temporary Habitat Disturbance via Export Cable Installation

242 Installation of the Offshore Export Cable from the Development Area to landfall will result in direct, temporary habitat disturbances via the action of the Export Cable installation tools on the seabed and also anchoring of Export Cable installation vessels. In total, the area affected will cover an area of the seabed of 3.02 km^2, over the total length of Export Cable which stretches approximately 83 km from the Export Cable landfall to the Development Area. Preferred cable protection is through burial, and as such the disturbance caused as a result of its installation is considered temporary. In addition, the majority of benthic species which will be directly affected as a result of this impact are considered likely to recover relatively fast (*Section 13.6.1*). Permanent loss of habitat, through provision of other protection methods (e.g. rock protection) is considered in the operational phase assessment (*Section 13.7.2*).

243 Temporary disturbance to the seabed within the Offshore Export Cable Corridor will affect many of the receptors identified in the baseline (*Section 13.4*) and the potential significance of this impact for all receptors is discussed below in relation to the magnitude of the effect and the specific sensitivity of the receptor.

Mobile Fish Species

244 Temporary habitat disturbance via Export Cable installation is predicted to create negligible magnitude effects on mobile fish species in this area. This is due to their high level of mobility, broad spectrum diet and the very small area of seabed affected by these works which will allow these species to utilise similar, adjacent habitat at little energetic cost. Additionally, most of these species spawn into the water column and as such, critical spawning habitat will not be affected by Export Cable installation. Effects of temporary habitat disturbance due to Export Cable installation on spawning grounds are therefore considered of negligible magnitude as this effect is not expected to have anything other than very small impacts on the size or structure of wider stocks of fish that spawn in the area around the Offshore Export Cable Corridor. This receptor group is considered to be of low sensitivity, and therefore a negligible/minor impact is predicted.

Hearing Specialists

245 The same conclusions with respect to mobile fish species apply for this specific receptor. The Offshore Export Cable Corridor does not overlap with recorded herring spawning grounds (Figure 13.11). Therefore, there is no scope for direct temporary habitat disturbance on herring spawning grounds as a result of installation of Export Cables. Due to the increased sensitivity (moderate) assigned to this receptor, the combination of negligible magnitude of effect and moderate sensitivity results in a minor impact being predicted.

Prey Species

246 The key prey species considered with respect to this potential impact is sandeel. As outlined above, the sandeel suitability map created for the entire Project using sedimentary composition and distribution data identified that the Offshore Export Cable Corridor will almost be entirely unsuitable for sandeel habitation. Spawning grounds of sandeels have been identified as present along the Offshore Export Cable Corridor (Ellis *et al.,* 2012), however this is considered unlikely due to the conclusions drawn from the sandeel suitability map. Export Cable installation will also result in only a discrete, temporary disturbance to the seabed.

247 Therefore, an effect of negligible magnitude is predicted on this moderate sensitivity receptor due to the low abundance of this species along the Offshore Export Cable Corridor and also the large amount of wider available sandeel habitat. Combined with the moderate sensitivity of this receptor group, this results in a minor impact prediction.

Electro-sensitive Elasmobranchs

248 The same magnitude conclusions with respect to mobile fish species apply for this specific receptor. The sensitivity of this receptor group is defined as low, therefore, combined with a negligible magnitude, an impact of negligible/minor is predicted via temporary habitat disturbance from Export Cable installation on electro-sensitive elasmobranchs.

SAC Qualifying Feature Species

249 The SAC qualifying species identified in the baseline (*Section 13.4*) may potentially use the Offshore Export Cable Corridor for foraging during migrations. However, the Export Cable installation will also result in only a discrete, temporary disturbance to the seabed, which is a tiny proportion of the available feeding habitat these species have available to them. In addition these species will not be reliant on seabed habitats within the Offshore Export Cable Corridor as feeding grounds. Therefore, the magnitude of the impact is negligible, which combined with a high sensitivity results in a minor/moderate impact prediction.

Shellfish

250 The baseline data (*Section 13.4*) indicated that shellfish do occur along the Offshore Export Cable Corridor, with ICES landings data highlighting the importance of the area through which the majority of the Export Cable passes to certain species, including *Nephrops,* brown crab and lobster. These species will be impacted to a slightly greater degree than more mobile fish species by Export Cable installation, however these species are relatively tolerant to disturbance and individuals are expected to be able to recover quickly with minimal effect on populations (Sabatini and Hill, 2008). As such, the effects of the temporary habitat disturbance produced by cable installation are considered to be of negligible magnitude. The sensitivity of this receptor group is judged to be low, and as such temporary habitat disturbance via Export Cable installation is predicted to result in a negligible/minor impact. A summary of impacts significance can be found below.

Table 13.31: Impact Summary of Direct Temporary Habitat Disturbance via Export Cable Installation

Impact	Receptor	Magnitude	Sensitivity	Significance
Direct temporary habitat disturbance via Export Cable installation	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in SSC via Export Cable Installation

251 Export Cable laying operations will lead to an increase in SSC in the immediate vicinity of the works. Modelling of the sediment plume following energetic means (assessed as the worst case for re-suspension of sediments (*Section 10.6.1.*)) shows that along the Offshore Export Cable Corridor elevated levels of SSC can be expected to be within 3 - 10 mgl^{-1} above background concentrations, with localised peaks of up to 300 mgl^{-1}. Higher concentrations will occur very close to the Export Cable but these will be limited to within a few tens of metres of burial activities, and most of the resulting sediment plume will settle out over a period of seconds or minutes. The finest (mud and silt) sediment fractions will persist for longer in the water column and be carried further, but these will generally not be advected beyond three kilometres, and will settle out within a few hours of disturbance.

252 The deposition footprint resulting from Export Cable installation is predicted to extend to a maximum of three kilometres either side of the Offshore Export Cable Corridor. However, the more distant parts of this deposition footprint will be very thin, typically <1 mm beyond one kilometre distance from the Export Cable and >98 per cent of the displaced material will settle out within one kilometre and over a period of five to 10 minutes after release. Peak deposition depths of up to five millimetres are predicted, although this represents an average value and there may be localised peaks of deposition greater than five millimetres within 10 m of the Export Cable installation works.

253 These predictions are conservative as they assume that the entire contents of the trench are re-suspended by the cabling operation. In reality, much of the coarser material displaced by Export Cable installation will simply re-settle within the immediate area and will not contribute to any longer-lasting plumes, which will be mainly comprised of finer sediments.

Mobile Fish Species

254 Increased SSC levels produced via Export Cable installation are predicted to result in the temporary avoidance of the areas of highest increases by mobile fish species. Due to the short-term nature of any SSC peaks, any avoidance will be of a short duration as most of the resulting sediment plume will settle out over a period of seconds or minutes, and is only likely to occur within 1.4 km of the cabling operation where SSC are predicted to be between 3 and 10 mg l^{-1} with peaks of up to 300 mg l^{-1} (*Section 10.6.1*).

255 Whiting, lemon sole and plaice are all noted as having spawning grounds that overlap with the Offshore Export Cable Corridor, although these species will actually lay pelagic eggs and not be over-reliant on the seabed habitats in the area. Lethal effects of suspended sediments to pelagic eggs are predicted to be of negligible magnitude due to the highly localised extent and short duration of peak SSC (up to 300 mgl^{-1}). Avoidance of the area by spawning adults is predicted to be of short duration and is only likely to occur within 1.4 km of the release site where SSC are predicted to typically be 3 to 10 mgl^{-1} above background levels. Avoidance by spawning adults is thus also considered to be of negligible magnitude. The effect of increased suspended sediments on mobile fish is thus considered to be of negligible magnitude.

256 This prediction of magnitude also applies to those mobile fish species that have distinct migratory phases including migratory species such as sea trout, European eel and sparling. As these species all have estuarine stages in their life-cycle they will be regularly exposed to high levels of SSC and as such will have adaptations to this effect. Studies on salmon which show that unless a whole body of water is blocked, migration will not be significantly affected (see assessment below in relation to SAC qualifying features receptor), can also be applied to these species, as can the avoidance threshold of 100 mg kg^{-1} over one hour. While these migratory species are vulnerable to anthropogenic impacts, the position of the Offshore Export Cable Corridor, not covering the mouth of an estuary and the low levels of suspended sediments predicted (elevated levels typically between 3 and 10 mgl^{-1} with peaks of up to 300 mgl^{-1} (*Section 10.6.1)* above background (15 mgl^{-1}) within 1.4 km of release locations) presents limited barrier effects from increased SSC, with migratory species likely to show some localised avoidance from these discrete areas.

257 This receptor group has a low sensitivity, combined with negligible magnitude, results in a predicted negligible/minor impact.

Hearing Specialists

258 The same conclusions with respect to mobile fish species apply for this specific receptor. Herring and sprat spawning habitats do not overlap with the Offshore Export Cable Corridor, therefore, no impacts via increased SSC levels and subsequent sediment deposition are predicted on these habitats, as any suspended sediment is predicted to settle out before reaching herring spawning grounds. Sections of the Offshore Export Cable Corridor do overlap with low intensity cod spawning grounds however; as this species is a pelagic spawner the same conclusions as for mobile fish species apply, with a negligible magnitude.

259 In addition, the Offshore Export Cable Corridor passes through nursery areas for a number of fish species. Juvenile herring show avoidance behaviour to relatively low SSC and are thus expected to avoid areas within one kilometre of the release site. Lethal effects are expected to be negligible due to the highly localised area and short duration of the high SSC, and considering the large areas of available fish habitat in the area, effects on juvenile fish are expected to be of negligible magnitude.

260 However, due to the increased sensitivity (moderate) assigned to this receptor (due to its wider ecological importance as a prey item), the combination of negligible magnitude of effect and moderate sensitivity results in a minor impact due to increased suspended sediment and deposition via Export Cable installation.

Prey Species

261 Spawning grounds of sandeels have been identified as present along the Offshore Export Cable Corridor (Ellis *et al.,* 2012), however the sandeel suitability map created for the area using sedimentary composition and distribution data identified that the Offshore Export Cable Corridor will almost be entirely unsuitable for sandeel habitation. As there is very little suitable sandeel habitat predicted to occur along the Offshore Export Cable Corridor, the magnitude of effects of any increase in suspended sediments and deposition are predicted to be negligible. Even adopting a precautionary approach that there may be some suitable sandeel habitat along the Offshore Export Cable Corridor, sediment deposition via Export Cable installation is predicted to produce a negligible effect on sandeels, as the depth of deposition will be at a level that sandeels will be able to cope with (as they cope with natural storm events) and there will be no long-term change in the overall PSA characteristics of the Offshore Export Cable Corridor (see *Section 13.6.1* in relation to suspended sediment impacts during Development Area construction). This receptor group is judged to be of moderate sensitivity, which combined with a negligible magnitude results in a minor impact predicted.

Electro-sensitive Elasmobranchs

262 The same conclusions with respect to mobile fish species apply for this specific receptor, and the sensitivity of this receptor group is defined as low. Therefore, combined with a negligible magnitude, a negligible/minor impact is predicted via increased suspended sediment levels and deposition disturbance on electro-sensitive elasmobranchs due to Export Cable installation.

SAC Qualifying Feature Species

263 The same key conclusions with respect to the potential for increased sediment plumes to adversely affect the migration pathways of SAC qualifying species (salmon and lamprey) for construction in the Development Area apply to the Offshore Export Cable Corridor. The main difference is that increased suspended sediment levels (and plumes) predicted to arise from Export Cable installation are much less than those assessed for works in the Development Area, therefore any impacts will also be no less (or at least no greater) than those assessed

with respect to the Development Area. The only potential issue to consider in more detail, with regard to any plumes across the Offshore Export Cable Corridor is whether the more inshore location of these plumes may act as more of a constraint to migration, than the plumes generated further offshore.

264 The Offshore Export Cable Corridor does not cover the mouth of an estuary, and the low levels of suspended sediments predicted in relation to threshold levels results in a low magnitude of barrier effects from increases in suspended sediments. Sediment in individual rivers and estuaries change on an almost daily basis depending on rainfall, tide and storm events and there is a wide range of background suspended sediment concentrations in UK estuaries through which fish migrations occur. For example, salmon and lamprey successfully pass through estuaries with extremely high suspended sediments such as the Severn and its sub estuaries the Wye, Usk and Parrett, which naturally contain up to several thousand milligrams per litre (FARL, 1995), concentrations as high as 9,000 mg l^{-1} have been recorded in the path of runs in the Usk Estuary (Alabaster, 1993).

265 While the Offshore Export Cable Corridor does extend into the Firth of Forth estuary, and in its totality could restrict migration from the south, Export Cable operations are transient, with working rates of between up to 300 m and 500 m per hour. Suspended sediment will settle out over a period of seconds or minutes. The finest (mud and silt) sediment fractions will persist for longer in the water column and be carried further, but these will settle out within a few hours of disturbance (*Section 10.6.1*). The estuary at the mouth of the Firth of Forth is 15 km wide, and as the Offshore Export Cable Corridor runs in a north-easterly direction, at no point during the installation of the Export Cable is it predicted that elevated suspended sediments will form a barrier to migration by completely blocking access to the estuary. Coastal migration, northwards for Salmon, may also be effected, with localised avoidance but no complete barrier to migration created.

266 Overall, the magnitude of this effect is judged to be negligible as salmon and lamprey migrate over a broad geographic front and any barrier generated by increased suspended sediments is judged to be minimal and will have only very small (if any) impact on the stocks of these species. With a high sensitivity due to their status as SAC qualifying features, a minor/moderate impact is predicted.

Shellfish

267 Of the habitats mapped along the length of the Offshore Export Cable Corridor (*Chapter 12*), a number are known to contain *Nephrops,* with areas of spawning activity for this species also identified in this area (Coull *et al.,* 1998). The presence of this species along the Offshore Export Cable Corridor is confirmed by commercial fish landings from the ICES rectangle which the Offshore Export Cable Corridor passes, which indicates that *Nephrops* is the main shellfish species landed in the period 2007 to 2011 (*Chapter 18*).

268 The Marine Life Information Network (MarLIN, 2011), assesses *Nephrops* as tolerant to smothering and increased suspended sediments of the levels predicted via Export Cable installation, and as such impacts to *Nephrops* are predicted to be of negligible magnitude.

269 Scallops, which provide the resource for another locally important fishery, are identified to be present at the more offshore area of the Corridor (*Appendix 18B: Commercial Fisheries Baseline Offshore Export Cable Corridor*). The low increases in suspended sediments and very small depositional thicknesses predicted to occur from Export Cable installation are not expected to cause significant impacts to this species, which is assessed as having a low sensitivity to these impacts (Marshall and Wilson, 2009). Impacts to scallops from the installation of the Export Cable are therefore predicted to be of negligible magnitude. The shellfish receptor group is considered to have a low sensitivity, and as such a negligible/minor impact is predicted. A summary of impacts significance can be found below.

Table 13.32: Impact Summary of Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in SSC via Export Cable Installation

Impact	Receptor	Magnitude	Sensitivity	Significance
Indirect disturbance as a result of sediment deposition and temporary increases in SSC via Export Cable installation	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Barrier Effects, Disturbance or Physical Injury Associated with Construction Noise (Export Cable Installation)

270 Much of the focus regarding noise and the construction of wind farms is on piling due to the fact this activity produces the largest noise propagation. During cable laying, noise is also produced by the cable laying activities. Cable laying has been recorded to produce noise at a source level of 178 dB re 1 µPa at one metre from source (Nedwell *et al*., 2003) and represents the worst case in terms of noise audibility distances from sources. Using the SPEAR Model output for cable laying noise levels are not estimated to exceed 90 dB_{ht} (Species) beyond <1 m from the at the point of emission any of the fish species. The 75 dB_{ht} audibility distance varies between <1 m and 66 m dependant on species, the implications of which are discussed in the receptor groups below.

Mobile Fish Species (Hearing Generalists)

271 Modelling for a number of mobile fish species, that are defined as hearing generalists, using measured noise levels during cable burial shows that while levels will be above background and detectable, the level is below 90 dB_{ht}, thus strong avoidance reactions would not be expected for any of these species (BERR, 2008). The SPEAR Model output for cable laying for

dab revealed that the audibility distances are not estimated to exceed 90 dB_{ht} or 75 dB_{ht} beyond <1 m. Therefore, effects on hearing generalist fish populations are considered to be of a negligible magnitude, which when combined with the low sensitivity of this receptor group result in a negligible/minor impact prediction**.**

Hearing Specialists

272 As per the approach adopted with regard to the assessment of piling noise, the following assessment presents noise impacts from Export Cable installation for hearing specialists. In this context the potential effects of Export Cable installation are discussed in terms of the impact on spawning aggregations of adult fish. Therefore, they are placed in the context of potential overlap of noise effects with adjacent spawning grounds. In fact, of these species only cod is predicted to exhibit behavioural effects to a distance of 10 m from Export Cable installation operations.

273 SPEAR modelling output for cable laying for herring and cod revealed that the audibility distance is not estimated to exceed 90 dB_{ht} beyond <1 m. For 75 dB_{ht} beyond the audibility distance was only 20 m and 66 m for cod and dab respectively. Due to these very small areas of avoidance predicted, the magnitude of effects on hearing specialists is considered to be negligible as any such behavioural responses to cable noise is unlikely to have any impact on the overall size or structure of stocks of these species in the region.

274 Spawning areas of herring are located approximately 10 km to the north and south from the nearest point of the Offshore Export Cable Corridor, while spawning areas for sprat are located approximately 15 km from the nearest point of the Offshore Export Cable Corridor. Noise levels from Export Cable installation that would cause an avoidance reaction in sprat and herring are not expected to overlap with these spawning grounds, therefore no impact is predicted. The northern section of the Offshore Export Cable Corridor overlays spawning areas for cod, however given the small area that would be affected by noise, this is considered negligible, especially in comparison to the large areas of spawning grounds available to cod.

275 As a result, the magnitude of noise effects from cable laying operations on hearing specialists is predicted to be negligible. The sensitivity of this group is moderate, therefore a minor impact is predicted.

Prey Species

276 Due to the lack of suitable sandeel habitat along the Offshore Export Cable Corridor, and very low hearing sensitivity of this species (based on sand lance audiograms as a surrogate species), the magnitude of any noise from Export Cable installation on this species is judged to be negligible. With this receptor group having a moderate sensitivity, a minor impact is predicted on sandeels.

Electro-sensitive Elasmobranchs

277 The same conclusions with respect to mobile fish species apply for this specific receptor. The sensitivity of this receptor group is defined as low, therefore, combined with a negligible magnitude, a negligible/minor impact is predicted on electro-sensitive elasmobranchs, due to noise generated from Export Cable installation.

SAC Qualifying Feature Species

278 A detailed assessment of the potential for construction noise from piling to impact the migration routes of SAC qualifying features is presented earlier in this chapter (*Section 13.6.1*). Whilst noise from Export Cable installation works has the potential to be detected by post-smolts, grilse and adult salmon migrating to, and from, freshwater habitats to spawn, noise modelling conducted for general cable construction indicates no avoidance or significant behavioural reactions of salmon (Nedwell *et al.*, 2003). In addition, SPEAR Model output for cable laying for salmon revealed that the audibility distances is not estimated to exceed 90 dB_{ht} or 75 dB_{ht} beyond <1 m and two metres respectively. Lamprey, as explained earlier in the chapter (*Section 13.6.1*), possesses no specialist noise sensitive organs, therefore are unlikely to be affected by this relatively low noise source. Thus, despite noise being detectable along the Offshore Export Cable Corridor, the magnitude of this effect on salmon and lamprey is judged to be negligible. The sensitivity of this receptor group is high, combined with negligible magnitude results in a minor/moderate impact being predicted on this receptor, due to noise generated by Export Cable installation.

Shellfish

279 As discussed previously in relation to the impacts of construction noise within the Development Area (piling) (*Section 13.6.1*), the magnitude of the effect of underwater noise on mobile invertebrates is considered to be negligible. The sensitivity of these species is considered to be low, and therefore a negligible/minor impact is predicted. A summary of impacts significance can be found below.

Table 13.33: Impact Summary of Disturbance or Physical Injury Associated with Construction Noise (Export Cable Installation)

Impact	Receptor	Magnitude	Sensitivity	Significance
Disturbance or physical injury associated with construction noise (export cable installation)	Mobile fish species (hearing generalists)	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate

Impact	Receptor	Magnitude	Sensitivity	Significance
	Shellfish	Negligible	Low	Negligible/Minor

13.7.2 Effects of Operation and Maintenance

Long Term Loss of Original Habitat

280 In the operational phase, there will be some long term loss of existing seabed habitats associated with the Export Cable due to presence of cable protection. For the purpose of this assessment, it has been assumed that 20 per cent of all Export Cables will require some form of cable protection, resulting in a long term loss of 0.60 km^2 of original habitat along the total length of the Offshore Export Cable (approximately 83 km).

Mobile Fish Species

281 Effects of habitat loss associated with cable protection along the Offshore Export Cable Corridor on the majority of the natural fish and shellfish species in the area are expected to be negligible, due to the high level of mobility and broad spectrum diet of these species, and the very small area affected. A number of species are thought to spawn in the area affected by the Export Cable installation. The area affected is however, very small in comparison to the wider extent of the habitats within the area (*Appendix 12A*), and the overall extent of the spawning and nursery areas in the region (Coull *et al.,* 1998; Ellis *et al*., 2012). The magnitude of this effect is judged to be negligible, which combined with low sensitivity, results in a negligible/minor impact.

Hearing Specialists

282 The same general magnitude conclusions with respect to mobile fish species apply for this specific receptor. Herring and sprat spawning grounds do not overlap with the Offshore Export Cable Corridor in which this long term loss of original habitat will occur and therefore, will not be affected. Cod spawning grounds do overlap with the Offshore Export Cable Corridor, however cod are pelagic spawners and the area affected is very small in comparison to the wider extent of the spawning habitats. The magnitude of this effect is judged to be negligible, combined with moderate sensitivity results in a minor impact being predicted, due to loss of original habitat along the Offshore Export Cable Corridor, in the operational phase.

Prey species

283 Ellis *et al*., 2012 predicts that sandeel spawning grounds do overlap with the Offshore Export Cable Corridor in which this long term loss of original habitat will occur. However, the sandeel suitability map created for the Project area using sedimentary composition and distribution data, identified that the Offshore Export Cable Corridor will almost be entirely unsuitable for sandeel habitation. As such, loss of habitat due to Export Cable protection will

only create a negligible effect on prey species. This receptor group is considered to be of moderate sensitivity, and as such a minor impact is predicted.

Electro-sensitive Elasmobranchs

284 The same magnitude conclusions with respect to mobile fish species apply for this receptor, and the sensitivity of this receptor group is defined as low, therefore, combined with a negligible magnitude, a negligible/minor impact is predicted, due to loss of original habitat along the Offshore Export Cable Corridor, in the operational phase.

SAC Qualifying Feature Species

285 The SAC qualifying species identified in the baseline (*Section 13.4*) may potentially use the Offshore Export Cable Corridor for foraging during migrations. However, the Export Cable protection will also result in only a discrete loss of original habitat, which is a tiny proportion of the available feeding habitat these species have available to them. Therefore they will not be reliant on seabed habitats within the Offshore Export Cable Corridor as feeding grounds. The long term loss of habitat within the Offshore Export Cable Corridor will have a negligible effect on salmon or lamprey. Although Malcolm *et al*. (2010) noted that salmon appear to continue feeding when offshore as they approach their natal rivers, it is judged that the loss of habitat via Export Cable protection will represent a negligible proportion of similar habitats that may provide prey items for salmon. Lamprey do not feed on the benthos (they are parasitic on fish), therefore loss of benthic habitat will impact them as an indirect impact at the same magnitude of their host species. The sensitivity of this receptor group is high, therefore a minor/moderate impact is predicted.

Shellfish

286 Shellfish species present along the Offshore Export Cable Corridor, e.g. *Nephrops*, will be affected by long term habitat loss to a greater degree than more mobile species, with a proportion of populations of these species displaced from the Offshore Export Cable Corridor. These species will however be able to utilise similar, adjacent habitat and so will not be significantly affected at a population level. As such, effects to these species are considered to be of low magnitude. Shellfish are considered to be of low sensitivity, therefore, a minor impact is predicted. A summary of impacts significance can be found below.

Table 13.34: Impact Summary of Long Term Loss of Original Habitat (Offshore Export Cable)

Impact	Receptor	Magnitude	Sensitivity	Significance
Long term loss of original habitat (Offshore Export Cable)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Low	Low	Minor

Behavioural Responses to EMF Associated with Cabling (Offshore Export Cable)

287 It is anticipated that in the worst case the Export Cable will comprise of up to six 275 kV AC cables each with a length of approximately 83 km. An overview of behavioural response to EMF in respect to the inter-array cabling is detailed in *Section 13.6.2* above. The EMF generated from the Export Cables will differ from those emitted from inter-array cables, as they will carry a higher voltage. In addition, the geographical spread of the effect is greater as EMF will be emitted upon the whole length of the Offshore Export Cable Corridor which runs from the Development Area to landfall, passing though shallower water and therefore potentially creating a barrier to coastal movements.

288 Modelling conducted in support of an application for a wind farm in the Moray Firth indicated that B-fields from 220 kV (800 mm^2 at 775 A) cables would be 21 µT at the seabed (based on one metre burial) and dissipate to approximately 0.80 µT at five metres above the seabed (MORL, 2012). Magnetic field strength increases with a linear relationship based on the size and current of the cable, however, values are unlikely to be significantly greater than those reported by MORL (2012). This is below the strength of the Earth's natural geomagnetic field which is assumed to be 50 µT.

289 Induced electrical fields modelled during a COWRIE funded project indicated a maximum value of 2.5 µV/m in the sea water above the point of burial of 33 kV cables (buried to 1.5 m) (Gill et al., 2005). The Export Cables will produce iE fields that are likely to be greater than those found in this study and of the 66 kV inter-array cabling proposed for the Wind Farm. The strength of the iE field will be dependent on the current within the Export Cable, the rate of change of the AC current, and the orientation and bundling of Export Cables. It is therefore difficult to determine general values of iE fields to apply to the current assessment. However, it should be noted that high voltage subsea cabling is prevalent in UK waters and internationally, with numerous interconnections between countries and islands at analogous voltages in proximity to the Project and beyond.

290 Although the B-fields associated with the Export Cable are greater than those for the inter-array cabling, the field strength will dissipate to levels below the earth's natural geomagnetic field at the seabed and to negligible levels within five metres. This is only slightly beyond those expected within inter-array cables and so the magnitude conclusions reported for each receptor group within the Development Area are applicable to the Offshore Export Cable Corridor. Induced E-fields are also likely to be stronger along the Offshore Export Cable Corridor.

291 The Embedded Mitigation described in *Section 13.3* details mitigation relating to EMF impacts. As with the inter-array cables, the Export Cables will be suitably buried or will be protected by other means when burial is not practicable. Burial will increase the distance for attenuation of B and iE fields prior to potential contact with fish and shellfish receptors above the seabed/seawater interface. As such the assessment considers values at the seabed and beyond when considering impact on natural fish and shellfish species.

Mobile Fish Species

292 As stated in the assessment of inter-array cables certain species of teleost fish are also capable of detecting EMF, although the sensory mechanism of detection is not yet properly understood. This receptor group has limited detection thresholds to iE fields (8-25 µV/m; Gill *et al*., 2005), therefore the magnitude of this effect is considered to be negligible. The sensitivity of this receptor group is low, therefore, a negligible/minor impact is predicted on mobile fish species from EMF effects from Export Cables.

Hearing Specialists

293 Research was conducted on Baltic herring (*Clupea harengus membras* a subspecies of Atlantic herring) at the Nysted offshore wind farm in Denmark to identify effects of the 132 kV AC export cable. This concluded no effects on herring as a result of electric fields (Pedersen and Leonhard, 2006), therefore the Export Cable is unlikely to have any impacts on Atlantic herring or sprat. This research did, however, find cod to be receptive to EMF generated from 132 kV AC export cable, although no impact was found on their survival. Therefore the same negligible magnitude conclusions with respect to effects of EMF on mobile fish species apply for this specific receptor. However, the increased sensitivity of this receptor (moderate) combined with a negligible magnitude results in a minor impact being predicted, due to EMF effects in the operational phase.

Prey Species

294 The same magnitude conclusions with respect to effects of EMF on mobile fish species apply for this specific receptor. However, the increased sensitivity of this receptor (moderate) combined with a negligible magnitude results in a minor impact being predicted, due to EMF effects in the operational phase.

Electro-sensitive Elasmobranchs

295 Elasmobranchs likely to occur in and around the Offshore Export Cable Corridor include lesser spotted dogfish, spurdog and tope. The inter-array assessment included details of experiments on lesser spotted dogfish in relation to unshielded and unburied 150 kV cable carrying 600 A (Gill and Taylor, 2001). This study showed that avoidance behaviour was only observed when field strengths reached 1,000 µV/cm (100,000 µV/m) and that this behaviour was elicited on average 10.4 cm from the source (Gill and Taylor, 2001). Although no figures are available on the predicted iE field strength based on the modelled 2.5 µV/m fields on 33 kV cables at Kentish Flats (buried to 1.5 m), the iE in the Kentish Flats study, which solicited a response, far exceed those likely to occur at the export cable and no avoidance behaviours are predicted in the areas surrounding the cables. Although no avoidance behaviour is predicted, due to the uncertainties in the B and iE field strengths associated with cables carrying this voltage, the conservative approach has been adopted and a magnitude of low has been ascribed to this effect. The sensitivity of this receptor group is judged to be low; therefore a minor impact is predicted.

SAC Qualifying Feature Species

296 With respect to salmon concerns exist due to potential effects on migration routes from magnetic fields which may inhibit the ability of individuals to navigate. Salmon may have to cross the Offshore Export Cable Corridor en route to and from their natal rivers. Salmon are reported to predominately swim in the upper 10 m of the water column (Malcolm *et al.,* 2010), and it is considered that EMF impacts to salmon from subsea cables will not be present in water depths greater than 20 m due to the attenuation of EMF in seawater (Gill and Bartlett, 2010). Any interaction between migratory species and magnetic fields produced during Export Cable operation will be unlikely, and is supported by modelling of subsea cables in the Moray Firth which indicates B fields will remain below that of the Earth's geomagnetic field. This assumption is supported by findings from the Solway Firth in relation to the Robin Rigg offshore wind farm (Thorley, 2013). However due to the uncertainties in the predictions of field strengths associated with cables carrying this voltage, and the coastal migrations likely undertaken by this species, the conservative approach has been adopted and the magnitude of EMF effects to salmon from the Export Cables are considered to be low.

297 Sea lamprey are reported as having a low detection threshold to the iE fields generated from subsea cables. They are able to detect fields down to 10 μVm^{-1}, however no evidence of response to B fields exists (Gill and Bartlett, 2010). The predicted strength of the iE field for the Export Cables has not been modelled specifically for this project. The detection thresholds are higher than the expected iE fields at the surface of the seabed above 33 kV inter-array cables. In addition to this there is a lack of evidence for any magneto-sensitive response. However, given the uncertainties in the predictions of field strengths associated with cables of this voltage, the conservative approach has been adopted and a magnitude of low is predicted on sea lampreys from the EMF emitted by the Offshore Export Cable.

298 The low magnitude of this impact combined with the high sensitivity of this receptor this results in a moderate impact.

Shellfish

299 Although some species of shellfish (such as lobsters) can detect EMF, no direct evidence exists of impacts to invertebrates from subsea cable EMF exists (Bochert and Zettler, 2004) Therefore the magnitude of EMF effects on low mobility species is considered to be negligible, with a low sensitivity, resulting in a negligible/minor impact. A summary of impacts significance can be found below.

Table 13.35: Impact Summary of Behavioural Responses to EMF Associated with Cabling (Offshore Export Cable)

Impact	Receptor	Magnitude	Sensitivity	Significance
Behavioural responses to EMF associated with cabling (Offshore Export Cable)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Low	Low	Minor
	SAC qualifying feature species	Low	High	Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Creation of New Habitat due to Presence of Project Infrastructure (Cable Protection)

300 During the operational phase of the Project, the presence of cable protection along approximately 20 per cent of the Offshore Export Cable Corridor has the potential to create new habitat for fish and shellfish. The potential impact of this infrastructure on the various fish and shellfish receptor groups, is assessed below.

Mobile Fish Species

301 The magnitude of this effect on mobile fish is judged to be negligible as the area of additional habitat created is extremely small in comparison with wider area of habitats and there is also no expectation that this new habitat will lead to anything other than very small changes in overall stock size or structure. With a low sensitivity assigned to this receptor a negligible magnitude results in a negligible/minor (positive) impact being predicted.

Hearing specialists

302 The introduction of hard substrate in the form of cable protection along 20 per cent of the Offshore Export Cable Corridor is not predicted to create either an adverse or beneficial

impact on this receptor group. Because loss of original habitat has already been assessed above, no impact is predicted from this effect.

Prey Species

303 Sandeels are not sensitive to this specific impact as they do not utilise hard substrate habitat. And because loss of original habitat has already been assessed above no impact will occur from this effect.

Electro-sensitive Elasmobranchs

304 The same conclusions with respect to mobile fish species apply for this specific receptor. The sensitivity of this receptor group is defined as low, therefore, combined with a negligible magnitude, a negligible/minor (positive) impact is predicted for electro-sensitive elasmobranchs, due to the presence of cable protection in the Offshore Export Cable Corridor.

SAC Qualifying Feature Species

305 The presence of cable protection covering an area of 0.60 km^2 and the potential increased habitat complexity associated with this substrate is not predicted to affect either salmon or lamprey. Because loss of original habitat has already been assessed above no impact is predicted on this receptor group from this effect.

Shellfish

306 Increased habitat complexity and provision of hard substrata will add refugia and increase food provisions (e.g. blue mussels) for certain shellfish species. The area affected by cable protection (0.60 km^2) is however, small in comparison to the wider area of habitat, and as such the magnitude of the effect is predicted to be negligible. The sensitivity of shellfish is judged to be low, therefore a negligible/minor (positive) impact is predicted. A summary of impacts significance can be found below.

Table 13.36: Impact Summary of Creation of New Habitat due to Presence of Project Infrastructure (Cable Protection)

Impact	Receptor	Magnitude	Sensitivity	Significance
Creation of new habitat due to presence of project infrastructure (cable protection)	Mobile fish species	Negligible	Low	Negligible/Minor (positive)
	Hearing specialists	No Impact	Moderate	No Impact
	Prey species	No Impact	Moderate	No Impact
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor (positive)
	SAC qualifying feature species	No Impact	High	No Impact

Impact	Receptor	Magnitude	Sensitivity	Significance
	Shellfish	Negligible	Low	Negligible/Minor (positive)

Direct Temporary Habitat Disturbance from Operations and Maintenance (O&M) Activities

307 During the operational phase, temporary habitat disturbance from any necessary Export Cable reburial will occur due to routine O&M activities. As detailed in Table 13.2, a total area of 0.007 km^2 of seabed would be subject to temporary disturbance, resulting from the action of the cable installation tools and anchoring of cable installation vessels, assuming reburial of 20 per cent of the total length of six Export Cables. Therefore, an assumption has been made that the magnitude of this effect will be no greater than that assessed via temporary habitat disturbance during the construction phase (during which a total area of 3.02 km^2 is predicted to be disturbed). Also assuming that the sensitivity of the various receptor groups remains the same, then it can be concluded that the significance of impacts on these receptor groups will be the same (or less) than those predicted for temporary habitat disturbance via the initial Export Cable installation.

308 Table 13.37, below presents a summary of the impact significance predictions for the fish and shellfish receptors based on temporary habitat disturbance via construction. These impacts are predicted to be similar (or less) for any subsequent temporary habitat disturbance via O&M activities. This is due to the significantly lower areas of disturbance inherent in the O&M activities when compared to construction.

Table 13.37: Impact Summary of Direct Temporary Habitat Disturbance from Operations and Maintenance (O&M) Activities

Impact	Receptor	Magnitude	Sensitivity	Significance
Direct temporary habitat disturbance from O&M activities	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

13.7.3 Effects of Decommissioning

309 The potential effects of decommissioning related to the activities in the Offshore Export Cable Corridor are considered to be equivalent to and potentially lower than the worst case effects assessed for the construction phase. This assumes that the Export Cables are removed and not left *in situ* which may be the option with least environmental impact. The approach to decommissioning is described in *Section 7.12.* A decommissioning plan will be prepared in accordance with the requirements of the *Energy Act 2004* (see *Section 3.2.5*) and will be subject to approval from Department of Energy and Climate Change prior to implementation.

13.8 Cumulative Impacts of the Project

310 In addition to separately describing the potential impacts for the Development Area and Offshore Export Cable Corridor during the construction/decommissioning and operation phases, the cumulative impacts of the Wind Farm and OfTW combined are described below. The worst case scenario parameters from the Design Envelope are simply the combined values from Tables 13.2 (Development Area) and 13.3 (Offshore Export Cable Corridor) and are not, therefore, repeated here.

13.8.1 Effects of Construction

Direct Temporary Habitat Disturbance

311 The combination of the Wind Farm and OfTW installation (within the Development Area and the Offshore Export Cable Corridor) will result in a total area of temporary habitat disturbance of 8.56 km^2 based upon the worst case scenario. As described within the Development Area and Offshore Export Cable Corridor discussions above (*Section 13.6 and 13.7*), the disturbance is considered to be localised for most receptors in relation to the wider geographical context of available habitats. The proportion of the wider geographical area which is impacted by this effect will be no larger than for the Development Area and Offshore Export Cable Corridor in isolation.

312 The magnitude of this impact was found to be negligible for most receptors and low for prey species (sandeel) in the assessment on both the Development Area and the Offshore Export Cable Corridor. As the temporary loss of habitat represents small areas, the cumulative impact of temporary habitat loss is also negligible or low. As the sensitivities of the various fish and shellfish receptor groups range from low to high, impacts on these receptor groups range from negligible/minor to minor/moderate. A summary of impacts significance can be found below.

Table 13.38: Impact Summary of Direct Temporary Habitat Disturbance (the Project)

Impact	Receptor	Magnitude	Sensitivity	Significance
Direct temporary	Mobile fish species	Negligible	Low	Negligible/Minor

Impact	Receptor	Magnitude	Sensitivity	Significance
habitat disturbance	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish,	Negligible	Low	Negligible/Minor

Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in SSC

313 *Chapter 10* concluded that if dredging and cable burial coincides, the resultant rise in SSC could increase. However, such concentrations will be limited in both space (extending no more than a few kilometres from the discharge point) and time (settling out within a few hours of release). It is therefore considered that the cumulative effects on SSC and the sediment transport regime within the Project will be no greater than those effects already evaluated for the individual construction activities.

314 As such, due to the small area ultimately affected by increases in suspended sediments, and with no barrier to migration presented, an effect of negligible magnitude is predicted for most receptor groups, and low magnitude for prey species (sandeel). The most sensitive receptor group is the SAC qualifying features group comprising salmon and lamprey (high sensitivity); therefore a cumulative impact across the Project of minor/moderate is predicted for that receptor, with either negligible/minor or minor/moderate being predicted for all other fish receptor groups. A summary of impacts significance can be found below.

Table 13.39: Impact Summary of Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in SSC (the Project)

Impact	Receptor	Magnitude	Sensitivity	Significance
Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Barrier Effects, Disturbance or Physical Injury Associated with Construction Noise

315 Cumulative noise modelling has been undertaken for The Project, and for The Project with other projects in *Chapter 11*.

316 The worst case for cumulative impacts of noise at the Project would be to assume that piling and cable protection/burial would be carried out simultaneously. However, due to the low levels of noise predicted during cable laying operations in relation to that for piling at the Development Area, no increase in effect magnitude is predicted above that likely to arise at the Development Area. As such, the magnitude of effects is considered to be as presented in relation to piling noise alone. With a range in receptor sensitivities, the overall significance of impact of construction noise from the Project is predicted to be at worst minor/moderate for all receptors other than herring (a hearing specialist), for whom a moderate impact is predicted. A summary of impacts significance can be found below.

Table 13.40: Impact Summary of Barrier Effects, Disturbance or Physical Injury Associated with Construction Noise (the Project)

Impact	Receptor	Magnitude	Sensitivity	Significance
Barrier effects disturbance or physical injury associated with construction noise (the Project)	Mobile fish species (hearing generalists)	(Mortality and injury) = Negligible (Behavioural responses) = Low	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	Hearing specialists	(Mortality and injury) = Negligible (Behavioural responses) Herring = Moderate Cod & sprat = Low	Moderate	(Mortality and injury) = Minor (Behavioural responses) Herring = Moderate Cod & sprat = Minor/Moderate
	Prey species	(Mortality and injury) = Negligible (Behavioural responses) = Low	Moderate	(Mortality and injury) = Minor (Behavioural responses) = Minor/Moderate
	Electro-sensitive elasmobranchs	(Mortality and injury) = Negligible (Behavioural responses) = Low	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) =Minor
	SAC qualifying feature species	(Mortality and injury) = Negligible (Behavioural responses) = Low	High	(Mortality and injury) = Minor/Moderate (Behavioural responses) = Moderate

Impact	Receptor	Magnitude	Sensitivity	Significance
	Shellfish	(Mortality and injury) = Negligible (Behavioural responses) = Negligible	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Negligible/Minor

13.8.2 Effects of Operation and Maintenance

Long Term Loss of Original Habitat

317 The combination of the Development Area and Offshore Export Cable Corridor installation will result in a total area of permanent habitat loss of 2.47 km^2 based upon the worst case scenario. As described within the Development Area and Offshore Export Cable Corridor discussions above, the effect is considered to be localised and although the area, in relation to the wider geographical context of available habitats is small, the long term nature and key habitats affected (spawning areas, key prey species habitat, etc.) mean the magnitude of this effect is considered to be at worst low. No impact on herring spawning habitat is predicted via long term habitat loss as herring spawning grounds do not exist within the Development Area or Offshore Export Cable Corridor.

318 The sensitivity of potential receptors ranges from low to high, therefore, this cumulative impact is considered to be at worst minor/moderate for the Project. A summary of impacts significance can be found below.

Table 13.41: Impact Summary of Long Term Loss of Original Habitat (the Project)

Impact	Receptor	Magnitude	Sensitivity	Significance
Long term loss of original habitat (the Project)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Low	Low	Minor

Behavioural Responses to EMF Associated with Cabling

319 It is anticipated that the inter-array cables will comprise of a maximum of 353 km of 66 kV AC cables. The Export Cable is anticipated to comprise of up to six 83 km of 275 kV AC cables. These cables have the potential to illicit behavioural responses in a number of

species, and the behavioural responses elicited are likely to be both species and individually specific. The potential impact of EMF acting as a barrier to migratory species, particularly salmon, is a key consideration of this assessment. Salmon are reported to predominately swim in the upper 10 m of the water column (Malcolm *et al.,* 2010), and it is considered that EMF impacts to salmon from subsea cables will not be present in water depths greater than 20 m due to the attenuation of EMF in seawater (Gill and Bartlett, 2010). This assumption is supported by a review of salmon data from the Solway Firth in relation to the construction and operation of the Robin Rigg offshore wind farm which concluded that the wind farm had no significant impact on the salmon populations of the local river (Thorley, 2013).

320 While it is recognised that the combined area that will be effected by EMF from both the Offshore Export Cable and the inter-array cabling is larger than for either component alone, the areas affected are very localised and will not overlap, therefore no additional cumulative effect is predicted, beyond what is predicted for the Offshore Export Cable. No barrier effects are predicted for either the Development Area or Offshore Export Cable Corridor, and as such the magnitude of the cumulative effect is considered to be negligible for most receptors, and low for elasmobranchs and SAC qualifying feature species (which represents a conservative estimate due to the uncertainties in the field strengths associated with the Offshore Export Cable, see *Section 13.6.2*). A negligible/minor or minor impact is predicted for all receptors with the exception of SAC species, which as a result of their high sensitivity (due to their higher conservation status) results in a moderate impact. A summary of impact significance can be found below.

Table 13.42: Impact Summary of Behavioural Responses to EMF Associated with Cabling (the Project)

Impact	Receptor	Magnitude	Sensitivity	Significance
Behavioural responses to EMF associated with cabling (the Project)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Low	Low	Minor
	SAC qualifying feature species	Low	High	Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Disturbance or Physical Injury Associated with Operational Noise

321 As detectable operational noise is predicted to come from the Development Area only (and not the Offshore Export Cable Corridor) during operation, no cumulative impact of the Project exists.

Reduced Fishing Activity

322 As reduction in fishing pressure during the operational phase is predicted to occur within the Development Area only (i.e. not along the Offshore Export Cable Corridor) no cumulative impact of the Project exists.

Creation of New Habitat Due to Presence of Project Infrastructure

323 The Wind Farm and OfTW together have the potential to create new hard substrate covering an area of 2.47 km^2. However, due to the large area over which this substrate will be created, the overall effect is expected to be small. Reef fishes and crustaceans are likely to be primary users of the new habitat, and will benefit from the increased habitat complexity offering greater food resources and refugia. As a partial alteration of the baseline conditions to one of hard substrata, the magnitude of this effect is considered to be negligible for most species, but moderate for shellfish. For most receptor groups the cumulative impacts are negligible/minor (positive) or minor**,** but for shellfish they are minor/moderate (positive). A summary of impact significance can be found below.

Table 13.43: Impact Summary of Creation of New Habitat Due to Presence of Infrastructure (the Project)

Impact	Receptor	Magnitude	Sensitivity	Significance
Creation of new habitat due to presence of infrastructure (the Project)	Mobile fish species	Negligible	Low	Negligible/Minor (positive)
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor (positive)
	SAC qualifying feature species	No Impact	High	No Impact
	Shellfish	Moderate	Low	Minor/Moderate (positive)

Temporary Habitat Disturbance from Operations and Maintenance (O&M) Activities

324 Table 13.44 below presents a summary of the impact significance predictions for the fish and shellfish receptors based on temporary habitat disturbance via construction of the Project. These impacts are predicted to be similar (or less) for any subsequent temporary habitat disturbance via O&M activities.

Table 13.44: Impact Summary for Temporary Habitat Disturbance via O&M Activities (the Project)

Impact	Receptor	Magnitude	Sensitivity	Significance
Temporary habitat disturbance via O&M activities	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

13.8.3 Effects of Decommissioning

325 The potential effects of decommissioning are considered to be equivalent to, and potentially lower than, the worst case effects assessed for the construction phase. The approach to decommissioning is described in *Section 7.12*. A decommissioning plan will be prepared in accordance with the requirements of the *Energy Act 2004* (see *Section 3.2.5*) and will be subject to approval from Department of Energy and Climate Change prior to implementation.

326 It should be noted, however, that piling is not envisaged to be required during decommissioning and hence, effects associated with noise attributed to this phase will likely be significantly smaller than those assessed for the construction phase above.

13.9 Cumulative Impacts of the Project with Other Projects

327 In line with *Chapter 4* (*Section 4.7*) all elements of the Project with other relevant projects must be considered together in order to allow a full cumulative impact assessment to be undertaken. A range of other projects, both onshore and offshore were identified through consultation with relevant stakeholders for cumulative impacts with the Project (full details can be found in *Section 4.7.3*; Figure 4.1). Cumulative impacts for fish and shellfish receptors arising from the impacts of the Project in conjunction with other planned marine developments and activities are described below.

13.9.1 Developments Considered

Firth of Forth and Tay Wind Farms

328 The other offshore wind farms in the Firth of Forth and Tay area include the Firth of Forth Phase 1, and Neart na Gaoithe Offshore Wind Farms. The construction periods for the three projects are:

- Neart na Gaoithe – Construction to begin in March 2015, ending September 2016;
- Firth of Forth Phase 1 – Export cable October 2015, ending December 2017. WTGs from July 2016, ending December 2019;
- Inch Cape Wind Farm and OfTW – The programme states an expected two year piling period commencing in 2017. However for the purposes of a worst case cumulative assessment, it is assumed that piling could occur simultaneously with the Neart na Gaoithe and Firth of Forth Phase 1 projects.

329 The cumulative Assessment Parameters for each of the three projects are outlined below (Table 13.45).

Table 13.45: Summary of Cumulative Assessment Parameters Including Other Projects

Impact	Neart na Gaoithe	Firth of Forth Phase 1	ICOL Project
Construction (and Decommissioning)			
Direct temporary habitat disturbance	Total of 2.88 km^2 2.11 km^2 disturbed -site area 0.75 km^2 disturbed - export cable area	Total of 15.46 km^2 3.75 km^2 disturbed - Alpha 3.75 km^2 disturbed - Bravo 7.96 km^2 disturbed - Transmission	Total of 8.56 km^2 5.54 km^2 disturbed - Development Area 3.02 km^2 disturbance – Offshore Export Cable Corridor
Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Maximum plume extent – <5 km	Maximum plume extent – one tidal excursion	Maximum plume extent – 10 km (majority of the sediment settles within 3.5 km)
Barrier effects, disturbance or physical injury associated with construction noise	Area encompassed by 75 dB_{ht} (Herring) – 8062 km^2	Area encompassed by 75 dB_{ht} (Herring) – 10320 km^2	Area encompassed by 75 dB_{ht} (Herring) – 9223 km^2

Impact	Neart na Gaoithe	Firth of Forth Phase 1	ICOL Project
Operation and Maintenance			
Long term loss of original habitat	Total of 0.36 km^2 0.31 km^2 site area lost 0.05 km^2 export cable area lost	Total of 2.18 km^2 across Alpha, Bravo and export cable	Total of 2.47 km^2 1.87 km^2 Development Area 0.60 km^2 Offshore Export Cable Corridor
Behavioural responses to EMF associated with cabling	140 km inter-array cable buried to 1.0 – 3.0 m 2 x 33 km export cable buried to 1.0 – 3.0 m	355 km inter-array cable buried to 0.5 m minimum (for both Alpha and Bravo) 530 km export cable buried to minimum 0.5 m	353 km inter-array cable 6 x 83 km Export Cable Both buried at a range of 0.0 – 3.0 m with a target depth of 1.0 m
Disturbance or physical injury associated with operational noise	Literature values of operational noise used for all developments		
Effect on fish and shellfish resources due to changes in fishing activity	Qualitative assessment based on minimum loss of fishing grounds used for all developments		
Creation of new habitat due to presence of project infrastructure	0.37 km^2 area of seabed covered – site area (substations unknown) 0.09 km^2 area of seabed covered –export cable	1.75 km^2 area of seabed covered – site area (Alpha and Bravo) 0.42 km^2 area of seabed covered –export cable	1.87 km^2 area of seabed covered - Development Area 0.60 km^2 area of seabed covered – Offshore Export Cable Corridor
Temporary habitat disturbance from O&M activities	Assessment based on the assumption that O&M activities will have no worse an impact as construction activities		

Other Projects and Activities

Other Offshore Wind Farms

330 Other offshore wind farms for consideration include:

- European Offshore Wind Development Centre (Aberdeen);
- Hywind Demonstration Site (near Aberdeen);
- Methil (Fife Energy Park) Offshore Demonstration Wind Turbine;
- Beatrice Offshore Wind Farm (Moray Firth); and
- Moray Firth R3 Zone 1 (Eastern Development Area) (Moray Firth).

Other Coastal Projects

331 Other coastal projects for consideration include:

- Forth Replacement Crossing (Firth of Forth);
- Rosyth International Container Terminal Project (Rosyth);
- Coastal Improvement Works at the Mouth of the Barry Burn (Carnoustie);
- Edinburgh Harbour Master Plan (Edinburgh Waterfront Development) (Leith);
- Port of Dundee Expansion (Dundee Waterfront Development); and
- Montrose Tidal Array (GlaxoSmithKline Tidal Energy Project) (Montrose).

332 It is recognised that major projects along the east coast of Scotland and north east coast of England including other offshore wind farms and coastal projects could have cumulative impacts on fish and shellfish stocks. Fish and shellfish stocks that interact with the Project areas are in some cases far ranging species with potential to interact with projects at considerable distance. However, due to the remoteness of all these projects from the Development Area and Offshore Export Cable Corridor, distant projects will not interact with a significant proportion of any fish or shellfish stock that could result in an additive cumulative effect. As such this cumulative assessment concentrates on the impacts of the Firth of Forth and Tay offshore wind farms.

Onshore Wind Farms

333 No cumulative impacts with respect to Natural Fish and Shellfish

Other Onshore Projects

334 Other onshore projects for consideration include:

- Grangemouth Renewable Energy Plant (Grangemouth);
- Rosyth Renewable Energy Plant (Rosyth);
- Dundee Renewable Energy Plant (Dundee);

- Victoria and Albert Museum at Dundee;
- Captain Clean Energy Project (Caledonia Clean Energy Project) (Grangemouth);
- Cockenzie Combined Cycle Gas Turbine Power Station (Cockenzie)

335 No cumulative impacts with respect to natural fish and shellfish are predicted, and as such these projects are scoped out of the following assessment.

13.9.2 Effects of Construction

Direct Temporary Habitat Disturbance

336 Total habitat disturbance across all projects assessed as part of this cumulative assessment is estimated at 26.9 km^2 based upon all worst case scenarios (Table 13.45). While it is recognised that the combined area that will be effected by temporary habitat disturbance is larger than for any project alone, in relation to the wider geographical context of available habitats the disturbance is considered to be localised, of relatively short duration. Therefore, it is considered to be of negligible magnitude for most receptors and low magnitude for prey species (sandeel) which have high fidelity to the seabed.

337 The most sensitive of the various fish and shellfish receptor groups (SAC qualifying feature species) has a sensitivity of high due to its conservation importance. It is worth noting that this particular receptor will have limited sensitivity to temporary habitat disturbance due to the large extent of available habitat. However, in line with assessment methodology (*Chapter 4*), the overall significance of this impact on this receptor is judged to be minor/moderate. The impact is judged to be of minor/moderate significance for prey species (sandeel), and no worse than minor for other receptor groups. A summary of impacts significance can be found below.

Table 13.46: Impact Summary of Direct Temporary Habitat Disturbance (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Direct temporary habitat disturbance	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in SSC

338 The Coastal Processes assessment of cumulative Project effects on SSC and the sediment transport regime (*Section 10.7.1*) indicates that effects are both spatially localised and short-lived. While it is recognised that the combined area potentially effected by sediment deposition and temporary increases in SSC would be greater than for any individual project, *Section 10.7* concludes that there will be no cumulative effects on these processes beyond those already evaluated for the individual construction activities. Therefore, a magnitude of negligible or low is assigned for this effect. As per the cumulative impact of temporary habitat disturbance, the most sensitive of the various fish and shellfish receptor groups has a high sensitivity (SAC qualifying feature species) therefore, the overall impact on this receptor is judged to be minor/moderate, and the impact is judged to be of minor/moderate significance for prey species (sandeel), and no worse than minor for other receptor groups. A summary of impacts significance can be found below.

Table 13.47: Indirect Disturbance as a Result of Sediment Deposition and Temporary Increases in SSC (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Indirect disturbance as a result of sediment deposition and temporary increases in SSC (the Project with other projects)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

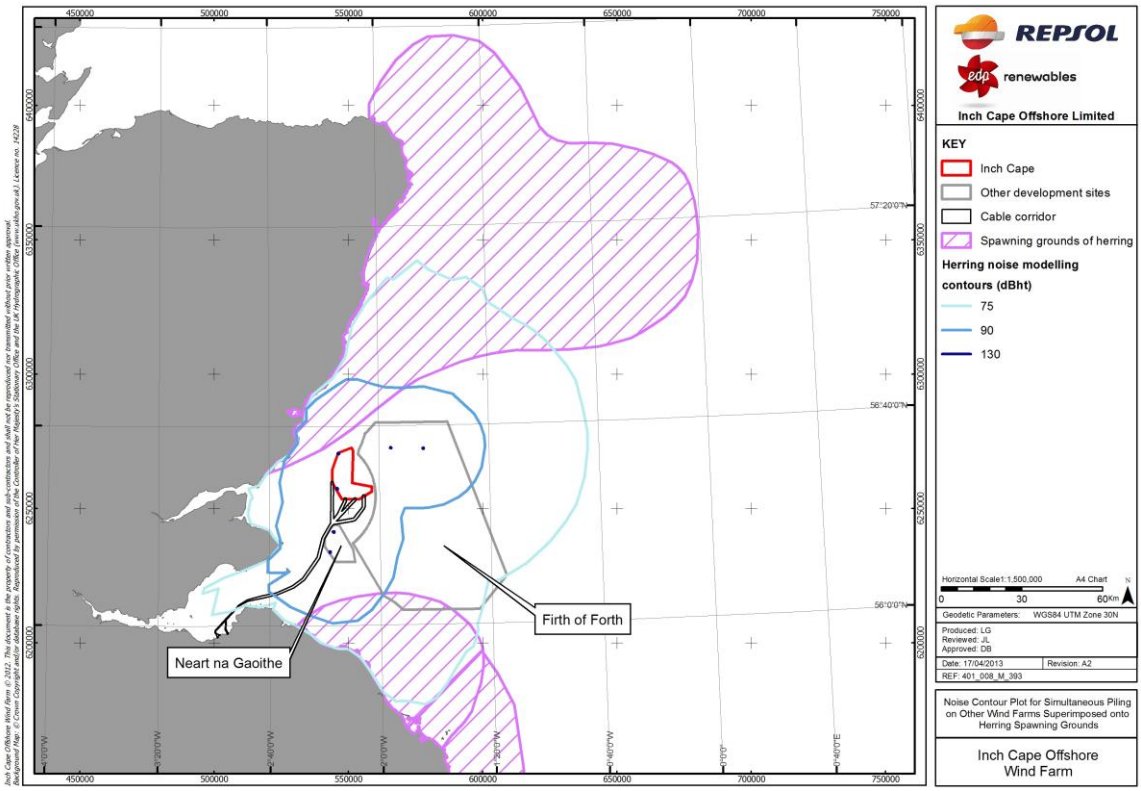
Barrier Effects, Disturbance or Physical Injury Associated with Construction Noise

339 Cumulative noise modelling has been undertaken for the Project in-conjunction with other Firth of Forth and Tay wind projects in *Chapter 11*.

340 Cumulative assessments highlight that noise emitted during piling operations for the three individual Firth of Forth and Tay developments overlap (*Chapter 11*). To assess the effects on a population the assessment takes into consideration any impacts on fish aggregations that may occur during specific periods of a species lifecycle at discrete locations (i.e. spawning grounds). This is most relevant for herring which have discrete areas of spawning habitat to the north and south of the Development Area where they congregate to spawn during August to October (Figure 13.18). The area where behavioural responses could be evoked associated with the 75 dB_{ht} (herring) and 90 dB_{ht} (herring) noise contours will impact upon 7.0 per cent and 1.5 per cent of the Shetland/Buchan spawning grounds respectively. Cumulative impacts associated with the 75 dB_{ht} (herring) and 90 dB_{ht} (herring) noise contours

will affect 9.4 per cent and 1.0 per cent of the Banks sub-population spawning grounds. However, when the cumulative behavioural noise contour plots for herring from the three Firth of Forth and Tay offshore wind farms are overlain on both the Coull *et al.* (1998) spawning ground extent and IHLS larval data (1991 to 2011), it is clear to note that spawning activity has not been uniformly distributed across the spawning ground. In reality, spawning to the north of the three wind farm sites has been concentrated off the north east Aberdeenshire coast, with spawning in the more southerly extent of this northern spawning ground much less apparent over this 20 year data set. Therefore, it is concluded that the actual proportion of herring spawning grounds impacted by cumulative noise contours will be much less than the 7.0 per cent and 9.4 per cent of the Shetland/Buchan and Banks spawning grounds respectively. In addition, herring have been reported to shift to alternative spawning locations between generations (Schmidt *et al.,* 2009). In the 1960's natural shifts in spawning ground usage were reported from areas around Buchan up to Shetland and then back again (Bainbridge and Forsyth, 1972). This ability to do so is hypothesised as a buffer against any environmental stressors acting on a population. However, it provides an indication of the ability of herring to adapt and use alternative suitable spawning grounds when necessary.

Figure 13.18: Cumulative Noise Contours for Herring Superimposed onto Herring Spawning Areas



341 The additive impacts of the cumulative noise contours result in an increased area of disturbance predominately to the east and south of the Development Area. Extension of the

area of potential behavioural disturbance has little consequence for the spawning herring stock as the main spawning grounds are to the north (Buchan grounds) and to the south (the northern periphery of the Banks grounds). Furthermore, data collected as part of the IHLS and commercial catch data (ICES, 2012) indicate that the highest intensity spawning grounds to the north are beyond the 75 dB_{ht} noise contour (*Appendix 13D*). Schmidt *et al.* (2009) report that the peripheral regions of spawning grounds are likely to be the last to be recolonised as the stock size increases, therefore it is possible that the peripheral regions of the spawning grounds affected will only be used during years where there is a high spawning stock biomass. In addition, spawning grounds supporting the sub-population that spawns at the Buchan grounds utilise spawning grounds as far north as Shetland. As herring, during the spawning season, have been reported to have a higher hearing threshold, disturbance effects may be reduced (Skaret *et al.*, 2005). Potential exclusion of herring from the peripheral spawning grounds overlapping the 75 dB_{ht} and 90 dB_{ht} hearing thresholds will not incur additional mortality to the spawning stock. It is likely that displacement will result in spawning herring moving to alternative spawning grounds to the north. Similarly, the southern extent of the cumulative noise impact area may displace herring spawning at locations supporting the Banks sub-population. However, additional alternative spawning resource exists to the south. Therefore, the magnitude of the cumulative effects remain as moderate. Coupled with a sensitivity of moderate the overall impact will be moderate.

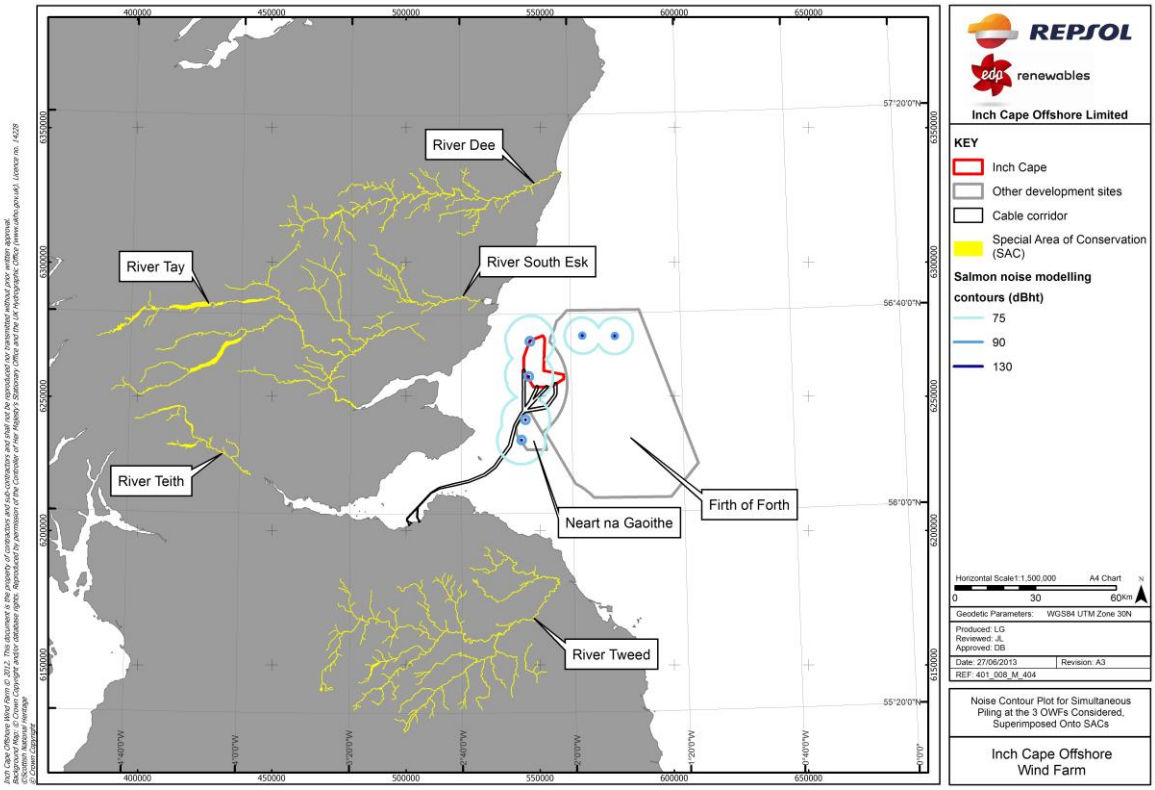
342 Cumulative impacts resulting from additive effects from simultaneous piling within the Development Area and the adjacent Firth of Forth Phase 1 and Neart na Gaoithe project will not result in a significant reduction in the spawning resources of sprat or cod (no cumulative noise modelled for cod). Both species have a ubiquitous distribution across the North Sea and further afield around Europe. ICES state that the sprat stock appears to be healthy and increasing (ICES, 2006). Conversely, the North Sea cod stock is reported to be at a critically low level. Any displacement effects will be inconsequential in the context of current fishing mortality. The magnitude of this effect on cod and sprat is low as they are unlikely to affect the size or structure of their stocks in the wider region. As cod and sprat are hearing specialists with moderate sensitivity to noise, a low magnitude of effect and moderate sensitivity results in an overall minor/moderate impact.

343 The other key receptor group that is at risk of cumulative noise impact is the SAC qualifying feature species receptor group, which comprises Atlantic salmon and river and sea lamprey. As outlined in the individual Project assessment, migratory species such as salmon and lamprey have the potential to be impacted by cumulative construction noise forming a barrier preventing migration into or out of their natal rivers. To assess this, a worst-case scenario of piling locations was assessed with modelling locations being selected on the western boundary of the sites, i.e. closest to adjacent coastlines, along which returning adult salmon (and smolts leaving natal rivers) are known to migrate.

344 Noise levels predicted to cause a strong avoidance response (90 dB_{ht} (*salmo salar*)) are predicted to occur at a distance of <3 km around each piling operation within each of the three Firth of Forth and Tay wind farms, and noise levels that will result in a mild avoidance reaction (75 dB_{ht} (*salmo salar*)) will occur within a distance of <17 km from the piling

location. Due to their spatial extent, areas of strong avoidance behaviour (as defined by the 90 dB_{ht} (*salmo salar)* contour) are not predicted to interact. However, there does appear to be scope for the mild behavioural response noise contours (75 dB_{ht} (*salmo salar)*) to interact as shown in Figure 13.19. Even though there does appear to be a cumulative effect via piling noise, from Figure 13.19 it can be noted that the 75 dB_{ht} contours do not interact in a way that creates a total barrier between the three sites and adjacent coastlines. Furthermore, piling noise will not be continuous throughout the construction phases. As such, it is not predicted that overall migration, either of returning adults or smolts leaving natal rivers, will be blocked via cumulative piling operations as there will still be large sea areas available around the Firth of Forth and Tay sites where noise levels will be lower than that predicted to create behavioural responses in salmon.

Figure 13.19: Cumulative Noise Contours for Salmon Overlaid onto SACs Designated for Migratory Fish and Freshwater Pearl Mussel



345 Other fish species which are not SAC qualifying features but which migrate between rivers and the sea, such as sea trout, sparling and European eel (assessed within the mobile fish receptor group) may also be impacted by cumulative noise effects, if they were to create a barrier to migration to spawning grounds. However, as outlined above for SAC qualifying feature species, construction noise will not cause a complete barrier across a river mouth, and piling noise will not be constant across the construction phase. Shad species (assessed within hearing specialists) are also migratory species which travel up rivers to their spawning grounds, however these species are only known to spawn in rivers on the west coast of the UK and therefore construction noise is considered highly unlikely to impact the spawning success of these species.

346 Limited specific information on migration routes means that there is some uncertainty within this assessment. As such a conservative assumption has been made that migration will take place through the areas in which the noise contours will overlap (*see Section 13.4.3, Section 13.13.3* and *Table 13.63*. It is also believed that salmon migrate over a broad area (Malcolm *et al*., 2010). With respect to the impact assessment, based on the criteria defined in Table 13.15, the magnitude of effect is predicted to be low, as only a small effect on the overall size or structure of fish species that form SAC qualifying features is envisaged due to the absence of a total barrier to migration, even when the 75 dB_{ht} contours are assessed together (Figure 13.19). The SAC qualifying feature receptor group has a high sensitivity, therefore an impact of moderate is predicted. A summary of impacts significance can be found below (*Table 13.48*).

Table 13.48: Impact Summary of Barrier Effects, Disturbance or Physical Injury Associated with Construction Noise (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Barrier effects disturbance or physical injury associated with construction noise (the Project with other projects)	Mobile fish species (hearing generalists)	(Mortality and injury) = Negligible (Behavioural responses) = Low	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	Hearing specialists	(Mortality and injury) Hearing specialist = Negligible (Behavioural responses) Herring = Moderate Cod & sprat = Low	Moderate	(Mortality and injury) = Minor (Behavioural responses) Herring = Moderate Cod & sprat = Minor/Moderate
	Prey species	(Mortality and injury) = Negligible (Behavioural responses) = Low	Moderate	(Mortality and injury) = Minor (Behavioural responses) = Minor/Moderate
	Electro-sensitive elasmobranchs	(Mortality and injury) = Negligible (Behavioural responses) = Low	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	SAC qualifying feature species	(Mortality and injury) = Negligible (Behavioural responses) = Low	High	(Mortality and injury) = Minor/Moderate (Behavioural responses) = Moderate
	Shellfish	(Mortality and injury) = Negligible (Behavioural responses) = Negligible	Low	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Negligible/Minor

13.9.3 Effects of Operation and Maintenance

Long Term Loss of Original Habitat

347 Total habitat loss across all projects assessed as part of this cumulative assessment is estimated at 5.01 km^2 based upon all worst case scenarios. In relation to the wider geographical context of available habitats, the effect is considered to be small and localised.

348 The most sensitive of the various fish and shellfish receptor groups has a high sensitivity, however, the long term loss of habitat within the three project areas will have a very limited impact on SAC qualifying feature species (salmon and sea lamprey) as these species are not thought to rely on the specific habitats within the sites for any particular ecological function, such as spawning or feeding. The lack of high abundances of sandeel in and around each of the sites (Figure 13.9) suggests that the sites are less important than surrounding areas in terms of prey resources.

349 Overall, the magnitude of effect of long term habitat loss on receptor groups is judged to be at worst low, as based on criteria in Table 13.15, this effect is not predicted to influence the size or structure of stocks in the wider region. A summary of impacts significance can be found below.

Table 13.49: Impact Summary of Long Term Loss of Original Habitat (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Long term loss of original habitat (the Project with other projects)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Low	Low	Minor

Behavioural Responses to EMF Associated with Cabling

350 The layout of the three Firth of Forth and Tay wind farm projects indicates that the area inshore of these projects will be exposed to a number of localised magnetic (B) and iE fields. While it is recognised that the combined areas that will be effected by EMF from cabling, of the three projects is larger than for the Project alone, the areas affected by EMF are very localised and will not overlap, therefore no additional cumulative effect is predicted.

351 Migratory SAC qualifying species typically swim in the upper 10 m of the water column (Malcolm *et al.*, 2010). They are also believed to migrate over a broad area (Malcolm *et al.,*

2010). These are the most sensitive receptor (*Section 13.5.1*), and are assigned a high sensitivity.

352 As such the magnitude of the effect is considered to be negligible for most receptors, and low for electro-sensitive elasmobranchs and SAC qualifying feature species (which may pass over export cables during coastal migrations). It should be noted that this is a conservative estimate as while there are uncertainties in the field strengths associated with the export cables, these are not predicted to elicit behavioural effects in these receptor groups.

353 Therefore, the impact of EMF from cables from the three Firth of Forth and Tay offshore wind farm projects considered in this assessment is judged to be moderate for SAC qualifying feature species, and no worse than minor for other receptor groups. A summary of impacts significance can be found below.

Table 13.50: Impact Summary of Behavioural Responses to EMF Associated with Cabling (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Behavioural responses to EMF associated with cabling (the Project with other projects)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Low	Low	Minor
	SAC qualifying feature species	Low	High	Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Disturbance or Physical Injury Associated with Operational Noise

354 Although operational noise at each development will cause levels elevated above background, no mortality or injury is predicted due to limited spatial extent and actual levels of these noise emissions. From measured data on operational wind farms, operational WTG noise is not estimated to exceed 75 dB_{ht}(*Species*) at the point of emission at the WTG tower for any of the fish species (*Chapter 11*). Therefore, the avoidance area around each WTG will be less than one metre. In addition, a number of offshore wind farms have found increased numbers of fish living in the wind farm during the operational phase compared to the baseline suggesting that operational noise is not having an adverse impact (Leonhard *et al*., 2011).

355 Avoidance responses are only predicted for hearing specialists within the immediate vicinity (approximately four metres, and only at very high wind speeds (13 ms^{-1}) (Wahlberg and Westerberg, 2005), therefore, overlap between projects resulting in cumulative impacts is not predicted. Detection of the three Firth of Forth and Tay offshore wind farm developments is species specific. Those with a poor sensitivity to noise, such as eel and dab,

are likely to detect operational noise levels within areas less than one kilometre from source, which would not cause overlap between the developments. Fish with higher sensitivity of sound pressure, e.g. herring and cod, might detect a wind farm at a longer range distance greater than 25 km as reported by Anderson (2011). The long detection ranges in combination with the multiple developments would increase the area over which natural fish populations will detect the noise above background. However, it should be noted that these detection ranges do not relate to distances in which avoidance behaviour will be elicited. Levels of operational noise are likely to be comparable to vessel movements, which will also elevate noise levels during operation as a result of maintenance; however, unlike the noise from WTGs, vessel noise is short lived.

356 Avoidance due to operational noise is restricted to small areas which, in general, do not overlap between developments. Studies at completed wind farms show no adverse behavioural effects (Leonhard *et al.,* 2011). Detection of operational noise by hearing generalists does not cause overlap between developments. Detection by hearing specialists may however present overlap between developments, and at a detectable range of 25 km, the herring spawning ground is also affected, however not at a noise level where adverse behavioural effects are likely. As a result, the magnitude of this effect is considered negligible. SAC qualifying feature species have been assigned a high sensitivity; therefore the greatest significance of this cumulative impact will be on this receptor group and is judged to be minor/moderate. A summary of impacts significance can be found below.

Table 13.51: Impact Summary for Disturbance or Physical Injury Associated with Operational Noise (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Disturbance or physical injury associated with operational noise (the Project with other projects)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

Reduced Fishing Activity

357 During the operational phase, the potential reduction in fishing activity within the three Firth of Forth and Tay offshore wind farms due to the presence of infrastructure may create a beneficial impact on existing fish and shellfish resources. Although there are uncertainties surrounding how much fishing pressure would be reduced across all three projects, it is considered likely that there will be some degree of reduction. The impact of a reduction in fishing activity and resulting benefits will be negligible/minor (positive) at best.

Creation of New Habitat Due to Presence of the Project Infrastructure

358 According to the published worst case scenarios of the three projects in the area, total production of hard substrate is expected to cover an area of approximately 5.01 km^2. This provision of additional habitat represents a partial alteration of the baseline conditions to one of hard substrata, albeit a very limited spatial extent compared to the wider resource of soft sediment. Reef fishes and crustaceans are likely to be primary users of the new habitat, and will benefit from the increased habitat complexity offering greater food resources and refugia. As a partial alteration of the baseline conditions to one of hard substrata, the magnitude of this effect is considered to be moderate. The species affected are of low sensitivity and as such a minor/moderate (positive) impact is predicted. The most sensitive of the various fish and shellfish receptor groups has a high sensitivity but this particular receptor (SAC qualifying feature species) will not be affected by this impact. The overall impact on other receptors is judged to be minor/moderate at most. A summary of impacts significance can be found below.

Table 13.52: Impact Summary of Creation of New Habitat Due to Presence of Project the Infrastructure (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Creation of new habitat due to presence of infrastructure (the Project with other projects)	Mobile fish species	Negligible	Low	Negligible/Minor (positive)
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Negligible	Moderate	Minor
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor (positive)
	SAC qualifying feature species	No Impact	High	No Impact
	Shellfish	Moderate	Low	Minor/Moderate (positive)

Temporary Habitat Disturbance from Operations and Maintenance (O&M) Activities

359 Table 13.53 below presents a summary of the impact significance predictions for the fish and shellfish receptors based on temporary habitat disturbance via construction of the three projects. These impacts are predicted to be similar (or less) for any subsequent temporary habitat disturbance via O&M activities.

Table 13.53: Impact Summary for Temporary Habitat Disturbance via O&M Activities (the Project with Other Projects)

Impact	Receptor	Magnitude	Sensitivity	Significance
Temporary habitat disturbance via O&M activities (the Project with other projects)	Mobile fish species	Negligible	Low	Negligible/Minor
	Hearing specialists	Negligible	Moderate	Minor
	Prey species	Low	Moderate	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible	Low	Negligible/Minor
	SAC qualifying feature species	Negligible	High	Minor/Moderate
	Shellfish	Negligible	Low	Negligible/Minor

13.9.4 Effects of Decommissioning

360 The potential effects of decommissioning are considered to be equivalent to and potentially lower than the worst case effects assessed for the construction phase. The approach to decommissioning is described in *Section 7.12.* A decommissioning plan will be prepared in accordance with the requirements of the *Energy Act 2004* (see *Section 3.2.5*) and will be subject to approval from DECC prior to implementation.

361 It should be noted, however, that piling is not envisaged to be required during decommissioning and hence, effects attributed to noise during this phase will likely be significantly smaller than those assessed for the construction phase above.

13.10 Impact Interactions

13.10.1 Impact Interactions Associated with the Project

362 The potential for individual impacts identified through the impact assessment to interact and create new, or more significant impacts on fish and shellfish receptors, has been assessed. Impacts during construction of the Wind Farm and OfTW within the Development Area are considered likely to have the greatest potential for impact interactions, due to the number and extent of impact of activities taking place during this phase. The impacts associated with the construction of the Wind Farm and OfTW within the Development Area are:

- Direct temporary habitat disturbance;
- Indirect disturbance as a result of sediment deposition and temporary increases in SSC; and
- Barrier effects, disturbance or physical injury associated with construction noise.

363 The worst case scenario for these three impacts (as assessed for the individual impact assessments) will not interact as they are associated with the installation of different

foundation types. The worst case scenario for sediment deposition/increased SSC and habitat disturbance is dependent on the installation of GBS, whereas the worst case scenario for noise impacts is dependent on piling of jacket structures. While it is recognised that a degree of habitat loss and increased sediment deposition/SSC may be expected if piling were to take place, and similarly, underwater noise may increase above background levels during seabed preparation for GBS, the individual assessments for these impacts are considered to carry sufficiently conservative estimates of impacts that the additive effect would not exceed the assigned significance for the individual assessment.

364 No potential for impact interactions, which would result in a new, or more significant impact than those assigned for the individual assessment, has been identified during the construction phase of the Export Cable within the Offshore Export Cable Corridor.

365 During the operational phase of the Project, while it is recognised that the combination of reduced fishing pressure and creation of new habitat could result in a benefit to fish and shellfish resources, the degree of benefits from an additive effect cannot be confidently assigned. No other impact interactions have been identified.

13.10.2 Impact Interactions Associated with the Project and Other Projects

366 The potential for impacts from other projects to interact with impacts identified in the impact assessment and cumulative impact assessment to result in a greater long term effect, has been assessed. No such interactions have been identified.

13.11 Mitigation

367 A number of Embedded Mitigation strategies are proposed for the Project with relevance to natural fish and shellfish populations as detailed in *Section 13.3*.

368 The natural fish ecology assessment has assessed worst case scenario impacts of the Project in isolation and cumulatively. This assessment has concluded that changes to the natural fish ecology within the Study Area will be, at most moderate significance, to the identified receptors (see *Sections 13.6* to *13.9*).

369 The assessment of impacts on the natural fish ecology has indicated that adoption of the Project Embedded Mitigation measures, listed in *Section 13.4* and collated in *Appendix 7A,* would reduce residual effects to an acceptable level and no further mitigation is proposed.

13.12 Conclusions and Residual Impacts

370 The following tables summarise pre and post mitigation significance for all effects considered for the Development Area, Offshore Export Cable Corridor, Project and Project with other projects.

371 As all the mitigation considered for the Development Area in this Chapter was Embedded Mitigation and therefore included in the assessment conclusions, only residual effects have been presented in these tables.

Table 13.54: Summary of Effects – Development Area

Impact	Receptor	Residual Significance
Construction (and Decommissioning)		
Direct temporary habitat disturbance	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Barrier effects disturbance or physical injury associated with construction noise	Mobile fish species (hearing generalists)	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	Hearing specialists	(Mortality and injury) = Minor (Behavioural responses) herring = Moderate Cod & sprat = Minor/Moderate
	Prey species	(Mortality and injury) = Minor (Behavioural responses) = Minor/Moderate
	Electro-sensitive elasmobranchs	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor

Impact	Receptor	Residual Significance
	SAC qualifying feature species	(Mortality and injury) = Minor/Moderate (Behavioural responses) = Moderate
	Shellfish	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Negligible/Minor
Operation and Maintenance		
Long term loss of original habitat	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Minor
Behavioural responses to EMF associated with cabling	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Disturbance or physical injury associated with operational noise	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor

Impact	Receptor	Residual Significance
Reduced fishing activity within the Development Area	All receptor groups	Negligible/Minor (positive)
Creation of new habitat due to presence of infrastructure	Mobile fish species	Negligible/Minor (Positive)
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor (positive)
	SAC qualifying feature species	No Impact
	Shellfish	Minor/Moderate
Temporary habitat disturbance via O&M activities	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor

Table 13.55: Summary of Effects – Offshore Export Cable Corridor

Impact	Receptor	Residual Significance
Construction (and Decommissioning)		
Direct temporary habitat disturbance via Export Cable installation	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor

Impact	Receptor	Residual Significance
Indirect disturbance as a result of sediment deposition and temporary increases in SSC via Export Cable installation	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Disturbance or physical injury associated with construction noise (Export Cable installation)	Mobile fish species (hearing generalists)	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Operation and Maintenance		
Long term loss of original habitat (Export Cable)	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Minor
Behavioural responses to EMF associated with cabling (Export Cable)	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Minor
	SAC qualifying feature species	Moderate

Impact	Receptor	Residual Significance
	Shellfish	Negligible/Minor
Creation of new habitat due to presence of Cable Protection	Mobile fish species	Negligible/Minor (positive)
	Hearing specialists	No Impact
	Prey species	No Impact
	Electro-sensitive elasmobranchs	Negligible/Minor (positive)
	SAC qualifying feature species	No Impact
	Shellfish	Negligible/Minor (positive)
Direct temporary habitat disturbance from O & M activities	Impacts on all receptors considered to be less than that of "Direct temporary habitat disturbance via Export Cable installation" during the construction phase (as outlined above).	

Table 13.56: Summary of Effects – the Project

Impact	Receptor	Residual Significance
Construction (and Decommissioning)		
Direct temporary habitat disturbance	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor

Impact	Receptor	Residual Significance
Barrier effects disturbance or physical injury associated with construction noise	Mobile fish species (hearing generalists)	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	Hearing specialists	(Mortality and injury) = Minor (Behavioural responses) herring = Moderate Cod & sprat = Minor/Moderate
	Prey species	(Mortality and injury) = Minor (Behavioural responses) = Minor/Moderate
	Electro-sensitive elasmobranchs	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	SAC qualifying feature species	(Mortality and injury) = Minor/Moderate (Behavioural responses) = Moderate
	Shellfish	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Negligible/Minor
Operation and Maintenance		
Long term loss of original habitat	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Minor
Behavioural responses to EMF associated with cabling	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor

Impact	Receptor	Residual Significance
	Electro-sensitive elasmobranchs	Minor
	SAC qualifying feature species	Moderate
	Shellfish	Negligible/Minor
Disturbance or physical injury associated with operational noise	No cumulative impact	
Reduced fishing activity within the Project	No cumulative impact	
Creation of new habitat due to presence of infrastructure	Mobile fish species	Negligible/Minor (positive)
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor (positive)
	SAC qualifying feature species	No Impact
	Shellfish	Minor/Moderate (positive)
Temporary habitat disturbance via O&M activities	Impacts on all receptors considered to be less than that of "Direct temporary habitat disturbance" during the construction phase (as outlined above)	

Table 13.57: Summary of Effects – the Project with Other Projects

Impact	Receptor	Residual Significance
Construction (and Operation)		
Direct temporary habitat disturbance	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Indirect disturbance as a result of sediment deposition and temporary increases in suspended sediment concentrations (SSC)	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Barrier effects disturbance or physical injury associated with construction noise	Mobile fish species (hearing generalists)	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor
	Hearing specialists	(Mortality and injury) = Minor (Behavioural responses) herring = Moderate Cod & sprat= Minor/Moderate
	Prey species	(Mortality and injury) = Minor (Behavioural responses) = Minor/Moderate
	Electro-sensitive elasmobranchs	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Minor

Impact	Receptor	Residual Significance
	SAC qualifying feature species	(Mortality and injury) = Minor/Moderate (Behavioural responses) = Moderate
	Shellfish	(Mortality and injury) = Negligible/Minor (Behavioural responses) = Negligible/Minor
Operation and Maintenance		
Long term loss of original habitat	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor/Moderate
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Minor
Behavioural responses to EMF associated with cabling	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Minor
	SAC qualifying feature species	Moderate
	Shellfish	Negligible/Minor
Disturbance or physical injury associated with operational noise	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	Minor/Moderate
	Shellfish	Negligible/Minor
Reduced fishing activity	All receptor groups	Negligible/Minor (positive)

Impact	Receptor	Residual Significance
Creation of new habitat due to presence of infrastructure	Mobile fish species	Negligible/Minor
	Hearing specialists	Minor
	Prey species	Minor
	Electro-sensitive elasmobranchs	Negligible/Minor
	SAC qualifying feature species	No Impact
	Shellfish	Minor/Moderate
Temporary habitat disturbance via O&M activities	Impacts on all receptors considered to be less than that of "Direct temporary habitat disturbance" during the construction phase (as outlined above)	

13.13 Habitats Regulations Appraisal (HRA)

372 The purpose of this section is to inform the HRA process following available and relevant guidance in assessing potential impacts which may arise during the construction, operation and decommissioning of the offshore elements of the Project (the Wind Farm and OfTW) by:

a) Identifying relevant Natura sites which include migratory fish and associated species as notified interest features and for which there is potential connectivity from an impact from the construction, operation and decommissioning activities associated with the Wind Farm and OfTW;

b) Identifying likely significant effects (LSE) associated with the construction, operation and decommissioning of the Wind Farm and OfTW; and

c) Considering potential impacts in relation to notified interest features of identified Natura sites in relation to their conservation objectives.

373 This report represents a review of available literature, modelling outputs, and Impact Assessment based upon the Project Design Envelope. This HRA report has been based on Marine Scotland's Scoping Opinion (9 March 2011), consultation with stakeholders and a review of available literature including Marine Scotland's review of migratory fish routes (Malcolm *et al.*, 2010) and the outcomes of the Project impact assessment.

13.13.1 Habitats Regulation Appraisal Process

374 This information has been prepared following the process described in *Section 4.8* and has been prepared to inform an Appropriate Assessment to be carried out by the Scottish Ministers, acting through Marine Scotland, in respect of the Project.

In-combination Effects

375 The Habitats Regulations require that the LSE and an HRA test is undertaken in relation to the potential effects which may arise from the plan or project alone or in-combination with other existing (or foreseeable) developments/activities.

376 In considering whether a plan or project either alone or in-combination is likely to have a significant effect it is necessary to consider the influences on the site which have affected, and are continuing to affect, the condition of the conservation objectives. The current condition of the interest feature(s) may be a reflection of the in-combination effects on them.

377 Where a feature for which the site has been selected as being of European importance is already in unfavourable condition or critical thresholds are being exceeded (or is subject to cumulative effects which will lead to either of these being the case), any additional plan or project which, either alone or in-combination, adds to these levels is likely to have a significant effect on the European Site.

13.13.2 Likely Significant Effect Assessment

378 European Commission guidance (2001) recommends that screening for LSE should fulfil the following steps and ICOL proposes to follow this process:

1. Determine whether the plan (or policy) is directly connected with or necessary for the management of Natura 2000 sites;
2. Describe the plan and describe and characterise any other plans or projects which, in-combination, have the potential for having significant effects on Natura 2000 sites;
3. Identify the potential effects on Natura 2000 sites; and
4. Assess the likely significance of any effects on Natura 2000 sites.

Step 1: Determine Whether the Plan is Directly Connected with or Necessary for the Management of Natura 2000 Sites

379 The Project is not considered necessary for the management of a European Marine Site though the benefits of renewable energy developments are well documented and are detailed in *Chapter 8: Benefits of the Project*.

Step 2: Describe the Plan and Describe and Characterise any Other Plans or Projects Which, In-combination, Have the Potential for Having Significant Effects on Natura 2000 Sites

Project Details

380 The migratory fish assessment contained within this HRA document includes the Inch Cape Offshore Wind Farm and associated OfTW.

381 The details of the Project are described in *Chapter 7*, with the parameters and scenarios relevant to the Natural Fish assessment found in *Section 13.3.* The key components of the offshore Project Design Envelope, as set out in Table 13.2 and Table 13.3, have the potential to affect the magnitude of effects that the offshore Project may have on migratory fish receptors. Identifying a worst-case scenario based on these components is integral to conducting a robust and meaningful HRA.

Relevant In-combination Impacts Assessed for Likely Significant Effect

382 In addition to assessing the cumulative impact of the Project, the HRA also assesses potential in-combination effects which may arise from other, existing (or foreseeable) developments/activities. The developments considered under this HRA (detailed in *Chapter 4, Section 4.7* and in *Section 13.9*) were determined through consultation with regulators.

Step 3: Identify the Potential Effects on Natura 2000 Sites

Designations Relevant to the HRA

383 Annex II migratory fish such as Atlantic salmon, river lamprey and sea lamprey represent qualifying interest features of several SACs along the east coast of Scotland. Although none of these species were captured in the fish surveys at the Development Area and Offshore Export Cable Corridor, the marine phase of these species life cycle is known to have a wide distribution, and it is therefore assumed that they may migrate through the Development Area and Offshore Export Cable Corridor at some point in their life cycle. FWPM are not present at the Development Area and Offshore Export Cable Corridor as adults, however this species rely on migrating anadromous salmonids during the glochidial stage of their life cycle when the larvae attach to the gills of passing fish (see *Appendix 13A* for full details). Therefore, impacts to salmon migration could affect their population. The Project has the potential for both direct and indirect effects on salmon, river lamprey and sea lamprey and also indirect effects on the FWPM population in Scottish east coast rivers and so has also been considered in this exercise.

384 Consultation with Marine Scotland, Joint Nature Conservation Committee (JNCC) and SNH identified potential SACs to be considered further. SACs identified were:

- River Tay SAC – Atlantic salmon, brook lamprey, river lamprey and sea lamprey;
- River Teith SAC – Atlantic salmon, brook lamprey, river lamprey and sea lamprey; and
- River South Esk SAC – Atlantic salmon and FWPM.

385 In addition to the SACs identified above, the screening stage has also highlighted other SACs along the north-east coast of Britain that were identified through consultation with fisheries organisations, to reflect the migratory patterns and foraging range of some of the Annex II species considered, namely:

- River Dee SAC – Atlantic salmon and FWPM; and
- River Tweed SAC – Atlantic salmon, brook lamprey, river lamprey and sea lamprey.

386 It is noted that several of the river SACs are designated for features additional to migratory fish (Table 13.58) such as otters or freshwater habitats. As there is no connectivity between these features and the Development Area and Offshore Export Cable Corridor for these species, there can be no LSE or adverse effect on site integrity arising from these features. Therefore they are not considered further in this HRA.

387 The conservation objectives of sites Designated for migratory fish are:

- To avoid deterioration of the habitats of the qualifying species (listed below) 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.

Table 13.58: Conservation Objectives of Sites Designated for Migratory Fish

Site	Specific conservation objectives:	Designated feature
River South Esk SAC	Population of the species, including range of genetic types for salmon, 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. No significant disturbance of the species. Distribution and viability of freshwater pearl mussel host species. Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.	Atlantic salmon Freshwater pearl mussel
River Dee SAC	Population of the species, including range of genetic types for salmon, 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. No significant disturbance of the species. Distribution and viability of freshwater pearl mussel host species. Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.	Atlantic salmon Freshwater pearl mussel Otter (*Lutra lutra*)
River Tay SAC	Population of the species, including range of genetic types for salmon, as a viable component of the site. Distribution of the species within site. Distribution and extent of habitats supporting the species.	Atlantic salmon Brook lamprey River lamprey Sea lamprey

Site	Specific conservation objectives:	Designated feature
	Structure, function and supporting processes of habitats supporting the species. No significant disturbance of the species.	Otter Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
Teith SAC	Population of the species, including range of genetic types for salmon, 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. No significant disturbance of the species.	Atlantic salmon Brook lamprey River lamprey Sea lamprey
River Tweed SAC	Population of the species, including range of genetic types for salmon, 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. No significant disturbance of the species.	Atlantic salmon Brook lamprey River lamprey Sea lamprey Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

388 Throughout this chapter all potential effects of the offshore components of the Project on migratory fish were assessed and it is this assessment which has been used to inform the preliminary impact assessment conducted as part of this HRA exercise. They key potential effects are summarised below (Table 13.59 and Table 13.60).

Table 13.59: Potential Effects on Migratory Fish Species – Works in the Development Area

Potential Effect	Description of Effect
Construction/Decommissioning	
Barrier effects, disturbance or physical injury associated with construction noise	Noise from construction activities (piling particularly) will result in increased levels of noise which may act as a barrier to migration to and from natal rivers, as a result of avoidance behaviour.
Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Construction activities will mobilise and deposit sediments, therefore increasing suspended sediments in the water column which may act as a barrier to migration as a result of avoidance responses.
Direct temporary habitat disturbance	Temporary habitat loss arising from construction activities may potentially reduce area of available habitat for foraging during migration.
Operation/Maintenance*	
Behavioural responses to EMF associated with cabling	Migratory fish are known to use the earth's magnetic field as an aid to navigation; therefore EMF arising from inter-array could in theory act as a barrier to migration.
Long term loss of original habitat	Long term habitat loss arising from the Wind Farm and OfTW footprint may potentially reduce the area of available habitat for foraging during migration.
Disturbance or physical injury associated with operational noise	Increases to background noise have the potential to cause changes in behaviour and could have masking effects on navigation.
*No impact on SAC species was predicted during EIA as a result of creation of new habitat. The scale of effect on SAC species from temporary habitat disturbance via O&M activities was considered to be so minor that it was not likely to contribute an LSE on any Designated Sites. These two effects have therefore been excluded from HRA.	

Table 13.60: Potential Effects on Migratory Fish Species – Works in the Offshore Export Cable Corridor

Potential Effect	Description of Effect
Construction/Decommissioning	
Disturbance or physical injury associated with construction noise	Migratory fish are known to use sound as an aid to navigation. During cable laying, noise is produced by the motion of the plough or trencher through the seabed, and increased noise could in theory act as a barrier to migration.

Potential Effect	Description of Effect
Construction/Decommissioning	
Direct temporary habitat disturbance via Export Cable installation	Temporary habitat loss arising from cable laying activities may potentially reduce area of available habitat for foraging during migration.
Operation/Maintenance*	
Behavioural responses to EMF associated with cabling (Export Cable)	Migratory fish are known to use the earth's magnetic field as an aid to navigation; therefore EMF arising from the Export Cable could in theory act as a barrier to migration.
Long term loss of original habitat (Export Cable)	Cable protection would change original habitat which may potentially reduce area of available habitat for foraging during migration.
*No impact on SAC species was predicted during EIA as a result of creation of new habitat. The scale of effect on SAC species from temporary habitat disturbance via O&M activities was considered to be so minor that it was not likely to contribute an LSE on any Designated Sites. These two effects have therefore been excluded from HRA.	

Step 4: Assess the Likely Significance of Any Effects on Natura 2000 Sites

389 For each of the European sites, a judgement for each of the relevant notified interest features has been made to determine whether there are any LSE arising from the Project's construction, operation or decommissioning (Table 13.61) either alone or in-combination with the projects listed in *Section 13.9*.

Table 13.61: LSE Assessment for European Sites which are within the Potential Zone of Ecological Impact of the Project in Combination with Other Projects for Migratory Fish and Associated Species

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
River Tay SAC	37	Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzn marinus*), river lamprey (*Lampetra fluviatilis*), brook lamprey (*Lampetra planeri*).	All Favourable Maintained	Atlantic salmon - The River Tay supports a high-quality Atlantic salmon population, with rod catch returns showing that the Tay is consistently one of the top three salmon rivers in Scotland.	Atlantic Salmon is an anadromous species that migrates between freshwater spawning grounds and feeding grounds in the northern Atlantic. Little is known about the migration of smolt leaving Scottish east coast rivers, however they are likely to travel in a northerly and easterly direction en route to feeding grounds around Greenland (Malcolm *et al.*, 2010). Smolt leaving rivers in other counties have been recorded moving quickly to deeper more offshore waters when entering the marine environment, with no evidence for coastal migration and there is no reason to believe that Scottish smolt	**Construction Phase** Increased noise, SSC and temporary habitat disturbance during construction, have the potential to affect smolts, grilse and adult salmon migrating to and from the River Tay SAC. Noise modelling conducted for the Development Area (for impact pilling) indicates an area of approximately 14 km^2 may be affected by noise levels that would create a strong avoidance reaction in salmon (90 dBht) and 475 km^2 affected by noise levels that would potentially create mild avoidance reactions (75 dBht) assuming two piling vessels operate simultaneously. Noise modelling conducted for general cable construction indicates no avoidance or significant behavioural reactions of salmon (Nedwell *et al.*, 2003) thus despite noise being detectable along the Offshore Export Cable Corridor, no effects on migration are predicted. Despite this species being a hearing generalist, due to the likely direction of migration of adults and smolt (i.e. northwards and offshore	Atlantic salmon (Y)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
					would behave differently. It is postulated that smolt may migrate over a broad area unless there are areas of strong coastal currents (Malcolm *et al.*, 2010). Adults returning to rivers on the east coast of Scotland are predominately multi sea winter adults and return migration routes are likely to be across a broad front. Adult spawners are believed to enter east coast Scottish rivers from the south (migrating up the coast from Northumberland - Malcolm *et al.*, 2010). The swim bladder of salmon plays no part in the hearing of the species, and Hawkins and Johnstone (1978) found salmon to show low sensitivity to noise.	respectively), and the position of the Development Area relative to the mouth of the River Tay, a behavioural response caused by construction noise on River Tay SAC populations cannot be ruled out. Increased suspended sediments in the water column may act as a barrier to migration as a result of avoidance responses. Studies on salmon demonstrate an avoidance threshold of 100 $mgkg^{-1}$ over one hour. Salmon, however as partially estuarine species are likely to commonly tolerate increases in suspended sediments and as such be pre-adapted to this impact. Additionally, studies have shown that unless a whole body of water is blocked, migration will not be significantly affected (ABPmer, 2011). This impact is not predicted to significantly impact the Tay salmon population, due to temporary nature of both the impact and subsequent potential avoidance, and level of pre-adaptation to increased SSC.	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
					Furthermore, salmon are used to relatively noisy riverine environments, providing for some pre-adaption to elevated noise levels (Hawkins and Johnstone, 1978; Thomsen *et al*., 2006).	**Operational Phase** Operational noise from offshore wind farms has been reported to be in the region of 2 dB noisier than the surrounding sea environment (Nedwell *et al*., 2007). The relatively low frequency of operational noise (WTGs and vessels) will only have avoidance impacts in the immediate vicinity of source, e.g. one metre or below for hearing specialists' such as herring detailed in *Chapter 11*. Species with a poor sensitivity to noise, such as salmon, are likely to show a lesser response to operational noise, and as such migratory routes of the River Tay Atlantic salmon are not predicted to be impacted over the duration of the operational phase. The Project will result in long term habitat loss of 2.47 km^2. Given the range of this species and the fact that it is predicted to forage across a wide range of habitats, any habitat loss arising from the Project is insignificant in relation to the amount of similar habitat across the wider region. EMF effects caused by the Offshore Export Cable during operation may	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
						result in limited interaction with the River Tay population of Atlantic salmon. However, salmon are reported to swim in the upper 10 m of the water column, and thus it is considered that EMF impacts to salmon from subsea cables will not be present due to their attenuation in water depths greater than 20 m (Gill and Bartlett, 2010). Salmon from the Tay SAC also may come into contact with above impacts arising from the construction and operation of the Firth of Forth Phase 1 and Neart na Gaoithe projects and their cable routes. The on-going offshore wind and other projects, in-combination with the Project, are remote enough to not increase ambient noise levels and suspended sediments within the Development Area and Offshore Export Cable Corridor.	
				Sea lamprey - No selection information is available as they are cited as a qualifying feature but not a primary reason for	Little is known about the distribution of sea lamprey during the adult phase of their life cycle when they leave the river and disperse into coastal and offshore environments.	Increased noise, SSC, habitat disturbance and EMF have the potential to affect sea lamprey migrating to and from the River Tay SAC during construction and operation of the Project.	Sea lamprey (Y)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				selection of the site.	Sea lamprey may range widely following migration to sea, and no specific directions or routes have been identified. Records have been reported in shallow coastal waters and deep offshore waters suggesting they have a wide range and utilise a range of habitat types (Maitland, 2003). Sea lampreys do not appear to home to their natal streams, but instead are thought to be attracted to spawning areas by chemical cues released by conspecific larvae (Li *et al.*, 1995; Bjerselius *et al.*, 2000; Vrieze and Sorensen, 2001, cited in Watt, 2008). They do not possess specialist sensory organs such as otoliths or a swim bladder suggesting that the species are hearing	No audiogram exists for sea lamprey; however, as they do not possess specialist sensory organs such as otoliths or a swim bladder, for the purposes of this assessment it is assumed that sea lamprey are hearing generalists. The likely attenuation of construction noise in water may result in avoidance of sea lamprey from the noise footprint; however, this will be temporary in duration, and localised in extent representing a relatively small part of the species natural range, as sea lamprey may range widely following migration to sea and do not spend their entire life cycle in the marine environments. Increased SSC in the water column may act as a barrier to migration as a result of avoidance responses. However, as partially estuarine species, sea lamprey are likely to tolerate increases in suspended sediments and as such be pre-adapted to this impact. Therefore this impact is not predicted to be significant. Given the range of this species and the fact that it is predicted to forage across a wide range of habitats, any habitat loss arising from the Project is	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
					generalists. Sea lamprey are reported as having a relatively low detection threshold to the iE fields generated from subsea cables, although are able to detect fields as low as 10 μVm^{-1} (in line with other migratory fish – 8-25 μVm^{-1}), however no evidence of response to B fields exists (Gill and Bartlett, 2010). The fields produced from the Export Cable are therefore likely to be within the detectable range of this species, with detectable fields attenuating within 20 m of the Export Cable.	insignificant in relation to the amount of similar habitat across the wider region. Gill and Bartlett (2010) report that there is evidence of a weak response of sea lamprey to electric E-fields but not to magnetic B-fields. As there will be cabling onshore to the north and south of the Tay estuary (as a result of the Project in-combination with other projects in the area), a barrier effect from EMF may occur. Although no behavioural responses have been observed in sea lampreys in relation to detectable iE fields, it is considered that this species variable swimming depth will avoid barrier effects of this impact along the Offshore Export Cable Corridor, with detectable fields attenuating within 20 m of the Export Cable. Furthermore, as the Offshore Export Cable Corridor represents only a very small area of this species entire range, interactions are likely to be rare. As a result of this, the magnitude of this effect is considered to be negligible. Sea lamprey from the Tay SAC also may come into contact with above impacts arising from the construction and operation of the Firth of Forth Phase 1	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
						and Neart na Gaoithe projects and their cable routes. The on-going offshore projects are remote enough to not increase ambient noise levels and suspended sediments within the Development Area and Offshore Export Cable Corridor.	
				River lamprey - No selection information is available as they are cited as a qualifying feature but not a primary reason for selection of the site.	River lamprey migrate downstream to estuaries during the adult phase of the lifecycle and spend the majority of their adult life in estuarine habitats with restricted movements to open sea (Maitland, 2003), rarely leaving estuarine habitats. Populations are concentrated on a relatively small area during spawning, and SNH (2011) focus conservation measures within river habitats.	There will be no interaction with the designated river lamprey population with the Project due to its proximity to the Development Area, Offshore Export Cable Corridor including landfall options. As populations are concentrated on a relatively small area during spawning and SNH (2011) focus conservation measures within river habitats, the Project will have no effect on spawning individuals during this period.	River lamprey (N)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				Brook lamprey- No selection information is available; they are cited as a qualifying feature but not a primary reason for selection of the site.	The life cycle of brook lamprey takes place exclusively in freshwater.	As the life cycle of brook lamprey takes place exclusively in freshwater there is no opportunity for interaction with the Project.	Brook lamprey (N)
River South Esk SAC	24	Atlantic salmon (*Salmo salar*), freshwater pearl mussel (*Margaritifera margaritifera*).	Atlantic salmon – unfavourable recovering.	Atlantic salmon - The River South Esk supports a large, high-quality population in a river draining a moderate-sized catchment on the east coast of Scotland. The high proportion of the South Esk which is accessible to salmon and the range of ecological conditions in the	See species specific information for River Tay SAC (above).	**Construction Phase** Increased noise, SSC and temporary habitat disturbance have the potential to affect smolts, grilse and adult salmon migrating to and from the River South Esk SAC during construction. Noise modelling conducted for the Development Area and Offshore Export Cable Corridor works indicates that despite this species being a hearing generalist (see information above in River Tay SAC), due to the likely direction of migration of adults and smolt (i.e. northwards and offshore respectively), and the position of the Development Area relative to the mouth of the South Esk, a behavioural response caused by construction noise	Atlantic salmon (Y)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				river allows it to support the full range of life-history types found in Scotland, with sub-populations of spring, summer salmon and grilse all being present.		on the salmon population cannot be ruled out. Increased SSC in the water column may act as a barrier to migration as a result of avoidance responses, however this effect is not predicted to significantly impact the South Esk population of salmon, due to the temporary nature of both the effect and subsequent potential avoidance impact, and level of pre-adaptation to changing SSC (see information above in River Tay SAC). **Operational Phase** Species with a poor sensitivity to noise, such as salmon, are unlikely to show significant response to operational noise (see information above in River Tay SAC), and as such migratory routes of the South Esk salmon are not predicted to be impacted over the duration of the operation phase. Given the range of this species and the fact that it is predicted to forage across a wide range of habitats, any habitat loss arising from the Project is insignificant in relation to the amount of similar habitat across the wider region. EMF effects caused by the Offshore	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
						Export Cable during operation may result in limited interaction with adult salmon returning to the River South Esk from the south. However, due to the attenuation of EMF in deeper waters and the swimming position of salmon (see information above for River Tay SAC), EMF impacts on River South Esk populations are considered to be insignificant. Salmon from the River South Esk SAC may also come into contact with above impacts arising from the construction and operation of the Firth of Forth Phase 1 and Neart na Gaoithe projects. The on-going offshore projects are remote enough to not increase ambient noise levels and suspended sediments within the Development Area and Offshore Export Cable Corridor.	
			Freshwater pearl mussel – unfavourable declining.	These are abundant in the River South Esk, representing the south-eastern range of the species in Scotland. The FWPM	This species spend their entire life cycle in freshwater habitats, adults, however, during spawning young larvae released by females, attach to the gills of anadromous salmonids for survival. This is	Freshwater pearl mussel are only found as adult mussels in riverine environments only, they will only come into contact with the offshore elements of the Project as parasites on salmon gills. There is little information on the impacts of effects on freshwater pearl mussel larvae, however as their lifecycle rely on migrating salmonids an	Freshwater pearl mussel (Y)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				population is most abundant in the middle reaches of the river where they attain densities > 20 m^2. The conservation importance of the site is further increased by the abundance of juveniles which comprise approximately 20% of the population.	known as the glochidial phase of their lifecycle. Populations of FWPM require healthy salmonid populations for survival.	impacts on salmonids could impact on their populations. Therefore, any impacts (from construction and operation) on salmon migration are directly applicable to freshwater pearl mussel populations. Since there is a LSE on the designated Atlantic salmon population, the possibility of a LSE on freshwater pearl mussels cannot be ruled out.	
River Teith SAC	109	River lamprey (*Lampetra fluviatilis*), Brook lamprey (*Lampetra planeri*), Sea lamprey (*Petromyzon marinus*), Atlantic salmon	Atlantic salmon – unfavourable recovering.	Atlantic salmon- No selection information is available as they are cited as a qualifying feature but not a primary reason for selection of the site.	See species specific information in River Tay SAC (above).	**Construction Phase** Increased noise, SSC and temporary habitat disturbance have the potential to affect smolts, grilse and adult salmon migrating to and from the River Teith SAC during construction. Due to the position of the River Teith in relation to the development it is likely that different stages of the life cycle of salmon may be affected by different impacts of the Project.	Atlantic salmon (Y)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
		(*Salmo salar*).				Noise modelling conducted for the Development Area (see information above in River Tay SAC for details) indicates that behavioural response could be experienced by smolt migrating from the River Teith towards their northern feeding grounds. Increasing SSC in the water column from both Wind Farm and OfTW construction (see information above for River Tay SAC salmon) may act as a barrier to migration as a result of avoidance responses, however this impact is not considered to significantly impact the River Teith population of salmon, due to temporary nature of both the impact and subsequent potential avoidance, and level of pre-adaptation to changing SSC. **Operational Phase** Species with a poor sensitivity to noise, such as salmon, are unlikely to show significant response to operational noise (see information above in River Tay SAC for details), and as such, migratory routes of the River Teith salmon are not predicted to be impacted over the duration of the	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
						operation phase. Given the range of this species and the fact that it is predicted to forage across a wide range of habitats, any habitat loss arising from the Project is insignificant in relation to the amount of similar habitat across the wider region. EMF effects caused by the Project during operation may result in limited interaction with adult salmon returning to the South Esk from the south (smolt head north). However, due to the attenuation of EMF in deeper waters and the swimming position of salmon (see information above in River Tay SAC), EMF impacts on River Teith population are considered to be negligible. Salmon from the River Teith SAC may also come into contact with above impacts arising from the construction and operation of the Firth of Forth Phase 1 and Neart na Gaoithe projects and their cable routes. The other project are remote enough to not increase ambient noise levels and suspended sediments within the Project areas.	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
			All lamprey species – favourable maintained, The conservation importance of the River Teith is increased by the fact that, unlike many British rivers, it supports populations of all three lamprey species.	River lamprey – the River Teith supports a strong population. The river lacks any significant artificial barriers to migration, has good water quality and the necessary habitat types (extensive gravel beds and marginal silt beds) to support the river lamprey's full life-cycle.	See species specific information above.	There will be no interaction with the designated river lamprey population with the Project due to its proximity to the Development Area, Offshore Export Cable Corridor including landfall options. As populations are concentrated on a relatively small area during spawning and SNH (2011) focus conservation measures within river habitats, the Project will have no effect on spawning individuals during this period.	River lamprey (N)
				Brook lamprey – The river system supports a strong population that have been recorded from the headwaters downstream to the lower reaches. The river provides	See species specific information above.	As the life cycle of brook lamprey takes place exclusively in freshwater, there is no opportunity for interaction with the Wind Farm and OfTW.	Brook lamprey (N)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				excellent habitat with usually pristine water quality, well-vegetated banks and a substantially unaltered river channel			
				Sea lamprey – the River Teith represents part of the east coast range in the UK. Young sea lampreys have been recorded throughout the lower reaches of the main river.	See species specific information above.	Increased noise, SSC, habitat disturbance and EMF have the potential to affect sea lamprey migrating to and from the River Teith SAC during construction and operation of the Wind Farm and OfTW. Due to sea lamprey status as likely hearing generalists, the attenuation of construction noise, and the temporary and localised nature of this impact within a broad species range (see information above relating to River Tay population), it is unlikely that construction noise will impact upon this migratory species. However, due to the lack of knowledge about this species' adult life history, and relative proximity to the Development Area and Offshore Export Cable Corridor, an impact on the River Teith population cannot be ruled	Sea lamprey (Y)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
						out. Increasing suspended sediments in the water column may act as a barrier to migration as a result of avoidance responses. However, as partially estuarine species, sea lamprey are likely to commonly tolerate increases in suspended sediments and as such be pre-adapted to this impact. Gill and Bartlett (2010) report that there is evidence of a weak response of sea lamprey to electric E-fields but not to magnetic B-fields. As there will be cabling onshore to the north and south of the River Teith estuary (as a result of cabling from the Project and other wind farm projects in the region) a barrier effect may occur. Due to the swimming behaviour of this species, attenuation of EMF, and the likely range of this species (see information above in River Tay above for details), an effect of EMF on the Teith population is considered unlikely, although it cannot be ruled out. The other on-going offshore projects are remote enough to not increase ambient noise levels and suspended sediments within the Development	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
						Area and Offshore Export Cable Corridor.	
River Dee SAC	45	Atlantic Salmon (*Salmo salar*), Freshwater pearl mussel (*Margaritifera margaritifera*) .	Atlantic salmon – favourable maintained.	Atlantic salmon - The River Dee supports a high-quality population in a river draining a large catchment on the east coast of Scotland. The river supports the full range of life-history types found in Scotland, with sub-populations of spring, summer salmon and grilse all being present. The headwaters which drain the southern Cairngorm and northern Grampian mountains are particularly important for	See species specific information above.	**Construction Phase** Construction noise, habitat disturbance and increased SSC are unlikely to affect smolt leaving the River Dee as they are likely to travel in a northerly direction towards their northerly feeding grounds and therefore not come into contact with the Development Area and Offshore Export Cable Corridor. Adult salmon returning to freshwater habitats to spawn migrate along the coast from the south therefore are unlikely to be affected by noise and SSC from the Wind Farm and OfTW. **Operational Phase** Species with a poor sensitivity to noise, such as salmon, are unlikely to show significant response to operational noise, and as such migratory routes of the River Dee salmon are not predicted to be impacted over the duration of the operation phase. Given the range of this species and the fact that it is predicted to forage across a wide range of habitats, any habitat loss arising from the Project is	Atlantic salmon (N)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				multi sea-winter spring salmon.		considered insignificant in relation to the amount of similar habitat across the wider region. EMF effects caused by the Export Cable during operation may result in limited interaction with adult salmon returning to the River Dee from the south. However, due to the attenuation of EMF in deeper waters and the swimming position of salmon, EMF impacts on River Dee population are considered to be insignificant. The cable routes from the Firth of Forth Phase 1 and Neart na Gaoithe projects also have the potential to interact with returning adult salmon from the River Dee SAC. The other on-going offshore projects are remote enough to not increase ambient noise levels and suspended sediments within the Development Area and Offshore Export Cable Corridor.	
			Freshwater pearl mussel – unfavourable no change.	Freshwater pearl mussel – The River Dee supports a functional	See species specific information above.	Freshwater pearl mussels are only found as adult mussels in riverine environments, they will only come into contact with the offshore elements of the Project as parasites on salmon gills.	Freshwater pearl mussel (N)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				population recorded from a location approximately 30 km from the river source to approximately six to seven kilometres upstream from its mouth. Juveniles make up approximately 30% of the recorded population, among the highest proportions recorded in Scotland. This indicates that the population is recruiting strongly and is one of the most important in the UK.		There is little information on the impacts of effects on freshwater pearl mussel larvae, however as their lifecycle rely on migrating salmonids, impacts on salmonids could impact on their populations. Therefore, any impacts (from construction and operation) on salmon migration are directly applicable to freshwater pearl mussel populations Since no LSE were concluded for the Atlantic salmon population, no LSE on freshwater pearl mussels can be concluded.	

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
River Tweed SAC	63	Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), brook lamprey (*Lampetra planeri*).	Atlantic salmon – unfavourable recovering.	The River Tweed supports a very large, high-quality Atlantic salmon population in a river which drains a large catchment on the east coast of the UK, with sub-catchments in both Scotland and England. The high proportion of the River Tweed accessible to salmon, and the variety of habitat conditions in the river, has resulted in the Scottish section of the river supporting the full range of salmon life-history types, with sub-populations of spring, summer	See species specific information above.	As returning adults are known to migrate from a southerly direction along the east coast, noise, increased SSC, habitat loss and EMF from the Development Area and Offshore Export Cable Corridor are unlikely to impact the returning adult population. Construction noise has the potential to affect smolts migrating to their northern feeding grounds, however, smolts have been recorded heading further offshore when entering the marine environment and there is no evidence of coastal migration. Due to the range of the species, and the offshore northward direction of migration and the likely temporary use of the area, disturbance from the Project and other offshore wind farm projects is very unlikely to significantly affect the designated River Tweed population of Atlantic salmon.	Atlantic salmon (N)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				salmon and grilse all being present. In recent years, the salmon catch in the River Tweed is the highest in Scotland, with up to 15% of all salmon caught.			
			All lamprey species – unfavourable no change.	Sea lamprey - No selection information is available as they are cited as a qualifying feature but not a primary reason for selection of the site.	See species specific information above.	Due to the distance of the River Tweed SAC from the Development Area and Offshore Export Cable Corridor, and the likely range of the species, increased noise, SSC, habitat disturbance and EMF, effects are considered unlikely to impact upon the sea lamprey population.	Sea lamprey (N)
				River lamprey - No selection information is available as they are cited as a qualifying feature but not a primary reason for selection of the	See species specific information above.	There will be no interaction with the designated river lamprey population and the Wind Farm and OfTW due to the distance of the Project from the populations. As populations are concentrated in relatively small areas during spawning SNH (2011) focus conservation measures within river habitats. The Wind Farm and OfTW will	River lamprey (N)

European Site Name	Distance to the Development Area (km)	Relevant Qualifying interest	Status	Species and Reason for Selection	Information on Species biology/life history	Potential impact of the Project or in-combination.	Likely Significant Effect? (Y/N)
				site.		have no effect on spawning individuals during this period.	
				Brook lamprey - No selection information is available as they are cited as a qualifying feature but not a primary reason for selection of the site.	See species specific information above.	The life cycle of brook lamprey takes place exclusively in freshwater, therefore, there is no opportunity for interaction with the Project.	Brook lamprey (N)

390 Based on the conclusions in Table 13.61 above impacts on Atlantic salmon, freshwater pearl mussels and sea lamprey will be the focus of the Appropriate Assessment.

13.13.3 Appropriate Assessment

391 An assessment of the potential impacts on Annex II fish species (defined as the "SAC qualifying features" receptor group in this chapter) resulting from the construction, O&M, or decommissioning of the Project and in-combination with other projects in the area, is provided within this chapter (see *Section 13.6 – 13.9* above). A summary of the predicted significance of impacts assessed within this chapter is provided in Table 13.62 below.

Table 13.62: Summary of Potential Effects on SAC Fish Species, from the EIA Assessment for the Project Related Activities In-combination with Other Projects

Potential Effect	Predicted significance of effect	
	Project	**In-combination**
Construction and Decommissioning Phases		
Barrier effects, disturbance or physical injury associated with construction noise	(Mortality and injury) = Minor/Moderate (Behavioral responses) = Moderate	(Mortality and injury) = Minor/Moderate (Behavioral responses) = Moderate
Direct temporary habitat disturbance	Minor/Moderate	Minor/Moderate
Indirect disturbance as a result of sediment deposition and temporary increases in SSC	Minor/Moderate	Minor/Moderate
Operation and Maintenance Phases		
Behavioural responses to EMF associated with cabling	Moderate	Moderate
Long term loss of original habitat	Minor/Moderate	Minor/Moderate
Disturbance or physical injury associated with operational noise	(Mortality and injury) = Minor/Moderate (Behavioural responses) = Moderate	Minor/Moderate

392 Potential effects on the prey species sandeels were also assessed within this chapter, as per scoping opinions. Analysis of the habitat suitability (*Appendix 13B*) within the Development Area shows the area to have very little habitat of prime suitability, and distinct areas, especially in the north of the Development Area, are identified as subprime habitat. The Offshore Export Cable

Corridor has only one site which shows suitability for sandeels, situated towards the offshore section of the corridor. The remainder of the Offshore Export Cable Corridor shows unsuitable habitat for sandeels, with the sediments being predominantly muddy sands. Due to the wide foraging areas of migratory fish, which may feed on this prey species, the small spatial scale of the impact in relation to the North Sea population of sandeels, and the relatively small areas of prime sandeel habitat within the Development Area and Offshore Export Cable Corridor, the effect of habitat disturbance on sandeels is considered to be of negligible magnitude, and impacts on sandeels are not further presented for assessment within the HRA.

393 Impacts on benthic habitats have been assessed in *Chapter 12*. Predicted impacts have been identified as being limited to the Development Area and Offshore Export Cable Corridor and significant far field effects are not expected. As there is no direct overlap with the SACs and the Development Area and Offshore Export Cable Corridor, impacts on habitats are not further presented for assessment within the HRA.

394 Due to these degrees of uncertainty surrounding estimation of impact on fish and shellfish held throughout academia and industry, the assessment incorporates a series of conservative assumptions about the potential impacts of noise on fish and shellfish. Table 13.63 provides details of the assumptions relevant to this assessment and why they represent an appropriate degree of conservatism to inform an Appropriate Assessment.

Table 13.63: Key Assumptions Made During the Fish and Shellfish Impact Assessment and their Degree of Conservatism

Impact	Assumption	Degree of conservatism
Construction phase		
Barrier effects, disturbance or physical injury associated with construction noise.	Noise modelling locations represent worst case noise scenarios for SAC qualifying feature species.	This approach introduces an inherent conservatism over the duration of the construction phase. Two piling locations closest to the sensitive receptors (SACs) have been chosen and affects modelled to occur for two years. This is an overestimation of effect as the majority of piling will be more distant than these most sensitive locations, and the piling will not be constant throughout the two year period.
	Audiograms for salmon are suitable surrogates for other SAC qualifying species.	No audiogram exists for sea lamprey; however, they do not possess any specialist sensory organs such as otoliths or a swim bladder suggesting that the species has lower hearing thresholds than that of salmon. Using salmon (a species with a swim bladder) as a surrogate for lamprey is therefore likely to produce an overestimation of associated effect upon the lamprey population.
Indirect disturbance as a result of sediment deposition and temporary	SSC modelling represents worst case sediment plume scenarios for SAC qualifying feature species.	The elevated levels of SSC predicted to occur during preparation of GBS foundations (of 213 WTGs, five OSPs and three met masts) are considered to be an over estimation based on worst case scenarios during construction (i.e. substrate type across the whole Development Area, and height at which dredged material is released). Conservatism is inherent to the modelling scenario; therefore, this is

Impact	Assumption	Degree of conservatism
increases in SSC.		carried through to the assessment of impacts on SAC qualifying feature species. Furthermore, SAC qualifying feature species spend part of their life cycle in riverine environments which are often highly turbid. Therefore these species are considered to have a degree of preadaptation to temporary increases in SSC.
Direct temporary habitat disturbance.	SAC qualifying feature species with a marine phase in their life history may use the Development Area and Offshore Export Cable Corridor as a foraging ground and/or pass through it on migrations to and from SACs.	This assumption introduces conservatism throughout both the construction and operational phases of the Project, as although there is uncertainty surrounding the migratory pathways taken by SAC qualifying feature species, these species are known to migrate over large distances. In the case of salmon, smolt are likely to travel in a northerly and easterly direction en route to feeding grounds around Greenland (Malcolm *et al*., 2010), and when leaving rivers they have been recorded moving quickly to deeper more offshore waters with no evidence for coastal migration. Furthermore, return migration routes of adult salmon returning to rivers on the east coast of Scotland are likely to be across a broad front, and are believed to enter east coast Scottish rivers from the south (migrating up the coast from Northumberland - Malcolm *et al.* (2010). Given the likely range of foraging area available for these species and the evidence to suggest rapid movement of smolt offshore, the assumption that these species use the Development Area is conservative. No specific migratory directions or routes have been identified for sea lamprey. However records have been reported in shallow coastal waters and deep offshore waters suggesting they, like salmon, range widely following migration to sea, and utilise a range of habitat types (Maitland, 2003). The assumption that these species use the Development Area is therefore also conservative.
Operational Phase		
Behavioural responses to EMF associated with cabling.	All migratory SAC qualifying feature species may be impacted by EMF (both B and iE fields).	Salmon are sensitive to magnetic (B) fields as they are known to use them (along with other senses) to navigate. However, the assumption that this may result in a change in their behaviour is conservative as studies of the behavioural reactions to B fields have been inconclusive, and indicate that it is unlikely that magnetic cues are solely relied upon for navigation, (Lohman *et al*., 2008). Furthermore, although there may be small behavioural changes in swimming behaviour of chum salmon, magnetic fields do not significantly affect migration patterns (Yano *et al*., 1997), and salmon are reported to predominately swim in the upper 10 m of the water column (Malcolm *et al*., 2010), and it is considered that EMF impacts to salmon from subsea cables will not be present in water depths greater than 20 m due to the attenuation of EMF in seawater (Gill and Bartlett,

Impact	Assumption	Degree of conservatism
		2010). Sea lamprey are reported as having a low detection threshold to the iE fields generated from subsea cables. They are able to detect fields down to 10 µV/m^{-1}, however, no evidence of response to B fields exists (Gill and Bartlett, 2010). Although information on the iE field for the inter-array cables has not been modelled, assuming similar values to the Kentish flats offshore wind farm predicted, iE fields of 2.5 µV/m. This would be below that detectable by sea lamprey.
	SAC qualifying feature species with a marine phase in their life history will pass through the Development Area.	As stated above, the assumption that SAC qualifying feature species pass through the Development Area (and therefore will interact with EMF produced by inter-array cables) introduces conservatism throughout both the operational and construction phase of the Wind Farm, as there is uncertainty surrounding the migratory pathways taken by these species (see 'Direct temporary substrate loss').
Long term habitat loss.	SAC qualifying feature species with a marine phase in their life history may use the Development Area and Offshore Export Cable Corridor as a foraging ground and/or pass through it on migrations to and from SACs.	As stated above, the assumption that SAC qualifying feature species utilise the Development Area and Offshore Export Cable Corridor as a foraging ground and/or pass through on migrations to and from SACs is conservative due to uncertainties in their migratory routes (see 'Direct temporary substrate loss').
Disturbance or physical injury associated with operational noise.	SAC qualifying feature species will be sensitive to operational noise within the Development Area.	This is a conservative assumption. Although a review by Wahlberg and Westerberg (2005) concluded that operational noise from an offshore wind farm would be detectable out to 25 km from source for salmon, the species specific noise modelling undertaken for the piling in the Development Area showed salmon to be the least sensitive of the fish species modelled for operational noise, and as for the other species, predicted an avoidance range of less than one metre from the WTGs. The relatively low frequency of operational noise (WTGs and vessels) will only have avoidance impacts in the immediate vicinity of source, e.g. one metre or below for hearing specialists' such as herring detailed in *Chapter 11*. Species with a poor sensitivity to noise, such as salmon, are likely to show a lesser response to operational noise.

395 Terminology used in this assessment is based on that suggested by the Intergovernmental Panel on Climate Change (IPCC) as agreed on consultation with regulators. Definitions provided by the IPCC for levels of confidence in an assessment can be found in Table 13.64 and Table 13.65 below.

Table 13.64: Definition for the Likelihood of a Defined Outcome Having Occurred or Occurring in the Future, as Defined by the IPCC

Terminology	Likelihood of occurrence/outcome
Virtually certain	>99% probability of occurrence
Very likely	>90% probability of occurrence
Likely	>66% probability of occurrence
About as likely as not	33-66% probability of occurrence
Unlikely	<33% probability of occurrence
Very unlikely	<10% probability of occurrence
Exceptionally unlikely	<1% probability of occurrence

Table 13.65: Quantitatively Calibrated Levels of Confidence Used in this Assessment as Defined by the IPCC

Terminology	Degree of confidence in being correct
Very high confidence	At least 9 out of 10 chance of being correct
High confidence	About 8 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than 1 out of 10 chance

396 Assignation of these confidence and likelihood values within the context of this assessment takes into account the conservative assumptions detailed in Table 13.63. It is considered that the sum of all these assumptions represents an overly conservative model, and that predicted impacts to the level of those described in the assessments are possible and not probable. Confidence that 'likely' impacts (Table 13.64 above) are within the ranges predicted by the models used is therefore 'high' or 'very high' (Table 13.65 above) for the assessment undertaken below.

397 As part of the EIA for designated sites, and to provide information to the competent authority, the following tables (Table 13.66 to Table 13.68) summarise the effects the Project and other projects may have on SACs under investigation. This has been carried out in respect of generic criterion of the conservation objectives. Where no LSE have been identified for a SAC, the site has not been carried forward into the Appropriate Assessment.

398 The following assessments are based upon information from a number of studies, and expert judgement. Where uncertainty prevents a confident prediction of impact this has been indicated with a lower confidence score. They are informed by the conclusions in *Section 13.9*.

Table 13.66: Assessment of the Conservation Objectives of the River Tay SAC from the Project Related Activities and In Conjunction with Other Projects ('In-combination')

Criterion	River Tay SAC Qualifying Migratory Species: Atlantic salmon, brook lamprey, river lamprey and sea lamprey
	Assessment
Population of the species, including range of genetic types for salmon, as a viable component of the site.	Increased noise levels during construction/decommissioning have the potential to affect Atlantic salmon and sea lamprey populations within the Tay SAC through the potential for barrier effects to migrating animals. No interactions of increased SSC levels produced via construction or decommissioning processes from the projects considered are predicted by the coastal processes assessment, and as such no cumulative barrier to migration is predicted to arise from this impact. Simultaneous piling at the Neart na Gaoithe wind farm and the Project are predicted to form a band of noise 50 km in extent in a north - south direction, detectable to salmon at 75 dB_{ht} i.e. at a level where mild behavioural responses are predicted to occur (for example changes in swimming direction, speed etc.). Simultaneous piling at the Firth of Forth Phase 1 site does not add to this barrier. This barrier covers half of the north - south extent of the sea area in this locale, and although it will not fully obstruct access to and from the Tay, it does have the potential to cause increased energetic cost to migration activities. The extent of potential behavioural effects at 75 dB_{ht}, at the closest point, is six kilometres away from the coastline and therefore species migrating to and from the Tay estuary, using the coastal environment, are not likely to encounter construction noise and vibration and therefore will not be displaced or affected in their normal movement. Due to the range of the species, the predominately northerly direction of migration, and the likely temporary use of the Project areas, acoustic disturbance and suspended sediment increases are not considered likely to significantly affect the population of Atlantic salmon or sea lamprey. The EIA assessment for the Project only and cumulative assessment have predicted noise piling, and increases in suspended sediment impacts on migratory fish to be at **most moderate adverse and therefore not significant in EIA terms**. During operation, it is possible that EMF from the Export Cable or inter-array cables may create barrier effects in close proximity to the River Tay SAC. Although it has been hypothesised that salmon may be disorientated during their return spawning migrations, Atlantic salmon and sea lamprey will only pass Project areas intermittently during migrations. In addition, the scale at which an individual will experience this effect will be only in close proximity to the Export Cables. The cumulative impact of EMF from cables from the Project and other projects considered in this assessment, is judged to be of **moderate significance and not significant in EIA terms**. There is no predicted potential impact on brook lamprey or river lamprey from the Project as there is no route to connectivity between the Project areas and these notified interests of the River Tay SAC.

Criterion	River Tay SAC Qualifying Migratory Species: Atlantic salmon, brook lamprey, river lamprey and sea lamprey
	Assessment
	• Changes in the population of species (Atlantic salmon, sea lamprey, brook lamprey, river lamprey), including range of genetic types in salmon, as a viable component of the Tay SAC are considered to be **unlikely** and **not significant** in the short or long term. • Confidence level: **High.**
Distribution of the species within site.	• The primary impacts which may change distribution of Atlantic salmon and sea lamprey within the SAC are barrier effects caused by increased suspended sediment, and increased anthropogenic noise levels during construction due to piling activities. Salmon and sea lamprey migrations are wide ranging, and suspended sediment increase is considered likely to cause only short term localised avoidance. The EIA assessments of Project alone cumulatively have predicted suspended sediment and noise impacts of piling on migratory fish to be at **most moderate adverse and therefore not significant.** There is no predicted impact on brook lamprey or river lamprey as there is no route to impact between the Project areas and the SAC. Changes in distribution of the species within the River Tay SAC are considered to be **unlikely and not significant** in the short or long term. • Confidence level: **High.**
Distribution and extent of habitats supporting the species.	Predictions made within this EIA as set-out above, indicate that habitat loss is insignificant for migratory species due to their potential range, and the fact that the River Tay SAC, the Project and other projects do not overlap. There is no predicted impact on brook lamprey, or river lamprey as there is no route to impact between the Project areas and the SAC. • Changes in distribution and extent of habitats within the River Tay SAC, supporting the qualifying species, are considered unlikely and **not significant** in the short or long term. • Confidence Level**: Very High.**
Structure, function and supporting processes of habitats supporting the species.	Predictions made within this EIA as set-out above, indicate that habitat loss is insignificant for migratory species due to their potential range, and the fact that the River Tay SAC, the Project and other projects do not overlap. • Changes in structure and function of supporting habitats supporting the qualifying species of the River Tay SAC are considered unlikely and **not significant** in the short or long term. • Confidence Level: **Very High.**

Criterion	River Tay SAC Qualifying Migratory Species: Atlantic salmon, brook lamprey, river lamprey and sea lamprey
	Assessment
No significant disturbance of the species.	The primary impact is considered to be increased noise from piling during construction, however the 90 dB_{ht} (salmon) noise contour for salmon do not extend to the River Tay SAC. Noise disturbance at sea has the potential to disturb some species associated with the SAC, in particular Atlantic salmon and sea lamprey migrating to and from the SAC, however is not predicted to form a barrier to movement. Due to the range of the species, the predominately northerly direction of migration, and the likely temporary use of the area, acoustic disturbance is not considered likely to significantly affect the population of Atlantic salmon or sea lamprey. There is no predicted impact on brook lamprey or river lamprey as there is no route to impact between the Project areas and the SAC. The EIA assessment for the Project alone and the cumulative assessment have predicted piling noise, and suspended sediment impacts on migratory fish to be at **most moderate adverse and therefore not significant** in EIA terms. • All other potential impacts on Atlantic salmon and sea lamprey were predicted to be of at worst moderate significance, as a result of the receptor groups' high sensitivity, assigned due to conservation importance, rather than sensitivity to the impact in question. The impact is therefore is **not significant** in the short or long term. • Confidence Level: **High.** **Even when considered in combination it is considered highly unlikely that these will cause significant disturbance to species.** There is no predicted impact on brook lamprey or river lamprey as there is no route to impact between the Project areas and the SAC. Significant disturbance of the qualifying species of the River Tay SAC is considered unlikely and not significant in the short or long term. **Confidence level: High.**

399 **It is predicted that the Project alone or in combination will not affect maintenance of the integrity of the River Tay SAC and that the River Tay SAC will maintain an appropriate contribution to achieving favourable conservation status of the qualifying species.**

Table 13.67: Assessment of the Conservation Objectives of the River South Esk SAC, the Project Related Activities and In Conjunction with Other Projects ('In-combination')

Criterion	River South Esk Qualifying Migratory Species: Atlantic salmon and Fresh water pearl mussels
	Assessment
Population of the species, including range of genetic types for salmon, as a viable component of the site.	Increased noise levels during construction/decommissioning have the potential to affect Atlantic salmon within the River South Esk SAC through the potential for barrier effects to migrating species. No interactions of increased SSC levels produced via construction or decommissioning processes from the projects considered are predicted by the coastal processes assessment, and as such no cumulative barrier to migration is predicted to arise from this impact. Simultaneous piling at the Neart na Gaoithe site and the Project is predicted to form a band of noise 50 km in extent in a north-south direction, detectable to salmon at 75 dB_{ht} (salmon) i.e. at a level where mild behavioural responses are predicted to occur (e.g. changes in swimming direction, speed etc.). Simultaneous piling at the Firth of Forth Phase 1 site does not add to this barrier. This barrier covers half of the north - south extent of the sea area in this locale, and although it will not fully obstruct access to and from the River South Esk, it does have the potential to cause increased energetic cost to migration activities. The extent of behavioural effects, at 75 dB_{ht} (salmon) at the closest point, is six kilometres away from the coastline and therefore species migrating to and from the River South Esk, using the coastal environment are not likely to encounter construction noise and vibration and therefore will not be displaced or affected in their normal movement. Due to the range of the species, the predominately northerly direction of migration, and the likely temporary use of the area, acoustic disturbance and suspended sediment are not considered likely to significantly affect the population of Atlantic salmon. The EIA assessment for the Project alone and in-combination assessment have predicted piling noise, and suspended sediment impacts on migratory fish to be at **most moderate adverse and therefore not significant in EIA terms**. During operation, it is possible that EMF from the Export Cable or inter-array cables may create barrier effects in close proximity to the River South Esk SAC. Although it has been hypothesised that salmon may be disorientated during their return spawning migrations, Atlantic salmon will only pass Project areas intermittently during migrations. In addition, the scale at which an individual will experience this effect will be only in close proximity to the Export Cables. The cumulative impact of EMF from cables from the Project and other projects considered in this assessment, is judged to be of **moderate significance and not significant in EIA terms**. As freshwater pearl mussel rely on migrating salmonids during the glochidial stage of their lifecycle when the larvae attach to the gills of passing fish, effects on salmon populations will be reflected in freshwater pearl mussel distribution. As changes in the River South Esk SAC Atlantic salmon populations are considered to be unlikely and not significant in the long term it can be concluded that effects on populations of freshwater pearl mussel will be of a similar or lesser magnitude.

Criterion	River South Esk Qualifying Migratory Species: Atlantic salmon and Fresh water pearl mussels
	Assessment
	• Changes in the River South Esk SAC Atlantic salmon and fresh water pearl mussel population are considered to be **unlikely and not significant** in the short or long term. • Confidence level: **High.**
Distribution of the species within site.	The primary impacts which may change distribution of Atlantic salmon within the SAC are barrier effects caused by increased suspended sediment and increased anthropogenic noise levels during construction due to piling activities. Salmon migrations are wide ranging and SSC increase is considered likely to cause only short term localised avoidance. The EIA assessments of the Project alone and in-combination have predicted SSC and noise impacts of piling on migratory fish to be at worse **moderate adverse and therefore not significant.** As freshwater pearl mussel rely on migrating salmonids during the glochidial stage of their lifecycle when the larvae attach to the gills of passing fish, effects on salmon distribution may be reflected in freshwater pearl mussel distribution. As changes in the distribution of the River South Esk SAC population of Atlantic salmon are considered to be unlikely, it can be concluded that effects on populations of freshwater pearl mussel will be of a similar or lesser magnitude. • Changes in distribution of the species within the River South Esk SAC are considered to be **unlikely and not significant** in the short or long term. • Confidence level: **High.**
Distribution and extent of habitats supporting the species.	Predictions made within this EIA as set-out above indicate that habitat loss is insignificant for migratory species due to their potential range, and the SAC and the Project and other projects do not overlap. As freshwater pearl mussel rely on migrating salmonids during the glochidial stage of their lifecycle when the larvae attach to the gills of passing fish, effects on salmon populations will be reflected in freshwater pearl mussel distribution. As changes in habitat distribution of River South Esk SAC, Atlantic salmon are considered not significant, it can be concluded that effects on populations of freshwater pearl mussel will be of a similar or lesser magnitude, therefore: • Changes in distribution and extent of habitats within the River South Esk SAC, supporting the qualifying species, are considered unlikely and **not significant** in the short or long term**.** • Confidence Level**: Very High.**

Criterion	River South Esk Qualifying Migratory Species: Atlantic salmon and Fresh water pearl mussels
	Assessment
Structure, function and supporting processes of habitats supporting the species.	Predictions made within this EIA as set-out above, indicate that habitat loss is insignificant for migratory species due to their potential range, and the fact that the SAC and the Project and other projects do not overlap. As freshwater pearl mussels rely on migrating salmonids during the glochidial stage of their lifecycle when the larvae attach to the gills of passing fish, effects on salmon populations will be reflected in freshwater pearl mussel distribution. As changes in structure and function of supporting habitats of River South Esk SAC, Atlantic salmon are considered not significant, it can be concluded that effects on populations of freshwater pearl mussels will be of a similar or lesser magnitude. • Changes in structure and function of supporting habitats supporting the qualifying species of the River South Esk SAC are considered unlikely and **not significant** in the short or long term. • Confidence Level: **Very High.**
No significant disturbance of the species.	The primary impact is considered to be increased noise from piling during construction, however the 90 dB_{ht} (salmon) noise contour for salmon do not extend to the River South Esk SAC. Noise disturbance at sea has the potential to disturb some animals associated with the SAC, (i.e. Atlantic salmon) migrating to and from the site, however is not predicted to form a barrier to movement. Due to the range of the species, the predominately northerly direction of migration, and the likely temporary use of the area, acoustic disturbance is not considered likely to significantly affect the population of Atlantic Salmon. The EIA assessment for Project alone and the cumulative assessment have predicted noise piling, and SSC impacts on migratory fish to be at most **moderate adverse and therefore not significant in EIA terms**. **All other potential impacts on Atlantic salmon were predicted to be of at worst moderate significance, as a result of the receptor groups' High sensitivity, assigned due to conservation importance, rather than sensitivity to the impacts in question.** As freshwater pearl mussels rely on migrating salmonids no significant disturbance is predicted for this species. • Even when considered in combination, it is considered highly unlikely this will cause significant disturbance to species, and therefore is **not significant** in the short or long term. • Confidence Level: **High.**

Criterion	River South Esk Qualifying Migratory Species: Atlantic salmon and Fresh water pearl mussels
	Assessment
Distribution and viability of freshwater pearl mussel host species.	As freshwater pearl mussel rely on migrating salmonids during the glochidial stage of their lifecycle when the larvae attach to the gills of passing fish, effects on salmon populations will be reflected in freshwater pearl mussel distribution. As changes in structure and function of supporting habitats of River South Esk SAC Atlantic salmon are considered not significant, it can be concluded that effects on populations of freshwater pearl mussel will be of a similar or lesser magnitude. • Changes in structure and function of supporting habitats supporting freshwater pearl mussel host species are considered unlikely and **not significant** in the short or long term**.** • Confidence Level: **High.**
Changes in structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.	As there is no connectivity between the freshwater habitats and the Development Area and Offshore Export Cable Corridor there is no possibility that the construction/operation/decommissioning effects could result in a changes in structure, function and supporting processes of habitats supporting freshwater pearl mussel host species. • Changes in structure and function of supporting habitats supporting freshwater pearl mussel host species are considered unlikely and **not significant** in the short or long term**.** • Confidence Level: **High.**

400 **It is predicted the Project will not affect maintenance of the integrity of the River South Esk SAC and that the River South Esk SAC will maintain an appropriate contribution to achieving favourable conservation status of the qualifying species.**

Table 13.68: Assessment of the Conservation Objectives of the River Teith SAC, the Project Related Activities and In Conjunction with Other Projects ('In-combination')

Criterion	River Teith SAC Qualifying Migratory Species: Atlantic salmon, brook lamprey, river lamprey and sea lamprey
	Assessment
Population of the species, including range of genetic types for salmon, as a viable component of the site.	Increased noise levels during construction/decommissioning have the potential to affect Atlantic salmon and sea lamprey populations within the River Teith SAC through the potential for barrier effects to migrating animals. No interactions of increased SSC levels produced via construction or decommissioning processes from the projects considered are predicted by the coastal processes assessment, and as such no cumulative barrier to migration is predicted to arise from this impact Simultaneous piling at the Neart na Gaoithe site and the Project areas is predicted to form a band of noise 50 km in extent in a north - south direction, detectable to salmon at 75 dB_{ht} i.e. at a level where mild behavioural responses are predicted to occur (for example changes in swimming direction, speed etc.). Simultaneous piling at the Firth of Forth Phase 1 site does not add to this barrier. This barrier covers half of the north - south extent of the sea area in this locale, and although it will not fully obstruct access to and from the River Teith SAC, it does have the potential to cause increased energetic cost to migration activities. The extent of potential behavioural effects at 75 dB_{ht} (salmon) at the closest point, is six kilometres away from the coastline and therefore species migrating to and from the Teith estuary using the coastal environment, are not likely to encounter construction noise and vibration and therefore will not be displaced or affected in their normal movement. Due to the range of the species, the predominately northerly direction of migration, and the likely temporary use of the area, acoustic disturbance and suspended sediment are not considered likely to significantly affect the population of Atlantic salmon or sea lamprey. The EIA assessment for the Project alone and cumulative assessments have predicted noise piling, and suspended sediment impacts on migratory fish to be at **most moderate adverse and therefore not significant in EIA terms**. • During operation, it is possible that EMF from the Export Cable or inter-array cables may create barrier effects in close proximity to the Teith SAC. Although it has been hypothesised that salmon may be disorientated during their return spawning migrations, Atlantic salmon and sea lamprey will only pass Project areas intermittently during migrations. In addition, the scale at which an individual will experience this effect will be only in close proximity to the Export Cables. The cumulative impact of EMF from cables from the Project and other projects considered in this assessment, is judged to be of moderate significance and not significant in EIA terms. There is no predicted potential impact on brook lamprey or river lamprey from the Wind Farm and OfTW as there is no route to connectivity between the Project area and these notified interests of the SAC. • Changes in the population of species (Atlantic salmon, sea lamprey, brook lamprey, river lamprey), including range of genetic types in salmon, as a viable component of the River Teith SAC are considered to be **unlikely** and **not significant** in the short or long term. • Confidence level: **High.**

Criterion	River Teith SAC Qualifying Migratory Species: Atlantic salmon, brook lamprey, river lamprey and sea lamprey
	Assessment
Distribution of the species within site.	The primary impacts which may change distribution of Atlantic salmon and sea lamprey within the SAC are barrier effects caused by increased suspended sediment and increased anthropogenic noise levels during construction due to piling activities. Salmon and sea lamprey migrations are wide ranging, and SSC increase is considered likely to cause only short term localised avoidance. The EIA assessments of the Project alone and cumulatively have predicted suspended sediment and noise impacts of piling on migratory fish to be at worse **moderate adverse and therefore not significant.** There is no predicted impact on brook lamprey or river lamprey as there is no route to impact between the Project areas and the SAC. • Changes in distribution of the species within the River Teith SAC are considered to be **unlikely and not significant in the long term.** • Confidence level: **High.**
Distribution and extent of habitats supporting the species.	Predictions made within this EIA as set-out above indicate that habitat loss is insignificant for migratory species due to their potential range and the fact that the SAC and the Project areas and other project areas do not overlap. There is no predicted impact on brook lamprey, or river lamprey as there is no route to impact between the Project areas and the SAC. • Changes in distribution and extent of habitats within the River Teith SAC, supporting the qualifying species, are considered unlikely and **not significant in the long term.** • Confidence Level**: Very High.**
Structure, function and supporting processes of habitats supporting the species.	• Predictions made within this EIA as set-out above, indicate that habitat loss is insignificant for migratory species due to their potential range, and the fact that the SAC and the Project areas and other project areas do not overlap. Changes in structure and function of supporting habitats of the qualifying species of the River Teith SAC are considered unlikely and **not significant** in the short or long term. • Confidence Level: **Very High.**

Criterion	River Teith SAC Qualifying Migratory Species: Atlantic salmon, brook lamprey, river lamprey and sea lamprey
	Assessment
No significant disturbance of the species.	The primary impact is considered to be increased noise from piling during construction, however the 90 dB noise contour for salmon do not extend to the River Teith SAC. Noise disturbance at sea from piling has the potential to disturb some animals associated with the SAC, in particular Atlantic salmon and sea lamprey migrating to and from the SAC, however is not predicted to form a barrier to movement. Due to the range of the species, the predominately northerly direction of migration, and the likely temporary use of the area, acoustic disturbance is not considered likely to significantly affect the population of Atlantic salmon or sea lamprey. There is no predicted impact on brook lamprey or river lamprey as there is no route to impact between the Project areas and the SAC. The EIA assessment for the Project alone and the in-combination assessment have predicted noise piling, and suspended sediment impacts on migratory fish to be at **most moderate adverse and therefore not significant in EIA terms**. **All other potential impacts on Atlantic salmon and sea lamprey were predicted to be of at worst moderate significance**, **as a result of the receptor groups' high sensitivity, assigned due to conservation importance, rather than sensitivity to the impacts in question.** **Even when considered in combination it is considered highly unlikely this will cause significant disturbance to species.** • There is no predicted impact on brook lamprey or river lamprey as there is no route to impact between the Project areas and the SAC. • Significant disturbance of the qualifying species of the River Teith SAC is considered unlikely and **not significant** in the short or long term. • Confidence level: **High.**

401 **It is predicted the Project will not affect maintenance of the integrity of the River Teith SAC and that the River Teith SAC will maintain an appropriate contribution to achieving favourable conservation status of the qualifying species.**

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