NORTH FALLS

Offshore Wind Farm

ENVIRONMENTAL STATEMENT

Chapter 11 Fish and Shellfish Ecology

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Glossary of Acronyms

AC	Alternating Current
B	Magnetic
BEIS	Department for Business, Energy and Industrial Strategy
BMM	Brown and May Marine Ltd
BOEM	Bureau of Ocean Energy Management
Cefas	Centre for Environment, Fisheries and Aquaculture
CEA	Cumulative Effects Assessment
CP-EGGS	North Sea Cod and Plaice Egg Surveys
CPUE	Catch Per Unit Effort
DATRAS	The Database of Trawl Surveys
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
E	Electric
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
ES	Environmental Statement
EPP	Evidence Plan Process
ETG	Expert Topic Group
GBS	Gravity Based Structure
GGOW	Greater Gabbard Offshore Wind Farm
GWF	Galloper Offshore Wind farm
HDD	Horizontal Directional Drilling
HRA	Habitat Regulations Assessment
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
ICES	International Council for the Exploration of the Sea
iE	Induced Electric
IBTS	North Sea International Bottom Trawl Survey
IHLS	International Herring Larval Survey
INNS	Invasive Non-native Species
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
IMARES	Institute for Marine Resources and Ecosystem Studies
KEIFCA	Kent and Essex Inshore Fisheries and Conservation Authority
MarESA	Marine Evidence based Sensitivity Assessment
MCZ	Marine Conservation Zone
MPA	Marine Protected Area
MMO	Marine Management Organisation
NFOW	North Falls Offshore Wind Farm Limited

NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
O&M	Operation and Maintenance
OCP	Offshore Converter Platform
OSP	Offshore Substation Platform
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PINS	Planning Inspectorate
PSA	Particle Size Analysis
SA	Sandeel Assessment
SAC	Special Area of Conservation
SELcum	Cumulative Sound Exposure Level
SPA	Special Protection Area
SPL	Sound pressure level
SSC	Suspended Sediment Concentration
TAC	Total Allowable Catch
TTS	Temporal Threshold Shift
UXO	Unexploded Ordnance
WTG	Wind Turbine Generators
ZSL	Zoological Society of London

Glossary of Terminology

Array area	The offshore wind farm area, within which the wind turbine generators, array cables, platform inter-connector cable, offshore substation platform(s) and/or offshore converter platform will be located.
Array cables	Cables which link the wind turbine generators with each other, the offshore substation platform(s) and/or the offshore converter platform.
Beam trawl	A trawl net whose lateral spread during trawling is maintained by a beam across its mouth.
Benthic	Relating to or occurring at the sea bottom.
Bioelectric	Relating to electricity or electrical phenomena produced within living organisms.
Bony fish	Any of a major taxon (class Osteichthyes or superclass Teleostomi) comprising fishes with a bony rather than a cartilaginous skeleton.
Clupeid	Any of various fishes of the family Clupeidae, which includes the herrings, sprats, sardines and shads.
Crustacean	An arthropod of the large, mainly aquatic group Crustacea, such as a crab, lobster, shrimp, or barnacle.
Demersal	Living on or near the seabed.
Diadromous	Migrating between fresh and salt water.
Elasmobranch	Any cartilaginous fish of the subclass Elasmobranchii which includes the sharks, rays and skates.
Electro-receptive	Ability to perceive electrical stimuli.
Epibenthic	Relative to the flora and fauna living on the surface of the sea bottom.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support HRA.
Gadoid	A bony fish of an order (Gadiformes) that comprises the cods, hakes, and their relatives.
Geomagnetic field	The Earth's magnetic field.
Gravid	Carrying eggs or young.
Horizontal directional drill	Trenchless technique to bring the offshore export cables ashore at the landfall. The technique will also be used for installation of the onshore export cables at sensitive areas of the onshore cable route.
Landfall	The location where the offshore cables come ashore at Kirby Brook.
Offshore cable corridor	The corridor of seabed from array area to the landfall within which the offshore export cables will be located.
Offshore converter platform	Should an offshore connection to an HVDC interconnector cable be selected, an offshore converter platform would be required. This is a fixed structure located within the array area, containing HVAC and HVDC electrical equipment to aggregate the power from the wind turbine generators, increase the voltage to a more suitable level for export and convert the HVAC power generated by the wind turbine generators into HVDC power for export to shore via a third-party HVDC interconnector cable.
Offshore export cables	The cables which bring electricity from the offshore substation platform(s) to the landfall, as well as auxiliary cables.
Offshore project area	The overall area of the array area and the offshore cable corridor.
Offshore substation platform(s)	Fixed structure(s) located within the array area, containing HVAC electrical equipment to aggregate the power from the wind turbine generators and increase the voltage to a more suitable level for export to shore via offshore export cables.

Onshore export cables	The cables which take the electricity from landfall to the onshore substation. These comprise High Voltage Alternative Current (HVAC) cables and auxiliary cables, buried underground.
Otter trawl	A trawl net fitted with two ‘otter’ boards which maintain the horizontal opening of the net.
Ovigerous	Carrying or bearing eggs.
Pelagic	Living in the water column.
Platform interconnector cable	Cable connecting the offshore substation platforms (OSP) or the OSP and offshore converter platform (OCP)
Piscivorous	Feeding on fish.
Safety zones	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area
Scour protection	Protective materials to avoid sediment being eroded away from the base of the wind turbine generator foundations and offshore substation platform foundations as a result of the flow of water.
Swim bladder	A gas-filled sac present in the body of many bony fish, used to maintain and control buoyancy.
The Applicant	North Falls Offshore Wind Farm Limited (NFOW).
The Project Or ‘North Falls’	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.
Wind turbine generator	Power generating device that is driven by the kinetic energy of the wind.

11 Fish and Shellfish Ecology

11.1 Introduction

1. This chapter of the Environmental Statement (ES) considers the likely significant effects of the North Falls Offshore Wind Farm (hereafter “North Falls” or “the Project”) on fish and shellfish ecology. The chapter provides an overview of the existing environment for the offshore project area, followed by an assessment of the likely significant effects for the construction, operation, maintenance, and decommissioning phases of the Project.

2. This chapter has been written by Brown and May Marine Ltd (BMM) with the assessment undertaken with specific reference to the relevant legislation and guidance, of which the principal policy documents with respect to Nationally Significant Infrastructure Projects (NSIPs) are the National Policy Statements (NPS). Details of these and the methodology used for the Environmental Impact Assessment (EIA) and Cumulative Effects Assessment (CEA) are presented in Section 11.4.

3. The assessment should be read in conjunction with following linked chapters:

   - ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10);
   - ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11);
   - ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12);
   - ES Appendix 12.3 Underwater Noise Modelling (Document Reference: 3.3.8); and
   - ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16).

4. Additional information to support the fish and shellfish ecology assessment includes:

   - ES Appendix 11.1 Fish and Shellfish Ecology Technical Report (Document Reference: 3.3.5).

11.2 Consultation

5. Consultation with regard to fish and shellfish ecology has been undertaken in line with the general process described in ES Chapter 6 EIA Methodology (Document Reference: 3.1.8). The key elements to date have included scoping and the ongoing technical consultation via the Seabed Expert Topic Group (ETG). The feedback received has been considered in preparing the ES. Table 11.1 provides a summary of how the consultation responses received to date have influenced the approach that has been taken.

6. This chapter has been updated following the consultation on the Preliminary Environmental Information Report (PEIR) in order to produce the final assessment. Full details of the consultation process will also be presented in the Consultation Report (Document Reference: 4.1) as part of the Development Consent Order (DCO) application.

Table 11.1 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the ES
Planning Inspectorate (PINS)	08/2021 Scoping Opinion	The Scoping Report states that long term habitat loss will be considered as part of the operation phase assessment and is not considered in the construction and decommissioning phase assessment to avoid duplication. This is reflected in Table 2.16. The Inspectorate is satisfied with this approach and for long-term habitat loss to be scoped out of the construction and decommissioning phase assessment.	Noted. Long term loss of habitat is addressed under the assessment of the potential impacts during operation (Section 11.6.2).
		The Scoping Report states that potential impacts from electromagnetic fields (EMFs) from operational cables will be considered as part of the ES. Table 2.16 shows that this matter will be assessed as part of the operation phase assessment and scoped out for the construction and decommissioning phases. The Inspectorate is satisfied with this approach and for EMF impacts to be scoped out of the construction and decommissioning phase assessment	Noted. Impacts from EMFs are addressed under the assessment of the potential impacts during operation (Section 11.6.2).
		The Scoping Report states that the North Falls impact assessment will be undertaken taking account of the distribution of fish stocks and populations irrespective of national jurisdictions. Therefore, the Applicant considers that a specific assessment of transboundary effects is unnecessary. The Inspectorate agrees that the distribution of fish species is independent of national geographical boundaries and consequently have no objection that a specific assessment of transboundary effects is unnecessary in relation to fish ecology. On this basis and given that transboundary impacts will be assessed in regard to commercial fisheries as part of the construction, operation and decommissioning phases of the Proposed Development, the Inspectorate is satisfied that this matter can be scoped out of the assessment.	Noted. A specific assessment of potential transboundary impacts in respect of fish and shellfish ecology has not been undertaken. Transboundary impacts on commercial fisheries are assessed in ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16).
		The Inspectorate notes that Paragraph 214 references European eel as a protected and migratory fish species that may be present within the offshore project area. However, no reference is made within the Scoping Report to the Eel Regulations 2009 nor Eel Recovery Plans. The ES should include reference to the Eel Regulations and any relevant requirements. The Applicant should agree the approach to meeting the requirements of the Eels Regulations with the EA and other relevant bodies, including any requirements for eel survey and the provision of eel and other fish pass facilities.	Reference to the Eel Regulations 2009 is included in Appendix 11.1 (Document Reference: 3.3.5). Requirements under the Eels Regulations in respect of eel surveys or provision of fish pass facilities are considered in ES Chapter 21 Water Resources and Flood Risk (Document Reference: 3.1.23).
		The Inspectorate considers the potential for protected and migratory fish species to occur within the vicinity of the Proposed Development, including species that move between both freshwater and marine environments (such as	Due consideration has been given in this chapter to the potential impact of the Project on European eel and lampreys. These species have been included as

Consultee	Date / Document	Comment	Response / where addressed in the ES
		European eel and River lamprey) which may be functionally linked to other nearby protected sites. The ES should establish the presence of such species and assess impacts associated with the construction and operation of the Proposed Development, including the potential for the development to impede / create a barrier to fish migration. The ES should also consider the potential of the Proposed Development to have long-term impacts on fish stocks, where significant effects are likely to occur.	receptors throughout the assessment together with other diadromous species, potentially transiting the area of the offshore project area (Section 11.5.5.1 and 11.5.7).
		The Scoping Report does not provide information regarding the presence and location of shellfish water protected areas, nor does it address the potential of the Proposed Development to impact native oysters / native oyster beds. The Inspectorate considers that there are offshore areas within proximity to the Proposed Development where native oysters may be present and that are designated for native oyster production / protection, including the Blackwater, Crouch, Roach and Colne Estuary MCZ [Marine Conservation Zone]. The ES should establish the presence of any native oysters / native oyster habitat and include an assessment of impacts, where significant effects are likely to occur. The ES should describe the location of relevant shellfish water protected areas and depict their location on a figure(s). Furthermore, if the Proposed Development is to be located in proximity to the shellfish protected areas and where likely significant effects are identified, a full assessment should be conducted to determine the resultant effects on the commercial shellfish trade. Where significant effects are likely, the ES should include detailed mitigation measures to address effects on designated sites and shellfish water protected areas, including any proposed measures to ensure that sediment and water quality does not deteriorate to the detriment of protected and/ or commercial fish and shellfish species. Cross-reference should be made to relevant assessments of the ES [Environmental Statement], e.g., Marine Water and Sediment Quality and Commercial Fisheries.	Reference to the presence and location of Shellfish Water Protected Areas is included in Appendix 11.1 (Document Reference: 3.3.5). Due consideration has been given in this chapter to the potential impact of the Project on native oysters. This species has been included as a receptor throughout the assessment.
		The Scoping Report states that there is potential for the introduction and spread of marine INNS via vessel traffic and / or the introduction of hard substrate. The ES should assess the potential for such activities and vessel movements to facilitate the spread of INNS, e.g. via ballast water and through accidents and spillages. The ES should describe any necessary mitigation and / or biosecurity precautions required to prevent the spread of INNS. Any measures relied upon in the ES should be discussed with relevant consultation bodies, including NE and the EA, in effort to agree the approach. Measures	Impacts from Invasive Non-Native Species (INNS) are addressed in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12).

Consultee	Date / Document	Comment	Response / where addressed in the ES
		relied upon in the ES should be adequately secured e.g. through a Construction Environmental Management Plan (CEMP).	
		Specific mitigation measures to avoid or reduce any potential impacts on fish and shellfish receptors should be described in the ES. When devising mitigation measures, the Applicant should consider any relevant conservation objectives and ongoing management measures associated with those designated sites identified as having potential to be impacted by the Proposed Development. The ES should include details of the proposed mitigation measures to be included in the Project Environment Management Plan (PEMP) (Document Reference: 7.6).	General embedded mitigation measures proposed by the Applicant of relevance to fish and shellfish receptors are outlined in Section 11.3.3 (Table 11.3). In addition, specific embedded mitigation has been identified in relation to the Downs herring. This is presented in Section 11.3.3 (Table 11.3) and included in the Outline Project Environmental Management Plan (Document Reference: 7.6).
		The Scoping Report does not state whether the Applicant intends to control the time of the proposed construction and / or operational activities to avoid key and sensitive periods to species, such as fish spawning seasons and fish migration periods. The ES should assess the duration of impacts in relation to the ecological cycles (e.g. life cycles, breeding and spawning seasons, etc.) of the receptors being assessed. The ES should also consider the potential of the Proposed Development to disrupt fishing and recreational activities (including restriction of access) during both the construction and operational phases and any likely significant effects should be reported within the relevant assessments of the ES (e.g. 'Socio-economics' and 'Tourism and recreation').	Consideration has been given in this assessment to fish species with known spawning and nursey grounds in areas relevant to the Project (Table 11.12). The potential impact of the Project on commercial fisheries is addressed in ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16).
		The Scoping Report does not address potential impacts on fish feeding grounds or over-wintering areas for crustaceans. The ES should assess these impacts where significant effects are likely to occur.	Reference to feeding grounds and overwintering areas for crustaceans is included in Section 11.5.7 and included in Appendix 11.1 (Document Reference: 3.3.5).
		The Scoping Report does not address potential impacts from direct damage (e.g. crushing) and disturbance to mobile demersal and pelagic fish, or sedentary shellfish species, resulting from the Proposed Development. The ES should assess these impacts where significant effects are likely to occur.	The potential impact of the Project on fish and shellfish receptors has been assessed for construction (Section 11.6.1), operation (Section 11.6.2) and decommissioning (Section 11.6.3).
		The Scoping Report does not address potential impacts from accidental pollution on shellfish and fish receptors. The ES should include information to explain the extent of the likely impact and assess any likely significant effects. The ES should include details of any proposed mitigation measures to be included in the PEMP (Document Reference: 7.6). The ES should also explain how such measures will be secured.	Consideration has been given in this Chapter to the re-mobilisation of contaminated sediments during construction (Section 11.6.1.3), operation (Section 11.6.2.4) and decommissioning (Section 11.6.3).

Consultee	Date / Document	Comment	Response / where addressed in the ES
			ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) outlines the embedded mitigation in relation to accidental pollution.
Marine Management Organisation (MMO)	08/2021 Scoping Opinion	The scoping report provides a high-level fish ecology baseline and correctly identifies that the proposed wind farm array and offshore export cable corridor are within or near to spawning grounds for several fish species. The MMO recognise that migratory fish species, European seabass (*Dicentrarchus labrax) and elasmobranchs* (sharks, skates and rays), including thornback ray (*Raja lavate*) have also been discussed and will be further considered within the EIA, which is appropriate.	Noted.
		Relevant impacts on fish receptors and commercial fisheries have been appropriately scoped in. Potential impacts to be considered within the EIA have previously been agreed with The Applicant through the Evidence Plan Process (EPP) ETG meeting on 5th July 2021. Therefore, MMO are content with the fish species and potential impacts scoped in for further assessment.	Noted.
		The MMO are in agreement with the Applicant that the distribution of fish species is independent of national geographical boundaries and consequently have no objection that a specific assessment of transboundary effects is unnecessary in relation to fish ecology. Transboundary impacts will be assessed in regard to commercial fisheries as part of the construction, operation, decommissioning which is appropriate.	Noted. A specific assessment of potential transboundary impacts in respect of fish and shellfish ecology has not been undertaken. Transboundary impacts on commercial fisheries are assessed in ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16).
		As part of the EPP ETG Meeting held on 5th July 2021 the MMO recommended the use of the latest data series for the International Council for the Exploration of the Sea (ICES) International Herring Larvae Survey (IHLS); to date, up to 2020 data are publicly available through the ICES website. Additionally, it is recommended to access the North Sea International Bottom Trawl Survey (IBTS) data to support the fish characterisation for the project area. The MMO welcome that the approach to data collection proposed to inform the characterisation of fish ecology and fisheries has now incorporated the most relevant and up-to-date data series. This is appropriate. The Applicant may wish to consider that Centre for Environment, Fisheries and Aquaculture (Cefas) also collects herring samples from the greater Thames area and southern North Sea (available here: https://data.cefas.co.uk/view/5) which provides some limited data on biological maturity and age data for the Thames / Blackwater herring stock, as well as stock allocation. This data may	Consideration has been given to the latest available IHLS data (December 2012- January 2022). The latest five years of available IBTS data (2017 to 2021) has been used to inform this chapter (Section 11.5.1). The Applicant has reviewed the publicly available data on the Thames/Blackwater herring stock and notes that the latest year for which this data is available is 2009 and that sampling is undertaken during the spawning period of the Downs herring (November) but outside of the Downs spawning grounds and therefore of limited value to the assessment. The data has been analysed and is presented in ES Appendix 11.1 (Document Reference: 3.3.5) for completeness.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		provide complementary data on herring spawning times for the Downs and Thames sub-stocks.	
		The MMO agree with The Applicant that given the amount of existing data available and the usefulness of sporadic fish surveys undertaken in the area, no site-specific fisheries surveys will be undertaken for North Falls.	Noted.
		Overall, appropriate fish receptors, potential impacts on fish receptors and commercial fisheries have been identified within the scoping report and will be taken forward for assessment. The MMO welcome that previous comments made during the EPP process have been incorporated into the EIA and the latest data available Will be used to inform the fish characterisation for this project.	Noted.
		The Scoping Report lists numerous sources for data which will be used to inform the EIA regarding commercial fisheries, in the main this data comes from relatively recent data sets (up to 2019), however there are several sources listed, especially relating to nursey and spawning ground research, that are older (2010/11). Given the changes that have been seen in fish distribution/quantities in the North Sea, with subsequent changing trends in species landed and the likely impacts on spawning/nursery ground it may be advisable that more recent studies (if available) be used as the reliability of these older studies may be questionable.	Noted. Coull et al (1998) and Ellis et al (2010) provide a broad scale overview of the potential extent of spawning/nursery grounds and relative intensity and duration of spawning. The limitations of these publications are noted in ES Appendix 11.1 (Document Reference: 3.3.5).
		The MMO consider that in view of the scope of proposals, the approach provided should be sufficient to fully identify and assess the potential impacts to shellfish populations.	Noted.
		In addition to the impacts identified, the MMO would expect to see the impacts of direct mortality (removals from the fishery) assessed. Direct mortality poses a problem for shellfish as a number of species are sedentary and therefore unable to move to avoid danger.	The likely significant effects of the Project on fish and shellfish receptors has been assessed for construction (Section 11.6.1), operation (Section 11.6.2) and decommissioning (Section 11.6.3). Consideration has been given in this chapter to the impact of commercial fishing on fish and shellfish receptors. Information on relevant fisheries is included in ES Appendix 11.1 (Document Reference: 3.3.5) with further information provided in ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16).

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		Site specific data is available for the proposed site however the data collected during Galloper Offshore Wind Farm (GWF) and Greater Gabbard Offshore Wind Farm (GGOW) is now considered dated and must be used with caution as it may not represent the current species composition of the site. The baseline presented should be comprised primarily of data obtained with the last 5 years.	Recent data from the IBTS has been used to inform the baseline characterisation. The results of the fish survey work carried out in the GWF and GGOW have been included as additional site-specific information for reference.
		The Applicant notes that the proposed area is commercially important for crab and lobster species (Section 2.6.1.2 of the Scoping Report) and that the impact assessment will use noise survey data combined with appropriate guidance to assess the level of potential noise impact upon fish, including shellfish (Section 2.6.4 234 of the Scoping Report). However, currently, there are no established noise criteria for crustaceans; therefore, The Applicant will need to draw on relevant scientific literature to support the impact assessment, and assessment conclusions.	Relevant scientific literature has been included in the assessment of noise during construction on shellfish receptors in Section 11.6.1.4.4.
		The MMO agree with The Applicant's conclusion to scope in the potential impact of underwater noise during construction, operation and decommission for both fishes (Section 2.6.3 of the Scoping Report) and marine mammals (Section 2.7.3 of the Scoping Report).	Noted.
		In Section 2.6.3.1 of the Scoping Report, unexploded ordnance (UXO) clearance was not mentioned as a potential impact on fish species during construction although it was for marine mammals in Section 2.7.3.1. Additionally, in Section 2.6.3.2 of the Scoping Report, underwater noise was not mentioned as a potential impact during operation despite ongoing vessel maintenance. The MMO would expect both the potential impacts of underwater noise arising from UXO clearance and increased presence of vessel traffic to be considered for both fish and marine mammal species.	Underwater noise and vibration from UXO clearance during construction is assessed in **Section 11.6.1.6**. The assessment of underwater noise and vibration during operation is provided in Section 11.6.2.5.
		In Section 2.6.1.1 (para 212) of the Scoping Report, The Applicant lists: sea bass (*Dicentrarchus labrax*) and thornback ray (*Rava clavata*) as using the outer Thames Estuary. In Section 2.9.1 (para 286) of the Scoping Report, The Applicant then lists the following fish species: mackerel (*Trachurus trachurus*) and haddock (*Melanogrammus aeglefinus*) as being present, with Twaite shad also recorded during site specific surveys. However, these fishes were not included in Table 2.1.14 of the Scoping Report or the subsequent maps showing spawning/ nursery grounds. The Applicant should clarify why these species were scoped out of this assessment	The key species identified, and the rationale for their inclusion within the assessment is provided in Table 11.14. This includes considerations such as presence/abundance in the study area, commercial importance, distribution of spawning and nursery grounds and conservation status.

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		The MMO suggest the Applicant groups fishes according to their potential auditory sensitivity (refer to Popper et al., 2014) in their underwater noise assessment as well as commercial importance. It is expected that some of the identified fishes, i.e., herring, will have higher sensitivity to sound pressure than others given that the swim bladder is also involved in their hearing mechanisms.	Reference has been made to Popper et al (2014) when grouping fishes according to their potential auditory sensitivity in Section 11.6.1.4.
		The MMO would expect potential barrier effects (in relation to migratory species) resulting from underwater noise to be considered and would recommend consultation with the Environment Agency.	Due consideration has been given in this chapter to the likely significant effects of the Project on migratory species. Diadromous species have been included as receptors throughout the assessment and are considered in reference to underwater noise in Section 11.6.1.4.5.
		A variety of fishes were identified as having potential spawning and/or nursery grounds within the vicinity of the proposed area and have a variety of different hearing sensitivities (see Popper et al., 2014), therefore it is expected they will have differing responses to underwater noise.	Noted. Reference has been made to Popper et al (2014) when grouping fishes according to their potential auditory sensitivity in Section 11.6.1.4.
Natural England	08/2021 Scoping Opinion	The table and accompanying maps of fish spawning areas are useful. Maps are indicative only as the underlying data is now relatively old and spawning locations may change over time.	Coull et al. (1998) and Ellis et al. (2010) provide a broad scale overview of the potential extent of spawning/nursery grounds and relative intensity and duration of spawning. The limitations of these publications are noted in ES Appendix 11.1 (Document Reference: 3.3.5). The Applicant notes, that whilst Coull et al. (1998) and Ellis et al. (2012) are dated, both are conservative in nature as they identify wide spawning /nursery areas as well as overall spawning seasons and are currently accepted as the main references to provide an indication of spawning/nursery area potential for fish around the UK. The Applicant also highlights that in addition to these publications the fish and shellfish ecology baseline characterisation is informed by a range of more recent datasets and site specific data. The sources of data and information used to inform the fish and shellfish ecology chapter were discussed in detail as part of the EPP with the MMO, Cefas,

Consultee	Date / Document	Comment	Response / where addressed in the ES
			Natural England and KEIFCA on 20th June 2022 "(see below)"and there was agreement that the datasets proposed were suitable and appropriate for the assessment.
		It is noted that no further survey work is proposed for identification of impacts to fish species. Natural England does not agree with this approach as the existing site specific data is in excess of 12 years old. Fish distribution changes temporally as well as spatially so this data may not be representative of the current fish community. Further survey work to characterise the fish community should be considered. Natural England will continue to engage with the applicant on this point through the Evidence Plan Process.	Discussions in relation to the need for survey work to inform the baseline were held with Natural England as part of the EPP. As outlined in "Natural England's June 2022 / Response to North Falls Offshore Wind Farm (NFOW) Fish Ecology Baseline Characterisation and Survey Data – Briefing" (see rows below), following the review and discussion on the Applicant's Baseline Characterisation and Survey Data - Briefing Note, Natural England were satisfied that no survey work was required in relation to fish and shellfish ecology aspects.
		Natural England considers the impacts scoped within Table 2.6 of the Scoping Report to be appropriate.	Noted.
Natural England	08/2021 Late Scoping Opinion on Migratory Fish	The works are very far offshore and are very unlikely to present a barrier to migration to fish traveling to and from spawning rivers in the south-east (e.g. Medway MCZ).	Noted.
		The report has noted the presence of protected species such as smelt and shad within the baseline datasets. These species are caught on occasion, so their presence in the dataset in these low numbers is not of particular concern	Noted.
		In regard to the migratory fish aspects, we are satisfied with the North Falls Scoping Report.	Noted.
		We defer to the Environment Agency on Water Framework Directive and European eel matters.	Noted.
Natural England	06/2022 Response to North Falls Offshore Wind Farm Fish Ecology Baseline Characterisation and Survey Data – Briefing note	Natural England welcomes the North Falls Fish Ecology Baseline Characterisation and Survey Data– Briefing Note. We are grateful to North Falls OWF [Offshore Wind Farm] project for providing the Fish Ecology Briefing note, prior to the ETG meeting on 20 June 2022. In line with our comments in the Seabed ETG meeting, Natural England are now content with the evidence that is being used and compiled in relation to fish. We do not feel that	Noted.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		additional surveys would add much weight or usefulness to the information that is already in place. Our previous comments related to the evidence that was used for the Greater Gabbard evidence collation, which are now in excess of 12 years old, however these, coupled with additional data sources and evidence, forms part of the overall picture for fish in the area.	
National Federation of Fishermen's Organisations	14/07/2023 Consultation response letter	We are concerned with many of the data sources used to characterise the baseline environment within this chapter. The PEIR uses data from studies that are temporally and spatially limited, mostly to areas that are beyond the boundaries of the development area and makes assessments of impacts from such data. This methodology only provides a 'temporal snapshot' of data specific to the studies cited and their spatial limits – a fundamental flaw in impact assessments. The reliance of offshore wind impact assessments on Coull et al., (1998) and Ellis et al., (2012) has been called into question in nearly all our responses to offshore developments. These data are over a decade old but seem to be used as a 'gold standard' to assess impacts on spawning and nursery grounds. We would expect to see a more precautionary use of these data within the assessments based on their well described limitations. There is minimal site-specific and contemporary data used that can support the assessments made within this chapter and little precautions given to the impacts assessed and conclusions drawn, not demonstrating a robust and sufficient approach. For example, Chapter 14 documented that shellfish species such as whelk, crab and lobster are important commercial fisheries species in the region. Minimal data has been presented in the PEIR with regards to potential impacts to these specific receptors, but any proposed impacts have been assessed as negligible in all cases with no mitigation needed (this is prevalent for all receptors assessed). A paucity of data and evidence should be treated with caution when assessing impacts to the described receptors. Data was analysed from monitoring projects of other OWF developments, however the methodology used for these monitoring projects (e.g. beam trawl) is not the correct methodology for sampling receptors that the data have been used to assess (e.g. shellfish and pelagic fish). This incorrect use of data, from inappropriate methodologies, should be accounted for when assessing impacts to receptors.	A description of the key sources of data and information used, including their limitations, are provided in ES Appendix 11.1 Fish and Shellfish Ecology Technical Report (Document Reference: 3.3.5). The Applicant notes, that whilst Coull et al. (1998) and Ellis et al. (2012) are dated, both are conservative in nature as they identify wide spawning /nursery areas as well as overall spawning seasons and are currently accepted as the main references to provide an indication of spawning/nursery area potential for fish around the UK. The Applicant also highlights that in addition to these publications the fish and shellfish ecology baseline characterisation is informed by a range of more recent datasets and site specific data. The sources of data and information used to inform the fish and shellfish ecology chapter were discussed in detail as part of the EPP with the MMO, Cefas, Natural England and KEIFCA and there was agreement that the datasets proposed were suitable and appropriate for the assessment.

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		Acknowledging the limitations of the data but subsequently ignoring them and treating that data as concrete evidence, with no caveats, misinforms the assessment of the impacts and calls into question their validity. We acknowledge the difficulties with the lack of site-specific, contemporary data, but we would expect to see some element of precaution taken when assessing impacts to fish and shellfish ecology, specifically when advised by inappropriate methodologies.	
RWS Netherlands	14/07/2023 Consultation response letter	In the current report it is not clear on the basis of which information the conclusion was drawn that there are no transboundary ecosystem effects to be expected.	The fish and shellfish impact assessment takes account of the distribution of fish stocks and populations irrespective of national jurisdictions. Therefore, the Applicant considers that a specific assessment of transboundary effects in relation to fish and shellfish ecology is unnecessary. The suitability of this approach has been confirmed by the MMO and PINS in their Scoping Opinion (see above).
MMO	14/07/2023 Consultation response letter	The receptors scoped in and out are appropriate for shellfish and shellfisheries, the assessment is proportionate to fully identify and assess the potential impacts.	Noted.
		The MMO notes that the Kent and Essex Inshore Fisheries Conservation Authority (KEIFCA) have been consulted in relation to location of cockle and native oyster beds. The MMO defers to KEIFCA for comments on potential impacts of the development on those features.	Noted.
		The Applicant has outlined embedded mitigation in the design in Table 11.3 of Chapter 11 Fish and Shellfish Ecology and Table 14.4 of Chapter 14 Commercial Fisheries. The MMO agrees with the mitigation measures proposed for shellfish.	Noted.
		The assessment of impacts to fish from underwater noise and habitat disturbance for some species (primarily herring and sandeel) requires further consideration and some changes are needed to ensure the ES is robust and fit for the purpose of assessing the likelihood of significant impacts occurring to fish.	An updated assessment on the impacts to fish from habitat disturbance and underwater noise are presented in Section 11.6.1.1 and Section 11.6.1.4, respectively.
		In the Fish and Shellfish Ecology Figures document (Chapter 11: Fish and Shellfish Ecology - Figures (Document Reference: 3.2.7)) the spawning and nursery grounds for sandeel have been mapped using Coull et al. (1998) and	A multi-layered map characterising sandeel habitat, including broad-scale BGS data, PSA data from the Cefas' OneBenthic Portal, PSA data collected from

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		Ellis et al. (2012). Figure 11.5 presents catch rates of sandeel for the North Sea International Bottom Trawl Survey (IBTS) for the years 2017 – 2021. Whilst IBTS date does demonstrate that sandeel are caught in the study area, the GOV trawl used in the survey does not adequately target sandeel and may be under representative of sandeel abundance. Figure 11.6 (from Jensen et al. 2011) shows the study area to be situated within an ICES sandeel assessment area, but not within one of the commercial sandeel fishing banks. Whilst the data presented in the PEIR overall do not suggest that the study area is of particularly high importance as sandeel habitat, the characterisation of sandeel habitat should include some additional sources of data, primarily to characterise seabed sediments in the array and cable corridor areas as the PSA data collected for the array area is somewhat sparse and this should be included in the ES.	the offshore project area as well as the data presented in Coull et al. (1998) and Ellis et al. (2012) and relevant commercial fishing data is presented in ES Figure 11.7 (Document Reference: 3.2.7).
		The MMO recommends the inclusion of a multi-layered map which presents broad-scale British Geological Survey (BGS) data indicating the sediment types in the study area, combined with the sandeel spawning and nursery grounds data as per Coull et al. (1998) and Ellis et al. (2012), and the existing PSA data collected during the benthic surveys. Further site-specific PSA data may also be available from Cefas' OneBenthic Portal (https://rconnect.cefas.co.uk/onebenthic_portal/) which contains benthic datasets including PSA from past surveys. Additional PSA from the OneBenthic portal could be used to supplement the Applicant's existing PSA data.	A multi-layered map presenting broad-scale BGS data, PSA data from the Cefas' OneBenthic Portal, PSA data collected from the offshore project area as well as the data presented in Coull et al. (1998) and Ellis et al. (2012) and relevant commercial fishing activity is shown in ES Figure 11.7 (Document Reference: 3.2.7).
		As with sandeel, the characterisation of Downs herring spawning habitat should include a multi-layered map presenting BGS data, herring spawning and nursery grounds data as per Coull et al. (1998) and Ellis et al. (2012), the existing PSA data collected during the benthic surveys, and PSA data from the Cefas' OneBenthic Portal.	A multi-layered map characterising Downs herring spawning ground using broad-scale BGS data, PSA data from the Cefas' OneBenthic Portal, PSA data collected from the offshore project area is shown in ES Figure 11.3 (Document Reference: 3.2.7).
		International Herring Larvae Survey (IHLS) data for the years 2012 – 2017 and 2019 - 2022 have been used to inform the assessment, which is appropriate, and the limitations relating to the absence of data and the change in the temporal extent of the Downs IHLS survey have been recognised. The plotted IHLS data in Figures 6.32 and 6.33 (Chapter 11: Fish and Shellfish Ecology - Figures (Document Reference: 3.2.7)) indicate the larvae are consistently caught in the study area and close to the array in all years where data are available. Plotting individual years of data as per Figures 6.32 and 6.33 is	Noted.

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		helpful to demonstrate the interannual variations in larval density as a proxy for spawning intensity.	
		In order to provide a more complete picture of the extent of Downs spawning activity over time the MMO recommends that a 'heat' map of all IHLS data combined for the years 2012 – 2017 and for 2018 – 2022 is presented. The mapped data for years 2018 – 2022 will account for the change in temporal extent of the IHLS survey. Please see MarineSpace (2013) for example of a heat map approach which assigns confidence scores to the various data layers used in heatmaps for determining potential herring spawning habitat.	A multi-layered map presenting IHLS data combined for the years 2012 – 2017 and for 2018 – 2022, using the MarineSpace (2013) approach is presented in ES Figure 6.33, ES Appendix 11.1 (Document Reference: 3.3.5).
		The overlap of the inshore portion of the study area with the spawning ground of the Thames/Blackwater herring population is acknowledged in the PEIR, however, their spawning season (between February and May) is not included in Table 11.12 (Chapter 11 Fish and Shellfish Ecology) for spawning seasons and nursery grounds in the study area. This should be corrected in the ES.	The spawning period of the Blackwater herring has been added to Table 11.12.
		In point 85 (Chapter 11: Fish and Shellfish Ecology - Figures (Document Reference: 3.2.7)) it is noted that the Blackwater herring is a receptor of 'low sensitivity' in the context of negligible magnitude due to the distance between the spawning ground and the project. Whilst it is accepted that this will be the case for impacts arising from physical seabed disturbance, the MMO does not agree that Blackwater herring will be a receptor of 'low sensitivity' in the context of underwater noise from piling and UXO clearance. The MMO recommends that in the ES, Blackwater herring are reclassified as a 'high sensitivity' receptor due to their sensitivity to underwater noise.	The Applicant has updated the noise and habitat disturbance assessments both for herring and sandeels. High sensitivity scores have been applied to these receptors where appropriate. The assessment presented in the PEIR provided lower sensitivities for these receptors in some cases, taking account of the limited potential exposure of the receptor to the impact/limited potential overlap between receptors and impact. This is a critical factor to define impact significance and inform assessments. In the ES chapter, aspects relating to the level of overlap between the impact and these receptors have been accounted for under impact magnitude instead, and therefore, magnitude scores have also been reviewed as appropriate.
		Concerning the effects of electro-magnetic fields (EMF) on electro-sensitive fish receptors such as elasmobranchs, eels and lampreys, the MMO notes that the intended average cable burial depth for array, interconnector and export cables will be 1.2m. In line the with the National Policy Statement EN3 (Department of Energy & Climate Change, 2011) The MMO recommends that where possible, cables are buried to a minimum depth of 1.5m (subject to local geology or seabed obstructions) as this will further increase the distance	The Applicant is committed to bury cables to appropriate depths, taking account of the outputs of the Cable Burial Risk Assessment (CBRA). Burial depth will bury along the cable route and may be ≥1.5 m at suitable locations. For the purposes of the assessment, however, the average cable burial depth (1.2m) and the target minimum cable burial depth

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		between electro-sensitive fish receptors and EMF, as well as reduce the risk of snagging and damage to cables by other marine vessels e.g. anchors, bottom-towed gear.	(0.6m) have been presented (Table 11.2) as these represent the realistic worst-case scenario. The Applicant notes that reference to 1.5 m made in the former version of the National Policy Statement EN3 (2011) is no longer referred to in the in effect version EN3 (DESNZ, 2023).
		The 186dB threshold presented in Figures 11.9 – 11.19 only show the predicted range of effect for temporary threshold shift (TTS) which is a temporary reduction in hearing sensitivity caused by exposure to intense sound. The impact ranges for mortality and potential mortal injury and recoverable injury have been provided in Tables 11.19 – 11.34, however these do not provide a complete visual representation of the overlap of noise effects with the spawning and nursery grounds.	ES Figures 11.9 to 11.19 (Document Reference: 3.2.7) have been updated to include a visual representation of the impact ranges for mortality and potential mortal injury and recoverable injury.
		For the ES, underwater noise modelling should be presented using thresholds for mortality and potential mortal injury (as per Popper et al., 2014, which classifies fish according to their hearing capabilities). For fish with no swim bladder (i.e., sole, plaice, lemon sole, sandeel, mackerel and elasmobranchs) the threshold for mortality and potential mortal injury is >219 dB cumulative sound exposure level (SELcum) or >213dB peak, for fish with a swim bladder that is not involved in hearing the threshold is 210dB SELcum or >207dB peak, and for fish with a swim bladder involved in hearing (i.e., herring, sprat and cod) the threshold is 207 dB SELcum or >207 dB peak. For eggs and larvae, a threshold of >210 dB SELcum or >207 dB peak should be used.	The thresholds for mortality and potential mortal injury described in Popper et al. (2014) were used to inform the assessment and presented in tables within section 11.6.1.4 of the PEIR. These have also been included in Table 11.17 to Table 11.34 and used to inform the assessment in the ES. Additionally, mortality and potential mortal injury impact ranges have also been included within relevant Figures (ES Figure 11.9 to 11.19 (Document Reference: 3.2.7)) in support of the underwater noise assessment included in Section 11.6.1.4.2 of the ES.
		Given the specific spawning habitat requirements of herring and their sensitivity to underwater noise, the MMO requests that additional noise modelling for the received levels of single strike sound exposure levels (SELss) at the Downs and Blackwater herring spawning grounds based on the 135dB (SELss) startle response (as per Hawkins et al. (2014) are presented (in mapped form) in order to predict the range of effect for behavioural responses in herring.	Charts presenting modelling for the received levels of SELss at the Downs and Blackwater herring spawning grounds based on the 135dB (SELss) startle response (as per Hawkins et al. (2014)) are provided in ES Figure 11.17 and ES Figure 11.18 (Document Reference: 3.2.7) respectively. The Applicant notes, however, that Hawkins et al. (2014) acknowledge that "these data cannot yet be used to define the sound exposure criteria" due to the limited nature of the study. Of particular note was that the study was conducted in a quiet lough (lake). The background noise generated in a calm lough environment is far

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			quieter than that generated in the open-water North Sea where 135 dB SEL is likely to be only slightly above the background noise level in a busy shipping area, based on measurements at the Hornsea Project Two Offshore Wind Farm. As such it is not appropriate to attempt to translate reaction patterns from one distinct environment to the other distinct environment.
		For the ES, the maps (Figures 11.9 – 11.19) should state the hammer energy and pile diameter used in the modelling. Modelling should be based on the maximum hammer energy (6000 kilojoules (kJ)) and pile diameter (17 metres (m)).	ES Figure 11.9 to 11.19 (Document Reference: 3.2.7) have been updated to state the hammer energy and pile diameter used in the modelling.
		Please note that whilst the MMO has no objection to additional modelling based on a fleeing receptor being presented, the MMO does not support the use of a fleeing animal model due to a lack of empirical evidence on fleeing speeds, direction and behaviour. The ‘fleeing’ speed of 1.5 metres per second (m/s) which has been used in the modelling is based on Hirata (1999). It should be noted that the assessments in Hirata (1999) are based upon a swimming speed, rather than fleeing speed, and do not constitute empirical evidence that fish will flee from a source of disturbance.	Both the fleeing and stationary receptors scenarios have been modelled and are included in the tables that summarise modelling result for fish in Section 11.6.1.4 of the ES and in ES Appendix 12.3 Underwater Noise Modelling (Document Reference: 3.3.8). For the purposes of assessing impacts and taking a conservative worst case scenario, consideration has only been given to the outputs of the stationary receptors modelling outputs. It is noted however, that basing the modelling on a stationary (zero flee speed) receptor is likely to greatly overestimate the potential risk to fish species, assuming that an individual would remain in the high noise level region of the water column, especially when considering the precautionary nature of the parameters already built into the cumulative exposure calculations.
		It is not obvious from reading the PEIR whether concurrent or simultaneous piling will be carried out during construction of the project. If there is potential for concurrent or simultaneous piling to be undertaken then MMO would expect this scenario to be modelled and presented in the ES, especially as it is expected that concurrent piling would result in a larger impact range than sequential piling. Alternatively, it should be made clear in the ES if concurrent piling is or is not to be undertaken.	Modelling is presented in ES Appendix 12.3 Underwater Noise Modelling (Document Reference: 3.3.8) using the worst-case monopile and pin pile sequential piling scenarios, for simultaneous piling at the East and South locations, representing a worst case spread of locations.

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		Further temporal restrictions may be necessary for other construction works that cause disturbance to the seabed during the herring spawning season, however, this will be subject to review of the herring spawning habitat characterisation in the ES.	Due consideration is given to the spawning grounds and sensitivity of herring in the assessment of impacts that result in physical disturbance to the seabed e.g. temporary habitat loss, SSC etc given the herring are demersal spawners. Multi-layered maps presenting broad-scale BGS data, PSA data from the Cefas' OneBenthic Portal, PSA data collected from the offshore project area as well as the data presented in Coull et al. (1998) and Ellis et al. (2012) is shown in ES Figure 11.3 (Document Reference: 3.2.7).
		The assessment on the magnitude of impact and the sensitivity of the receptor is very high level and does not consider the various sensitivities of fish receptors, particularly those with a swim bladder involved in hearing. Nor does the discussion consider the sensitive spawning periods of fishes or identify those fish with specific habitat requirements for part of all of their life cycles (e.g., herring, sandeel and oviparous elasmobranchs). For these primary reasons, the MMO does not agree that the impact to fish from UXO clearance will be of 'minor significance'. The MMO would expect a more detailed assessment on the impacts to fish from UXO clearance to be undertaken to support the ML application.	The assessment for UXO has been updated and now includes consideration of different species sensitivities and likely significant effects on spawning and nursery grounds (see Section 11.6.1.6).
		No coastal developments in the planning stages have been included in the list of projects for the cumulative and inter-related impact assessment. Projects in the planning stages such as port/harbour developments, power stations etc, should also be identified and assessed (where appropriate) in the ES, particularly in respect of construction works for the nearshore part of the cable corridor.	The assessment has been updated to take into account coastal developments. Table 11.52 provides the screening results for coastal developments.
		In light of comments in respect of the UWN modelling, it should be recognised that the range of effect for cumulative and inter-related effects may increase if the modelling shows an impact range exceeding 100km. With this in mind, there may be other offshore developments further afield that will require scoping into the assessment, should the UWN modelling show a range of effect of >100km.	As detailed in ES Appendix 12.3 Underwater Noise Modelling (Document Reference: 3.3.8) and summarised in Section 11.6.1.4 the worst-case impact range modelled in relation to underwater noise for fish is considerably smaller than 100 km
		For the reasons in relation to sandeel, herring and underwater noise respectively, the MMO does not currently agree with the conclusions on	Multi-layered maps presenting broad-scale BGS data, PSA data from the Cefas' OneBenthic Portal, PSA

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		cumulative effects. A more detailed characterisation of herring spawning habitat and sandeel habitat is required in order to ascertain the likely extent of impacts to these habitats in relation to the predicted range of effects. When the habitat characterisations have been completed and the sensitivity of herring changed to 'high' the magnitude and significance of effects should be re-evaluated. Once this is done, cumulative and inter-related impacts can also be re-assessed.	data collected from the offshore project area as well as the data presented in Coull et al. (1998) and Ellis et al. (2012) and commercial fishing activity (sandeel) is shown in ES Figure 11.3 and ES Figure 11.7 (Document Reference: 3.2.7) for herring and sandeel respectively. The Applicant has updated the noise and habitat disturbance assessments both for herring and sandeels. High sensitivity scores have been applied to these receptors where appropriate.
Cefas	20/12/2023 Response to Expert Topic Group (ETG) meeting	I am happy for International Bottom Trawl Survey (IBTS) data to be used to support the characterisation of the environment for sandeel for the ES. I note from the slides that the limitations associated with this data have been recognised with the technical report.	Noted.
		Thank you for sharing the seabed sediment maps in relation to sandeel and herring spawning habitat suitability. The maps have incorporated PSA data from the Cefas OneBenthic tool, alongside the site-specific PSA data collected as part of the project's benthic survey. Data have been overlaid onto the British Geological Survey (BGS) broadscale sediment map. The use of OneBenthic PSA data has improved the coverage in some areas of the array and export cable corridor (ECC) though there are still parts of the study area where PSA data are sparse.	Noted.
		In the sediment habitat suitability map for sandeel (slide on page 21), the OneBenthic data show a reasonably good agreement with the PSA data from the benthic survey. The areas best suited as sandeel habitat are those in the south-east portion of the array and mid-way along the ECC, where OneBenthic and project-specific PSA data have been classified as 'preferred'. This is further supported by the underlying BGS data layer which shows that these locations are comprised of sand, gravelly sand and slightly gravelly sand. One Benthic and site-specific survey PSA data for the remainder of the array and ECC indicate that these areas are unsuitable as sandeel habitat, and this is further supported by the underlying BGS layer which defines these areas as predominantly sandy gravel or muddy sandy gravel.	Noted.

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		In the sediment habitat suitability map for herring, it is interesting to see that the PSA data from OneBenthic and the project's benthic survey were all classified as 'unsuitable' spawning habitat in the western portion of the array and ECC, whereas the BGS layer suggests that the sediment here is predominantly sandy gravel, which would make the substrate suitable as herring spawning habitat. However, given the agreement between the OneBenthic and site-specific benthic survey I don't necessarily have any major concerns, although it would be helpful to understand why the sediments have been classified as unsuitable, for example, the mud content in the samples may have been too high. For the ES, it would be useful to include a table showing the various sediment component fractions of the samples collected during the benthic survey as a way of demonstrating why the sediments are, or are not, suitable as herring spawning habitat (and sandeel habitat). This can be included in the Benthic chapter, with signposting to it from the Fish Ecology chapter. The eastern boundary of the array is adjacent to, and overlaps with, the historic herring spawning ground for the Downs herring population to the east, as shown by Coull et al. (1998). PSA data from the OneBenthic tool show that three samples inside the array and approximately six samples just outside the eastern boundary of the array contained sediments classified as either sub-prime or suitable spawning habitat. The remaining OneBenthic PSA data for the eastern boundary of the array show that the sediments are largely unsuitable as spawning habitat. OneBenthic data also show that the number of sediments classed as sub-prime or suitable spawning habitat increases further east, i.e., towards the centre of the historic spawning ground. Given the proximity of the array to the spawning ground, underwater noise modelling for noise generating activities, i.e., piling activity and UXO clearance, should give careful consideration of the affects of noise on herring and their eggs and larvae at the Downs herring spawning ground.	Noted. Consideration is given to the effects of noise on herring in Sections 11.6.1.4.5, 11.6.1.5 and 11.6.1.6. The sediment categorisations are driven by the presence of certain proportions of mud (above or below 5%) and gravel (10%, 25%, 50%). These are provided in ES Appendix 11.1 Fish and Shellfish Ecology Technical Report (Document Reference: 3.3.5). Charts presenting modelling for the received levels of SELss at the Downs and Blackwater herring spawning grounds based on the 135dB (SELss) startle response. For the purposes of assessing impacts and taking a conservative worst case scenario, consideration has only been given to the outputs of the stationary receptors modelling outputs.

11.3 Scope

11.3.1 Study area

7. The study area for fish and shellfish ecology has been defined with reference to the International Council for the Exploration of the Sea (ICES) rectangles that overlap with the offshore project area (ES Figure 11.1, (Document Reference: 3.2.7)). The North Falls study area is the combined area of the following ICES rectangles:

- ICES rectangle 32F1, where the majority of the offshore project area is located (including the whole offshore cable corridor and practically the totality of the array area);
- ICES rectangle 32F2 – where a small section of the array area is located.

8. Where appropriate, however, broader geographic areas have been used to provide information in the wider context of the southern North Sea.

11.3.2 Realistic worst-case scenario

9. The final design of North Falls will be confirmed through detailed engineering design studies that will be undertaken post-consent. In order to provide a precautionary but robust impact assessment at this stage of the development process, realistic worst-case scenarios have been defined in terms of the potential impacts that may arise. This approach to EIA, referred to as the Rochdale Envelope, is common practice for developments of this nature, as set out in PINS Advice Note Nine (2018). The Rochdale Envelope for a project outlines the realistic worst-case scenario for each individual impact, so that it can be safely assumed that all other scenarios within the design envelope will have less impact. Further details are provided in ES Chapter 6 EIA Methodology (Document Reference: 3.1.8).

10. One area of optionality is in relation to the national grid connection point (discussed further in ES Chapter 5, Project Description (Document Reference: 3.1.5)). The following grid connection options are included in the Project design envelope:

- Option 1: Onshore electrical connection at a national grid connection point within the Tendring peninsula of Essex, with a project alone onshore cable route and onshore substation infrastructure;
- Option 2: Onshore electrical connection at a national grid connection point within the Tendring peninsula of Essex, sharing an onshore cable route and onshore cable duct installation (but with separate onshore export cables) and co-locating separate project onshore substation infrastructure with Five Estuaries; or
- Option 3: Offshore electrical connection, supplied by a third party.

11. The realistic worst-case scenarios for the fish and shellfish ecology assessment are summarised in Table 11.2. These are based on North Falls parameters described in ES Chapter 5 Project Description (Document Reference: 3.1.7), which provides further details regarding specific activities and their durations.

12. With regards to fish and shellfish ecology, Options 1 and 2 would be the same, and these represent the worst case scenario described in Table 14.3 and assessed in Section 14.6. For Option 3, there would be no project export cables to shore. Within the array area, under Options 1 and 2 there would be two offshore substation platforms (OSPs), whereas for Option 3 there would be one offshore converter platform (OCP) and up to one OSP, but with no change to the worst case foundation infrastructure.

Table 11.2 Realistic worst-case scenarios

Impact	Parameter	Notes
Construction		
Impact 1: Temporary habitat loss/ physical disturbance	**Array area:** Seabed preparation area of for gravity based systems (GBS) of 70m x 57 wind turbine generators (WTG) = 219,362m^2 Two offshore substation platforms (OSP) seabed preparation = 7,697m^2 (2 platforms with 70m preparation diameter or one OSP and one offshore converter platforms (OCP), in the case of grid connection Option 3) Array cable seabed preparation – 170km length with average 24m disturbance width = 4,080,000m^2 Platform interconnector cable seabed preparation – 20km length with average 24m disturbance width = 480,000m^2 Vessel jack up assuming 6 jack up location per WTG (275m^2 per jack up leg x 6 legs) per jack up leg x 6 legs x 354 jack up operations) = = 584,100m^2 Anchoring during WTG and OSP/OCP installation = 274,704m^2 (based on vessels with 8 anchors; and 5 anchoring events per WTG/OSP) Anchoring during array/platform interconnector cable installation = 235,878m^2 (based on 9 anchors per vessel each with 61m^2 footprint and 432 anchoring events) Boulder clearance – 25 boulders of up to 5m diameter = 491m^2 UXO clearance = 1,025m^2. Crater areas reported from other offshore wind farms range from approximately 2 to 25m^2, whereas the largest predicted in Ordtek (2018) is around 350m^2. It is 13 of the UXO would be of 25m^2 or less and two of up to 350m^2. Up to 15 UXO clearance operations predicted in the array area. Worst case scenario total disturbance footprint in the array area = 5.88km^2 **Offshore export cables:** Maximum temporary disturbance for seabed preparation within the offshore cable corridor = 3,009,600m^2 based on: Maximum total export cable trench length of 125.4km. Maximum width of temporary disturbance is approximately 24m. Anchor placement = 297,850m^2 (based on 9 anchors per vessel, each with 61m^2 footprint; and 545.5 anchoring events) Boulder clearance = 491m^2 (up to 25 boulders of 5m diameter)	Temporary disturbance relates to seabed preparation and installation activities. The persistent/ permanent footprint of infrastructure is assessed as an operation phase impact.

Impact	Parameter	Notes
	UXO clearance = 1,600m^2. Crater areas reported from other offshore wind farms range from approximately 2m^2 to 25m^2, whereas the largest predicted in Ordtek (2018) is around 350m^2. It is assumed 22 of the UXO would be of 25m^2 or less and three of up to 350m^2. Up to 25 UXO clearance operations predicted in the offshore cable corridor. Horizontal Directional Drilling (HDD) exit – up to 3 bores (2 offshore export cables + 1 contingency). Within the worst-case scenario footprint for the seabed preparation area Total disturbance footprint – 3.31km^2	
Impact 2: Increased suspended sediment concentrations and sediment re-deposition	**Array area:** Seabed preparation area of for GBS of 70m diameter x 57 WTG x average 5m sediment depth = 1,096,809m^3 Two OSPs seabed preparation x average 5m sediment depth = 38,485 m^3 or one OSP and one offshore converter platforms (OCP), in the case of grid connection Option 3 Worst case scenario volume for seabed preparation for foundation installation = 1,14Mm^3 Array cable sandwave levelling = 27,293,114m^3 Cable burial = 170km length with average 1m trench width x average 1.2m burial depth = 204,000m^3 Platform interconnector cable sandwave levelling = 1,436,480m^3 Platform interconnector cable burial – 20km length with average 1m trench width x average 1.2m burial depth = 24,000m^3 Worst case scenario volume for array and interconnector platform cables = 28.96Mm^3 Total array area suspended sediments = 30.1Mm^3 Drill arisings at 10% of largest WTGs = 34,728m3 (based on 34 of the largest turbines which is the worst case scenario) Drill arisings at 1 x monopile OSPs = 11,451m^3 (based on 50% of the	Seabed preparation (dredging using a trailing suction hopper dredger and installation of a bedding and levelling layer) may be required up to a sediment depth of 5m. The worst-case scenario assumes that sediment would be dredged and returned to the water column at the sea surface during disposal from the dredger vessel. Sandwave levelling may be required prior to offshore cable installation. Any excavated sediment due to sandwave levelling would be disposed of within the North Falls offshore project area, meaning there will be no net loss of sediment from the site. Sediment will be disposed of within the boundary of the offshore project area. Assumes drilling at up to 10% WTG locations. The offshore HDD exit location will be subtidal in 1 to 8m water depth. Sediment displacement is included in the totals for the export cable.

Impact	Parameter	Notes
	OSPs needing drilling) Worst case scenario drill arising volume due to foundation installation = 46,179m^3 NB, drill arising would not occur in the event that the GBS is used and therefore this parameter cannot be added to the maximum seabed levelling for GBS described above. **Offshore Export cables:** Export cable sandwave levelling = 1,544,891m^3 Export cable burial – 125.4km length with average 1m trench width x average 1.2m burial depth = 150,480m^3 Worst case scenario volume for offshore export cables = 1.7Mm^3	
Impact 3: Re-mobilisation of contaminated sediments	Maximum suspension of sediments as described above. No significant contaminated sediments were recorded in the offshore project area. See Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) for more detail.	This represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during construction activities.
Impact 4: Underwater noise and vibration associated with piling for foundation installation	**Spatial worst case:** <u>Mortality/potential mortal injury (fleeing and stationary receptor) and temporary threshold shift (TTS) and behavioural impacts (stationary receptor):</u> Installation of up to 59 monopiles (57 WTG and 2 OSPs or 57 WTG and 1 OSP and 1 OCP) with a maximum pile diameter of 17m using a hammer energy of 6,000kJ. Maximum number of monopiles to be installed per 24 hour period: three. Up to two simultaneous piling events. <u>TTS and behavioural impacts (fleeing receptor):</u> Installation of up to 456 pin piles with a maximum pile diameter of 6m, using a hammer energy of 4,400kJ. Installation of up to 24 pin piles with a maximum pile diameter of 3.5m, usinga hammer energy of 3,000kJ for two OSPs/OCP (12 pin-piles per foundation). Maximum number of pin piles to be installed per 24 hour period: six Up to two simultaneous piling events.	The spatial worst case would result in largest spatial noise impact ranges at a given time and hence in the maximum impact on fish and shellfish receptors. Consideration has also been given to the worst-case scenario in terms of piling duration. This would be associated with the installation of the maximum number of piles.

Impact	Parameter	Notes
	Temporal worst case: Duration of foundation installation: 12 months Installation of up to 456 pin piles with a maximum pile diameter of 6m, using a hammer energy of 4,400kJ. Installation of up to 24 pin piles with a maximum pile diameter of 3.5m, using a hammer energy of 3,000kJ for two OSPs/OCP (12 pin-piles per foundation). Piling time per WTG foundation: Monopiles – Maximum of 450 minutes (7.5 hours) of active piling time per monopile Or Pin piles – Maximum of 270 minutes (4.5 hours) of active piling time per pile Piling time per OSP/OCP: Monopiles – Maximum of 450 minutes (7.5 hours) of active piling time per monopile Or Pin piles – Maximum of 270 minutes (4.5 hours) of active piling time per pile Total active piling time for both WTGs and OSPs/OCP: Monopiles Maximum of 427.5 hours (17.8 days) of active piling time for all WTGs, plus Maximum of 15 hours (less than one day) of active piling time for both OSPs Or Pin piles: Maximum of 2,052 hours (85.5 days) of active piling time for all WTGs, plus Maximum of 108 hours (less than 4.5 days) of active piling time for all OSPs/OCP	

Impact	Parameter	Notes
Impact 5: Underwater noise and vibration from other construction activities	**Underwater noise and vibration from construction activities other than piling, including:** Cable installation (cable laying vessel noise, trenching, etc.) Seabed preparation Rock placement Construction vessels noise Maximum number of vessels on site at any one time: 35 Indicative construction vessel movements: 2,532 round trips over two year offshore construction period (average of 1,266 movements per year; 3 movements per day)	This would result in the greatest noise impacts as a result of project construction activities other than piling for foundation installation.
Impact 6: Underwater noise from UXO clearance	Maximum equivalent charge weight for the potential UXO devices that could be present in the offshore project area has been estimated to be 750kg. Worst case number of UXO: Up to 15 UXO The worst-case is an estimate. Actual UXO numbers would be determined by a pre-construction UXO survey.	This would result in controlled detonations with the greatest potential associated noise impacts.
Impact 7: Changes in fishing activity	See ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16)	
Operation and Maintenance		
Impact 8: Temporary habitat loss/ physical disturbance	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: Reburial of c.2.75% of array cable length is estimated over the life of the Project (24m disturbance width) = 112,200m^2 Reburial of c.2.75% of platform interconnector cable is estimated over the life of the project (24m disturbance width) = 13,200m^2 Reburial of c. 4% of export cable is estimated over the life of the Project (24m disturbance width) = 120,3840m^2 Five array/platform interconnector cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width = 72,000m^2 Four export cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width = 57,600m^2	This represents the maximum estimated total area of seabed disturbance from unplanned repairs and reburial of cables that may be required during operation and maintenance (O&M). Persistent/ permanent habitat loss as a result of infrastructure decommissioned in situ is assessed as an operational impact because the impact begins when the operation phase starts once the wind farm infrastructure is in place.

Impact	Parameter	Notes
	Anchored vessels placed during the no. of cable repairs included above = 4,914m^2 Maintenance of offshore infrastructure would be required during O&M. An estimated 177 major component replacement activities may be required per year, using jack up vessels and/or anchoring = 292,050m^2	
Impact 9: Long term habitat loss	**Array area:** WTGs: Total worst case WTG foundation footprint with scour protection, based on 57 x 65m GBS diameter = 189,143.5m^2 Scour protection - assumes all turbines have scour protection of up to 83,774m^2 (excluding turbine foundation footprint) = 4,775,118m^2 Array cable protection - Up to 34km of cable protection may be required in the unlikely event that array cables cannot be buried (based on 20% of the length) x 6m cable protection width = 204,000m^2 Interconnector cable protection – Up to 4km of cable protection may be required in the unlikely event that array cables cannot be buried (based on 20% of the length) x 6m cable protection width = 24,000m^2 Two OSPs with scour protection = 174,184m^2 (87,092m^2 each) or one OSP and one offshore converter platforms (OCP), in the case of grid connection Option 3. Worst case scenario total persistent footprint in the array area = 5.37km^2 **Offshore export cables:** Export cable protection - Up to 12.5km of cable protection may be required in the unlikely event that export cables cannot be buried (based on 10% of the length) x 6m cable protection width = 75,240m^2	This would result in the maximum area of seabed habitat loss for fish and shellfish receptors in respect of North Falls infrastructure.
Impact 10: Increased suspended sediment concentrations (SSC) and re-deposition	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: Reburial of c. 2.75% of array/platform-interconnector cable is estimated over the life of the Project (24m disturbance width) x average 1.2m depth = 150,480m^3 Reburial of c. 4% of offshore export cable is estimated over the life of the Project (24m disturbance width) x average 1.2m depth = 144,461m^3	This would result in the highest potential levels of SSCs and subsequent sediment re-deposition. Each O&M activity would be relatively short term and it is likely that the requirements for maintenance would be spread over the Project life, with suspended sediments becoming rapidly redeposited.

Impact	Parameter	Notes
	Five array cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width x average 1.2m depth = 86,400m^3 Four export cable repairs are estimated over the Project life. 600m section removed x 24m disturbance width x average 1.2m depth = 69,120m^3	
Impact 11: Re-mobilisation of contaminated sediments	Maximum suspension of sediments as described above. No significant contaminated sediments were recorded in the offshore project area. See ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) for more detail.	The 'worst-case' scenario is represented by that which could result in the maximum volume of arisings (and therefore, maximum volume of contaminated sediment that could be brought into suspension).
Impact 12: Underwater noise and vibration	**Underwater noise and vibration during operation:** WTG - mechanically generated vibration and noise Cable repairs and reburial (cable laying vessel noise, etc) Maintenance vessels noise Maximum number of vessels on site at any one time: 20 Indicative O&M vessel trips to port per year: 1,095 round trips of small vessels and 127 round trips of large vessels (1,222 in total).	This results in the maximum potential for noise disturbance on fish and shellfish receptors during the O&M phase.
Impact 13: Electromagnetic Fields (EMFs)	Array cables: Maximum cable length: 170km Maximum voltage: 132kV Minimum target burial depth: 0.6m (average burial depth: 1.2m) Up to 20% of total array cable length requiring protection (up to 34 km) Platform interconnector cable: Maximum cable length: 20km Maximum voltage: 132kV Minimum burial depth: 0.5m (average burial depth: 1.2m) Up to 20% of total array cable length requiring protection (up to 4km) Offshore export cables: Up to 2 cable circuits with 3x unbundled power cables per circuit. Maximum offshore cable length: 125.4km	The maximum length of cables and the minimum burial depth would result in the greatest potential for EMF related effects.

Impact	Parameter	Notes
	Maximum voltage: up to 400 KV Minimum target burial depth: 0.6m (average burial depth 1.2m) Up to 10% of total export cable length requiring protection (up to 12.5km)	
Impact 14: Introduction of hard substrate	Based on the long-term habitat loss (Impact 9) as a result of permanent infrastructure detailed for O&M 57 WTG and 2 OSP or one OSP and one OCP Volume of array cable protection = 204,000m^2 Volume of interconnector cable protection = 24,000m^2 Volume of offshore export cable protection = 75,240m^3	This would result in the greatest introduction of hard substrate and therefore in the greatest extent of impacts on fish and shellfish receptors.
Impact 15: Changes in fishing activity	See ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16)	
Decommissioning		
Impact 16: Temporary habitat loss/ physical disturbance	Vessel jack up assuming 6 jack up locations per 57 wind turbine (275m^2 per jack up leg x 6 legs x 6 locations) = 564,300m^2 Jack up vessel footprints for OSP/OCP (275m^2 per jack up leg x 6 legs x 6 jack up events per two platforms = 19,800m^2 Anchoring during WTG and OSP/OCP decommissioning = 274,704m^2 (based on vessels with 8 anchors, each with 116.4m^2 footprint; and 5 anchoring events per WTG/OSP) Anchoring during array/platform interconnector cable removal (if required) = 235,878m^2 (based on 9 anchors per vessel, each with 61m2 footprint; and 432 anchoring events) Anchor placement for export cable removal (if required) = 297,825.5m^2 (based on 9 anchors per vessel, each with 61m^2 footprint; and 546 anchoring events)	For the purposes of the worst-case scenario, it is anticipated that the impacts will be no greater than those identified for the construction phase. No decision has yet been made regarding the final decommissioning policy for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. However, the following infrastructure is likely be removed, reused or recycled where practicable: • WTGs including monopile, steel jacket and GBS foundations; • OSPs including topsides and steel jacket foundations; and • Offshore cables may be removed or left in situ depending on available information at the time of decommissioning. The following infrastructure is likely to be decommissioned *in situ* depending on available information at the time of decommissioning: • Scour protection; • Offshore cables may be removed or left in situ; and • Crossings and cable protection. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator.
Impact 17: Re-mobilisation of contaminated sediments	Maximum suspension of sediments as described above. No significant contaminated sediments were recorded in the offshore project area. See ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) for more detail.	
Impact 18: Underwater noise and vibration	WTG operational noise as described in ES Appendix 12.3 (Document Reference: 3.3.8).	

Impact	Parameter	Notes
Impact 19: Changes in fishing activity		Decommissioning arrangements will be detailed in a Decommissioning Plan, which will be prepared in accordance with the Energy Act 2004.

11.3.3 Summary of mitigation embedded in the design

13. This section outlines the embedded mitigation relevant to the fish and shellfish ecology assessment, which has been incorporated into the design of North Falls. Where other mitigation measures are proposed, these are detailed in the impact assessment (Section 11.6).

Table 11.3 Embedded mitigation measures

Parameter	Mitigation measures embedded into North Falls design
Cable burial	The Applicant is committed to burying offshore cables where practicable to a target minimum burial depth of 0.6m. This is secured through the Outline Project Environmental Management Plan (Document Reference: 7.6). Cable burial reduces the strength of EMFs to which fish and shellfish species may be exposed as it constitutes a physical barrier, with fish and shellfish species not able to transit the immediate proximity of cables where EMFs are strongest. In addition, cable burial reduces the amount of hard substrate which may be required and associated potential changes to seabed habitat.
Cable protection	Where cables cannot be buried to the minimum depth, appropriate surface laid cable protection will be used.
Construction noise	A soft start and ramp-up protocol will be used for pile driving. Each piling event would commence with a soft-start at a lower hammer energy followed by a gradual ramp-up to the maximum hammer energy required (the maximum hammer energy is only likely to be required at a few of the piling installation locations). This is secured through the Outline Marine Mammal Mitigation Plan (Document Reference: 7.7) and would benefit fish ecology by allowing mobile species to move away from the area of highest noise impact during installation of foundations.
Piling restriction	To reduce impacts to Downs herring, the Applicant is committed to restricting piling activities during a suitable period of time between 1 November and 31 January, the duration of which will be discussed with the MMO and their advisors. This is secured through the Outline PEMP (Document Reference: 7.6).
Pollution prevention	As outlined in ES Chapter 9 Marine Sediment and Water Quality (Document Reference: 3.1.11), the Applicant is committed to the use of industry good practice techniques and due diligence regarding the potential for pollution throughout all construction, O&M, and decommissioning activities. An outline PEMP (Document Reference: 7.6) will be developed and submitted alongside the DCO application to set out the details of the measures that will be taken in relation to accidental pollution events. The final PEMP would be agreed with the MMO prior to construction.

11.4 Assessment methodology

11.4.1 Legislation, guidance and policy

11.4.1.1 National Policy Statements

The assessment of likely significant effects upon fish and shellfish ecology has been made with specific reference to the relevant NPS. These are the principal decision-making documents for Nationally Significant Infrastructure Projects (NSIPs). The NPS relevant to the Project and fish and shellfish ecology is NPS for Renewable Energy Infrastructure (EN-3) (Department for Energy Security and Net Zero (DESNZ, 2023).

14. The specific assessment requirements for fish and shellfish ecology as detailed in the NPS, are summarised in Table 11.4 together with an indication of the section of the ES chapter where each is addressed.

Table 11.4 NPS of Relevance to Fish and Shellfish Ecology

NPS requirement	NPS reference	ES reference
NPS for Renewable Energy Infrastructure (EN-3)		
Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore wind farm EIAs, HRAs and MCZ assessments.	Paragraph 2.8.101	Section 11.6
Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects.	Paragraph 2.8.103	The methodology for assessing adverse and beneficial effects is described in Section 11.4.3, additionally the impact assessment is presented in Section 11.6.
Applicants should consult at an early stage of pre-application with relevant statutory consultees and energy not-for profit organisations/non governmental organisations as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options which should be undertaken.	Paragraph 2.8.104	Consultation has been undertaken throughout the pre-application stage, as described in Section 11.2
Any relevant data that has been collected as part of post-construction ecological monitoring from existing operational offshore wind farms should be referred to where appropriate.	Paragraph 2.8.106	Data sources, including monitoring from Greater Gabbard and Galloper offshore wind farms are described in Section 11.4.2
There is the potential for the construction and decommissioning phases, including activities occurring both above and below the seabed, to impact fish communities, migration routes, spawning activities and nursery areas of particular species.	Paragraph 2.8.148	Sections 11.6.1 and 11.6.3.
There are potential impacts associated with energy emissions into the environment (e.g. noise or electromagnetic fields (EMF)), as well as potential interaction with seabed sediments.	Paragraph 2.8.149	Sections11.6.1.4.
The Applicant should identify fish species that are the most likely receptors of impacts with respect to: • spawning grounds; • nursery grounds; • feeding grounds; • over-wintering areas for crustaceans; and migration routes; and • protected sites.	Paragraph 2.8.150	Section 11.5.7, 11.6.1.5, 11.6.1.6, 11.6.2.5, 11.6.2.6, 11.7.3.3, 11.7.3.4 and 11.7.3.5.
Applicant assessments should identify the potential implications of underwater noise from construction and unexploded ordnance including, where possible, implications of predicted construction and soft start noise levels in relation to mortality, permanent threshold shift (PTS), temporary threshold shift (TTS) and disturbance, and addressing	Paragraph 2.8.151	Section 11.6.1.4 and Section 11.6.2.6

NPS requirement	NPS reference	ES reference
both sound pressure and particle motion) and EMF on sensitive fish species.		
EMF in the water column during operation, is in the form of electric and magnetic fields, which are reduced by use of armoured cables for interarray and export cables. Burial of the cable increases the physical distance between the maximum EMF intensity and sensitive species. However, what constitutes sufficient depth to reduce impact may depend on the geology of the seabed.	Paragraph 2.8.245 and Paragraph 2.8.246	Consideration has been given to the target minimum cable burial depth in Section 11.3.3. The Applicant is committed to burying offshore cables where practicable to a target minimum burial depth of 0.6m.
It is unknown whether exposure to multiple cables and larger capacity cables may have a cumulative impact on sensitive species. It is therefore important to monitor EMF emissions which may provide the evidence to inform future EIAs.	Paragraph 2.8.247	Impacts from EMFs are addressed under the assessment of the potential impacts during operation (Section 11.6.2).
Construction of specific elements can also be timed to reduce impacts on spawning or migration. Underwater noise mitigation can also be used to prevent injury and death of fish species.	Paragraph 2.8.249	Consideration has been given in this assessment to fish species with known spawning and nursery grounds in areas relevant to the Project (Table 11.12). As described in Table 11.3, soft start and ramp-up mitigation will be used for pile driving to allow mobile species to move away from the area of highest noise impact during installation of foundations.

11.4.1.2 Other legislation, policy and guidance

15. In addition to the NPS, policy and guidance applicable to the assessment of fish and shellfish ecology is set out in the East Inshore and East Offshore Marine Plans and the South East Marine Plan. Relevant policies outlined in these marine plans are listed in Section 11.4.1.1.

16. Further detail on legislation, policy and guidance is provided in ES Chapter 3 Policy and Legislative Context (Document Reference: 3.1.5).

Table 11.5 Marine Plans Policies of Relevance to Fish and Shellfish Ecology

Marine Plan	Policy	Reference	ES Reference
East Inshore and East Offshore Marine Plans	Proposals should demonstrate, in order of preference: a) that they will not have an adverse impact upon spawning and nursery areas and any associated habitat b) how, if there are adverse impacts upon the spawning and nursery areas and any associated habitat, they will minimise them c) how, if the adverse impacts cannot be minimised they will be mitigated d) the case for proceeding with their proposals if it is not possible to minimise or mitigate the adverse impacts	FISH2	Section 11.6

Marine Plan	Policy	Reference	ES Reference
South East Marine Plan	Proposals that enhance essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes should be supported. Proposals that may have significant adverse impact on essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes, must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate Adverse impacts so they are no longer significant.	SE-FISH-2	Section 11.6

11.4.2 Data sources

17. The characterisation of the fish and shellfish ecology baseline on which to base the impact assessment, has been informed through a desktop review of available data and information. This has included information from fish surveys carried out at offshore wind farm projects in the proximity of the Project, namely the Greater Gabbard Offshore Wind Farm (GGOW) and Galloper Wind Farm (GWF), available data from ICES on the results of fish surveys which cover the study area and analysis of fisheries landings statistics.

18. In addition, the results of the sediment Particle Size Analysis (PSA) from grab samples collected in the offshore area during the benthic baseline characterisation survey carried out for the Project (Fugro, 2021), along with PSA data from Cefas' OneBenthic Portal (OneBenthic, 2020) have been used where appropriate to characterise the distribution of suitable habitat for species such as herring *Clupea harengus* and sandeels.

19. A description of the key sources of data and information used is provided in Table 11.6.

20. As agreed with the Seabed ETG during the meeting held on 20th June 2022 as part of the EPP, given the available data and information on the distribution of fish and shellfish species in the study area, the undertaking of site-specific surveys to aid the baseline characterisation in respect of the Project is not considered necessary.

Table 11.6 Other available data and information sources

Data Set	Spatial Coverage	Year	Notes
MMO UK Landings Data (weight) by species (MMO, 2023)	ICES rectangles in the study area (32F1 and 32F2), and adjacent rectangles (33F1, 34F0, 34F1, 34F2, 34F3, 33F2, 33F3, 32F0,31F1, 31F1, 31F2)	2016 -2020	Provides an indication of the principal species targeted around the Project.

Data Set	Spatial Coverage	Year	Notes
Benthic Baseline Characterisation Survey (Fugro, 2021)	Offshore project area	2021	PSA data from grab samples collected across the offshore project area analysed to assess seabed suitability as sandeel and spawning herring habitat.
ICES International Bottom Trawl Survey (IBTS) data	ICES rectangles in the study area (32F1 and 32F2) and wider North Sea	2017 -2021	IBTS data has been accessed via the ICES Data Portal (DATRAS, the Database of Trawl Surveys: http://datras.ices.dk). The data has been presented as catch per unit effort (CPUE) (individuals caught per hour) for the period 2017-2021.
ICES International Herring Larvae Survey (IHLS) data	Sothern North Sea and English Channel (Downs herring)	December 2012 to January 2022	IHLS data has been accessed via the ICES Data Portal (http://eggsandlarvae.ices.dk). The IHLS surveys routinely collect information on the size, abundance and distribution of herring eggs and larvae (and other species) in the North Sea.
North Sea Cod and Plaice Egg (CP-EGGS) Surveys in the North Sea	North Sea	2003 – 2004, 2008 - 2009	CP-EGGS data has been accessed via the ICES Data Portal (http://eggsandlarvae.ices.dk). CP-EGGS aim to studying fish egg and larval distributions in the North Sea.
Cefas Blackwater Herring Survey	Thames Estuary	1989 - 2009	Cefas data has been accessed via the Cefas data portal: (https://data.cefas.co.uk/view/10094) Aims to assess the state of herring (*Clupea harengus*) stocks through measurements of length samples and by ageing a stratified selection of fish.
Distribution of Spawning and Nursery Grounds as defined in Coull et al. (1998) and in Ellis et al (2010, 2012)	UK territorial waters and the North Sea	Coull et al., 1991 - 1996 Ellis et al., varies by species but generally includes data between 1983 and 2008	Coull et al (1998) and Ellis et al (2010, 2012) are the standard references that provide broad scale overviews of the potential spatial extent of nursery grounds, spawning grounds and the relative intensity and duration of spawning. Both Coull et al (1998) and Ellis et al (2010, 2012) are based on a compilation of a variety of data sources.
Galloper Offshore Wind Farm Adult and Juvenile Fish Surveys (BMM, 2009)	GWF array area, cable corridor and adjacent locations.	October/November 2008 and April 2009	Baseline adult and juvenile fish surveys undertaken for the GWF using a commercial otter trawl and a 2-m scientific beam trawl, respectively.
Greater Gabbard Offshore Wind Farm Epibenthic Surveys (CMACS, 2014)	GGOW array area, export cable corridor and adjacent locations.	2009 and 2013	Epibenthic baseline and post-construction surveys undertaken as part of the monitoring of benthic communities following construction of the GGOW. Dataset includes information on the principal fish species recorded in 2-m scientific beam trawl samples.
Greater Gabbard Offshore Wind Farm Elasmobranch survey (BMM, 2014)	GGOW array area, export cable corridor and adjacent locations.	2014	Post-construction surveys carried out using longlines to determine the distribution and abundance of elasmobranch species in and around the wind farm.

21. In addition to the data sources described above, the following resources have been accessed to inform this report:

- Kent and Essex Inshore Fisheries Conservation Authority (KEIFCA) publications;
- Centre for Environment, Fisheries and Aquaculture Science (Cefas) publications;
- Joint Nature Conservation Committee (JNCC) publications;
- Institute for Marine Resources and Ecosystem Studies (IMARES) publications;
- ICES publications; and
- Other relevant peer-reviewed publications.

11.4.3 Impact assessment methodology

22. ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) explains the general impact assessment methodology applied to North Falls. The following sections confirm the methodology used to assess the likely significant effects on fish and shellfish ecology.

11.4.3.1 Definitions

23. For each impact, the assessment identifies receptors sensitive to that impact and implements a systematic approach to understanding the impact pathways and the level of impacts on given receptors. The definitions of sensitivity and magnitude for the purpose of the fish and shellfish ecology assessment are provided in Table 11.7 and Table 11.8.

Table 11.7 Definition of sensitivity for a fish and shellfish ecology receptor

Sensitivity	Definition
High	Individual* receptor (species or stock) has very limited or no capacity to avoid, adapt to, accommodate or recover from the anticipated impact.
Medium	Individual* receptor (species or stock) has limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact.
Low	Individual* receptor (species or stock) has some tolerance to accommodate, adapt or recover from the anticipated impact.
Negligible	Individual* receptor (species or stock) is generally tolerant to and can accommodate or recover from the anticipated impact.

*In this case individual receptor does not refer to an individual organism but refers to the population or stock of a species

Table 11.8 Definition of magnitude for a fish and shellfish ecology receptor

Magnitude	Definition
High	Fundamental, permanent / irreversible changes, over the whole receptor, and / or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness.
Medium	Considerable, permanent / irreversible changes, over the majority of the receptor, and / or discernible alteration to key characteristics or features of the particular receptors character or distinctiveness.
Low	Discernible, temporary (throughout project duration) change, over a minority of the receptor, and / or limited but discernible alteration to key characteristics or features of the particular receptors character or distinctiveness.

Magnitude	Definition
Negligible	Discernible, temporary (for part of the Project duration) change, or barely discernible change for any length of time, over a small area of the receptor, and / or slight alteration to key characteristics or features of the particular receptors character or distinctiveness.

11.4.3.2 Significance of effect

24. In basic terms, the likely significance of an effect is a function of the sensitivity of the receptor and the magnitude of the impact (see ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) for further details). The determination of significance is guided by the use of an impact significance matrix, as shown in Table 11.9. Definitions of each level of significance are provided in Table 11.10.

25. Effects identified within the assessment as major or moderate are regarded as significant in terms of the EIA regulations. Appropriate mitigation has been identified, where practicable, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall effect in order to determine a residual effect upon a given receptor.

Table 11.9 Significance of effect matrix

		Negative Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	**High**	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 11.10 Definition of effect significance

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore no change in receptor condition.

11.4.4 Cumulative effects assessment (CEA) methodology

26. The CEA considers other plans, projects and activities that may impact cumulatively with North Falls. ES Chapter 6 EIA Methodology (Document Reference: 3.1.8) provides further details of the general framework and approach to the CEA.

27. For fish and shellfish ecology these activities include other OWFs, subsea cables and pipelines, oil and gas exploration, aggregate extraction and coastal developments. As a general rule, other activities are only screened into the CEA where there is a spatial and/or temporal overlap in effects such that a cumulative effect would be possible.

11.4.5 Transboundary impact assessment methodology

28. For fish and shellfish ecology, the potential for transboundary effects has been scoped out for assessment. As described in the Scoping Report (Royal HaskoningDHV, 2021), the fish and shellfish impact assessment has been undertaken taking account of the distribution of fish stocks and populations irrespective of national jurisdictions. Therefore, the Applicant considers that a specific assessment of transboundary effects in relation to fish and shellfish ecology is unnecessary. The suitability of this approach has been confirmed by the MMO and PINS in their Scoping Opinion (see Table 11.1).

11.4.6 Assumptions and limitations

29. The characterisation of the existing environment in respect of fish and shellfish receptors has been undertaken using a wide a range of sources of data and information. Key data sources used, including their sensitivities and limitations are described in detail in ES Appendix 11.1 (Document Reference: 3.3.5).

11.5 Existing environment

30. This section includes a summary of the fish and shellfish ecology baseline for the Project and identifies key fish and shellfish receptors requiring assessment. Further detailed information on the fish and shellfish ecology baseline can be found in ES Appendix 11.1 (Document Reference: 3.3.5).

31. Fish and shellfish ecology receptors have been identified taking account of the following parameters:

- Presence/abundance in the study area;
- Location of spawning and nursery grounds relative to the Project;
- Conservation importance;
- Commercial importance; and
- Role within the North Sea's food-web.

32. In addition, in identifying key fish and shellfish receptors, due consideration has been given to the feedback received in the Scoping Opinion of relevance to fish and shellfish ecology and the consultation undertaken with the Seabed ETG on fish and shellfish ecology issues as part of the EPP.

11.5.1 International Bottom Trawl Survey (IBTS)

33. Recent data from the IBTS (2017 - 2021) have been analysed to help characterise the fish and shellfish community in the study area and are presented in ES Appendix 11.1 (Document Reference: 3.3.5).

34. The demersal bony fish species recorded in the study area by the IBTS in greatest numbers was whiting *Merlangius merlangus.* Other species found in relatively high numbers included dab *Limanda limanda,* bib *Trisopterus luscus,* poor cod *Trisopterus minutus*, plaice *Pleuronectes platessa* and Dover sole *Solea solea*. Species such as lesser weever *Echiichthys vipera*, grey gurnard *Eutrigla gurnardus*, lemon sole *Microstopmus kitt* and stripped red mullet *Mullus surmuletus* were also relatively abundant but for the most part their catches were concentrated in rectangle 32F2, with relatively low numbers found in 32F1, where the majority of the offshore project area is located. The remaining species of demersal bony fish were all recorded in relatively low numbers.

35. Small spotted catshark *Scyliorhinus canicula* was the elasmobranch found in greatest numbers, followed by thornback ray *Raja clavata* and smoothhounds *Mustelus spp.*

11.5.2 Species of commercial importance in the study area

36. The principal commercial fish and shellfish species targeted in the study area have been identified through the analysis of landings statistics of UK vessels by weight by ICES rectangle presented in ES Appendix 11.1 (Document Reference: 3.3.5). Additional information on activities from UK vessels and from vessels of other nationalities known to be active in the study area is provided in ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16).

37. The species of commercial importance from the study area are considered to be Dover sole, whelk *Buccinum undatum*, bass *Dicentrarchus labrax*, thornback ray, horse mackerel *Trachurus trachurus*, herring, cod *Gadus morhua* and plaice.

38. The principal species landed by weight by UK vessels from the study area are molluscs, predominantly cockle *Cerastoderma edule* and whelk. However, cockles are not fished in the vicinity of the offshore cable corridor, as any cockle grounds that do overlap have been closed under the Cockle Fishery Flexible Permit Byelaw for the last 10 years. The active cockle fishery is in the southwest corner of ICES rectangle 32F1, and is therefore not considered further.

39. In ICES rectangle 32F1, where the majority of the offshore project area is located, the species of highest commercial importance are considered to be Dover sole, whelk, bass and thornback ray. Local vessels to the offshore cable corridor are reported as targeting species such as bass, Dover sole, skate, herring, turbot *Scophthalmus maximus*, brill *Scophthalmus rhombus*, lobster *Homarus gammarus* and brown crab *Cancer pagurus* from a mix of trawling, netting and potting.

40. Further detailed information on landings statistics is provided in ES Appendix 11.1 (Document Reference: 3.3.5) and in ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16).

11.5.3 Surveys undertaken in the Galloper and Greater Gabbard Offshore Wind Farms

41. Various fish surveys have been undertaken in the GGOW and GWF. These are outlined in Table 11.11. Whilst these surveys have not been carried out in recent

years, some of the stations sampled are within or in close proximity to the offshore project area and are therefore of relevance to the Project. A summary of the results of these surveys is provided below. For additional detail see ES Appendix 11.1 (Document Reference: 3.3.5).

Table 11.11 Surveys undertaken in the Galloper and Greater Gabbard Offshore Wind Farms

Survey	Gear Type	Survey Area	Sampling Effort	Time of Surveys
Adult and Juvenile Fish Survey (BMM, 2009)	Otter trawl and 2-m scientific beam trawl	GWF array areas, export cable corridor and adjacent areas	15 x 25-minute otter trawls 18 x 5-minute beam trawls	October/November 2008 and April 2009
Epibenthic Survey (CMACS, 2014)	2-m scientific beam trawl	GGOW array area, export cable corridor and adjacent areas	21 x 300m tows	Spring/Summer 2009
			26 x 300m tows	Spring/Summer 2013
Elasmobranch Survey (BMM, 2014)	Longlines	GGOW array, export cable corridor and adjacent locations	14 x 300m longlines (100 hooks per line, 3 m apart)	May 2014

42. In the surveys carried out using otter trawl gear at GWF (BMM 2009), whiting, cod and small-spotted catshark were the species caught in higher numbers, with other demersal species such as dab, bib, plaice, thornback ray, starry smoothhound *Mustelus asterias*, poor cod, lemon sole and tub gurnard *Chelidonichthys lucernus* also caught in relatively high numbers.

43. In the surveys undertaken using 2-m scientific beam trawl in the GWF and GGOW (BMM, 2009; CMACS, 2014) the main fish species recorded included various species of goby, Dover sole, Northern rockling *Ciliata septentrionalis*, dragonet *Callionymus lyra*, bib, poor cod, lesser weever, sea snail *Liparis liparis*, dab, small spotted cat-shark, lemon sole, pogge *Aganus cataphractus* and whiting.

44. Small spotted catshark was the principal elasmobranch species recorded during the longline elasmobranch survey carried out in the GGOW (BMM, 2014), followed by thornback ray and spurdog *Squalus acanthias*. Other species, such as smoothhounds. and tope *Galeorhinus galeus* were also reported from this survey but in much lower numbers (eleven and one individuals, respectively).

45. Further details on the results of these surveys are provided in ES Appendix 11.1 (Document Reference: 3.3.5).

11.5.4 Spawning and nursery grounds

46. Species for which spawning or nursery grounds have been defined in areas that overlap with the array area and offshore cable corridor are listed in Table 11.12 based on information provided in Coull *et al* (1998) and Ellis *et al* (2010, 2012).

47. As shown, spawning grounds for herring, lemon sole, plaice, sandeel (*Ammodytidae spp.*), Dover sole, sprat, whiting and cod have all been defined in the offshore project area.

48. Nursery grounds for the species mentioned above as well as mackerel, thornback ray, and tope have also been defined within the offshore project area. It should be noted that in the case of thornback ray and tope, there is currently

insufficient data on the occurrence of egg-cases or egg-bearing females in the spawning season with which to define spawning grounds. In the case of thornback ray, it is considered that these are likely to broadly overlap with nursery grounds (Ellis *et al*., 2012).

49. Most of the species listed in Table 11.12 are pelagic spawners, which release their eggs in the water column. Exceptions to this are herring and sandeel, which are substrate specific demersal spawners. Thornback ray also lay eggs on benthic substrates although they are not known to have the same degree of substrate-specific spawning requirements as herring and sandeels.

50. Further detailed information on the distribution of spawning and nursery grounds of the species described above, together with information relating to their ecology, is provided in ES Appendix 11.1 (Document Reference: 3.3.5).

Table 11.12 Species with spawning and/or nursery grounds in the offshore project area (Coull *et al.*,1998; Ellis *et al.*, 2010)

Species	Spawning Season												Spawning Intensity		Nursery Intensity	
Species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**				
Herring	D	B	B	B	B						D	D	D	n/a	D	D
Lemon Sole																
Plaice	*	*														
Sandeel																
Dover sole				*												
Sprat					*	*										
Whiting																
Mackerel					*	*	*						n/a	n/a		
Cod		*	*													
Tope	Gravid females found all year												n/a	n/a		
Thornback ray				*	*	*	*						n/a	n/a		

Spawning times and intensity colour key: orange = high intensity spawning/nursery grounds, yellow= low intensity spawning/nursery grounds, blue= spawning/ nursery intensity not defined, grey= spawning period, * = peak spawning, n/a= no overlap with spawning/nursery grounds. D = Downs herring, B = Blackwater herring.

11.5.5 Species of conservation importance

51. Fish and shellfish species of conservation importance which have the potential to be found in the study area are outlined in the following sections including:

- Diadromous migratory species;
- Elasmobranchs; and
- Other species with designated conservation status.

52. Detailed information on the ecology, conservation status and the use that these species may make of the offshore project area or areas in its proximity is provided within ES Appendix 11.1 (Document Reference: 3.3.5).

53. The offshore project area overlaps with the Southern North Sea Special Area of Conservation (SAC) and the array area is adjacent to the Kentish Knock East Marine Conservation Zone (MCZ).

54. The offshore cable corridor runs adjacent to the Margate and Long Sands SAC and the inshore section of the offshore cable corridor overlaps with the Outer Thames Estuary Special Protection Area (SPA). The inshore section of the offshore cable corridor is c. 5.9km from the Blackwater, Crouch, Roach and Colne Estuaries MCZ of which protected features include native oyster *Ostrea edulis* and native oyster beds.

55. The assessment of impacts on seabed and benthic features is detailed within (Document Reference: 3.1.10); ES Chapter 8 Marine Geology, Oceanography and Physical Processes and ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12). The assessment on marine mammals is presented in ES Chapter 12 Marine Mammal Ecology (Document Reference: 3.1.14) and the assessment on ornithology receptors in ES Chapter 13 Offshore Ornithology (Document Reference: 3.1.15).

56. With the exception of the Blackwater, Crouch, Roach and Colne Estuaries MCZ, where shellfish species (native oyster/oyster beds) are protected features for designation, the Marine Protected Areas (MPAs) mentioned above are not designated for the protection of fish or shellfish species, per se. These MPAs, however, provide habitat and support a wide range of crustaceans and fish and in some cases include foraging areas of importance for marine mammals and birds.

11.5.5.1 Diadromous species

57. Various diadromous species have the potential to transit parts of the offshore project area, during certain periods of their life cycle. These include:

- European eel *Anguilla anguilla*;
- Shads (*Alosa alosa* and *Alosa fallax*);
- River and sea lampreys (*Lampetra fluviatilis* and *Petromyzon marinus*);
- Atlantic salmon *Salmo salar*;
- Sea trout *Salmo trutta*; and

- Smelt *Osmerus eperlanus*.

58. The occurrence of species such as European eel, shad, sea trout and lampreys has been documented from the Blackwater, Crouch and Colne Estuaries and the Thames (APEM, 2018; Graham et al., 2021; Maitland, 2003; Zoological Society of London (ZSL), 2016; ZSL, 2018; ZSL, 2021). These and the remaining species listed above may be occasionally recorded in MMO commercial landings statistics, however, with the exception of twaite shad, none of these species were recorded at surveys undertaken in the GWF and GGOW or during recent IBTS surveys (ES Appendix 11.1, (Document Reference: 3.3.5)).

59. For the most part these species, if present in the area, would be expected in coastal areas (i.e. in inshore areas possibly in the proximity of the offshore cable corridor) rather than in the array area.

11.5.5.2 Elasmobranchs

60. Elasmobranchs (sharks, skates and rays) are considered particularly vulnerable to anthropogenic pressures due to their slow growth rates, late age at maturity and low reproductivity, resulting in slow increases in their population (Ellis et al., 2008; Sguotti et al., 2016). Stock levels of many elasmobranch species are considered low and are therefore the focus of conservation efforts including international advice and management measures (Dulvy et al., 2017; ICES, 2021). Those potentially present in the study area are listed in Table 11.13.

61. Thornback ray, blonde ray *Raja brachyura,* small spotted catshark, smoothhounds, spurdog and tope were recorded in either the GWF or GGOW fish ecology surveys. Similar species were recorded in the IBTS. Further detailed information on survey and IBTS sampling results is provided in ES Appendix 11.1 (Document Reference: 3.3.5).

Table 11.13 Principal elasmobranch species potentially found in areas of relevance to the offshore project area

Common Name	Scientific name
Sharks	
Basking shark	*Cetorhinus maximus*
Starry smoothhound	*Mustelus asterias*
Smoothhound	*Mustelus mustelus*
Spurdog	*Squalus acanthias*
Thresher shark	*Alopias vulpinus*
Tope	*Galeorhinus galeus*
Skates and rays	
Blonde ray	*Raja brachyura*
Cuckoo ray	*Leucoraja naevus*
Common skate complex	*Dipturus intermedius/ Dipturus flossada*
Spotted ray	*Raja montagui*
Thornback ray	*Raja clavata*

Common Name	Scientific name
Undulate skate	*Raja undulata*
White skate	*Rostroraja alba*

11.5.5.3 Other species of conservation importance

62. In addition to diadromous fish and elasmobranchs, a number of fish and shellfish species found in the study area are of conservation interest, being listed as species of principal importance under the UK Post-2010 Biodiversity Framework and Section 41 of the Natural Environment and Rural Communities Act 2006 (England). In addition, some fish and shellfish species are protected features in MCZs. These are presented in ES Appendix 11.1 (Document Reference: 3.3.5), along with other conservation designations (e.g. Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR; Oslo/Paris Convention) and International Union for Conservation of Nature (IUCN) listings). It should be noted that many of these species are commercially exploited in the area, either directly or indirectly as by-catch.

11.5.6 Prey species and food web linkages

63. Various fish species found in the study area, particularly sandeels (*Ammodytidae spp.*), and clupeids (e.g. herring and sprat *Sprattus sprattus*), play an important role in the North Sea's food web as prey to predators such as birds, marine mammals and piscivorous fish (ICES, 2019).

64. Sandeels, herring and sprat were present in surveys carried out in GGOW and GWF and, whilst the main focus of the IBTS is on demersal fish sampling, shoaling pelagic species, particularly sprat and to a lesser extent herring were recorded in relatively high numbers over the 2017 to 2021 period.

65. While herring and sprat are currently commercially exploited in the study area, the UK government has prohibited the fishing of sandeels within English waters of ICES Area IV (North Sea) and therefore within the study area from April 2024, before the start of the next sandeel fishing season. This measure applies to all vessels of any nationality (DEFRA, 2024). It should be noted, however that there are no active sandeel fisheries reported from the offshore project area in recent years nor historically.

66. The ecology of these prey species is described in further detail within ES Appendix 11.1 (Document Reference: 3.3.5).

11.5.7 Key fish and shellfish species

67. In order to identify key species, due regard has been given to the feedback provided by stakeholders on fish and shellfish ecology related issues in the Scoping Opinion issued by PINS (PINS, 2021), during ETG meetings as part of the EPP and the feedback received on the PEIR.

68. The key species identified, and the rationale for their inclusion within the assessment is provided in Table 11.14. This includes considerations such as presence/abundance in the study area, commercial importance, distribution of spawning and nursery grounds and conservation status.

69. Detailed information regarding the ecology of these species and the use that they may make of the study area is provided in ES Appendix 11.1 (Document Reference: 3.3.5).

Table 11.14 Principal Fish and Shellfish Species in the Study Area

Relevant Fish and Shellfish Species	Rationale
Principal Demersal Bony Fish	
Cod	• Common in the study area • Species of conservation interest (Principal Importance, OSPAR, IUCN) • Commercially important in the study area • Low intensity spawning and nursery areas overlap with offshore project area
Whiting	• Common in the study area • Species of Principal Importance • Low intensity spawning and nursery areas overlap with the offshore project area
Dover sole	• Common in the study area • Species of Principal Importance • Commercially important in the study area • High intensity spawning area overlaps with the offshore project area • High intensity nursery area overlaps with the inshore section of the offshore cable corridor; low intensity nursery area overlaps with the array area.
Plaice	• Common in the study area • Species of Principal Importance • Commercially important in the study area • High intensity spawning area and low intensity nursery area overlap with the offshore project area
Lemon sole	• Common in the study area • Undefined intensity spawning area and nursery area overlaps with the offshore project area
Bass	• Common in the study area • Of importance to commercial and recreational fisheries in the study area • Bass fishing heavily regulated due to stock concerns
Other Species (i.e. dab, gobies, gurnards)	• Species characteristic of the southern North Sea fish assemblage • Common species in the study area • Possible prey items for fish, bird and marine mammal species
Ammodytidae (Sandeels)	
Lesser sandeel Small sandeel Greater sandeel	• Found in the study area • Species of Principal Importance • Key prey species for fish, birds and marine mammals • Low intensity spawning and nursery areas overlap with the offshore project area
Principal Pelagic Fish Species	
Herring	• Common in the study area • Species of Principal Importance • Commercially important in the study area • Spawning grounds of Downs herring located in areas adjacent to the array area • Spawning grounds of Blackwater herring located in the proximity of the inshore section of the offshore cable corridor

Relevant Fish and Shellfish Species	Rationale
	• High intensity nursery area overlaps with the offshore project area • Key prey species for fish, birds and marine mammals
Sprat	• Common in the study area • Low commercial importance in the study area • Undefined intensity spawning grounds and nursery grounds overlap with the offshore project area • Key prey species for fish, birds and marine mammals
Horse mackerel	• Common in the study area • Species of Principal Importance • Commercial importance in the study area
Mackerel	• Found in the study area • Species of Principal Importance • Low commercial importance in the study area • Low intensity nursery area overlaps with the offshore project area
Elasmobranchs	
Thornback ray	• Abundant in the study area • Commercially important in the study area • Conservation importance ('Near Threatened' IUCN status and OSPAR list) • Low intensity nursery area overlaps with the offshore project area
Other rays, skates and sharks (e.g. spotted ray, common skate, blonde ray, small spotted catshark, smoothhounds, spurdog, tope)	• Present in the vicinity of the study area • Some species are Species of Principal Importance or OSPAR listed, and several are classified Endangered or Critically Endangered on the IUCN Red List with landings restricted or prohibited • Some species are of commercial importance in the study area • Tope have low intensity nursery grounds overlapping with the offshore project area
Diadromous Fish Species	
European eel	• Present in rivers in the proximity of the study area • Species of conservation importance (Species of Principal Importance, OSPAR list, listed as 'Critically Endangered' by IUCN) • May transit/feed in the study area during marine migration
European smelt	• Populations of smelt reported from estuaries in the proximity of the offshore project area • Species of Principal Importance • May transit/feed in vicinity of the inshore section of offshore cable corridor
Twaite shad Allis shad	• Species of conservation interest (Species of Principal Importance, protected under Bern Convention, Wildlife and Countryside Act, Habitats Regulations and included in OSPAR list (allis shad) • May transit/feed in vicinity of the study area during marine phase • Caught in surveys carried out in the GWF
River lamprey Sea lamprey	• Species of conservation interest (Species of Principal Importance, protected under the Habitats Regulations, the Bern Convention and listed by OSPAR as declining and/or threatened (sea lamprey only) • May transit/feed in vicinity of the study area during marine migration
Atlantic salmon	• Species of conservation interest (Species of Principal Importance, protected under the Habitats Regulations, the Bern Convention, listed by OSPAR as declining and/or threatened and classified as "vulnerable" by IUCN

Relevant Fish and Shellfish Species	Rationale
	• May occasionally transit/feed in the study area during marine migration
Sea trout	• Reported from estuaries in the proximity of the offshore project area • Species of Principal Importance • May transit/feed in the study area during marine migration
Shellfish species	
Cockle	• Commercially important in the study area • Managed by the Cockle Flexible Permit Byelaw and the Thames Estuary Cockle Fisheries Order 1994
Whelk	• Commercially important in the study area • Managed by the Whelk Fishery Flexible Permit Byelaw
Native oyster	• Species of Principal Importance and protected in the Blackwater, Crouch, Roach and Colne Estuaries MCZ • Managed by Native Oyster Fishery Flexible Permit Byelaw
Lobster	• Commercial importance in the study area
Brown crab	• Commercial importance in the study area • May overwinter within the study area and the wider area

11.5.8 Future trends in baseline conditions

70. The existing baseline conditions within the study area described above are considered to be relatively stable in terms of fish and shellfish receptors. Multiple sources of fish and shellfish data are available at different spatial resolutions for varying time periods that exhibit similar trends in species presence and abundance. The fish and shellfish baseline environment of the southern North Sea is however influenced by environmental factors and commercial fishing activity and therefore subject to change.

71. Species distribution shifts during the last decades have been documented at varying scales across oceans and taxonomic groups (Sorte *et al*., 2010). ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12) highlights that North Sea benthic communities are under significant pressure from climate change and that a north westerly shift in geographical distribution is predicted for benthic communities. Fish communities are also likely to follow this trend.

72. Commercial fishing activity is subject to multiple factors including variations in target species abundance, changes in the quotas of pressure stock species, the imposition of conservation measures including spatial restrictions, local byelaws, effort limits and vessel and gear regulations. Economic effects as well as national and international politics may also result in changes at local, regional and national scales.

73. As mentioned in Section 11.5.6, the UK government now prohibits the fishing of sandeels within English waters of ICES Area IV (North Sea). This measure applies to all vessels of any nationality, and was implemented on 26 March 2024, before the start of the next sandeel fishing season. Given the lack of a sandeel fishery in the study area either historically or in recent years (see ES Appendix 11.1 Fish and Shellfish Ecology Technical Report (Document

Reference: 3.3.5)), it is unlikely that the sandeel ban will have a direct impact on the baseline fish and shellfish ecology in areas of relevance to the Project.

74. It is anticipated that the baseline will continue to evolve as a result of global trends which include the effects of climate change as well as trends at the European level such as changes in fisheries regulations and policies.

11.6 Assessment of significance

11.6.1 Likely significant effects during construction

75. The potential impacts of the Project on fish and shellfish receptors during construction are assessed below. As outlined in Table 11.2, these include the following:

- Impact 1: Physical disturbance and temporary habitat loss;
- Impact 2: Increased SSCs and sediment re-deposition;
- Impact 3: Re-mobilisation of contaminated sediments;
- Impact 4: Underwater noise from piling for foundation installation;
- Impact 5: Underwater noise from other construction activities;
- Impact 6: Underwater noise from UXO clearance; and
- Impact 7: Changes in fishing activity.

11.6.1.1 Impact 1: Physical disturbance and temporary habitat loss

11.6.1.1.1 Magnitude of impact

76. During the construction phase of the Project, activities such as foundation installation of WTGs and OSPs/OCP as well as array, platform interconnector and export cable installation have the potential to result in physical disturbance and/or temporary loss of habitat to fish and shellfish receptors. Similarly, the presence of machinery on the seabed (i.e. jack up vessel legs, vessel anchors) could also result in physical disturbance or temporary habitat loss.

77. Offshore works are anticipated to be carried out over an indicative 2-year construction programme. As described in Table 11.2, the total area disturbed during construction within the North Falls array area would be 5.88km^2. This would account for a small percentage of the total area of the array (approx. 6.19%). Similarly, the maximum area of disturbance associated with construction activities in the offshore cable corridor would also be relatively small (total disturbance footprint = 3.3km^2 which is 6% of the total area of the offshore cable corridor.

78. Physical disturbance/loss of habitat would occur at localised discrete locations (i.e. in the immediate proximity of infrastructure/machinery) at any given time as construction works progress and would be temporary and short term.

79. In general terms the areas affected are minimal in the context of the wide distribution range of fish and shellfish species, including areas used for spawning/nursery.

80. In the case of herring, it is noted that spawning grounds for the Downs stock are located immediately to the east of the array area and that the degree of overlap

between spawning grounds and areas within the offshore project area where physical disturbance/temporary loss of habitat may occur would be very small (ES Figure 11.2, and ES Figure 11.3 (Document Reference: 3.2.7)). Blackwater herring spawning grounds are located in inshore areas around the Blackwater Estuary and Herne Bay at considerable distance from the offshore project area (ES Figure 11.2, (Document Reference: 3.2.7)) and therefore would not be subject to direct disturbance/temporary loss of habitat as a result of construction works.

81. As shown in ES Figure 11.4 (Document Reference: 3.2.7), the offshore project area overlaps with the large low intensity sandeel (*Ammodytidae* spp.) spawning and nursery grounds defined by Ellis et al. (2012) that cover the majority of the southern North Sea. The closest high intensity sandeel spawning areas are found in the Dogger Bank at a considerable distance from the offshore project area.

82. In line with this, analysis of IBTS data for lesser sandeel, the species of sandeel that is most abundant in the North Sea, shows low CPUE values in the study area, with other areas within SA area 1r, particularly the Dogger Bank, recording considerably higher CPUEs values (ES Figure 11.5, (Document Reference: 3.2.7)).

83. Whilst sandeels are expected to be found in some numbers in the study area, available information from the IBTS (ES Figure 11.5, (Document Reference: 3.2.7)), the distribution of defined spawning and nursery grounds (ES Figure 11.4, (Document Reference: 3.2.7)), known sandeel grounds and fishing areas (ES Figure 11.6, (Document Reference: 3.2.7)) and available information on the sediments in the offshore project area, all suggest that the offshore project area is not a key sandeel area (ES Figure 11.7 (Document Reference: 3.2.7) and ES Appendix 11.1, (Document Reference: 3.3.5)). It is therefore expected that the extent of sandeel habitat, affected by physical disturbance/temporary habitat loss as a result of construction works will be very small.

84. Similarly, for other species that are demersal spawners such as thornback ray, the level of overlap between area affected by habitat disturbance/loss of habitat would be minimal in the context of the wide areas identified as spawning/nursery grounds (low intensity) for this species.

85. In the particular case of shellfish receptors of limited mobility such as cockles and oysters, there is no expected direct overlap between the works and the receptors. The offshore cable corridor area overlaps with two cockle harvest areas however, it is understood from consultation with KEIFCA that there is no overlap between cockle beds that are being commercially targeted and the offshore cable corridor (ES Appendix 14.1 Commercial Fisheries Technical Report (Document Reference: 3.3.15)). Similarly, while the offshore cable corridor is in the proximity (c.5.9km) of the Blackwater, Crouch, Roach and Colne Estuaries MCZ (specifically designated for the protection of native oysters/oyster beds) there is no overlap with the offshore cable corridor.

86. As previously mentioned, the area of disturbance will be very small and the seabed is anticipated to quickly recover to its original condition (see ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12)). Considering this in the context of the wide distribution ranges of fish and shellfish species and the very limited overlap of the proposed works with key habitats for these

species (and no overlap in some cases) the magnitude of the impact of physical disturbance/temporary habitat loss is considered to be negligible for all fish and shellfish receptors.

11.6.1.1.2 Sensitivity of receptor

87. Most of the fish species that are found in the study area are highly mobile and would be able to make use of suitable undisturbed areas in the vicinity of works. The sediment and benthic species around the offshore project area are considered to be characteristic of highly disturbed environments and would be expected to return to its original condition over a relatively short time frame once construction activities have ceased in a given area. As such no significant impacts on the benthic community are anticipated in relation to disturbance during construction (impact assessed as negligible in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12).

88. In general terms, fish and shellfish species are considered receptors of low sensitivity.

89. Species that depend on specific substrates for burrowing or spawning and species of life stages of reduced mobility, may however be more susceptible to the impact of physical disturbance/temporary habitat loss. In the study area, these include the following:

- Herring: require specific substrates on which to lay their eggs (demersal spawners);
- Sandeels: require specific substrates on which to burrow as well as for spawning (demersal spawners);
- Elasmobranch species with spawning grounds in the offshore project area that lay egg cases on the seabed (i.e. thornback ray); and
- Shellfish species: have lower mobility in comparison to fish species and in some cases carry their eggs or lay them on the seabed.

90. A separate assessment of sensitivity is provided for these species/species groups below.

Herring

91. Herring are demersal spawners and require the presence of suitable coarse substrate on which to lay their eggs. As such, physical disturbance to the seabed and temporary habitat loss associated with construction works could result in detrimental impacts on herring spawning. With this in mind, herring is considered a receptor of high sensitivity.

Sandeels

92. Sandeels depend on the presence of an appropriate sandy substrate in which to burrow and lay their eggs on the seabed (demersal spawners). Therefore, physical disturbance to the seabed and temporary habitat loss associated with construction works could result in detrimental impacts on this species. As such, sandeels are considered a receptor of high sensitivity.

Elasmobranchs – Thornback ray

93. Thornback rays lay egg cases on the seabed and therefore have increased sensitivity to the effect of physical disturbance. However, they are not known to have the same degree of substrate-specific spawning requirements as species such as herring and sandeels. Thornback ray is considered a receptor of medium sensitivity.

Shellfish

94. Shellfish are much less mobile than fish species and may be less able to avoid areas where construction activity is occurring and therefore be more vulnerable to physical disturbance and temporary loss of habitat. Mobile shellfish species such as crab and lobster have adopted a reproductive strategy of high egg production to compensate for losses during egg extrusion and the extended incubation period (McQuaid et al., 2009). Females are ovigerous, with the eggs remaining attached to the abdomen until hatching. In the case of crabs, females may remain buried in sediments when bearing eggs for periods ranging from four to nine months. Other species such as whelks lay demersal egg cases which are often found attached to subtidal rocks, stones or shells (Ager, 2008). Both adults and egg masses (pre-hatching) of shellfish receptors could be vulnerable to physical damage during construction activities and are considered receptors of medium sensitivity.

95. Sedentary/sessile shellfish species such as cockles and oysters would be expected to be the most vulnerable to physical disturbance (Perry *et al*., 2017). Native oysters and cockles are considered receptors of high sensitivity.

11.6.1.1.3 Significance of effect

96. For the majority of fish species, taking account of the identified magnitude of impact (negligible) and receptor sensitivity (low), effects associated with physical disturbance and temporary habitat loss during construction are considered to result in an impact of **negligible significance which is not significant in EIA terms.**

97. Of the fish species assessed separately herring and sandeels were considered of high sensitivity and thornback ray of medium sensitivity.

98. These sensitivities combined with the impact magnitude (negligible) result in impacts of minor significance for herring, sandeels and thornback ray.

99. For shellfish, considered in general of medium sensitivity, and for cockles and oysters, both assessed as high sensitivity, the impact is considered to be of minor significance.

11.6.1.2 Impact 2: Increased SSCs and sediment re-deposition

11.6.1.2.1 Magnitude of impact

100. An expert-based assessment of the potential increase in SSCs and associated sediment re-deposition resulting from the construction of the Project (including seabed preparation and installation of offshore infrastructure) is given in detail within ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10). Relevant information included in the assessment is summarised here and has been used to inform the definition of the magnitude of the impact.

101. Activities associated with the construction phase that have potential to result in increased SSCs and sediment re-deposition include the following:

- Seabed preparation and drilling for foundation installation; and
- Cable installation (export cables and array/interconnector cables).

102. The maximum design scenario associated with increases in SSC is given in Table 11.2. As described in ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10), medium to coarse sand sediments are most prevalent in the array. Therefore, disturbed sediment in the array is likely to settle rapidly back to the seabed within minutes or tens of minutes and within tens of metres along the axis of tidal flow from the point at which it was released. The small proportion of fine sand and mud would stay in suspension for longer and form a passive plume. This plume (tens of mg/l) would be likely to exist for around half a tidal cycle (i.e. approximately 6 hours). Sediment would settle to the seabed within a few hundred metres up to approximately 1km along the axis of tidal flow from the location at which it was released. These deposits would be very thin (millimetres).

103. Fine sands and mud are most prevalent along the offshore cable corridor where mud-sized sediments would be advected further distances and persist in the water column for hours to days, before depositing a thin layer on the seabed. Plume modelling simulations carried out for GWF showed a maximum dispersion distance of 15km for coarse silt and indicated that fine sands would result in the greatest bed thickness changes, however the worst-case level sediment smothering and deposition is approximately <1mm (see ES Chapter 8 Geology, Oceanography and Physical Processes, (Document Reference: 3.1.10)).

104. Although SSCs will be elevated they are likely to be lower than concentrations that would develop in the water column during storm conditions, that are likely to drive greater changes to the seabed than the changes that would occur due to the presence of the wind farm infrastructure. Also, tidal currents are likely to rapidly disperse the suspended sediment (i.e. over a period of a few hours). It is likely that the increase in concentrations would be greatest in the shallowest sections of the offshore cable corridor, but in these locations the background concentrations are also greater than in deeper waters.

105. Overall changes from SSC and deposition of fine sands and mud-sized sediment will not be measurable due to prevailing hydrodynamic conditions with high wave activity agitating the seabed regularly.

106. As described previously for the assessment of impacts in respect of physical disturbance/temporary loss of habitat (Section 11.6.1.1), available information from the IBTS (ES Figure 11.5, (Document Reference: 3.2.7)), the distribution of defined spawning and nursery grounds (ES Figure 11.4, (Document Reference: 3.2.7)), known sandeel grounds and fishing areas (ES Figure 11.6, (Document Reference: 3.2.7)) and the result of analysis of sediment samples collected in the offshore project area (see ES Appendix 11.1, (Document Reference: 3.3.5)), all suggest that the offshore project area is of comparatively low importance to sandeel species.

107. Defined spawning grounds for the Downs herring are located immediately to the east of the array area with limited overlap with the offshore project area (ES Figure 11.2, (Document Reference: 3.2.7)).

108. Increased SSCs along the offshore cable corridor (potential habitat for egg bearing and spawning crab and lobster in the fish and shellfish study area) will only affect a small area at any one time and will be temporary in nature, with sediments settling to the seabed quickly following disturbance as detailed in ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10).

109. Taking account of the anticipated levels of increase in SSCs and the expected level of sediment deposition, the magnitude of the impact of construction activities for the offshore project area is considered to be negligible.

11.6.1.2.2 Sensitivity of receptor

110. In general terms, adult and juvenile fish, being mobile, would be expected to rapidly redistribute to undisturbed areas within their habitat range. Given that the SSCs are likely to be within the range of natural variability for these species, they are considered receptors of low sensitivity.

111. It is recognised that species and life stages of relatively low mobility, and those highly dependent on the presence of specific substrates may have increased sensitivity to the impact of SSCs and sediment deposition. For instance, eggs and early larval stages may drift passively in the water column or be present on benthic substrates. This results in reduced capacity to avoid areas impacted by increased SSCs and re-deposition of sediments and an increased susceptibility to the potential negative effects of the impact. Similarly, shellfish species, having lower mobility in comparison to most fish species, may be more susceptible as they may not be able to avoid areas affected by increased SSCs and re-deposition.

112. Separate assessments are given below for species highly dependent on the characteristics of the substrate, early life stages (eggs and larvae) and shellfish, as follows:

- Sandeels (demersal spawners);
- Herring (demersal spawners);
- Other species with known spawning grounds in the offshore project area; and
- Shellfish species.

Sandeels

113. Sandeels spend a significant proportion of their life cycle buried within the seabed and are demersal spawners. Therefore, increased SSCs and sediment re-deposition associated with the Project may have increased potential to adversely impact this species group.

114. Sandeels deposit eggs on the seabed in the vicinity of their burrows. Grains of sand may become attached to the adhesive egg membranes. Tidal currents can cover sandeel eggs with sand to a depth of a few centimetres, however, experiments have shown that the eggs are capable of developing normally and hatch as soon as currents uncover them again (Winslade, 1971).

115. Research by Behrens *et al*. (2007) on the oxygenation in the burrows of sandeel *A. tobianus* found that the oxygen penetration depth at the sediment interface was only a few millimetres. Sandeels were typically buried in anoxic sediments at depths of 1-4cm. In order to respire, they appear to induce an advective transport through the permeable interstice to form an inverted cone of porewater with 93% oxygen saturation.

116. In addition to direct effect on adults and early life stages, increased SSCs and redeposition associated with construction activity could also result in a change in the substrate characteristics causing a change/loss of habitat to sandeels. It should be noted, however, that for the most part any sediment re-deposited would be similar to that in the surrounding seabed and therefore no significant change in seabed sediment type is to be expected (ES Chapter 8 Marine Geology Oceanography and Physical Processes, (Document Reference: 3.1.10)).

117. From the above, it is apparent that despite their limited mobility and substrate dependence, sandeel early life stages and adults are relatively tolerant to SSCs and sediment re-deposition. They are therefore considered receptors of medium sensitivity.

Herring

118. Herring are demersal spawners requiring the presence of a coarse substrate on which to lay their eggs. Therefore, increased SSCs and sediment re-deposition associated with the Project may have increased potential to adversely impact this species.

119. Laboratory studies have established that herring eggs are tolerant to elevated SSCs as high as 300mg/l and can tolerate short term exposure at levels up to 500mg/l (Kiørboe *et al.*, 1981). These studies concluded that dredging and other similar operations are not likely to result in harmful effects to herring spawning grounds. Herring eggs have been recorded to successfully hatch at SSCs up to 7,000mg/l (Messieh *et al*., 1981).

120. In addition to impacts on early life stages, increased SSCs and sediment redeposition associated with the Project could result in an impact on herring spawning grounds by means of changes in the characteristics of the substrate. As previously described, however, there is little potential for significant changes in the characteristics of the seabed sediment type to occur as a result of construction activities.

121. Whilst the substrate dependence/demersal nature of herring spawning activity is recognised, in light of the relative tolerance of herring eggs to increases in SSCs such as those associated with the construction of the Project, herring are considered receptors of medium sensitivity.

Other species with known spawning grounds

122. As described in Section 11.5.4, there are a number of other fish species with defined spawning grounds located in areas relevant to the offshore project area. These include lemon sole, plaice, sole, sprat, whiting, cod and thornback ray.

123. Most of the species listed in Table 6.8 are pelagic spawners, which release their eggs in the water column. The exception is thornback ray, which lay eggs on benthic substrates although they are not known to have the same degree of

substrate-specific spawning requirements as species such as herring and sandeels.

124. Given that the SSCs are likely to be within the range of natural variability for these species, they are considered receptors of low sensitivity.

Shellfish

125. Marine Evidence based Sensitivity Assessment (MarESA) has been used in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12) to determine sensitivity of specific biotopes and dominant macrofauna, including shellfish species which is of relevance to shellfish receptors. Crabs are considered to have a low sensitivity to suspended sediments and smothering, however, they are likely to avoid areas of increased suspended sediment concentration as they rely on visual acuity during predation (Neal and Wilson, 2008). This assessment is based on shellfish species being able to escape from under silt and migrate away from an area.

126. While there is no MarESA available for lobster, there is for the spiny lobster (*Nephropidae*) which belong to the same taxonomic family and can provide a relevant comparison given the physiological similarities between these species. The MarESA concludes that spiny lobster is tolerant and not sensitive to increased SSCs and smothering.

127. In line with the above, in a review of the effects of elevated SSCs, Wilber and Clark (2001) reported that in studies examining the tolerance of adult crustaceans, the majority of mortality was induced by concentrations exceeding 10,000mg/l (considerably higher than those generated by construction activities associated with the installation of foundations and offshore cables). Crab and lobster are therefore considered receptors of low sensitivity to increased SSCs and sediment deposition.

128. There is limited information on the sensitivity of the common whelk to increased SSCs and deposition. The MarESA for the dog whelk *Nucella lapillus* (which belongs to the same taxonomic order (Neogastropoda)), however, indicates that the species is not sensitive to increased SSCs and smothering (Tyler-Walters, 2007). This is in line with a reported preference for soft substrates (Ager, 2008). Given that the SSCs are likely to be within the range of natural variability for this species, it is considered a receptor of low sensitivity.

129. Sedentary/sessile filter feeders such as cockles and oysters are amongst the most vulnerable to increased SSCs and smothering effects from sediment re-deposition (BERR, 2008). However, oysters and cockles habitats are subjected to a degree of natural variation in suspended sediments, given their location in typically nearshore, shallow banks. These species are considered receptors of medium sensitivity.

11.6.1.2.3 Significance of effect

130. In general terms, adult and juvenile fish are considered receptors of low sensitivity to increased SSCs and deposition. This, in combination with the negligible magnitude of the impact associated with the Project, would result in an effect of negligible significance.

131. Of the receptors that were assessed separately, herring, sandeels, and sedentary/sessile filter feeders are considered receptors of medium sensitivity which results in an effect of minor significance.

132. Shellfish receptors and other species with known spawning grounds are assessed to be of low sensitivity, which results in an effect of **negligible significance, which is not significant in EIA terms.**

11.6.1.3 Impact 3: Re-mobilisation of contaminated sediments

11.6.1.3.1 Magnitude of impact

133. As a result of construction activities within both the subtidal and intertidal region there is the potential for contaminants in the sediments to be re-suspended and to have adverse effects on fish and shellfish receptors. Impacts to water quality as receptors are assessed in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11).

134. As outlined in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12) benthic samples collected during the offshore site investigation were analysed for contaminants. A comparison of levels of sediment contamination against recognised sediment quality guidelines is given in ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11).

135. The assessment of subtidal sediment contamination (see ES Chapter 10 Benthic and Intertidal Ecology, (Document Reference: 3.1.12)), concluded that sediment contamination levels were generally at levels that would not be of concern to the marine environment.

136. Given the prevailing hydrodynamic conditions, released sediment bound contaminants would be expected to be dispersed quickly therefore the level of effect is predicted to be small. There is therefore, negligible magnitude of impact to fish and shellfish ecology receptors from re-mobilisation of contaminated sediments

11.6.1.3.2 Sensitivity of receptor

137. Fish and shellfish receptor sensitivity to re-mobilised contaminated sediments will vary depending on a range of factors including species and life stage. Adult fish are less likely to be affected by contaminants due to their increased mobility.

138. Receptors with sessile life history (e.g. cockles and oysters) or life stages that are planktonic (fish eggs and larvae) are likely to be more vulnerable to toxic effects from marine pollutants.

139. Given the levels of contaminants found are within environmental protection standards, all receptors are assessed as not sensitive (negligible sensitivity) to changes that remain within these standards.

11.6.1.3.3 Significance of effect

140. The effect of re-mobilisation of contaminated sediment on fish and shellfish receptors is considered to be of **negligible significance, which is not significant in EIA terms,** given the negligible magnitude of impact and negligible receptor sensitivity.

11.6.1.4 Impact 4: Underwater noise and vibration from piling for foundation installation

141. During the construction phase, activities associated with foundations for turbines and OSPs/OCP would result in underwater noise and vibration. As a worst case, it is assumed that all foundations will be installed using pile driving as this would result in the greatest noise impacts.

142. The assessment presented in this section is supported by the underwater noise modelling carried out for the Project in respect of piling noise (see ES Appendix 12.3 (Document Reference: 3.3.8)).

11.6.1.4.1 Impact Criteria

143. The noise impact criteria used for assessment of piling noise on fish are shown in Table 11.15. These are based on the Popper et al. (2014) study, which provides a summary of the latest research and represents current best available guidance on fish exposure to sound.

144. Popper et al. (2014) groups fish species into four categories for analysing the effects of sounds on them. Three of these categories are defined on the basis of whether or not fish species have a swim bladder and whether it is involved in hearing, with a fourth separate category focused on fish eggs and larvae, as follows:

- Fish species with no swim bladder or other gas chamber (e.g. dab and other flat fish species). These species are less susceptible to barotrauma and only detect particle motion, not sound pressure. However, some barotrauma may result from exposure to sound pressure;
- Fish species with swim bladder in which hearing does not involve the swim bladder or other gas volume (e.g. Atlantic salmon). These species are susceptible to barotrauma although hearing only involves particle motion, not sound pressure;
- Fish species in which hearing involves a swim bladder or other gas volume (e.g. cod, herring and relatives). These species are susceptible to barotrauma and detect sound pressure as well as particle motion; and
- Fish eggs and larvae.

145. As shown in Table 11.15, in some cases, the noise levels used to define the criteria are the same for multiple effects. This is because data available to create the criteria is limited and most criteria are defined as “greater than” (>), with a precise threshold not identified. Impact ranges associated with criteria defined as “>”, are therefore somewhat conservative.

146. For behavioural effects on fish, given that the best research available is limited to very specific studies on species often under artificial conditions. Popper et al. (2014) does not recommend the use of a quantitative approach for assessment. Instead, Popper et al. (2014) describes behavioural criteria in a qualitative manner on the basis of the relative risk (high, moderate, low) to the animal at various distances from the source of noise (near (N), intermediate (I) and far (F)). For the purposes of this assessment, and in line with the definitions proposed by Popper et al. (2014), these distances are considered as follows:

- Near: within tens of metres;
- Intermediate: within hundreds of metres; and
- Far: within thousands of metres.

Table 11.15 Fish noise impact criteria for pile driving (Popper *et al.*, 2014)

Fish Category	Mortality and potential mortal injury	Recoverable injury	TTS	Behaviour
No swim bladder (particle motion detection)	>219 dB SEL cum or >213 dB peak	>216 dB SEL cum or >213 dB peak	>>186 dB SEL cum	(N) High (I) Moderate (F) Low
Swim bladder is not involved in hearing (particle motion detection)	210 dB SEL cum or >207 dB peak	203 dB SEL cum or >207 dB peak	>186 dB SEL cum	(N) High (I) Moderate (F) Low
Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL cum or >207 dB peak	203 dB SEL cum or >207 dB peak	186 dB SEL cum	(N) High (I) High (F) Moderate
Eggs and larvae	>210 dB SEL cum or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low
(N) within tens of metres; (I) within hundreds of metres; (F) within thousands of metres				

147. Despite increasing research on the impact of underwater noise on invertebrates in recent years (i.e. Tidau and Briffa, 2016, Edmonds *et al*., 2016, Solan *et al*., 2016, Jones *et al*., 2020), hearing in shellfish species is still poorly understood, and noise exposure criteria similar to those developed for fish (Popper et al., 2014) are yet to be defined for invertebrates. In the absence of standard criteria, the assessment of piling noise on shellfish has been undertaken through a review of available research on the impact of underwater noise on marine invertebrates.

11.6.1.4.2 Noise Modelling

148. Underwater noise modelling has been carried out at three representative locations (East, South and West) covering the extents and various water depths at the array area (ES Appendix 12.3, (Document Reference: 3.3.8)). The modelling locations are outlined in Table 11.16.

Table 11.16 Summary of Underwater Noise Modelling Locations

Modelling locations	East	South	West
Latitude	51.7368°N	51.6293°N	51.7742°N
Longitude	002.0443°W	001.8721°E	001.8578°W
Water depth (m)	34.7	34.0	31.2

149. Two foundation scenarios were considered for modelling:

- A monopile worst case scenario, installing a 17m diameter pile with a maximum hammer energy of 6,000kJ; and
- A pin pile worst case scenario, installing a 6m diameter pile with a maximum hammer energy of 4,400kJ.

150. For SEL_{cum} criteria, the soft start and ramp up of hammer energies along with the total duration of piling and strike rate was considered. This is summarised in Table 11.17 and Table 11.18 for the two piling scenarios.

151. As described in ES Appendix 12.3 (Document Reference: 3.3.8), in a 24-hour period, it is expected that up to two monopile foundations or four pin pile foundations can be installed. Scenarios covering a single pile installation, multiple sequential pile installation and simultaneous multiple location installation were all considered as part of the modelling exercise.

Table 11.17 Soft start and ramp-up scenario for monopile worst case modelling

Monopile worst case	900 kJ	1,800 kJ	2,700 kJ	3,700 kJ	4,800 kJ	6,000 kJ
Number of strikes	100	600	600	600	600	10,880
Duration (minutes)	10	30	30	30	30	320
Strike rate (blows/minute)	10	20	20	20	20	~34
13,300 strikes, 7.5 hours per pile/ 40,140 strike, 22.5 hours for 3 piles						

Table 11.18 Soft start and ramp-up scenario for pin pile worst case modelling

Pin pile worst case	660 kJ	1,320 kJ	1,980 kJ	2,640 kJ	3,520 kJ	4,400 kJ
Number of strikes	100	400	400	400	400	6,120
Duration (minutes)	10	20	20	20	20	180
Strike rate (blows/minute)	10	20	20	20	20	34
6,620 strikes, 3.5 hours per pile/ 26,480 strikes, 14 hours for 4 piles						

152. Both fleeing animal and stationary animal scenarios have been modelled with regard to SEL_{cum} and are presented in this chapter. As noted in ES Appendix 12.3 (Document Reference: 3.3.8), most species are likely to move away from a sound that is loud enough to cause harm, some may seek protection in the sediment and others may dive deeper in the water column. For species that flee, the speed used for the modelling of $1.5ms^{-1}$, is relatively slow in relation to data from Hirata (1999) and therefore considered somewhat conservative.

153. Although it is feasible that some species will not flee, those that are likely to remain are thought more likely to be benthic species or species without a swim bladder, and therefore the least sensitive species to underwater noise (ES Appendix 12.3 (Document Reference: 3.3.8)).

154. Furthermore, as noted in ES Appendix 12.3 (Document Reference: 3.3.8), modelling on a stationary (zero flee speed) receptor, is likely to greatly overestimate the potential risk to fish species, assuming that an individual would remain in the high noise level region of the water column, especially when

considering the precautionary nature of the parameters already built into the cumulative exposure calculations.

Modelling Results

155. The results of the modelling carried out using Popper *et al*. (2014) criteria for fish are given in Table 11.19 to Table 11.34, separately for "fish with no swim bladder", "fish with swim bladder not involved in hearing", "fish with swim bladder involved in hearing" and "eggs/larvae".

156. The largest mortality/potential mortal injury and recoverable injury ranges (207 and 203dB SELcum thresholds) are predicted to be up to 8.4km and 13km respectively, assuming a stationary receptor for two sequentially installed monopiles. Assuming a fleeing receptor, the impact ranges for both mortality/potential mortal injury and recoverable injury are reduced to less than 100m.

157. Maximum TTS ranges (186 dB SELcum threshold) are predicted up to 17km assuming a fleeing animal, increasing to up to 39km when considering a stationary receptor. In terms of TTS ranges, when considering a fleeing animal, the pin pile scenario impact ranges are greater than those predicted for the monopile scenario due to the faster ramp-up to full energy and faster strike rate for the pin pile scenario. For stationary receptors, the increased number of strikes combined with the higher hammer energies from the worst case monopile scenario result in larger impact ranges than the worst-case pin pile scenario.

158. When comparing the impact ranges for a single pile installation and sequential pile installations, the overall increases are negligible when considering a fleeing animal, as by the time subsequent piles are installed the fleeing receptors is at such a distance that the additional exposure is minimal. When considering a stationary animal, the ranges are significantly increased as the receptor is essentially receiving noise from either double or quadruple the number of pile strikes from monopiles and pin piles respectively.

159. Whilst the outputs of the modelling for both the fleeing and stationary receptors are presented, for the purpose of assessing potential impacts, reference is only made to the impact ranges modelled under the stationary receptor scenario. As previously mentioned, this is likely to greatly over-estimate potential risks to fish and should therefore be taken as a highly conservative worst-case.

Fish with no swim bladder

Table 11.19 Summary of the unweighted sound pressure level (SPL) peak impact ranges using the Popper *et al* (2014) criteria for fish with no swim bladder for the monopile worst case modelling scenario

			Full energy (6,000 kJ)				First strike (900 kJ)			
Location	**Criteria**	**SPLpeak**	**Area**	**Max**	**Min**	**Mean**	**Area**	**Max**	**Min**	**Mean**
East	Mortality and potential mortal injury	>213 dB	0.05 km2	120 m	120 m	120 m	0.01 km2	60 m	50 m	60 m
	Recoverable injury									
South	Mortality and potential mortal injury	>213 dB	0.05 km2	120 m	120 m	120 m	0.01 km2	60 m	50 m	60 m
	Recoverable injury									
West	Mortality and potential mortal injury	>213 dB	0.04 km2	120 m	120 m	120 m	0.01 km2	50 m	50 m	50 m
	Recoverable injury									

Table 11.20 Summary of unweighted SPLpeak impact ranges using the Popper *et al* (2014) criteria for fish with no swim bladder for the pin pile worst case modelling scenario

			Full energy (4,400 kJ)				First strike (660 kJ)			
Location	**Criteria**	**SPLpeak**	**Area**	**Max**	**Min**	**Mean**	**Area**	**Max**	**Min**	**Mean**
East	Mortality and potential mortal injury	>213 dB	0.04 km^2	110 m	110 m	110 m	0.01 km^2	< 50 m	< 50 m	< 50 m
	Recoverable injury									
South	Mortality and potential mortal injury	>213 dB	0.04 km^2	110 m	110 m	110 m	0.01 km^2	< 50 m	< 50 m	< 50 m
	Recoverable injury									
West	Mortality and potential mortal injury	>213 dB	0.04 km^2	110 m	110 m	110 m	0.01 km^2	< 50 m	< 50 m	< 50 m
	Recoverable injury									

Table 11.21 Summary of unweighted SELcum (cumulative sound exposure level) impact ranges using Popper *et al* (2014) pile driving criteria for fish with no swim bladder for the monopile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single monopile installation				Sequential monopile installation (2 monopiles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	>219 dB	<0.1. km^2	< 100 m	< 100 m	< 100 m	<0.1. km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	>216 dB	<0.1. km^2	< 100 m	< 100 m	< 100 m	<0.1. km^2	< 100 m	< 100 m	< 100 m
		TTS	>>186 dB	430 km^2	15 km	7 km	11 km	430 km^2	15 km	7 km	11 km
	Stationary	Mortality and potential mortal injury	>219 dB	3.9 km^2	1.2 km	1.1 km	1.1 km	15 km^2	2.3 km	2.1 km	2.2 km
		Recoverable injury	>216 dB	9.2 km^2	1.8 km	1.6 km	1.7 km	34 km^2	3.5 km	3.1 km	3.3 km
		TTS	>>186 dB	2,400 km^2	33 km	21 km	28 km	3,600 km^2	42 km	25 km	34 km
South	Fleeing	Mortality and potential mortal injury	>219 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	>216 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>>186 dB	340 km^2	12 km	7.7 km	10 km	340 km^2	12 km	7.7 km	10 km
	Stationary	Mortality and potential mortal injury	>219 dB	3.7 km^2	1.1 km	1.1 km	1.1 km	14 km^2	2.2 km	2.1 km	2.1 km
		Recoverable injury	>216 dB	8.6 km2	1.7 km	1.6 km	1.7 km	32 km^2	3.3 km	3.1 km	3.2 km
		TTS	>>186 dB	2,100 km^2	29 km	18 km	25 km	3,000 km^2	36 km	20 km	31 km

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single monopile installation				Sequential monopile installation (2 monopiles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
West	Fleeing	Mortality and potential mortal injury	>219 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	>216 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>>186 dB	230 km^2	11 km	5.9 km	8.5 km	230 km^2	11 km	5.9 km	8.5 km
	Stationary	Mortality and potential mortal injury	>219 dB	3.4 km^2	1.1. km	1.0 km	1.0 km	13 km^2	2.1 km	1.9 km	2.0 km
		Recoverable injury	>216 dB	7.9 km^2	1.6 km	1.5 km	1.6 km	28 km^2	3.1 km	2.8 km	3.0 km
		TTS	>>186 dB	1,700 km^2	28 km	17 km	23 km	2,600 km^2	35 km	20 km	29 km

Table 11.22 Summary of unweighted SELcum impact ranges using Popper *et al* (2014) pile driving criteria for fish with no swim bladder for the pin pile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	>219 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	>216 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>>186 dB	450 km^2	15 km	7.1 km	12 km	450 km^2	16 km	7.2 km	12 km

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
	Stationary	Mortality and potential mortal injury	>219 dB	1.5 km^2	730 m	680 m	700 m	15 km^2	2.3 km	2.1 km	2.2 km
		Recoverable injury	>216 dB	3.7 km^2	1.1 km	1.1 km	1.1 km	34 km^2	3.5 km	3.1 km	3.3 km
		TTS	>>186 dB	1,800 km^2	28 km	18 km	24 km	3,600 km^2	42 km	25 km	34 km
South	Fleeing	Mortality and potential mortal injury	>219 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	>216 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>>186 dB	350 km^2	12 km	7.6 km	11 km	350 km^2	12 km	7.6 km	11 km
	Stationary	Mortality and potential mortal injury	>219 dB	1.5 km^2	700 m	680 m	690 m	14 km^2	2.2 km	2.1 km	2.1 km
		Recoverable injury	>216 dB	3.5 km^2	1.1 m	1.1 m	1.1 m	31 km^2	3.3 km	3 km	3.2 km
		TTS	>>186 dB	1,500 km^2	25 km	17 km	22 km	3,000 km^2	36 km	19 km	31 km
West	Fleeing	Mortality and potential mortal injury	>219 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	>216 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>>186 dB	240 km^2	11 km	5.8 km	8.6 km	240 km^2	11 km	5.8 km	8.7 km

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
	Stationary	Mortality and potential mortal injury	>219 dB	1.4 km^2	680 m	650 m	660 m	12 km^2	2.1 km	1.9 km	2 km
		Recoverable injury	>216 dB	3.3 km^2	1.1 km	1 km	1 km	27 km^2	3.1 km	2.8 km	3 km
		TTS	>>186 dB	1,200 km^2	24 km	15 km	20 km	2,600 km^2	35 km	20 km	29 km

Fish with a swim bladder that is not involved in hearing

Table 11.23 Summary of the unweighted SPLpeak impact ranges using the Popper *et al* (2014) criteria for fish with a swim bladder that is not involved in hearing for the monopile worst case modelling scenario

			Full energy (6,000 kJ)				First strike (900 kJ)			
Location	Criteria	SPLpeak	Area	Max	Min	Mean	Area	Max	Min	Mean
East	Mortality and potential mortal injury	>207	0.3 km^2	310 m	310 m	310 m	0.06 km^2	140 m	140 m	140 m
	Recoverable injury									
South	Mortality and potential mortal injury	>207	0.3 km^2	310 m	310 m	310 m	0.06 km^2	140 m	140 m	140 m
	Recoverable injury									
West	Mortality and potential mortal injury	>207	0.28 km^2	300 m	300 m	300 m	0.06 km^2	140 m	140 m	140 m
	Recoverable injury									

Table 11.24 Summary of unweighted SPLpeak impact ranges using the Popper *et al* (2014) criteria for fish with a swim bladder that is not involved in hearing for the pin pile worst case modelling scenario

			Full energy (6,000 kJ)				First strike (900 kJ)			
Location	Criteria	SPLpeak	Area	Max	Min	Mean	Area	Max	Min	Mean
East	Mortality and potential mortal injury	>207	0.126 km^2	290 m	290 m	290 m	0.04 km^2	110 m	110 m	100 m
	Recoverable injury									
South	Mortality and potential mortal injury	>207	0.25 km	290 m	280 m	290 m	0.04 km^2	110 m	110 m	110 m
	Recoverable injury									
West	Mortality and potential mortal injury	>207	0.24 km^2	280 m	280 m	280 m	0.03 km^2	110 m	100 m	110 m
	Recoverable injury									

Table 11.25 Summary of unweighted SELcum impact ranges using Popper *et al* (2014) pile driving criteria for fish with a swim bladder that is not involved in hearing for the monopile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single monopile installation				Sequential monopile installation (2 monopiles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	210 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>186 dB	430 km^2	15 km	7.0 km	11 km	430 km^2	15 km	7.0 km	11 km
	Stationary	Mortality and potential mortal injury	210 dB	47 km^2	4.1 km	3.6 km	3.9 km	140 km^2	7.4 km	6.0 km	6.8 km
		Recoverable injury	203 dB	230 km^2	9.4 km	7.1 km	8.5 km	530 km^2	15 km	10 km	13 km
		TTS	>186 dB	2,400 km^2	33 km	21 km	28 km	3600 km^2	42 km	25 km	34 km
South	Fleeing	Mortality and potential mortal injury	210 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>186 dB	340 km^2	12 km	7.7 km	10 km	340 km^2	12 km	7.7 km	10 km
	Stationary	Mortality and potential mortal injury	210 dB	44 km^2	3.9 km	3.6 km	3.7 km	130 km^2	6.9 km	5.9 km	6.5 km
		Recoverable injury	203 dB	210 km^2	8.7 km	7.1 km	8.1 km	480 km^2	13 km	10 km	12 km
		TTS	>186 dB	2,100 km^2	29 km	18 km	25 km	3,000 km^2	36 km	20 km	31 km

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single monopile installation				Sequential monopile installation (2 monopiles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
West	Fleeing	Mortality and potential mortal injury	210 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>186 dB	230 km^2	11 km	5.9 km	8.5 km	230 km^2	11 km	5.9 km	8.5 km
	Stationary	Mortality and potential mortal injury	210 dB	38 km^2	3.6 km	3.3 km	3.5 km	110 km^2	6.3 km	5.4 km	6 km
		Recoverable injury	203 dB	170 km^2	7.9 km	6.6 km	7.4 km	380 km^2	12 km	9.4 km	11 km
		TTS	>186 dB	1,700 km^2	28 km	17 km	23 km	2,600 km^2	35 km	20 km	29 km

Table 11.26 Summary of unweighted SELcum impact ranges using Popper *et al* (2014) pile driving criteria for fish with a swim bladder that is not involved in hearing for the pin pile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	210 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>186 dB	450 km^2	15 km	7.1 km	12 km	450 km^2	16 km	7.2 km	12 km
	Stationary	Mortality and potential mortal injury	210 dB	21 km^2	2.7 km	2.4 km	2.6 km	140 km^2	7.3 km	5.9 km	6.7 km
		Recoverable injury	203 dB	120 km^2	6.7 km	5.5 km	6.2 km	520 km^2	15 km	10 km	13 km

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
		TTS	>186 dB	1,800 km^2	28 km	18 km	24 km	3,600 km^2	42 km	25 km	34 km
South	Fleeing	Mortality and potential mortal injury	210 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>186 dB	350 km^2	12 km	7.6 km	11 km	350 km^2	12 km	7.6 km	11 km
	Stationary	Mortality and potential mortal injury	210 dB	19 km^2	2.6 km	2.4 km	2.5 km	130 km^2	6.8 km	5.8 km	6.4 km
		Recoverable injury	203 dB	110 km^2	6.3 km	5.5 km	5.9 km	470 km^2	13 km	10 km	12 km
		TTS	>186 dB	1,500 km^2	25 km	17 km	22 km	3,000 km^2	36 km	19 km	31 km
West	Fleeing	Mortality and potential mortal injury	210 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	>186 dB	240 km^2	11 km	5.8 km	8.6 km	240 km^2	11 km	5.8 km	8.7 km
	Stationary	Mortality and potential mortal injury	210 dB	17 km^2	2.4 km	2.2 km	2.4 km	110 km^2	6.2 km	5.3 km	5.9 km
		Recoverable injury	203 dB	93 km^2	5.7 km	4.9 km	5.4 km	380 km^2	12 km	9.3 km	11 km
		TTS	>186 dB	1,200 km^2	24 km	15 km	20 km	2,600 km^2	35 km	20 km	29 km

Fish with a swim bladder involved in hearing

Table 11.27 Summary of the unweighted SPLpeak impact ranges using the Popper *et al* (2014) criteria for fish with a swim bladder that is involved in hearing for the monopile worst case modelling scenario

			Full energy (6,000 kJ)				First strike (900 kJ)			
Location	**Criteria**	**SPLpeak**	**Area**	**Max**	**Min**	**Mean**	**Area**	**Max**	**Min**	**Mean**
East	Mortality and potential mortal injury	>207 dB	0.3 km^2	310 m	310 m	310 m	0.06 km^2	140 m	140 m	140 m
	Recoverable injury									
South	Mortality and potential mortal injury	>207 dB	0.3 km^2	310 m	310 m	310 m	0.06 km^2	140 m	140 m	140 m
	Recoverable injury									
West	Mortality and potential mortal injury	>207 dB	0.28 km^2	300 m	300 m	300 m	0.06 km^2	140 m	140 m	140 m
	Recoverable injury									

Table 11.28 Summary of unweighted SPLpeak impact ranges using the Popper *et al* (2014) criteria for fish with a swim bladder that is involved in hearing for the pin pile worst case modelling scenario

			Full energy (4,400 kJ)				First strike (660 kJ)			
Location	**Criteria**	**SPLpeak**	**Area**	**Max**	**Min**	**Mean**	**Area**	**Max**	**Min**	**Mean**
East	Mortality and potential mortal injury	>207 dB	0.26 km^2	290 m	290 m	290 m	0.01 km^2	< 50 m	< 50 m	< 50 m
	Recoverable injury									
South	Mortality and potential mortal injury	>207 dB	0.25 km^2	290 m	280 m	290 m	0.04 km^2	110 m	110 m	110 m
	Recoverable injury									
West	Mortality and potential mortal injury	>207 dB	0.19 km^2	250 m	250 m	250 m	0.24 km^2	280 m	280 m	280 m
	Recoverable injury									

Table 11.29 Summary of unweighted SELcum impact ranges using Popper *et al* (2014) pile driving criteria for fish with a swim bladder that is involved in hearing for the monopile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single monopile installation				Sequential monopile installation (2 monopiles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	207 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	186 dB	430 km^2	15 km	7.0 km	11 km	430 km^2	15 km	7.0 km	11 km
	Stationary	Mortality and potential mortal injury	207 dB	97 km^2	6.0 km	5.0 km	5.6 km	260 km^2	10 km	7.4 km	9.1 km
		Recoverable injury	203 dB	230 km^2	9.4 km	7.1 km	8.4 km	530 km^2	15 km	10 km	13 km
		TTS	186 dB	2,400 km^2	33 km	21 km	28 km	3,600 km^2	42 km	25 km	34 km
South	Fleeing	Mortality and potential mortal injury	207 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	186 dB	340 km^2	12 km	7.7 km	10 km	340 km^2	12 km	7.7 km	10 km
	Stationary	Mortality and potential mortal injury	207 dB	88 km^2	5.6 km	5 km	5.3 km	240 km^2	9.3 km	7.5 km	8.7 km
		Recoverable injury	203 dB	210 km^2	8.7 km	7.1 km	8.1 km	480 km^2	13 km	10 km	12 km
		TTS	186 dB	2,100 km^2	29 km	18 km	25 km	3,000 km^2	36 km	20 km	31 km

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single monopile installation				Sequential monopile installation (2 monopiles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
West	Fleeing	Mortality and potential mortal injury	207 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	186 dB	230 km^2	11 km	5.9 km	8.5 km	230 km^2	11 km	5.9 km	8.5 km
	Stationary	Mortality and potential mortal injury	207 dB	77 km	5.2 km	4.5 km	4.9 km	190 km^2	8.5 km	7 km	7.9 km
		Recoverable injury	203 dB	170 km^2	7.9 km	6.6 km	7.4 km	380 km^2	12 km	9.4 km	11 km
		TTS	186 dB	1,700 km^2	28 km	17 km	23 km	2,600 km^2	35 km	20 km	29 km

Table 11.30 Summary of unweighted SELcum impact ranges using Popper *et al* (2014) pile driving criteria for fish with a swim bladder that is involved in hearing for the pin pile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	207 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	186 dB	450 km^2	15 km	7.1 km	12 km	450 km^2	16 km	7.2 km	12 km
	Stationary	Mortality and potential mortal injury	207 dB	46 km^2	4.1 km	3.6 km	3.8 km	260 km^2	10 km	7.4 km	9 km

Location	Fleeing / stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
		Recoverable injury	203 dB	120 km^2	6.7 km	5.5 km	6.2 km	520 km^2	15 km	10 km	13 km
		TTS	186 dB	1,800 km^2	28 km	18 km	24 km	3,600 km^2	42 km	25 km	34 km
South	Fleeing	Mortality and potential mortal injury	207 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	186 dB	350 km^2	12 km	7.6 km	11 km	350 km^2	12 km	7.6 km	11 km
	Stationary	Mortality and potential mortal injury	207 dB	43 km^2	3.8 km	3.5 km	3.7 km	230 km^2	9.3 km	7.5 km	8.6 km
		Recoverable injury	203 dB	110 km^2	6.3 km	5.5 km	5.9 km	470 km^2	13 km	10 km	12 km
		TTS	186 dB	1,500 km^2	25 km	17 km	22 km	3,000 km^2	36 km	19 km	31 km
West	Fleeing	Mortality and potential mortal injury	207 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		Recoverable injury	203 dB	< 0.1 km^2	< 100 m	< 100 m	< 100 m	< 0.1 km^2	< 100 m	< 100 m	< 100 m
		TTS	186 dB	240 km^2	11 km	5.8 km	8.6 km	240 km^2	11 km	5.8 km	8.7 km
	Stationary	Mortality and potential mortal injury	207 dB	37 km^2	3.6 km	3.2 km	3.4 km	190 km^2	8.4 km	7 km	7.8 km
		Recoverable injury	203 dB	93 km^2	5.7 km	4.9 km	5.4 km	380 km^2	12 km	9.3 km	11 km
		TTS	186 dB	1,200 km^2	24 km	15 km	20 km	2,600 km^2	35 km	20 km	29 km

Eggs and Larvae

Table 11.31 Summary of the unweighted SPLpeak impact ranges using the Popper *et al* (2014) criteria for fish eggs and larvae for the monopile worst case modelling scenario

			Full energy (6,000 kJ)				First strike (900 kJ)			
Location	**Criteria**	**SPLpeak**	**Area**	**Max**	**Min**	**Mean**	**Area**	**Max**	**Min**	**Mean**
East	Mortality and potential mortal injury	>207 dB	0.3 km^2	310 m	310 m	310 m	0.06 km^2	140 m	140 m	140 m
South			0.3 km^2	310 m	310 m	310 m	0.06 km^2	140 m	140 m	140 m
West			0.28 km^2	300 m	300 m	300 m	0.06 km^2	140 m	140 m	140 m

Table 11.32 Summary of unweighted SPLpeak impact ranges using the Popper *et al* (2014) criteria for fish eggs and larvae for the pin pile worst case modelling scenario

			Full energy (4,400 kJ)				First strike (660 kJ)			
Location	**Criteria**	**SPLpeak**	**Area**	**Max**	**Min**	**Mean**	**Area**	**Max**	**Min**	**Mean**
East	Mortality and potential mortal injury	>207 dB	0.26 km^2	290 m	290 m	290 m	0.04 km^2	110 m	110 m	110 m
South			0.25 km^2	290 m	280 m	290 m	0.04 km^2	110 m	110 m	110 m
West			0.24 km^2	280 m	280 m	280 m	0.03 km^2	110 m	110 m	110 m

Table 11.33 Summary of unweighted SELcum impact ranges using Popper *et al* (2014) pile driving criteria for fish eggs and larvae for the monopile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single monopile installation				Sequential monopile installation (2 monopiles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	>210 dB	< 0.1 km2	< 100 m	< 100 m	< 100 m	< 0.1 km2	< 100 m	< 100 m	< 100 m
	Stationary			47 km2	4.1 km	3.6 km	3.9 km	140 km2	7.4 km	6 km	6.8 km
South	Fleeing			< 0.1 km2	< 100 m	< 100 m	< 100 m	< 0.1 km2	< 100 m	< 100 m	< 100 m
	Stationary			44 km2	3.9 km	3.6 km	3.7 km	130 km2	6.9 km	5.9 km	6.5 km
West	Fleeing			< 0.1 km2	< 100 m	< 100 m	< 100 m	< 0.1 km2	< 100 m	< 100 m	< 100 m
	Stationary			43 km2	3.8 km	3.5 km	3.7 km	230 km2	9.3 km	7.5 km	8.6 km

Table 11.34 Summary of unweighted SELcum impact ranges using Popper *et al* (2014) pile driving criteria for fish eggs and larvae for the pin pile worst case modelling scenario assuming both a fleeing and stationary animal

Location	Fleeing / Stationary	Criteria	Unweighted SELcum	Single pin pile installation				Sequential pin pile installation (4 pin piles)			
				Area	Max	Min	Mean	Area	Max	Min	Mean
East	Fleeing	Mortality and potential mortal injury	>210 dB	< 0.1 km2	< 100 m	< 100 m	< 100 m	< 0.1 km2	< 100 m	< 100 m	< 100 m
	Stationary			21 km2	2.7 km	2.4 km	2.6 km	140 km2	7.3 km	5.9 km	6.7 km
South	Fleeing			< 0.1 km2	< 100 m	< 100 m	< 100 m	< 0.1 km2	< 100 m	< 100 m	< 100 m

11.6.1.4.3 Receptor Groups

160. In order to facilitate the assessment of piling noise on fish, receptors have been grouped into categories depending on their hearing system. In line with Popper et al. (2014) these have been based on whether or not fish have a swim bladder and on whether or not it is involved in hearing (Table 11.35).

Table 11.35 Hearing categories of the fish receptors "(*)" denotes uncertainty or lack of current knowledge with regard to the potential role of the swim bladder in hearing)

Hearing Category	Fish Receptor
Fish with no swim bladder or other gas chamber	• Dover sole • Plaice • Dab • Sandeels • Lemon sole • Mackerel and horse mackerel • Elasmobranchs • River and sea lamprey
Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume	• Atlantic salmon • Sea trout • Smelt (*) • Bass (*) • Gurnards (*) • Gobies
Fish in which hearing involved a swim bladder or other gas volume	• Herring • Sprat • Cod • Whiting • European eel (*) • Allis and twaite shad

11.6.1.4.4 Assessment of mortality and recoverable injury

Fish with no swim bladder

Magnitude of impact

161. Mortality/potential mortal injury and recoverable injury in fish with no swim bladder has been modelled to have potential to occur at ranges up 1.2km and 1.8km, respectively. This is based installation of one monopile and would increase to up to 1.8km and 3.5km under a 3 monopile sequential installation scenario (Table 11.21).

162. Taking the small areas potentially affected in the context of the wide distribution ranges of fish species within the fish with no swim bladder group, including the extent of areas used for spawning/nursery, and the temporary, short term and intermittent nature of piling activity the magnitude of the impact is considered to be negligible.

Sensitivity of receptor

163. The fish receptors included within the group "fish with no swim bladder" (Table 11.35) are mobile and have the ability to vacate the area in which the impact could occur with onset of "soft start" piling. As noted in ES Appendix 12.3 (Document Reference: 3.3.8), although it is feasible that some species will not flee, available evidence suggest that little damage may occur to fish without a

swim bladder except at very short ranges, as these are the species less sensitive to noise.

164. Fish with no swim bladder are therefore considered receptors of low sensitivity. In the particular case of sandeels, given their burrowing behaviour and substrate dependence, may have limited capacity to flee to other areas and are therefore considered receptors of medium sensitivity**.**

Significance of effect

165. Taking account of the identified magnitude of impact (negligible) and receptor sensitivity (low for species without a swim bladder in general and medium for sandeels), mortality and recoverable injury effects associated with piling noise are considered to result in an effect of **negligible significance** for species without a swim bladder in general and of **minor significance** in the case of sandeels, both of which are **not significant in EIA terms**.

Fish with a swim bladder that is not involved in hearing

Magnitude of impact

166. Mortality/potential mortal injury and recoverable injury in fish with a swim bladder that is not involved in hearing has been modelled to have potential to occur at ranges up to 4.1km and 9.4km, respectively. This is based on installation of one monopile and would increase to up to 7.4km and 15km respectively under a 3 monopile sequential installation scenario (Table 11.21).

167. Taking the small areas potentially affected in the context of the wide distribution ranges of the species within the fish with a swim bladder that is not involved in hearing category, including areas used for spawning/as nursery grounds, and the temporary, short term and intermittent nature of piling activity, the magnitude of the impact is considered to be negligible.

Sensitivity of receptor

168. The fish receptors included within the group "fish with a swim bladder that is not involved in hearing" (Table 11.35) are mobile and have the ability to vacate the area in which the impact could occur with onset of "soft start" piling.

169. In general terms, fish with a swim bladder that is not involved in hearing are considered receptors of low sensitivity. Exceptions to this are gobies as they have limited mobility compared to other fish species in this category and therefore limited capacity to escape the greatest noise levels. Given the relatively short life cycle of goby species (Teal *et al*., 2009) their population would be expected to recover quickly if subject to localised lethal or injury impacts associated with piling. With the above in mind, gobies are considered receptors of medium sensitivity.

Significance of effect

170. Taking account of the identified magnitude of impact (negligible r) and receptor sensitivity (low for species with a swim bladder that is not involved in hearing in general and medium for gobies), mortality and recoverable injury effects associated with piling noise are considered to result in an effect of **negligible significance** for species with a swim bladder that is not involved in hearing in general and of **minor significance** in the case of gobies, both of which are **not significant in EIA terms**.

Fish with a swim bladder that is involved in hearing

Magnitude of impact

171. Mortality/potential mortal injury and recoverable injury in fish with a swim bladder that is involved in hearing has been modelled to have potential to occur at a range of 6km and 9.4km, respectively. This is based on installation of one monopile and would increase to up to 10km and 15km respectively under a 3 monopile sequential installation scenario.

172. Taking the areas potentially affected in the context of the wide distribution range of fish and shellfish species, including for spawning and as a nursery grounds (ES Figure 11.14 to 11.17, (Document Reference: 3.2.7) for cod, whiting, sprat and herring respectively), and in light of the temporary, short term and intermittent nature of piling activity, the magnitude of the impact is considered to be negligible.

Sensitivity of receptor

173. The fish receptors included within the group fish with a swim bladder that is involved in hearing (Table 11.35) are mobile and therefore have the ability to move away from the area in which the impact could occur with the onset of "soft start" piling. However, given their increase sensitivity to noise, compared to other species, in general terms, they are considered receptors of medium sensitivity.

174. In the particular case of herring, however, given that they are demersal spawners that require access to discrete suitable grounds for spawning, they are considered receptors of high sensitivity.

Significance of effect

175. Taking account of the identified magnitude of impact (negligible) and receptor sensitivity (medium in general and high for herring), mortality and recoverable injury effects associated with piling noise are considered to result in an effect of **minor significance, which is not significant in EIA terms**.

Eggs and Larvae

Magnitude of impact

176. Mortality/potential mortal injury in fish eggs and larvae has been modelled to have potential to occur at a range up to 4.1km. This is based on installation of one monopile and would increase to up to 7.4km under a 3 monopile sequential installation scenario.

177. With regard to recoverable injury, quantitative criteria for fish eggs and larvae are not currently available. Popper *et al*. (2014), however, proposed the following qualitative criteria specific to this receptor group: moderate effects at distances near the source (tens of metres) and low effects at intermediate and far distances (hundreds of metres to thousands of metres).

178. It should be noted that distribution of fish eggs and larvae extends over wide areas at a given time and therefore, whilst eggs and larvae may not be able to flee the vicinity of piling, the level and frequency of interaction with piling events would be expected to be low. Furthermore, any egg/larval mortality/mortal injury potentially resulting from piling would be expected to be very low in comparison

to the natural mortality rates associated with fish egg and larval stages, and for most species prolonged exposure would likely be reduced by the drift of eggs/larvae due to water currents. With this in mind and taking account of the areas potentially affected at a given time and the temporary, short term and intermittent nature of piling, the magnitude of the impact is considered to be negligible.

Sensitivity of receptor

179. Fish eggs and larvae are critical life stages and would not be able to actively flee the vicinity of the foundations during piling. and are therefore considered receptors of high sensitivity.

Significance of effect

180. Taking account of the identified magnitude of impact (negligible) and receptor sensitivity (high), mortality and recoverable injury effects associated with piling noise are considered to result in an effect of **minor significance** on fish eggs and larvae **which is not significant in EIA terms**.

Shellfish

Magnitude of impact

181. There are no specific criteria currently published in respect of mortality or recoverable injury for shellfish species. Decapod crustaceans are thought to be physiologically resilient to noise as they lack gas filled spaces (Popper et al., 2001). In line with this, research carried out on lobster *Homarus americanus* has shown no effect on mortality, appendage loss of the ability of animals to regain normal posture after exposure to very high sound levels (> 220dB) (Payne *et al*., 2007). Similarly, Kosheleva (1992) found no adverse effect on benthic invertebrates, following exposure to a single air gun at a range of 0.5m. However, behavioural changes in mussels were observed in response to simulated pile-driving, with increased filtration rates observed in blue mussels (Spiga *et al*., 2016).

182. Effects on shellfish species are predicted to be limited, as they are considered to be less sensitive to noise than fish species, though data on sensitivity of these receptors is acknowledged to be scarce. Injury or behavioural effects on shellfish receptors would not be expected beyond the injury response ranges presented for demersal fish species.

183. The potential for piling noise to result in mortality/potential mortal injury or recoverable injury in shellfish species is expected to be very low, being likely limited to very short ranges. As such the magnitude of the impact is considered to be negligible.

Sensitivity of receptor

184. There has been little research into the impact of underwater sound on marine invertebrates (including shellfish) and at present there are no published sensitivity thresholds for this receptor group.

185. Studies on marine invertebrates have shown sensitivity to substrate borne vibration (Roberts *et al*., 2016). However, many invertebrate species are equipped with a number of receptor types potentially capable of responding to the particle motion component of underwater noise (e.g. the vibration of the

water molecules which results in the pressure wave) (Popper *et al*., 2001; Hawkins *et al*., 2014; Popper and Hawkins, 2018).

186. Effects on shellfish species are predicted to be limited, as they are considered to be less sensitive to noise than fish species, though data on sensitivity of these receptors is acknowledged to be scarce. The potential for mortality/potential mortal injury or recoverable injury on shellfish receptors are not expected to be beyond the ranges presented for demersal fish species.

187. Given the relatively low mobility of shellfish species in comparison to most fish and the commercial importance of some species in the study area, they are considered receptors of medium sensitivity.

Significance of effect

188. Taking account of the identified magnitude of impact (negligible) and receptor sensitivity (medium), mortality and recoverable injury effects associated with piling noise are considered to result in an impact of **minor significance** on shellfish species **which is not significant in EIA terms**.

11.6.1.4.5 Assessment of TTS and behavioural impacts

189. Impacts associated with TTS could result in reduced fitness, whilst behavioural impacts could cause changes in distribution, such as moving from preferred sites for feeding and spawning, or alteration of migration patterns. In both cases, any impact would be temporary.

190. The assessment of the impact of TTS and behavioural impacts has been focused on key species, selected on the basis of the presence, known spawning and nursery grounds in the offshore project area, conservation status and commercial value. On this basis, the species listed in Table 11.36 have been taken forward for detailed assessment.

Magnitude of impact

191. The outputs of the underwater noise modelling for the spatial worst-case scenario indicate that TTS may occur at distances up to 33km and 42km for single monopile and sequential monopiles installation. Behavioural responses would be expected within these ranges and potentially in wider areas depending on the hearing ability of the species under consideration.

192. As shown in Table 11.2, in terms of temporal worst case the maximum duration of piling would be equivalent to 90 days (2,160 hours), although this would not be continuous.

Species with no swim bladder (Dover sole, plaice, lemon sole, mackerel, sandeels, elasmobranchs and lampreys)

193. The offshore project area is located within high intensity spawning grounds and low intensity nursery grounds for Dover sole and plaice (ES Figure 11.9 and ES Figure 11.10 (Document Reference: 3.2.7)). In addition, the offshore project area overlaps with lemon sole spawning and nursery grounds and with mackerel nursery grounds (intensity not defined) (ES Figure 11.11 and ES Figure 11.12, (Document Reference: 3.2.7)).

194. As illustrated in ES Figure 11.9 to ES Figure 11.12 (Document Reference: 3.2.7), however, the degree of overlap between spawning and nursery grounds and ranges at which TTS may occur would be very small in the context of the

total spawning/nursery areas available to these species, and therefore impact magnitude is considered to be negligible.

195. In the case of Dover sole, taking account of its more restricted overall distribution range (see ES Appendix 11.1 (Document Reference: 3.3.5)) and the smaller extent of their spawning and nursery grounds in a North Sea context, the magnitude of the impact is considered to be low.

196. As shown in ES Figure 11.13 (Document Reference: 3.2.7), the offshore project area overlaps with low intensity spawning and nursery grounds for sandeels. The degree of overlap between sandeel spawning/nursery grounds and sandeel habitat and areas where TTS may occur would however be very small. In this context it is important to note that important sandeel grounds have not been previously reported from the study area, with no overlap between known sandeel grounds in Sandeel Assessment Area 1r and the offshore project area (ES Figure 11.6 (Document Reference: 3.2.7); Jensen *et al*., 2011). In addition, PSA data from benthic grab samples collected in the offshore project area combined with BGS data, indicates that for the most part, the sediment found is either not suitable for sandeels or of marginal suitability as sandeel habitat (ES Figure 11.7 (Document Reference: 3.2.7)). The magnitude of the impact is therefore considered to be low.

197. For elasmobranchs, areas potentially affected by TTS (up to 42km) and where behavioural impacts may occur would be small in the context of their wide distribution ranges. This includes spawning/nursery grounds for relevant species (i.e. thornback ray and tope; see ES Figure 11.19, (Document Reference: 3.2.7)) and as such impact magnitude is considered to be negligible. In the case of diadromous species, including lampreys, as described in Section 11.5.5.1 and in ES Appendix 11.1 (Document Reference: 3.3.5)), they are only anticipated to be present in the offshore project area on an occasional basis and predominantly in inshore areas. The potential for these species to be subject to piling noise would be low and given the distance from the array area to the coast and therefore to rivers, there is no potential for piling noise to affect these species during critical periods of their migration such as river entry and river exit. As such impact magnitude for these species is considered to be negligible.

Species with a swim bladder that is not involved with hearing (Bass, Atlantic salmon and sea trout)

198. Bass is a species of commercial importance to local fisheries using the offshore project area and is relatively abundant in the study area, particularly in inshore areas. Since 2017 its commercial and recreational fisheries have been heavily regulated due to conservation concerns over bass stocks (ES Appendix 11.1, (Document Reference: 3.3.5)).

199. Areas where bass may be affected by TTS may extend up to 42km (Table 11.24 and Table 11.25). Bass would be expected to be more commonly found in the offshore cable corridor rather than in the array area where piling operations will be undertaken. With this in mind and considering the distribution range of the species and the relatively small areas where TTS and behavioural impacts may occur, the magnitude of impact is considered to be negligible.

200. As described in Section 11.5.5.1 and in ES Appendix 11.1 (Document Reference: 3.3.5), diadromous species, including Atlantic salmon and sea trout

are only anticipated to be present in the offshore project area on an occasional basis and predominantly in inshore areas. The potential for these species to be subject to piling noise would be low and given the distance from the array area to the coast and therefore to rivers, there is no potential for piling noise to affect these species during critical periods of their migration such as river entry and river exit. As such impact magnitude is considered to be negligible.

Species with a swim bladder that is involved in hearing (Herring, sprat, cod, Allis and Twaite shad and European eel)

201. As shown in ES Figure 11.14 and ES Figure 11.16 (Document Reference: 3.2.7), the offshore project area overlaps with low intensity cod spawning and nursery grounds and with sprat spawning and nursery grounds (intensity not defined) respectively. Given these species are pelagic spawners and are therefore not dependent on discrete spawning grounds with specific substrate characteristics for spawning. The degree of overlap between the spawning/nursery grounds of these species and the area impacted by TTS would however be very small relative to the total area used by these species for spawning/nursery. The magnitude of the impact is therefore considered to be negligible.

202. As illustrated in ES Figure 11.17 (Document Reference: 3.2.7), the offshore project area is located immediately to the west of the spawning grounds that have been defined for the Downs herring. In addition, it overlaps with high intensity herring nursery grounds. Inshore spawning grounds have also been identified in the study area for the spring spawning Blackwater herring, however these are at considerable distance from the array area, and therefore from locations where piling may be undertaken (ES Figure 11.18, (Document Reference: 3.2.7)).

203. As shown in ES Figure 11.17 (Document Reference: 3.2.7), a part of one of the discrete grounds identified for spawning of Downs herring may be affected by noise levels where TTS could occur under the conservative assumption of a stationary receptor. Downs herring grounds located further south in the English Channel would however remain unaffected.

204. In addition to Popper *et al*. (2014) criteria for TTS/behavioural impacts, as part of the assessment for herring, information is presented on the outputs of the modelling for 135 dB SEL (ES Figure 11.17 and ES Figure 11.18 (Document Reference: 3.2.7)) as requested by the MMO (Table 11.1). The Applicant notes, however, that the use of 135 dB SEL as an indication of levels at which behavioural reactions may occur in herring is over conservative. Reference to 135 dB SEL is made in Hawkins *et al*. (2014) where it is acknowledged that "these data cannot yet be used to define the sound exposure criteria" due to the limited nature of the study, which was conducted in a quiet lough. The background noise generated in a calm lough environment is far quieter than that generated in the open-water North Sea where 135 dB SEL is likely to be only slightly above the background noise level in a busy shipping area (Nedwell & Cheesman, 2011; Marchant *et al*., 2014; Basan *et al.,* 2023) Chapter 15 Shipping and Navigation, (Document Reference: 3.1.17) identifies major routeing measures located within the study area, notably the Sunk routeing measures such as Traffic Separation Schemes (TSSs) and pilot stations.

205. Furthermore, as described in Table 11.3, the Applicant is committed to apply a suitable piling restriction to minimise potential overlap between piling and Downs herring spawning activity (Table 11.12).

206. The magnitude of the impact with regard to Downs herring is therefore considered to be negligible.

207. In the case of the Blackwater herring, there would be no overlap with spawning grounds (ES Figure 11.18 (Document Reference: 3.2.7)) therefore the magnitude of the impact would be negligible.

208. As described in Section 11.5.5.1 and in ES Appendix 11.1 (Document Reference: 3.3.5), diadromous species such as Allis and twaite shad and European eel, are only anticipated to be present in the offshore project area on an occasional basis and predominantly in inshore areas. The potential for these species to be subject to piling noise would be low and given the distance from the array area to the coast and therefore to rivers, there is no potential for piling noise to affect these species during critical periods of their migration such as river entry and river exit. As such impact magnitude is considered to be negligible for these species.

Sensitivity of receptor

209. The sensitivity to underwater noise for the species included in the assessment to TTS and behaviours impacts is as previously identified for assessment of mortality/potential mortal injury and recoverable injury (Section 11.6.1.4.4) and summarised in Table 11.36 below.

Table 11.36 Hearing categories of key fish species and their sensitivity to noise for the assessment of TTS and behavioural impacts

Group	Species	Sensitivity to Noise
Fish with no swim bladder or other gas chamber	Dover sole	Low
	Plaice	Low
	Lemon sole	Low
	Mackerel	Low
	Sandeels	Medium
	Elasmobranchs	Low
	Diadromous species (lampreys)	Low
Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume	Bass	Low
	Diadromous species (Salmon and sea trout)	Low
Fish in which hearing involved a swim bladder or other gas volume	Herring (Downs and Blackwater)	High
	Sprat	Medium
	Cod	Medium
	Diadromous species (Allis and Twaite shad and European eel)	Medium

Significance of effect

210. Taking account of the identified magnitude of impact (negligible to low) and the receptor sensitivities identified above for each species (low to high), TTS and

behavioural effects associated with piling noise are considered to result in effects of negligible to minor significance for most species, with the exception of Downs herring for which an effect of moderate significance has been identified. The outcomes of the assessment are summarised by species in Table 11.37.

Table 11.37 Summary of assessment outcomes by receptor

Receptor	Magnitude of impact	Sensitivity to noise	Significance of effect
Dover sole, plaice, lemon sole and mackerel	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Sandeels	Low	Medium	**Minor (which is not significant in EIA terms)**
Bass	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Cod and sprat	Negligible	Medium	**Minor (which is not significant in EIA terms)**
Downs herring	Negligible	High	**Minor (which is not significant in EIA terms)**
Blackwater herring	Negligible	High	**Minor (which is not significant in EIA terms)**
Elasmobranchs	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Diadromous species (Salmon and sea trout)	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Diadromous species (Allis and Twaite shad and European eel)	Negligible	Medium	**Minor (which is not significant in EIA terms)**

11.6.1.5 Impact 5: Underwater noise and vibration from other construction activities

211. The following section provides an assessment of the potential impact of underwater noise during construction, other than piling noise, on fish and shellfish receptors.

212. Potential sources of underwater noise, aside from piling, that could be present during the construction phase of the Project are listed in Table 11.38.

Table 11.38 Summary of possible noise making activities during construction other than impact piling

Activity	Description
Cable laying	Noise from the cable laying vessel and any other associated noise during the offshore cable installation.
Dredging	Dredging may be required on site for seabed preparation work for certain foundation options, as well as for the export cable, array/ platform interconnector cables installation. Suction dredging has been assumed as a worst-case.

Activity	Description
Trenching	Plough trenching may be required during offshore cable installation.
Rock placement	Potentially required on site for installation of offshore cables (cable crossings and cable protection) and scour protection around foundation structures.
Vessel noise	Jack-up barges for piling substructure and WTG installation. Other large and medium sized vessels to carry out other construction tasks and anchor handling.

213. In order to define the magnitude of the impact, consideration has been given to Popper *et al*. (2014) criteria for continuous noise sources. These are described in Table 11.39.

214. As shown, for the most part, Popper *et al*. (2014) criteria are qualitative being provided in terms of relative risk (high, moderate, low) to the animal at various distances from the source of noise (near (N), intermediate (I) and far (F)). Exceptions to this are the recoverable injury and TTS criteria for fish with a swim bladder involved in hearing. As illustrated in Table 11.39, for these criteria quantitative thresholds have been defined. As such, impact ranges for these criteria have been modelled and are presented in Table 11.40.

Table 11.39 Popper *et al* (2014) criteria for fish in respect of shipping and continuous sounds

Category	Mortality/Mortal Injury	Recoverable Injury	Temporary Threshold Shift (TTS)	Behavioural
Fish with no swim bladder	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Moderate (F) Low
Fish with swim bladder not involved in hearing	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Moderate (F) Low
Fish with swim bladder involved in hearing	(N) Low (I) Low (F) Low	170 dB rms for 48 h	158 dB rms for 12 h	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Moderate (F) Low
(N) Near: within few tens of metres; (I) Intermediate: within hundreds of metres; and (F) Far: within thousands of metres.				

Table 11.40 Summary of impact ranges for fish from Popper et al 2014 for shipping and continuous noise, covering the different construction noise sources

Unweighted SPL_{RMS}	Cable laying	Suction dredging	Trenching	Rock placement	Vessels (large)	Vessels (medium)
Recoverable injury 170 dB (48 hours)	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
TTS 158 dB (12 hours)	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m

11.6.1.5.1 Magnitude of impact

215. Noise associated with construction activities other than piling may take place intermittently at discrete locations over the overall 2-year construction period. From the information provided above, however, it is apparent that these construction activities have only potential to result in localised disturbance to fish and shellfish receptors. In addition, as described in Table 11.40, the risk of mortality would be very low, even in close proximity to the source of noise. This would also be the case with regard to the risk of any injury or TTS with reference to the SPL_{RMS} guidance for continuous noise sources (see Table 11.40). Considering the duration of potential impacts and the small areas affected in the context of the wide distribution ranges of all fish and shellfish species of relevance in the study area (including areas used for spawning and as nursery grounds) the magnitude of the impact is considered negligible.

11.6.1.5.2 Sensitivity of receptor

216. The sensitivity of receptors with regards to underwater noise is as previously presented in Section 11.6.1.4.5 and summarised in Table 11.41 below.

Table 11.41 Hearing categories of key fish species and their sensitivity to noise

Group	Species	Sensitivity to noise
Fish with no swim bladder or other gas chamber	Species in general	Low
	Sandeels	Medium
Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume	All species in general	Low
	Gobies	Medium
Fish in which hearing involved a swim bladder or other gas volume	Species in general	Medium
	Herring	High
Eggs and larvae	In general	High
Shellfish	In general	Medium

11.6.1.5.3 Significance of effect

217. Taking account of the identified magnitude of impact (negligible) and receptor sensitivity (low to high depending on the species under consideration), effects associated with construction noise other than piling are considered to result in an impact of **negligible to minor significance** on fish and shellfish species, **which is not significant in EIA terms**.

11.6.1.6 Impact 6: Underwater noise and vibration from UXO clearance

218. Unexploded ordnance (UXO) clearance does not form part of the DCO application and will be subject to an additional marine licence informed by a detailed UXO survey to be carried out prior to construction, however an indicative assessment is provided here. Whilst any UXO identified would be preferably avoided, there may be instances when it is considered unsafe to retrieve the UXO from the seabed and a controlled detonation may be required.

219. As described in ES Appendix 12.3 (Document Reference: 3.3.8), it is possible that UXO devices with a range of charge weights (or quantity of contained explosive) may be present within the offshore project area. In order to assess potential underwater noise levels associated with UXO clearance a selection of explosive sizes has been considered based on what may be present in the area.

220. In all cases the worst-case estimation has been used, assuming that the UXO to be detonated is not buried, degraded or subject to any other significant attenuation from its "as new" condition.

221. Taking account of Popper *et al*. (2014) explosion noise criteria for fish impact ranges associated with UXO detonation have been modelled (see ES Appendix 12.3 (Document Reference: 3.3.8)) and are summarised in Table 11.42 for potential mortality/mortal injury.

222. For recoverable injury, TTS and behavioural impacts the qualitative criteria defined in Popper *et al*. (2014) have been used to inform the assessment. These are outlined in Table 11.43.

Table 11.42 Summary of the impact ranges of UXO detonation using the unweighted SPL_{peak} explosion noise criteria from Popper *et al.* (2014) for fish species

Unweighted SPL_{peak}		0.5 kg	25 kg +donor	55 kg +donor	120 kg +donor	240 kg +donor	525 kg +donor	750 kg +donor
Mortality & potential mortal injury	234 dB	< 50 m	170 m	230 m	300 m	370 m	490 m	550 m
	229 dB	80 m	290 m	380 m	490 m	620 m	810 m	910 m

Table 11.43 Popper *et al.* (2014) qualitative criteria for explosions for recoverable injury, TTS and behavioural impacts in fish species

Category	Recoverable injury	TTS	Behaviour
Fish with no swim bladder	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) High (I) Moderate (F) Low
Fish with swim bladder not involved in hearing	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) High (I) High (F) Low
Fish with swim bladder involved in hearing	(N) High (I) High (F) Low	(N) High (I) High (F) Low	(N) High (I) High (F) Low
Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F). (N), (I) and (F) are equivalent to tens, hundreds and thousands of metres respectively			

11.6.1.6.1 Magnitude of impact

223. The detonation of UXOs found in the offshore project area may result in injury and disturbance to fish and shellfish species in the vicinity of the detonation. Physical injury/trauma would be expected in close proximity to the detonation (tens to hundreds of meters, depending on charge) with TTS and behavioural impacts potentially occurring at greater distances. In all cases, however, high risks are only anticipated at short distances. With this in mind and considering the short term and intermittent nature of this activity (limited to instances when detonation of UXO is required) and the wide distribution ranges of fish and

shellfish species (including areas used for spawning and as nursery grounds), the impact is considered to be of negligible magnitude.

11.6.1.6.2 Sensitivity of receptor

224. The sensitivity of fish and shellfish receptors with regards to underwater noise is as previously presented in Section 11.6.1.4.5 and summarised in Table 11.44 below.

Table 11.44 Hearing categories of key fish species and their sensitivity to noise

Group	Species	Sensitivity to noise
Fish with no swim bladder or other gas chamber	Species in general	Low
	Sandeels	Medium
Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume	All species in general	Low
	Gobies	Medium
Fish in which hearing involved a swim bladder or other gas volume	Species in general	Medium
	Herring	High
Eggs and larvae	In general	High
Shellfish	In general	Medium

11.6.1.6.3 Significance of effect

225. Taking account of the identified magnitude of impact (negligible) and receptor sensitivity (low to high depending on species), effects associated with noise from UXO detonation are considered to result in an impact of **negligible to minor significance** on fish and shellfish species, **which is not significant in EIA terms**.

11.6.1.7 Impact 7: Changes in fishing activity

11.6.1.7.1 Magnitude of impact

226. The presence of safety zones associated with the Project during the construction phase could result in changes to fishing activity within the offshore project area but also in the wider area (i.e. due to displacement of fishing activity into other areas). Fishing activity may be reduced within the offshore project area as a result of 500m construction safety zones around offshore construction vessels, advisory safety zones and the physical presence of infrastructure within the array area.

227. As described in ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16), significant effects (i.e. exceeding minor significance) in respect of loss of fishing grounds and associated potential for displacement have not been identified for any of the fleets active in areas relevant to the Project. With this in mind and considering the short-term and temporary nature of the construction phase the magnitude of the impact is assessed as negligible.

11.6.1.7.2 Sensitivity of receptor

228. Detailed information on the principal commercial fish and shellfish species targeted in the study area is presented in ES Appendix 11.1 (Document Reference: 3.3.5). The fish species of highest commercial importance include sole, bass, thornback ray, horse mackerel, herring, cod and plaice. These species are highly mobile and would be available to fisheries in the wider study area outside of the boundaries of the offshore project area.

229. Shellfish species such as whelk, lobster and crab are also targeted in the study area, which would likely benefit most from a reduction in fishing effort. Roach *et al*. (2018) found that temporary restrictions of fishing areas led to an increase in lobster abundance and size. It is suggested that temporary restrictions of fishing activity can enable uninterrupted contribution to the spawning stocks through protection of habitats that became a refuge for young and spawning fish (Byrne Ó Cléirigh *et al*., 2000).

230. It should be noted, however that fishing activity is primarily regulated through the setting of annual total allowable catches (TACs) and limitations in fishing effort. It is not expected that overall fishing pressure over these species will be affected by changes in activity associated with the construction works for the Project, as fishing will continue until TACs or set limitations in effort are reached for the stocks in questions (i.e. through vessel's fishing in the wider grounds available in the southern North Sea). The sensitivity of fish and shellfish species to changes in fishing activity associated with the Project is therefore considered to be low.

11.6.1.7.3 Significance of effect

231. Fish and shellfish receptors in general are considered to have low sensitivity to changes in fishing activity associated with the Project. This, in combination with the low magnitude of the impact, would result in an effect of **negligible significance, which is not significant in EIA terms.**

11.6.2 Likely significant effects during operation

232. The potential impacts of the Project on fish and shellfish receptors during O&M are assessed below. As outlined in Table 11.2, these include the following:

- Impact 8: Temporary habitat loss/ physical disturbance;
- Impact 9: Long term habitat loss;
- Impact 10: Increased suspended sediment concentrations and re-deposition;
- Impact 11: Re-mobilisation of contaminated sediments;
- Impact 12: Underwater noise and vibration;
- Impact 13: Electromagnetic Fields (EMFs);
- Impact 14: Introduction of hard substrate; and
- Impact 15: Changes in fishing activity.

11.6.2.1 Impact 8: Temporary habitat loss/ physical disturbance

11.6.2.1.1 Magnitude of impact

233. During the operational phase of the Project, activities such as export cable repairs and reburial and turbine repairs have the potential to result in temporary habitat loss/physical disturbance to fish and shellfish receptors. Similarly, the presence of machinery on the seabed (i.e. jack up vessel legs, vessel anchors) could also result in physical disturbance or temporary habitat loss. The area disturbed would be comparatively much smaller than during construction (see Table 11.2).

234. The following planned and unplanned maintenance activities are assumed as worst-case scenarios:

- Reburial of c.2.75% of array cable length is estimated over the life of the Project (approximately 0.1km^2 disturbance);
- Reburial of c.2.75% of platform interconnector cable is estimated over the life of the Project (approximately 0.01km^2 disturbance);
- Reburial of c. 4% of export cable is estimated over the life of the Project (approximately 0.1km^2 disturbance);
- Five array/platform interconnector cable repairs are estimated over the Project life (approximately 0.07km^2 disturbance);
- Four export cable repairs are estimated over the Project life (approximately 0.06km^2 disturbance);
- Anchored vessels placed during the no. of cable repairs included above (approximately 0.005km2); and
- Maintenance of offshore infrastructure would be required during O&M. An estimated 177 major component replacement activities may be required per year, using jack up vessels and/or anchoring (approximately 0.3km^2 disturbance).

235. The impacts from planned maintenance and repair works during the operational phase would be temporary, localised and small scale and overall there would be less impact on fish and shellfish receptors than during construction (see Section 11.6.1.1).

236. As identified for construction, the area of disturbance will be very small and the seabed is anticipated to quickly recover to its original condition (see ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12)). Considering this in the context of the wide distribution ranges of fish and shellfish species and the very limited overlap of the proposed works with key habitats for these species (an no overlap in some cases) the magnitude of the impact of physical disturbance/temporary habitat loss is considered to be negligible for all fish and shellfish receptors.

11.6.2.1.2 Sensitivity of receptor

237. The sensitivity of fish and shellfish receptors identified in the offshore project area in relation to physical disturbance and temporary habitat loss for the construction phase (Impact 1) in Section 11.6.1.1.2 also applies to the operation phase.

238. As previously described, fish species are considered receptors of low sensitivity with the exception of herring, sandeels, oysters and cockles for which sensitivity is considered to be high, and thornback ray and shellfish species in general, for which sensitivity is considered to be medium.

11.6.2.1.3 Significance of effect

239. Based on the magnitude of the impact (negligible) and the sensitivity of fish and shellfish species (low to high depending on the species), the effect of temporary habitat loss and physical disturbance during operation is assessed as to be of

negligible to minor significance for the offshore project area. A summary of the assessment is provided in Table 11.45 below.

Table 11.45 Summary of assessment by fish and shellfish receptors for temporary habitat loss/physical disturbance

Receptor	Magnitude of impact	Sensitivity to noise	Significance of effect
Fish species in general	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Downs herring	Negligible	High	**Minor (which is not significant in EIA terms)**
Blackwater herring	Negligible	High	**Minor (which is not significant in EIA terms)**
Sandeels	Negligible	Medium	**Minor (which is not significant in EIA terms)**
Oysters and cockles	Negligible	High	**Minor (which is not significant in EIA terms)**
Thornback ray (elasmobranchs)	Negligible	Medium	**Minor (which is not significant in EIA terms)**
Shellfish species in general	Negligible	Medium	**Minor (which is not significant in EIA terms)**

11.6.2.2 Impact 9: Long term habitat loss

11.6.2.2.1 Magnitude of impact

240. The worst-case potential permanent loss of habitat during the operational phase is presented in Table 11.2. This would be primarily a result of the introduction of foundations associated with turbines, and any required scour around these structures, as well as protection measures introduced for the array/ interconnector and export cables.

241. Within the array area it is estimated that a worst-case permanent loss of habitat would represent an area of approximately 5.37km^2 which is 5.7% of the array area. Within the offshore cable corridor, the estimated worst-case loss of habitat is approximately 0.075km^2, which is 0.14% of the offshore cable corridor

242. Loss of habitat would be permanent throughout the expected design life of the Project. However, as described in Table 11.2, the area of seabed potentially lost would be very small, being localised to areas where project infrastructure is located. The potential overlap with fish and shellfish receptors, including spawning and nursery grounds would be minimal.

243. In the case of herring, it is noted that spawning grounds for the Downs stock are located immediately to the east of the array area and that the degree of overlap between spawning grounds and areas within the offshore project area where long term habitat loss may occur would be very small (ES Figure 11.2, and ES Figure 11.3 (Document Reference: 3.2.7)). Blackwater herring spawning grounds are located in inshore areas around the Blackwater Estuary and Herne

Bay at considerable distance from the offshore project area (ES Figure 11.2, (Document Reference: 3.2.7)) and therefore would not be subject to direct long term loss of habitat.

244. Whilst sandeels are expected to be found in some numbers in the study area, available information from the IBTS (ES Figure 11.5, (Document Reference: 3.2.7)), the distribution of defined spawning and nursery grounds (ES Figure 11.4, (Document Reference: 3.2.7)), known sandeel grounds and fishing areas (ES Figure 11.6, (Document Reference: 3.2.7)) and available information on the sediments in the offshore project area, all suggest that the offshore project area is not a key sandeel area (ES Figure 11.7 (Document Reference: 3.2.7), see ES Appendix 11.1, (Document Reference: 3.3.5)). It is therefore expected that the extent of potential sandeel habitat lost as a result of the introduction of Project infrastructure would be very small.

245. Similarly, for other species that are demersal spawners such as thornback ray, the level of overlap with Project infrastructure would be minimal in the context of the wide areas identified as spawning/nursery grounds (low intensity) for this species.

246. In the particular case of shellfish receptors of limited mobility such as cockles and oysters, there is no expected direct overlap between the works and the receptors. The offshore cable corridor area overlaps with two cockle harvest areas however, it is understood from consultation with KEIFCA that there is no overlap between cockle beds that are being commercially targeted and the offshore cable corridor (see details in ES Appendix 14.1 Commercial Fisheries Technical Report (Document Reference: 3.3.15)). Similarly, while the offshore cable corridor is in the proximity (c.5.9km) of the Blackwater, Crouch, Roach and Colne Estuaries MCZ (specifically designated for the protection of native oysters/oyster beds) there is no overlap with the offshore cable corridor.

247. As previously mentioned, any permanent loss of habitat will be highly localised, occurring over small discrete areas where Project infrastructure is located, considering this in the context of the wide distribution ranges of fish and shellfish species and the very limited overlap of the proposed works with key habitats for these species (no overlap in some cases) the magnitude of the impact is considered to be negligible for all fish and shellfish receptors.

248. In this context it is important to note that as indicated in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12), significant effects on the benthos associated with permanent loss of habitat are not expected (effects assessed as of minor adverse significance in ES Chapter 10 Benthic and Intertidal Ecology, (Document Reference: 3.1.12)).

11.6.2.2.2 Sensitivity of receptor

249. The sensitivity of fish and shellfish species to habitat loss is described in detail in Section 11.6.1.1.2, with regards to the construction phase. The same sensitivities would apply during operation. These are as follows:

- Low for fish in general;
- Medium for shellfish in general and for thornback ray; and
- High for herring, sandeels and cockles and oysters.

11.6.2.2.3 Significance of effect

250. Taking account of the impact magnitude identified (negligible) and the sensitivity of fish and shellfish species (low to high depending on the species), the effect of permanent loss of habitat during operation is assessed to be of **negligible to minor significance, which is not significant in EIA terms.**

11.6.2.3 Impact 10: Increased suspended sediment concentrations and re-deposition

11.6.2.3.1 Magnitude of impact

251. During the operational phase of the Project, activities such as export cables, array cables and platform interconnector cable repairs and reburial and turbine maintenance have the potential to result in increases in SSC within the water column and subsequent deposition onto the seabed. The effects of increased SSCs have been assessed in ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10), which found that the worst-case volumes of sediment released following O&M activities are considerably less than in the construction phase.

252. During construction it was considered that overall changes from SSC and deposition of fine sands and mud-sized sediment will not be measurable due to prevailing hydrodynamic conditions and impact magnitude was assessed to be negligible (Section 11.6.1.2.1) for all fish and shellfish receptors. As operational activities will be more localised and at a smaller scale, the magnitude of the impact is also considered to be negligible.

11.6.2.3.2 Sensitivity of receptor

253. The sensitivity of fish and shellfish receptors will be as assessed for construction (Section 11.6.1.2.2). In general terms, adult and juvenile fish, being mobile, would be expected to rapidly redistribute to undisturbed areas within their habitat range. Similarly, it is understood that motile shellfish species will be relatively tolerant of the small increases in SSCs and low levels of re-deposition given the anticipated levels of SSCs are considered to be within the range of natural variability for the area. As such, fish and shellfish in general are considered receptors of low sensitivity.

254. As previously described, of the receptors that were assessed separately, herring, sandeels, and sedentary/sessile filter feeders (oysters and cockles) are considered receptors of medium sensitivity.

11.6.2.3.3 Significance of effect

255. In general terms, given the sensitivity of fish and shellfish receptors is low, in combination with the negligible magnitude of the impact associated with the Project, this would result in an effect of negligible significance.

256. Of the receptors that were assessed separately, Downs herring, sandeels, and oysters and cockles are considered to be receptors of medium sensitivity which results in an effect of minor significance.

257. Shellfish receptors and other species with known spawning grounds are assessed to be of low sensitivity, which results in an effect of **negligible significance, which is not significant in EIA terms**.

11.6.2.4 Impact 11: Re-mobilisation of contaminated sediments

11.6.2.4.1 Magnitude of impact

258. During the operational phase of the Project, activities such as export cables, array cables and platform interconnector cable repairs and reburial and turbine maintenance have the potential to disturb contaminated sediment and re-mobilise it back into the water column. However, ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) assessed the impact in more detail and concluded that even though there are some elevated levels of contaminants within the sediments, they align with typical levels for the region and do not pose a high risk. The magnitude of impact is considered negligible.

11.6.2.4.2 Sensitivity of receptor

259. As noted in Section 11.6.1.3.2, the levels of contaminants found are within environmental protection standards, therefore, all fish and shellfish receptors are assessed as not sensitive (negligible sensitivity) to changes that remain within these standards.

11.6.2.4.3 Significance of effect

260. The overall worst-case effect is considered to be of **negligible significance (which is not significant in EIA terms)** from the remobilisation of contaminated sediments given the negligible magnitude and negligible sensitivity to the existing contaminant levels found in the area.

11.6.2.5 Impact 12: Underwater noise and vibration

11.6.2.5.1 Magnitude of impact

261. During operations underwater noise and vibration will occur as a result of vessel activity for maintenance activities, as well as from operational turbines, where mechanically generated vibration from the turbines, is transmitted into the sea through the structure of the support pile and foundations (ES Appendix 12.3, (Document Reference: 3.3.8)).

262. Noise from the operation of wind turbines would be present for the design life of the Project and would contribute to the ambient noise in the region. As described in ES Appendix 12.3 (Document Reference: 3.3.8), in line with the modelling carried out in respect of operational wind turbines, impact ranges associated with operational noise from wind turbines would be very small (i.e. <50m in respect of fish for recoverable injury/PTS) (Table 11.46).

263. In respect of noise associated with O&M vessels servicing the Project, it should be noted that a maximum of 1,222 vessel round trips are expected to occur each year (average of 4/day) during the operational phase. This would be very small in the context of the current levels of vessel traffic in the area (ES Chapter 15 Shipping and Navigation, (Document Reference: 3.1.17)) and less than that modelled during construction (Table 11.40).

Table 11.46 Summary of the operational WTG noise impact ranges using the continuous noise criteria from Popper et al. (2014) for fish (swim bladder involved in hearing)

Popper et al. (2014) Unweighted SPL_{RMS}	Operational WTG (14 MW)	Operational WTG (25 MW)
Recoverable injury 170 dB (48 hours) Unweighted SPLRMS	< 50 m	< 50 m
TTS 158 dB (12 hours) Unweighted SPLRMS	< 50 m	< 50 m

264. From the information provided above, it is understood that O&M activities only have potential to result in localised disturbance to fish and shellfish receptors. As described in Table 11.39the risk of mortality would be very low, even in close proximity to the source of noise. This would also be the case with regard to the risk of any injury or TTS with reference to the SPLRMS guidance for continuous noise sources (see Table 11.40).

265. Taking the small increase above background noise levels expected during operation and the localised nature of the potential impact, in the context of the distribution ranges of fish and shellfish species, including areas used for spawning and as nursery, the magnitude of the impact is considered to be negligible.

11.6.2.5.2 Sensitivity of receptor

266. The results from monitoring programmes indicate that the presence of operational wind farms has not identified significant impacts on fish and shellfish communities. Further information is provided on the studies of fish populations and assemblages within operational offshore wind farms in Section 11.6.2.7. Considering this and the small areas potentially affected by operational noise in the context of the distribution ranges of fish and shellfish species, their sensitivity to operational noise have been assessed as low to high (Table 11.47).

Table 11.47 Hearing categories of key fish species and their sensitivity to noise

Group	Species	Sensitivity to noise
Fish with no swim bladder or other gas chamber	Species in general	Low
	Sandeels	Medium
Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume	All species in general	Low
	Gobies	Medium
Fish in which hearing involved a swim bladder or other gas volume	Species in general	Medium
	Herring	High
Eggs and larvae	In general	High
Shellfish	In general	Medium

11.6.2.5.3 Significance of effect

267. Taking account of the identified magnitude of impact (low) and receptor sensitivity (low), effects associated with operational noise and maintenance activities are considered to result in an impact **of negligible to minor significance** on fish and shellfish species, **which is not significant in EIA terms.**

11.6.2.6 Impact 13: Electromagnetic Fields (EMFs)

11.6.2.6.1 Magnitude of impact

268. The transport of electricity through cables generates a localised EMF which could potentially affect the sensory mechanisms of some species of fish and shellfish. EMF will result from the operation of up to 228km of High Voltage Alternating Current (HVAC) array and platform interconnector cables (maximum operating voltage of 132 kilovolts (kV), and 125.4km of HVAC export cable (comprising of up to four cables operating at a capacity up to 400kV).

269. EMF comprise both the electric (E) fields, and the magnetic (B) fields. In nature, E-fields are induced in the sea when saltwater, a conductor, moves in the natural B-field, and will vary with the B-field strength and current speeds. Background measurements of B-fields are approximately 50μT (micro tesla) in the North Sea and the naturally occurring E-field in the North Sea is approximately 25μVm-1 (Tasker *et al*., 2010). The B- and induced electric (iE) fields produced by Alternating Current (AC) change in direction and magnitude over time as the current flow alternates between positive and negative polarity. Therefore, the B-fields that HVAC cables generate are constantly changing. As a result, the motion of these B-fields through the surrounding seawater continuously induces varying iE-fields.

270. It has been shown that industry-standard AC cables can be effectively insulated to prevent E-field emissions but not B-field emissions (Scott *et al*., 2018). B-fields are expected to attenuate rapidly with distance from cables and given their dependence on B-fields, iE-fields are also expected to attenuate rapidly both horizontally and vertically with distance from the cables (CMACS, 2012). Normandeau *et al*. (2011) modelled expected B-fields using design characteristics taken from a range of undersea cable projects. For eight of the ten AC cables modelled it was found that the intensity of the B-fields was a function of voltage (ranging from 33kV to 345kV) although separation between the cables and burial depth also influenced field strengths. The predicted B-fields were strongest directly over the cables and decreased rapidly with vertical and horizontal distance from the cables (Table 11.48).

Table 11.48 Averaged magnetic (B-field) strength values from AC cables buried 1m (Normandeau *et al*., 2011)

Distance above seabed (m)	Magnetic Fields Strength (μT) Horizontal distance (m) from cable		
	0	4	10
0	7.85	1.47	0.22
5	0.35	0.29	0.14
10	0.13	0.12	0.08

271. As part of the embedded mitigation measures stated in Section 11.3.3 (Table 11.3), offshore cables will be buried to a target minimum burial depth of 0.6m (average burial depth of 1.2m), where practicable. Where substrate conditions prevent burial, and at cable or pipeline crossings, cable protection would be deployed.

272. The areas affected by EMFs generated by the worst-case scenario (minimum indicative target depth cable burial (0.6m) and highest power-rating) associated with the Project are expected to be small, being limited to the offshore project area, and restricted to the immediate vicinity of the cables (i.e. within metres). In addition, EMFs are expected to attenuate rapidly in both horizontal and vertical plains with distance from the source. Considering the wide distribution ranges of fish and shellfish species (including those used for spawning and as nursery areas) it is expected that in general terms the level of overlap between fish and shellfish receptors and EMFs from the Project will be minimal.

273. With the exception of elasmobranchs and shellfish species such as lobster and crab, which are expected to be frequently found in the offshore project area, fish and shellfish species known to be electro-sensitive are only expected to transit the offshore project area on an occasional basis.

274. Spawning of lampreys occurs in rivers, therefore, lampreys are only expected to be sporadically present in the vicinity of the Project during the marine migration phase, primarily in areas relevant to the offshore cable corridor.

275. The potential interaction of salmon and sea trout with the offshore project area would only be expected to occur on an occasional basis during marine migration/feeding in coastal areas (i.e. in inshore areas possibly in the proximity of the offshore cable corridor), as indicated in Section 11.5.5.1.

276. As indicated in Section 11.5.5.1 the potential interaction of European eel with the offshore project area would only be expected to occur on an occasional basis during marine migration/feeding in coastal areas (i.e. in inshore areas possibly in the proximity of the offshore cable corridor).

277. The magnitude of the impact is therefore considered to be negligible for all receptors except for lobster, crab and elasmobranchs which are considered low.

11.6.2.6.2 Sensitivity of receptor

278. Marine fish and shellfish species are known either to be sensitive to natural magnetic, electric, and electromagnetic fields or have the potential to detect them (Gill and Taylor, 2001; Gill *et al.*, 2005; Hutchison *et al*., 2020). These species can be categorised into two groups based on their mode of magnetic field detection, which may be iE-field detection (electro-receptive) or direct B-field detection (magneto-receptive), noting that some species may use both (Anderson *et al.*, 2017).

279. Electro-receptive species include elasmobranchs (sharks, skates and rays), holocephalans (e.g. ratfish) and agnathans (i.e. lampreys). These can detect the presence of a B-field either indirectly by detection of the iE-field induced by the movement of water through a B-field or directly by their own movement through that field. In natural scenarios, iE-fields usually result from organisms positioning themselves in tidal currents and animals may time activities such as foraging or migration by detecting diurnal cues resulting from varying tidal flows.

280. The detection mechanisms of magneto-receptive species are less well understood but are believed to use magnetite-based and photochemical systems (Nordmann *et al*., 2017). It is generally believed that they are able to detect magnetic cues such as the Earth's geomagnetic field to orientate during migration.

281. The sensitivity of the main receptors found in the study area for which there is evidence of a response to E or B-fields, together with an assessment of the potential impacts arising from the proposed worst-case cabling, is given separately for elasmobranchs, diadromous migratory species, other fish species and shellfish. It is understood that the sensitivity and biological relevance of EMFs may vary throughout species' life history and electro-sensitivity may include detection of prey, predator avoidance, communication and reproductive behaviours (Hutchison *et al*., 2020). Magneto-sensitivity may support long or short-range migrations or movements including orientation, homing, and navigation (Gill *et al*., 2005; Normandeau *et al*., 2011).

Elasmobranchs

282. Elasmobranchs are the species group considered to be the most electro-sensitive. These species naturally detect bioelectric emissions from prey, conspecifics and potential predators and competitors through sensitivity to very weak voltage gradients (Gill *et al.*, 2005). They are also known to detect magnetic fields. A number of laboratory and field experiments have been carried out with elasmobranchs using cables of the type used by the offshore renewable energy industry that indicated that EMF can be detected by electro-sensitive species such as rays and dogfish (Gill and Taylor, 2001; Gill *et al*., 2005; Gill *et al*., 2009; CMACS, 2003; COWRIE, 2009).

283. Both attraction and repulsion reactions to E-fields have been observed in elasmobranch species however, the responses were variable between both species and individuals and were not predictable and did not always occur. A study by Love *et al*., (2016) found no evidence to suggest that electro-sensitive species such as elasmobranchs were either attracted or repelled by the EMFs emitted from the energised power cables. An increase in distance travelled was observed in studies of thornback ray in response to an AC cable emitting EMF within the range of detectability of the skate, whereas lesser spotted dogfish were more likely to be found within the zone of EMF emissions (Gill *et al*., 2009). Research carried out by Hutchison *et al*. (2018) on the impact of HVDC cables on the little skate *Leucoraja erinacea* found evidence of behavioural responses in elasmobranchs in the proximity of the cables such as changes to their movement and distribution. These were interpreted as attraction responses, consistent with benthic elasmobranchs foraging behaviour. It was noted that the larger distances travelled and increased number of large turns observed, could represent an increased energetic expense.

284. Information gathered as part of the monitoring programmes at Burbo Bank offshore wind farm suggested that certain elasmobranch species feed inside the wind farm and demonstrated that they are not excluded during periods of low power generation (Cefas, 2009). Monitoring at Kentish Flats found an increase in thornback rays, smoothhounds and other elasmobranchs during post-construction surveys in comparison to pre-construction surveys. There appeared to be no discernible difference however, between the data for the wind farm and reference areas in terms of changes to population structure and it was concluded that the population increase observed was unlikely to be related to the operation of the wind farm (Cefas, 2009).

285. A study commissioned by the MMO (2014) evaluated the results of post environmental data associated with post-consent monitoring of licence conditions of offshore wind farms. The report concluded the following:

"*From the results of post-consent monitoring conducted to date, there is no evidence to suggest that EMFs pose a significant threat to elasmobranchs at the site or population level, and little uncertainty remains. Targeted research using high tech equipment and experimental precision has been unable to ascertain information beyond that of fish being able to detect EMFs and at what levels they become attracted or abhorrent to them. EMFs emitted from standard industry cables for offshore wind farms are unlikely to be repellent to elasmobranchs beyond a few metres from the cable if buried to sufficient depth. It is likely that the subtler effects of EMF, including attraction of elasmobranchs,* *inquisitiveness and feeding response to low level EMFs, may occur. The Burbo Bank offshore wind farm post-consent monitoring undertook EMF specific surveys including stomach analysis of common elasmobranch species. Fish caught at the cable site (and hence subject to EMFs) were well fed. No deleterious effects were recorded to fish populations, at least when this effect occurs in association with the probable increased feeding opportunities reported as a result of increased habitat heterogeneity*".

286. In light of the above it is considered that at worst, any EMF related effects are expected to result in temporary behavioural reactions rather than cause a barrier to migration or result in long term impacts upon feeding in elasmobranch species. As such they are considered species of medium sensitivity.

Lamprey

287. Lampreys, like elasmobranchs, possess electroreceptors that are sensitive to weak, low-frequency E-fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983). Whilst responses to E-fields have been reported in these species, information on the use that they make of the electro-sensitivity is limited. It is likely however, that they use it in a similar way as elasmobranchs to detect prey, predators or conspecifics and potentially for orientation or navigation (Normadeau *et al*., 2011). There is also a concern that EMF has the potential to interfere with navigation during migration, and their sensitivity to EMFs is considered to be medium.

Salmon and sea trout

288. As magneto-sensitive species, there is a concern that EMF has the potential to interfere with the navigation of migrating salmon and sea trout however, any potential impacts on movement and behaviour in salmonids would be closely linked to the proximity of the fish to the EMF source. Gill and Bartlett (2010) suggest that any impact associated with EMFs on the migration of salmon and sea trout would be dependent on the depth of water and the proximity of home rivers to development sites. During the later stages of marine migration, salmon and sea trout rely on their olfactory system to find and identify their natal river. During these stages, they are likely to be migrating in the mid to upper layers of the water column, increasing their physical distance from the offshore cables.

289. Swedpower (2003) found no measurable impact when subjecting salmon and sea trout to B-fields twice the magnitude of the geomagnetic field. Similarly, in a study conducted by Marine Scotland Science (MSS; Armstrong *et al*., 2016) on the behaviour of captive Atlantic salmon, no evidence of unusual behaviour was found associated with B-fields up to 95μT. Furthermore, Atlantic salmon migration in and out of the Baltic Sea over a number of operational subsea HVDC cables has been observed to continue apparently unaffected by the EMFs produced by the cables (Walker, 2001). Research carried out in San Francisco Bay in respect of the impact of a HVDC cable on the migration of Chinook salmon *Oncorhynchus tshawytscha*, found the HVDC cable had a mixed but limited effect on the movements and migration success of smolts (Wyman *et al*., 2018). Similarly, a study by Bureau of Ocean Energy Management (BOEM) (2016) reported that energised cables do not appear to present a strong barrier to the natural seasonal movement patterns of migratory fish and while they may be attracted to the cable after activation, they do not

appear to be impeded from successfully migrating through the Bay (BOEM, 2016).

290. Taking the above into account, Atlantic salmon and sea trout are considered receptors of low sensitivity.

European eel

291. European eel, similar to Atlantic salmon, can use magneto-sensitivity for orientation and direction-finding during migration (Gill and Bartlett, 2010). Experiments undertaken at the operational wind farm of Nysted detected potential barrier effects, however correlation analysis between catch data and data on power production showed no indication that the observed effects were attributable to EMFs. Furthermore, mark and recapture experiments showed that eels did cross the offshore export cable (Hvidt *et al.*, 2005). Similarly, a study carried out by Marine Scotland Science (Orpwood *et al*., 2015) where European eels were exposed to an AC magnetic field of 9.6μT found no evidence of a difference in movement, nor observations of startle or other obvious behavioural changes.

292. Any potential impacts on movement and behaviour would be closely linked to the proximity of the fish to the EMF source. While eels are likely to be distributed through the water column they are highly mobile (Righton et al., 2016). Taking the above into account, European eel is therefore considered a receptor of low sensitivity.

Other fish species in general

293. In addition to the fish species mentioned above, studies have also indicated responses to EMF in other fish species such as cod and plaice (Gill *et al*., 2005). Responses have been suggested to be behavioural, potentially in relation to feeding, predator or conspecific detection or navigation, however limited data are available to support this (Normandeu *et al*., 2011). A recent study on haddock larvae has identified that haddock larvae orientation at sea is guided by a magnetic compass mechanism (Cresci *et al*., 2019). A similar study on herring larvae found no evidence of magnetic compass orientation at that life stage (Cresci *et al.*, 2020).

294. As suggested in the assessments of operational noise and introduction of hard substrate sections (Section 11.6.2.5 and 11.6.2.7), the results of monitoring programmes carried out in operational wind farms to date do not suggest that significant changes in the fish assemblage have occurred during the operational phase of offshore wind farms. It has been suggested that the localised reef/refuge attraction effect of fish to offshore wind farm foundations and scour protection indicates that EMFs from cabling do not seem to have an observable impact on the fish and shellfish (Leonhard and Pedersen, 2006; Lindeboom *et al*., 2011).

295. In line with this, research carried out at the Nysted offshore wind farm in Denmark that focused on detecting and assessing possible impacts of EMFs on fish during power transmission (Hvidt *et al*., 2005) found no differences in the fish community composition after the wind farm became operational. A study of the effect of EMFs from subsea cables on marine organisms found no evidence that there were significant differences in fish communities between energised

and unenergised cables (Love *et al*., 2016). In light of the above the sensitivity of other fish species in general to EMF is assessed as low.

Shellfish

296. While research on the ability of marine invertebrates to detect EMF has been limited, in recent years, research effort has been focused on reducing the knowledge gaps on the impact of EMF on invertebrates. Although there is no direct evidence of effects to invertebrates from undersea cable EMFs (Normandeau *et al.*, 2011), the ability to detect magnetic fields has been studied for some species and there is evidence in some of a response to B-fields, including molluscs and crustaceans. Crustacea, including lobster and crabs, have been shown to demonstrate a response to B-fields. The Caribbean spiny lobster *Palinurus argus* and the American lobster *Homarus americanus* both use magneto-sensitivity in navigation (Boles and Lohmann, 2003; Hutchison *et al*., 2020). It is uncertain, however, if other crustaceans including commercially important brown crab and European lobster are able to respond to B-fields in this way. Limited research undertaken with the European lobster found no neurological response to B-field strengths considerably higher than those expected directly over an average buried power cable (Normandeau *et al*, 2011; Ueno *et al.*, 1986).

297. Hutchison *et al*. (2018; 2020) studied the potential impact of a HVDC cable on American lobster *Homarus americanus* and reported subtle changes in behavioural activity when they were exposed to the cable's EMFs. The results however indicate that the cable did not represent a barrier to migration. Taormina *et al*. (2020) found no statistically significant effect on the exploratory and sheltering behaviours of juvenile lobsters when exposed to B-fields of up to 200µT.

298. In a laboratory study using comparatively high B-fields (2.8mT and 40mT, compared to nT- or µT-level EMFs measured in the field) Scott *et al*. (2018) identified a clear attraction to EMF exposed shelters (B-fields of 2.8mT) and a decrease in roaming behaviour. In addition, the daily behavioural and physiological rhythmic processes of the haemolymph L-Lactate and D-Glucose levels were disrupted. The EMF did not however appear to affect stress related parameters (i.e. hemocyanin concentrations, respiration rate, activity level or the antennular flicking rate). In a subsequent study, Scott *et al*. (2021) investigated the effects of exposure to different EMF strengths (250µT, 500µT, 1000µT) on edible crabs and found limited impacts at exposure to 250µT. Exposure to 500 and 1000µT was found to disrupt the L-Lactate and D-Glucose circadian rhythm and alter total haemocyte count, with crabs showing clear attraction to EMF exposed shelters and a significant reduction in time spent roaming.

299. A study undertaken by Love *et al*. (2017) on the potential for energised cables off southern California to impact commercially important crab species in the area found no evidence that the EMF influenced the catchability of these two species.

300. From a benthic community perspective, Love *et al*. (2016) found no evidence that there were significant differences in invertebrate assemblages between energised and unenergised cables in the Pacific region. Indirect evidence from post construction monitoring programmes undertaken in operational wind farms

also does not suggest that shellfish species have been affected by the presence of submarine power cables.

301. In light of the above and noting that the updated State of the Science report summarised that research concerning invertebrates since 2016 generally supports previous studies that demonstrated no or minor effects of encounters with EMFs (Gill and Desender, 2020), the sensitivity of shellfish species to EMFs is considered to be low.

11.6.2.6.3 Significance of effect

302. EMF from array, interconnector and export cables will represent a long term and continuous impact throughout the lifetime of the Project. However, any effects will be highly localised i.e. within metres of the cables, therefore will only affect a relatively small proportion of the fish and shellfish habitats in the study area and the wider southern North Sea.

303. Overall, the sensitivity of fish and shellfish receptors (excluding elasmobranchs and lamprey) is low and the magnitude of the impact is deemed to be negligible for all receptors except for lobster, crab and elasmobranchs which are considered low.

304. The effect will, therefore, be of minor significance for elasmobranchs and lamprey and negligible for the other fish and shellfish receptors. A summary of the outcomes of the assessment are given in Table 11.49.

Table 11.49 Summary of assessment outcomes by receptor

Receptor	Magnitude of impact	Sensitivity of receptor	Significance of effect
Elasmobranchs	Low	Medium	**Minor (which is not significant in EIA terms)**
Lamprey	Negligible	Medium	**Minor (which is not significant in EIA terms)**
Salmon and sea trout	Negligible	Low	**Negligible (which is not significant in EIA terms)**
European eel	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Other fish species	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Shellfish	Negligible	Low	**Negligible (which is not significant in EIA terms)**

11.6.2.7 Impact 14: Introduction of hard substrate

11.6.2.7.1 Magnitude of impact

305. The introduction of subsurface infrastructure associated with the Project has the potential to alter the structure of benthic habitats and associated faunal assemblages. All Project infrastructure that has a subsea surface element would represent a potential substrate for colonisation by marine fauna and flora, including non-native species (see ES Chapter 10 Benthic and Intertidal Ecology,

(Document Reference: 3.1.12)). Hard substrates introduced would include turbines, foundations and associated scour protection as well as any cable protection. The area of introduced substrate would be proportional to the permanent loss of area estimated for the Project (see Section 11.6.2.2).

306. The southern North Sea is considered an open, sandy marine environment and the seabed across the offshore project area is characterised predominantly by medium sand in the array area and offshore cable corridor (ES Chapter 8 Marine Geology, Oceanography and Physical Processes, (Document Reference: 3.1.10)). The introduction of hard substrate would increase habitat heterogeneity through the installation of hard structures in an area predominantly characterised by soft substrate habitat. As described in Section 10.6.2.7 of ES Chapter 10 Benthic Ecology (Document Reference: 3.1.12), as this represents a potential change from the existing environmental baseline it is not considered to be beneficial.

307. The hard substrate associated with the installation of the Project would occupy discrete areas only (i.e. around foundations) and would not be continuous along large lengths of offshore cables. Given the wide distribution ranges of fish and shellfish species and the highly localised nature of the hard substrate the magnitude of the impact is considered to be negligible for all fish and shellfish receptors.

308. Taking this into account and the relatively small overall area occupied by the infrastructure, the magnitude of the impact is considered to be negligible.

11.6.2.7.2 Sensitivity of receptor

309. The potential for marine subsea structures to attract and concentrate fish is well documented (Bohnsack, 1989; Bohnsack and Sutherland, 1985; Jørgensen *et al*., 2002; Sayer *et al*., 2005). Through the colonisation of marine fauna on introduced hard substrate, the expected increase in diversity and productivity of seabed communities may have an impact on fish assemblages, resulting in either attraction, increased productivity or changes in species composition (Hoffman *et al*., 2000).

310. A study by Stenberg *et al*. (2015) on the effects of the Horns Rev 1 offshore wind farm on fish abundance, diversity and spatial distribution seven years post-construction found overall fish abundance increased slightly inside the offshore wind farm and declined in the control area. However, none of the key fish species or functional fish groups showed signs of negative long-term effects due to the presence of the wind farm. Overall, results indicated that some fish species benefited from the more diverse and complex habitat. It was also found, however, that the impacted area was not large enough to have adverse negative effects on species inhabiting the original sand bottom between turbines (i.e. dab and sandeels). A study by van Hal *et al.* (2017) on a Dutch offshore wind farm five years post-construction suggested that weather conditions and seasonality had more effect on fish aggregation levels than the wind farm structures and that abundance of pelagic fish species such as horse mackerel, herring and sprat were unaffected by the presence of scour protection.

311. Similarly, a review of the short-term ecological effects of the offshore wind farm Egmond aan Zee in the Netherlands, based on post-construction monitoring after two years (Lindeboom *et al.*, 2011) found minor effects upon fish assemblages, especially near the monopiles, where there was evidence of

increased abundances of small demersal fish species (e.g. gobies and goldsinny wrasse). A similar study conducted at Bligh Bank wind farm found that there was a decrease in overall demersal fish densities within the wind farm compared to control sites, however, for a number of commercially important species (turbot, sole and plaice), higher densities/increases in length distribution were observed (Vandendriessche *et al*., 2012). It was not possible to determine whether this was attributable to a refuge effect (commercial fishing is excluded from Belgian wind farms), changes in epibenthic fauna (e.g. prey), substrate composition, or any combination of these variables.

312. Monitoring studies carried out at the Lillgrund wind farm in Sweden on the abundance and distribution patterns of benthic fish communities found no large-scale effects on fish diversity and abundance post-construction (Bergström *et al*., 2013). Changes at smaller spatial scales were noted, particularly an increase in piscivores (cod, eel, shorthorn sculpin), as well as the reef-associated goldsinny wrasse, which were all observed close to the foundations in the first year of operation. Any changes in populations observed over time, however, were considered to be driven by wider environmental factors. Similarly, the results of pre-construction and post-construction monitoring surveys in North Hoyle and Barrow offshore wind farms in the UK suggest the abundance of commercial fish species has remained broadly comparable and in line with long term trends in the regional area (Walker *et al*., 2009). A review by Glarou *et al*. (2020) found that that artificial structures often increase the abundance of hard-bottom species as well as fish diversity in the local area. It was suggested that while the loss of soft-bottom substrate may result in negative effects on soft-bottom species at the local scale, any effects should be evaluated at larger spatial scales and related to the fish species populations and life history.

313. Crustaceans would be expected to exhibit the greatest affinity to hard substrate installed for scour protection material, foundation bases and cable protection through the expansion of their natural habitats (Linley *et al*., 2007). There may be therefore potential for increases of benthic species including crabs and lobsters as a result of colonisation of subsurface structures by subtidal sessile species on which they feed (Linley *et al*., 2007). Post construction monitoring surveys at the Horns Rev 1 offshore wind farm noted that the hard substrates were used as a hatchery or nursery ground for several species and was particularly successful for edible crab. They concluded that larvae and juveniles rapidly invade the hard substrates from the breeding areas (BioConsult, 2006).

314. In general terms, fish and shellfish species are considered receptors of low sensitivity.

11.6.2.7.3 Significance of effect

315. As suggested by the results of the post-construction monitoring surveys cited above, any changes in the community structure and abundance of fish and shellfish species within the offshore project area would be expected to be small and for the most limited to the immediate vicinity of the hard substrate introduced. Fish populations are unlikely to show noticeable benefits as a result of this impact, though there is evidence that shellfish populations (particularly brown crab and lobster) would benefit from the introduction of hard substrates.

316. Taking the negligible magnitude of the impact assessed for the Project and the low sensitivity of the receptors, the effect is considered to be of **negligible significance, which is not significant in EIA terms.**

11.6.2.8 Impact 15: Changes in fishing activity

11.6.2.8.1 Magnitude of impact

317. The presence of infrastructure associated with the Project during the operation phase could result in changes to fishing activity within the offshore project area but also in the wider area (i.e. due to displacement of fishing activity into other areas). The intensity of fishing activities (including trawling and potting) may be reduced as a result of the physical presence of the infrastructure. This has the potential to enhance fish and shellfish populations by providing refuge from commercial fishing activities (Byrne Ó Cléirigh, 2000; Roach *et al*., 2018).

318. The maximum design scenario for reduced fishing activity in the offshore project area assumes no restrictions to fishing within the array area (except for advisory safety zones around the turbines) or the offshore cable corridor during the design life (see Table 11.2). It is assumed, however, that trawling activity may potentially be reduced within the array area for logistical and safety reasons. Given the multiple factors that can influence the spatial and temporal intensity of commercial fishing (e.g. legislation, quota, weather, natural variation of target species, climate change, individual fishers choice) the extent to which this additional reduction will take place is not possible to quantify.

319. As described in Section 11.5.2, the species of commercial importance in the study area include sole, whelk, bass, thornback ray, horse mackerel, herring, cod, plaice, lobster and crab. These species are targeted across the southern North Sea, with the offshore project area accounting for a small area in the context of the overall fishing grounds for these species (see ES Chapter 14 Commercial Fisheries, (Document Reference: 3.1.16)), therefore it would not be expected that any changes in fishing activities in this area would lead to changes in populations of these species in the fish and shellfish study area. Whilst the long-term nature of the operational phase is recognised, considering the above the magnitude of the impact is assessed as low**.**

11.6.2.8.2 Sensitivity of receptor

320. The sensitivity of fish and shellfish species to changes in fishing activity was described in detail in Section 11.6.1.7, with regards to the construction phase. The same sensitivities would apply during operation. The sensitivity of fish and shellfish receptors in respect of potential changes in fishing activity as a result of the Project is therefore considered to be low.

11.6.2.8.3 Significance of effect

321. Taking the low receptor sensitivity and low magnitude of the impact the resulting impact arising from changes in fishing activity is considered of **negligible significance, which is not significant in EIA terms.**

11.6.3 Likely significant effects during decommissioning

322. The final decommissioning policy is yet to be decided as it is recognised that rules and legislation change over time in line with best industry practice. The decommissioning methodology and programme would need to be finalised

nearer to the end of the lifetime of the Project to ensure it is in line with the most recent guidance, policy and legislation.

323. The scope of the decommissioning works would most likely involve removal of the accessible installed components. This is outlined in ES Chapter 5 Project Description (Document Reference: 3.1.7) and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of all of the wind turbine components and part of the foundations (those above seabed level), and removal of some or all of the array and export cables. Scour and cable protection would likely be left in situ.

324. During the decommissioning phase, there is potential for wind turbine foundation and cable removal activities to cause effects that would be comparable to those identified for the construction phase and the operational phase, specifically:

- Impact 16: Temporary habitat loss / physical disturbance;
- Impact 17: Re-mobilisation of contaminated sediments;
- Impact 18: Underwater noise and vibration; and
- Impact 19: Changes in fishing activity.

325. Permanent habitat loss as a result of infrastructure decommissioned in situ is assessed as for the operational impact because the impact begins when the operation phase starts when the wind farm infrastructure is in place.

326. The magnitude of decommissioning effects will be comparable to or less than the construction phase. Accordingly, given that comparable impacts were assessed to be of negligible or minor significance for the identified fish and shellfish ecology receptors during the construction phase, it is anticipated that the same would be true for the decommissioning phase.

11.7 Cumulative effects

11.7.1 Identification of potential cumulative effects

327. The first step in CEA process is the identification of which residual effects assessed for the Project on their own have the potential for a cumulative effect with other plans, projects and activities. This information is set out in Table 11.50 below. The development activities taken forward for cumulative assessment have been selected on the basis of availability and quality of information and the probability of a cumulative effect occurring, including, where relevant, spatial overlap.

Table 11.50 Potential cumulative impacts

Impact	Potential for cumulative effect	Rationale
Construction		
Impact 1: Physical disturbance and temporary habitat loss;	Yes	Effects will occur at isolated locations for a time-limited duration and are local in nature. Given the presence of nearby offshore wind farms, however, cumulative effects must be assessed.

Impact	Potential for cumulative effect	Rationale
Impact 2: Increased SSCs and sediment re-deposition;	Yes	Increases in SSC are expected to be localised at the point of discharge and short-term. The small quantities of fine sediment may be transported further; however, it will be widely and rapidly dispersed and not increase the volume of sediment already present in the benthos. The elevation of SSC is expected to be lower than concentrations that would develop in the water column during storm conditions. However, due to nearby offshore wind farms, cumulative effects must be assessed.
Impact 3: Re-mobilisation of contaminated sediments	No	The level of contaminated sediment found in the offshore site investigation are not of significant concern and present a negligible magnitude for effect on the fish and shellfish receptors, and so no significant effects likely.
Impact 4: Underwater noise from piling for foundation installation	Yes	There is potential for cumulative effects from underwater noise associated with offshore wind farm activities.
Impact 5: Underwater noise from other construction activities	Yes	
Impact 6: Underwater noise from UXO clearance	Yes	
Impact 7: Changes in fishing activity	No	The sensitivity of fish and shellfish receptors to changes in fishing activity is considered to be low. It is anticipated that the level of commercial fishing would be largely unaffected by changes in activity associated with the Project, as fishing will continue until TACs or set limitations in effort are reached. Therefore, no significant effects are likely.
Operation & Maintenance		
Impact 8: Temporary habitat loss/ physical disturbance	Yes	Effects will occur at isolated locations for a time-limited duration and are local in nature with a negligible impact magnitude. Given the presence of nearby offshore wind farms, however, cumulative effects must be assessed.
Impact 9: Long term habitat loss	Yes	Additive habitat loss across the region. Other developments in the region have the potential to have cumulative habitat loss impacts.
Impact 10: Increased suspended sediment concentrations and re-deposition	Yes	Effects will occur at isolated locations for a time-limited duration and are local in nature with a negligible impact magnitude. However, due to nearby offshore wind farms, cumulative effects must be assessed.
Impact 11: Re-mobilisation of contaminated sediments	No	The level of contaminated sediment found in the offshore site investigation are not of significant concern and present a negligible magnitude for effect on the benthic environment, so no significant effects are likely.
Impact 12: Underwater noise and vibration	Yes	There is potential for interactive effects from underwater noise associated with offshore wind farm activities.
Impact 13: Electromagnetic Fields (EMFs)	Yes	EMF will be highly localised around the offshore cable corridor, array cables and platform interconnector cables. However, due to nearby offshore wind farms, cumulative effects must be assessed.
Impact 14: Introduction of hard substrate	Yes	The introduction of subsurface infrastructure associated with the Project has the potential to alter the structure of benthic habitats and associated faunal assemblages. It is anticipated that any

Impact	Potential for cumulative effect	Rationale
		changes in the community structure and abundance of fish and shellfish species within the Project would be expected to be limited to the immediate vicinity of the hard substrate introduced.
Impact 15: Changes in fishing activity	No	The sensitivity of fish and shellfish receptors to changes in fishing activity is considered to be low. It is anticipated that the level of commercial fishing would be largely unaffected by changes in activity associated with the Project, as fishing will continue until TACs or set limitations in effort are reached. Therefore, no significant effects are likely.
Decommissioning		
Impact 16: Temporary habitat loss / physical disturbance	Yes	Effects will occur at isolated locations for a time-limited duration. Given the presence of nearby offshore wind farms, however, cumulative effects must be assessed.
Impact 17: Re-mobilisation of contaminated sediments	No	The level of contaminated sediment found in the offshore site investigation are not of significant concern and present a negligible magnitude for effect on the benthic environment, so no significant events are likely.
Impact 18: Underwater noise and vibration	Yes	There is potential for interactive effects from underwater noise associated with offshore wind farm decommissioning activities and projects within a representative 100km buffer of the North Falls array area are considered.
Impact 19: Changes in fishing activity	No	The sensitivity of fish and shellfish receptors to changes in fishing activity is considered to be low It is anticipated that the level of commercial fishing would be largely unaffected by changes in activity associated with the Project, as fishing will continue until TACs or set limitations in effort are reached. Therefore, no significant effects are likely.

11.7.2 Other plans, projects and activities

328. The second step in the cumulative assessment is the identification of the other plans, projects and activities that may result in cumulative effects for inclusion in the CEA (described as ‘project screening’). This information is set out in Table 11.51 below, together with a consideration of the relevant details of each, including current status (e.g. under construction), planned construction period, closest distance to the offshore project area, status of available data and rationale for including or excluding from the assessment.

329. The Project screening has been informed by the development of a CEA Project List which forms an exhaustive list of plans, projects and activities in a very large study area relevant to North Falls. The list has been appraised, based on the confidence in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out.

330. Other projects/activities have been considered within a 50km buffer area from the Project to enable the assessment of activities within relevant fish and shellfish habitats (including spawning and nursery grounds) that are representative of those relevant to North Falls. Given that the habitats recorded in the offshore project area are characteristic of the wider southern North Sea region the impacts and receptors affected by projects within this buffer are likely

to be similar to those for North Falls. For the impact of underwater noise, a larger area of search was used (100km), given the predicted greater area of effect noise is predicted to have. The distances from the offshore project area to other offshore projects and activities are summarised in Table 11.51.

331. Coastal development projects on the east coast of England were also considered in the Project screening. These included projects such as ports, harbours, and coastal defence schemes and are summarised in Table 11.52. Projects with the potential for activities to take place after the start of the North Falls baseline surveys (in March 2019), or those with applications submitted but not yet approved, were considered further. All coastal developments that were completed prior to March 2019 are considered to be part of the baseline. Whilst four projects have the potential to overlap with the construction of North Falls, the Project activities are for minor maintenance, therefore are not expected to result in any significant effect to any fish and shellfish receptors. As such, all coastal development projects have been screened out of further assessment within the CEA.

Table 11.51 Summary of offshore projects considered for the CEA in relation to fish and shellfish receptors (project screening)

Project	Status	Construction period	Closest distance from the array area (km)	Distance from the offshore cable corridor (km)	Confidence in data	Included in the CEA (Y/N)	Rationale
Offshore wind farms							
Greater Gabbard offshore wind farm	Operational since 2012	N/A	0 km	3.9 km	High	Yes	Both GGOW and GWF are operational therefore there is potential cumulative effect on fish and shellfish receptors from ongoing maintenance activities.
Galloper OWF offshore wind farm	Operational since 2018	N/A	0 km	6.4 km	High	Yes	
Five Estuaries offshore wind farm	In Planning	Late 2020s	0 km	12.9 km	High	Yes	Potential for cumulative effect during construction and operational phases. Fish and shellfish receptors could be affected if construction of North Falls occurs at a similar time to Five Estuaries OWF due to the close proximity of the Project.
East Anglia TWO offshore wind farm	Consent granted	Construction planned mid 2020s	31.5 km	37.6 km	High	Yes	Potential for cumulative effect during construction and operational phase.
Thanet offshore wind farm	Operational since 2010	N/A	24.9 km	36.2 km	High	No	Any ongoing effects of maintenance activity from these offshore wind farms will be highly localised and therefore, given the distance from the North Falls offshore project area, there is no pathway for significant cumulative effects. This approach is in keeping with the GWF EIA, where it was agreed with Cefas and Defra that no assessment of cumulative effects was required with other Round 2 sites in the Thames strategic area (except GGOW). Given the proximity and similarity between GWF and North Falls, they have not been considered in this assessment (ABPmer, 2010).
London Array offshore wind farm	Operational since 2013	N/A	20.6 km	15.5 km	High	No	
Gunfleet Sands offshore wind farm	Operational since 2010	N/A	39 km	6 km	High	No	

Project	Status	Construction period	Closest distance from the array area (km)	Distance from the offshore cable corridor (km)	Confidence in data	Included in the CEA (Y/N)	Rationale
East Anglia ONE	Operational since 2020	N/A	53.8 km	57.7 km	High	No	Sited outside 15km- 50km radius.
East Anglia ONE North	Consent Authorised	2023-2026	63.4 km	67.5 km	High	Yes	Potential for cumulative effect during construction and operational phase.
Princess Elisabeth - Noordhinder Noord (Belgian)	In Planning	Unknown	32.9 km	47.5 km	Medium	No	Sited in 15km- 50km radius, however it is unlikely there will be any overlap with piling activities. Furthermore, there is currently insufficient information available to conduct a CEA.
Princess Elisabeth - Nordhinder Zuid (Belgian)	In Planning	Unknown	33.8 km	48 km	Medium	No	Sited in 15km- 50km radius, however it is unlikely there will be any overlap with piling activities. Furthermore, there is currently insufficient information available to conduct a CEA.
Seamade (Mermaid)	Operational since 2020	N/A	46.1 km	60.8 km	High	No	Sited in 15km- 50km radius, however any ongoing effects of maintenance activity from these offshore wind farms will be highly localised and therefore, given the distance from the North Falls offshore project area, there is no pathway for significant cumulative effects.
Northwester 2	Operational since 2020	N/A	47.4 km	62.2 km	High	No	Sited in 15km- 50km radius, however any ongoing effects of maintenance activity from these offshore wind farms will be highly localised and therefore, given the distance from the North Falls offshore project area, there is no pathway for significant cumulative effects.

Project	Status	Construction period	Closest distance from the array area (km)	Distance from the offshore cable corridor (km)	Confidence in data	Included in the CEA (Y/N)	Rationale
Kentish Flats + extension	Operational since 2005	N/A	54.6 km	37.5 km	High	No	Sited in 15km- 50km radius, however any ongoing effects of maintenance activity from these offshore wind farms will be highly localised and therefore, given the distance from the North Falls offshore project area, there is no pathway for significant cumulative effects.
Norfolk Vanguard	Consent authorised	2025-2027	95.76 km	117.16 km	High	No	Sited in 50km- 100km radius and no overlap with piling activities.
East Anglia THREE	Consent authorised	2023-2026	81.75 km	104.67 km	High	No	Sited in 50km- 100km radius and no overlap with piling activities.
BELWIND	Operational since 2010	N/A	51.8 km	66.7 km	High	No	Sited in 50km- 100km radius
Nobelwind	Operational since 2017	N/A	53.4 km	68.3 km	High	No	Sited in 50km- 100km radius
Seamade (Seastar)	Operational since 2020	N/A	55.2 km	70.1 km	High	No	Sited in 50km- 100km radius
North Wind	Operational since 2014	N/A	58.4 km	73.4 km	High	No	Sited in 50km- 100km radius
Rentel	Operational since 2018	N/A	60.9 km	75.9 km	High	No	Sited in 50km- 100km radius
Thornton Bank 1-3	Operational since 2009-2013	N/A	62.1 km	77 km	High	No	Sited in 50km- 100km radius

Project	Status	Construction period	Closest distance from the array area (km)	Distance from the offshore cable corridor (km)	Confidence in data	Included in the CEA (Y/N)	Rationale
Norther	Operational since 2019	N/A	66.9 km	81.8 km	High	No	Sited in 50km- 100km radius
Borselle 1-5	Operational since 2020-2021	N/A	50.4 km	65 km	High	No	Sited in 50km- 100km radius
Subsea cables and pipelines							
NeuConnect Interconnector	Pre-construction	2023-2028	2.5 km	0 km	High	Yes	The NeuConnect Interconnector bisects the North Falls offshore cable corridor and interconnector cable corridor and there is potential for temporal overlap of cable installation activities.
BritNed Interconnector	Operational since 2009	N/A	0 km	9.3 km	High	No	The BritNed Interconnector passes through the array but has been operational since 2009. There is therefore no potential for cumulative impact on the identified receptors.
Nautilus Interconnector	Pre-application	2025-2028	Cable route unknown	Cable route unknown	Low	Yes	The offshore study area for Nautilus intersects with the North Falls offshore project area, Therefore, there is potential for cumulative effects, subject to the final location and programme for the interconnector.
Sea Link	Pre-application	2026-2030	5.4 km	0 km	Medium	Yes	The emerging preferred and alternative routes for Sea Link intersect with the North Falls offshore cable corridor. Therefore, there is potential for cumulative effects, subject to the final location and programme for the interconnector.
Tarchon Energy Interconnector	Pre-application	2027 - 2030	Cable route unknown	Cable route unknown	Low	Yes	Interconnector between UK and Germany with potential to be in proximity to the North Falls offshore project area.

Project	Status	Construction period	Closest distance from the array area (km)	Distance from the offshore cable corridor (km)	Confidence in data	Included in the CEA (Y/N)	Rationale
Aggregate areas							
Thames D aggregates production agreement area 524	Production agreement secured 2022	2022-2036	0 km	10.3 km	Low	Yes	There is potential for some interaction between dredging and aggregate exploration on fish and shellfish ecology. Removal of sediment and sediment plumes have the potential to have a cumulative effect. The annual report produced by the Crown Estate for aggregate dredging within the Thames estuary region states that only approximately 6% of the total licensed aggregate extraction areas was dredged at any one time. Furthermore, the area dredged with high intensity was 0.62km² however, 90% of regional dredging effort took place within 1.77km². (Crown Estate 2021).
Thames D aggregates production agreement area 524	Production agreement secured 2022	2022-2036	0 km	10.3 km	Medium	No	Sites which were operational at the time of the North Falls characterisation surveys are a component of the baseline environment.
Southwold East aggregates production agreement area 430	Operational since 2012	N/A	50.1 km	48.4 km	Medium	No	
North Inner Gabbard aggregate	Operational since 2015	N/A	24.7 km	24 km	Medium	No	

Project	Status	Construction period	Closest distance from the array area (km)	Distance from the offshore cable corridor (km)	Confidence in data	Included in the CEA (Y/N)	Rationale
production area 498							
Shipwash aggregate exploration and option area 507	Operational since 2016	N/A	19.6 km	9.8 km	Medium	No	
Longsand aggregate exploration and option area 508	Operational since 2014	N/A	13.9 km	5.8 km	Medium	No	
Longsand aggregate exploration and option area 509	Operational since 2015	N/A	13.8 km	2.1 km	Medium	No	
Longsand aggregate exploration and option area 510	Operational since 2015	N/A	9.5 km	3.5 km	Medium	No	
North Falls East aggregate exploration and option area 501	Operational since 2017	N/A	13.2 km	27.5 km	Medium	No	

Table 11.52 Summary of coastal development projects considered for the CEA in relation to fish and shellfish receptors (project screening)

Project	Type of project / activity	Status	Marine Licence dates	Activity start date	Activity end date	Potential for overlap with North Falls construction?	Included in the CEA (Y/N)
Port of Felixstowe, Dooley Terminal - Upgrade to RORO 3 & 4	Berth extension	Approved	Aug 19 to Jan 21	May-19	Mar-20	No	No. Four projects have the potential to overlap with the construction of North Falls, however the project works are for minor maintenance activities only.
Foulness Island - X5-Headway Refurbishment	Coastal defence	Approved	Apr 21 to Apr 22	-	-	No	
Happisburgh to Winterton Sea Defences	Coastal defence	Approved	Sep 15 to Aug 20	-	-	No	
Headland and Block Sands Coastal Protection Scheme	Coastal defence	Approved	Apr 15 to Oct 20	-	-	No	
Hythe Ranges Coastal Protection Works	Coastal defence	Approved	Jul 20 to Dec 21	Mar-20	Nov-20	No	
Potters leisure sea defence	Coastal defence	Approved	Unknown	2016	-	No	
South Withernsea Coastal Defences	Coastal defence	Approved	Dec 19 to Dec 24	-	-	No	
Installation of Blyth Bay Marker buoys	Construction	Approved	Jul 15 to Jun 26	-	-	No	
Marsden Lifeguard Station and Redwell Steps	Construction	Approved	Aug 19 to Dec 21	-	-	No	
Withernsea Long Sea Outfall Replacement Environmental Impact Assessment (EIA)	Construction outfall	Approved	Apr 20 to Apr 21	-	-	No	
Naze north cliff stabilisation emergency works project	Emergency works	Approved	Apr 22 to Apr 23	Jun-22	Sep-22	No	
Cromer Pier	Minor maintenance	Approved	Jul 22 to Jul 23	-	-	No	
Gorleston Beach Lifeguard Area	Minor maintenance	Approved	May 17 to May 27	-	-	No	

Project	Type of project / activity	Status	Marine Licence dates	Activity start date	Activity end date	Potential for overlap with North Falls construction?	Included in the CEA (Y/N)
Happisburgh Marine License	Minor maintenance	Approved	Jul 18 to Jul 28	-	-	Yes	
Lindisfarne causeway ditching	Minor maintenance	Approved	Apr 18 to Dec 28	-	-	Yes	
NDDC	Minor maintenance	Approved	Jul 18 to Jul 28	-	-	Yes	
RNLI North Division - Regional Licence for Low Impact Maintenance Works	Minor maintenance	Approved	Sep 17 to Sep 27	-	-	No	
RNLI Whitley Bay Beach Lifeguard Area	Minor maintenance	Approved	Sep 17 to Sep 27	-	-	No	
SABIC 3 Jetty Maintenance	Minor maintenance	Approved	May 22 to May 23	-	-	No	
Sealife Hunstanton	Minor maintenance	Approved	Jul 22 to Jul 23	-	-	No	
Southend Pier - Maintenance	Minor maintenance	Approved	Jul 22 to Jun 32	-	-	Yes	
Southern Water minor maintenance works	Minor maintenance	Approved	Sep 21 to Sep 31	-	-	Yes	
Yorkshire Water Services - Long term maintenance and repair marine licence	Minor maintenance	Approved	Jun 17 to Jun 27	-	-	No	
Footprint of new lifeboat station and access route for construction	New lifeboat station	Approved	Mar 21 to Jun 23	-	-	No	
RNLI Wells	New lifeboat station	Approved	Sep 18 to Jul 21	-	-	No	
BLF (includes outer bar), MBIF and CDO investigations	NPP -	Approved	May 19 to Dec 23	-	-	No	

Project	Type of project / activity	Status	Marine Licence dates	Activity start date	Activity end date	Potential for overlap with North Falls construction?	Included in the CEA (Y/N)
Walton Pier Concrete Repair Programme 2019	offshore works	Approved	Apr 19 to Apr 20	-	-	No	
Trawl Dock Area Lowestoft Outer Harbour	Pier repairs	Approved	Aug 20 to Aug 22	-	-	No	
Marina pontoon maintenance and upgrade.	Pontoon extension	Approved	Aug 20 to Aug 29	2020	2023	No	
Northern Gateway Container Terminal	Pontoon maintenance and upgrade	Approved	Feb 22 to Dec 29	Target completion date of 7th May 2028		Port construction	
Berth 9 Container Yard, Port of Felixstowe	Port construction	Approved	Aug 17 to Aug 19	Sep-17	Nov-18	No	
Hamilton Dock	Port expansion	Approved	Mar 13 to Dec 19	-	-	No	
Teesport Ro-Ro No.2 Linkspan Replacement Works	Port expansion	Approved	Oct 21 to Oct 24	-	-	No	
Kessingland Works Area	Port replacement	Approved	Feb 21 to Feb 22	-	-	No	
Tees Seagrass Project	Removal of structures	Approved	May 22 to Apr 24	-	-	No	
Seaweed and Mussel aquaculture off the Yorkshire Coast	Seagrass project	Approved	Mar 18 to Mar 23	-	-	No	
Hemsby rock berm scheme	Seaweed farm	Submitted	N/A	Unknown (30-week programme)		Coastal defence	
Project_Rissa_A_LB_Location	Coastal defence	Submitted	N/A	2022	Feb-23	No	

Project	Type of project / activity	Status	Marine Licence dates	Activity start date	Activity end date	Potential for overlap with North Falls construction?	Included in the CEA (Y/N)
Scotland to England Green Link 1 / Eastern Link 1	Habitat creation for birds	Submitted	N/A	2025	2027	No	
Stonehill Wall Rock Revetment Extension	Interconnector cable	Submitted	N/A	2022	2023	No	

11.7.3 Assessment of cumulative impacts

11.7.3.1 Cumulative impact 1: Physical disturbance and temporary habitat loss during construction

332. There is the potential for cumulative physical disturbance and temporary habitat loss as a result of construction activities associated with North Falls and activities at other offshore wind farm projects, aggregate extraction sites and interconnector cables. Temporary physical disturbance to the seabed will result in an increase in suspended sediments and temporary habitat loss.

333. North Falls is being built as an extension of GGOW and, therefore there is potential for construction works to be conducted at the same time, or similar time, to maintenance works at GGOW and/or the neighbouring GWF. The construction programmes of East Anglia TWO OWF and East Anglia ONE North OWF also indicate that they will also be operational when North Falls is being constructed.

334. The construction programme of North Falls (2028-2030) will likely overlap with the construction programme of Five Estuaries OWF (2028-2030).

335. The NeuConnect Interconnector cable bisects the North Falls offshore cable corridor and there is potential for temporal overlap of cable installation activities. It is unlikely however, for health and safety and navigational safety reasons, that cable installation works for North Falls and the NeuConnect interconnector would occur in the same place at the same time.

336. There may also be temporal overlap from marine aggregate extraction sites in adjacent areas. It is noted however that only approximately 6% of the total licensed aggregate extraction areas in the Thames estuary region were dredged at any one time in 2021 (Crown Estate, 2021).

337. As assessed for North Falls, activities from other OWFs, interconnector cable installation and aggregate extraction sites would occur at localised, discrete locations (i.e. limited to the immediate vicinity of works) and would be temporary and short term. As such, the magnitude of the impact of cumulative physical disturbance/temporary habitat loss is considered to be low.

338. The sensitivity of the fish and shellfish receptors will be as detailed in Section 11.6.1.1. Fish and shellfish species in general are considered to be low sensitivity. In the case of species which depend on specific substrates and species or life stages of reduced mobility the sensitivity is considered to be medium to high.

339. Potential cumulative effects from physical disturbance and temporary habitat loss is therefore assessed to be of **minor significance, which is not significant in EIA terms.**

11.7.3.2 Cumulative impact 2: Increased SSCs and sediment re-deposition during construction

340. There may be potential for increased SSCs and sediment re-deposition associated with other projects to cumulatively add to the impact identified for North Falls, provided construction/works schedules coincide. The North Falls construction programme may overlap with maintenance works at the operational GGOW and GWF, the construction programmes of the NeuConnect

Interconnector and Five Estuaries OWF, and aggregate extraction activities (Table 11.51).

341. As detailed for cumulative effect 1 (paragraph 335), while there is potential for temporal overlap it is unlikely that offshore export cable installation works for North Falls and the NeuConnect interconnector would occur in the same place at the same time. It is also considered that plumes from adjacent wind farms (e.g. Five Estuaries OWF) would be unlikely to overlap due to the short-term and highly localised nature of plumes arising from construction works. As discussed in ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10), overall changes from increased suspended sediments and deposition of fine sands and mud-sized sediment will not be measurable due to prevailing hydrodynamic conditions with high wave activity agitating the seabed regularly.

342. To assess the potential for cumulative effects from North Falls and marine aggregate extraction activities in adjacent areas, ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) references the GWF EIA and supporting technical appendix by ABPmer (2011). The CEA for GWF determined that based on previous modelling investigations undertaken for dredging areas, no cumulative impact was predicted.

343. Taking the above into consideration the cumulative impact is assessed to be of negligible magnitude.

344. The sensitivity of fish and shellfish receptors is as detailed in Section 11.6.1.2.2 for construction for the Project alone. In general, fish and shellfish are considered receptors of low sensitivity. Of the receptors that were assessed separately, herring, sandeels, and sedentary/sessile filter feeders (oysters and cockles) are considered receptors of medium sensitivity.

345. The cumulative effect of increased SSCs and sediment re-deposition is therefore predicted to be of **negligible to minor significance** during construction, which is **not significant in EIA terms**.

11.7.3.3 Cumulative impact 3: Underwater noise from piling for foundation installation during construction

346. There is potential for noise generated during piling activity in the North Falls array area and other wind farm projects to result in cumulative impacts on fish species. This would be a result of either increased spatial or temporal effects resulting from concurrent or sequential piling at different OWFs, or a combination of both. The construction programme of North Falls (2028-2030) is likely to overlap with the construction programme of Five Estuaries OWF (2028-2030).

347. Active piling will only occur over a small percentage of the overall construction period of OWF projects and it is unlikely that piling will occur concurrently at multiple OWF projects, therefore the potential for the Project to significantly contribute to a cumulative impact would be limited. Whilst the increased spatial (if construction occurs concurrently) or temporal (if construction occurs sequentially) effects associated with piling at Five Estuaries OWF in addition to North Falls, is recognised, taking account of the intermittent and short term nature of piling, the relative small areas affected at a given time in the context of the wide distribution range of fish and shellfish species (including for

spawning and as nursery areas) in general terms, and the piling restrictions outlined in Table 11.3, the magnitude of the potential impact is considered to be negligible.

348. The sensitivity of fish and shellfish species is as previously identified for assessment of underwater noise impacts in respect of the Project alone (Table 11.36).

349. In view of the above, the cumulative effect of construction noise from piling on fish species is considered to be of **minor significance** (Table 11.53).

Table 11.53: Summary of assessment outcomes by receptor

Receptor	Magnitude of impact	Sensitivity to noise	Significance of effect
Dover sole, plaice, lemon sole and mackerel	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Sandeels	Low	Medium	**Minor (which is not significant in EIA terms)**
Bass	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Cod and sprat	Negligible	Medium	**Minor (which is not significant in EIA terms)**
Downs herring	Negligible	High	**Minor (which is not significant in EIA terms)**
Blackwater herring	Negligible	High	**Minor (which is not significant in EIA terms)**
Elasmobranchs	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Diadromous species (Salmon and sea trout)	Negligible	Low	**Negligible (which is not significant in EIA terms)**
Diadromous species (Allis and Twaite shad and European eel)	Negligible	Medium	**Minor (which is not significant in EIA terms)**

11.7.3.4 Cumulative impact 4: Underwater noise from other construction activities during construction

350. In addition to piling noise, there may be other activities associated with construction works at other projects that could result in potential disturbance to fish and shellfish receptors (i.e. vessel transit, cable installation, rock placement, dredging). The indicative construction programme of North Falls (2028-2030) may overlap with the construction programme of Five Estuaries OWF (2028-2030), and the NeuConnect Interconnector bisects the North Falls offshore cable corridor and there is potential for temporal overlap of cable installation activities for the NeuConnect Interconnector.

351. As described in Section 11.6.1.5 for the Project alone, potential impacts on fish and shellfish associated with this would occur over very small areas (i.e. in the immediate proximity of construction works/ construction vessels).

352. Whilst the potential for additive disturbance to occur as a result of construction activities in other OWFs, either temporally (where construction is sequential) or spatially (where construction occurs concurrently) is recognised, given the small

and localised areas affected, in the context of wide distribution ranges of all fish and shellfish species of relevance in the study area (including areas used for spawning and as nursery grounds) the magnitude of the cumulative impact is considered to be negligible.

353. The sensitivity of fish and shellfish species is as previously identified for assessment of underwater noise impacts in respect of the Project alone (Table 11.36).

354. The cumulative effects associated with construction noise other than piling are therefore considered to be of negligible to minor significance on fish and shellfish species.

11.7.3.5 Cumulative impact 5: Underwater noise from UXO clearance during construction

355. As described for assessment of noise from UXO removal for the Project alone (Section 11.6.1.6.2), the detonation of UXO associated with other offshore wind farm developments, would also result in injury and disturbance to fish species in the vicinity of the detonation. Physical injury / trauma would occur in close proximity to the detonation with TTS and behavioural effects occurring at greater distances.

356. Whilst it is recognised that the number of UXO detonations required will increase considering the other projects included for cumulative assessment, UXO clearance will still be an activity that is localised, short term and intermittent in nature (only occurring where UXO cannot be removed by other means). Given the wide distribution ranges of fish and shellfish species (including areas used for spawning and as nursery grounds), the impact is considered to be of negligible magnitude.

357. The sensitivity of fish and shellfish receptors with regards to underwater noise is as previously presented in Section 11.6.1.4.5.

358. Cumulative noise from UXO detonation is therefore considered to result in an effect of negligible to minor significance on fish and shellfish species.

11.7.3.6 Cumulative impact 6: Temporary habitat loss/ physical disturbance during operation

359. There is the potential for cumulative physical disturbance and temporary habitat loss as a result of maintenance activities associated with North Falls and activities at other offshore wind farm projects, aggregate extraction sites and interconnector cables. Temporary physical disturbance to the seabed will result in an increase in suspended sediments and temporary habitat loss.

360. There is potential for maintenance works to be conducted at the same time, or similar time, to maintenance works at the adjacent operational wind farms (GGOW, GWF) and potentially East Anglia TWO OWF, East Anglia ONE North OWF and Five Estuaries OWF based on their construction programmes.

361. The NeuConnect Interconnector bisects the North Falls offshore cable corridor and there is potential for temporal overlap of cable maintenance activities. It is unlikely however, for health and safety and navigational safety reasons, that maintenance works for North Falls and the NeuConnect interconnector would occur simultaneously.

362. There may be temporal overlap from marine aggregate extraction sites in adjacent areas. It is noted however that only approximately 6% of the total licensed aggregate extraction areas in the Thames estuary region were dredged at any one time in 2021 (Crown Estate 2021).

363. As assessed for North Falls, activities from other OWFs, interconnector cable installation and aggregate extraction sites would occur at localised, discrete locations (i.e. limited to the immediate vicinity of works) and would be temporary and short term. Given that the cumulative impact during operation would be less than that for construction the magnitude of the impact of physical disturbance/temporary habitat loss to fish and shellfish receptors in general is assessed as negligible.

364. Of note is that ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12) describes the sediment and benthic community around the offshore project area as characteristic of highly disturbed environments that are expected to quickly recover from disturbance.

365. The sensitivity of fish and shellfish species to habitat loss is described in detail in Section 11.6.1.1.2, with regards to the construction phase. These are as follows:

- Low for fish in general;
- Medium for shellfish in general and for thornback ray; and
- High for herring, sandeels and cockles and oysters.

366. Potential cumulative effects from physical disturbance and temporary habitat loss during operation is therefore assessed to be of **negligible to minor significance depending on the receptor, which is not significant in EIA terms.**

11.7.3.7 Cumulative impact 7: Long term habitat loss during operation

367. The associated loss of habitat through the introduction of infrastructure associated with North Falls together with that associated with other projects could result in cumulative impacts on fish and shellfish species in terms of loss of seabed habitat.

368. It should be noted, however, that the loss of seabed habitat would be widely dispersed between projects, and localised to discrete areas within projects (e.g. where cable protection was required and around foundations). The cumulative assessment in ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12) determined that the cumulative habitat loss was of low magnitude in the context of the wider North Sea region.

369. Any permanent loss of habitat will be highly localised, occurring over small discrete areas where infrastructure is located, considering this in the context of the wide distribution ranges of fish and shellfish species and the limited overlap of the proposed works with key habitats for these species (no overlap in some cases) the cumulative magnitude of the impact is considered to be negligible for all fish and shellfish receptors.

370. The sensitivity of fish and shellfish species to long term habitat loss during operation is detailed in Section 11.6.2.2 for North Falls.

371. The cumulative effect of permanent loss of habitat during operation is therefore assessed to be of **negligible to minor significance, which is not significant in EIA terms.**

11.7.3.8 Cumulative impact 8: Increased SSCs and re-deposition during operation

372. There may be potential for increased SSCs and sediment re-deposition associated with other projects to cumulatively add to the impact identified for North Falls once operational. The North Falls maintenance works may overlap with maintenance works at the operational GGOW and GWF, the NeuConnect Interconnector, Five Estuaries OWF, and aggregate extraction activities.

373. The worst-case volumes of sediment released following operational activities are considerably less than in the construction phase (Section 11.7.3.2). Should maintenance activities occur simultaneously at adjacent OWFs, the short-term and highly localised nature of plumes mean that they are unlikely to overlap and contribute to a cumulative effect. Similarly for marine aggregate extraction activities no cumulative impact is predicted (ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)).

374. Taking the above into consideration, and that overall changes from increased suspended sediments and deposition of fine sands and mud-sized sediment will not be measurable as a result of the prevailing hydrodynamic conditions of the area the magnitude is assessed as negligible.

375. The sensitivity of fish and shellfish receptors is detailed in Section 11.6.1.2.2 and the cumulative effect of increased SSCs and sediment re-deposition is therefore considered to be of **negligible to minor significance during operation, which is not significant in EIA terms**.

11.7.3.9 Cumulative impact 9: Electromagnetic Fields (EMFs) during operation

376. EMFs associated with cables within the offshore project area, other OWF projects and the NeuConnect Interconnector cable could result in a cumulative impact on sensitive fish and shellfish species (particularly elasmobranchs).

377. As described in the assessment of EMFs for the Project alone, the areas affected by EMFs would be expected to be very small, being limited to the immediate vicinity of the offshore cables (i.e. within metres). It is anticipated therefore that only a relatively small proportion of the fish and shellfish habitats would be affected cumulatively in the context of the wider southern North Sea. The magnitude of the impact is therefore considered to be negligible.

378. A detailed assessment of the sensitivity of the fish and shellfish receptors is provided in Section 11.6.2.6. In general, the sensitivity of fish and shellfish receptors (excluding elasmobranchs) is low. Elasmobranchs are assessed as having medium sensitivity given their increased ability to detect EMFs compared to other species groups.

379. The cumulative effect is therefore assessed to be of **negligible to minor significance, which is not significant in EIA terms.**

11.7.3.10 Cumulative impact during decommissioning

380. As outlined for the Project alone (Section 11.7.6), it is anticipated that the types of effect on fish and shellfish receptors during the decommissioning phase in a

cumulative context would be comparable to those identified for the construction phase. The potential cumulative impacts identified for decommissioning include:

- Impact 10: Temporary habitat loss / physical disturbance;
- Impact 11: Underwater noise and vibration

381. The sensitivity of receptors during the decommissioning is therefore assumed to be the same as given for the construction phase. The magnitude of impact is considered to be no greater and, in all probability, less than considered for the construction. Therefore, it is anticipated that any cumulative decommissioning impacts would not be greater, and probably less than those assessed for the construction phase.

11.8 Transboundary impacts

382. Transboundary effects over fish and shellfish ecology have been scoped out of further assessment in accordance with the Scoping Opinion (Planning Inspectorate, 2021).

383. As informed in Section 11.4.5, the fish and shellfish impact assessment has taken account of the distribution of fish stocks and populations irrespective of national jurisdictions. Thus, a specific assessment of transboundary effects in relation to fish and shellfish ecology is unnecessary. The suitability of this approach has been confirmed by the MMO and PINS in their Scoping Opinion (see Table 11.1).

11.9 Interactions

384. Interactions exist between the fish and shellfish ecology topic and several other topics that have been considered within this ES. Table 11.54 provides a summary of the principal interactions, related chapters and signposts to where those issues have been addressed in this chapter.

Table 11.54 Fish and shellfish ecology interactions

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Construction			
Physical disturbance and temporary habitat loss	ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12)	Impacts as a result of physical disturbance and temporary habitat loss are assessed in Section 11.6.1.1.	The benthic environment provides habitat and prey species for fish and shellfish receptors. Impacts on benthic ecology can have subsequent impacts on fish and shellfish.
Suspended sediments and deposition	ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10)	Impacts as a result of suspended sediment and deposition are assessed in Section 11.6.1.2.	Changes in suspended sediment concentrations are assessed in ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10). Changes in suspended sediment concentrations and associated sediment deposition could have potential impacts on benthic habitats and species.

Topic and description	Related chapter	Where addressed in this chapter	Rationale
Re-mobilisation of contaminated sediments	ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)	Re-mobilisation of contaminated sediments during construction is assessed in Section 11.6.1.3.	ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) provides an assessment of the potential for contaminants to be present in the study area. Re-mobilisation of contaminated sediments and associated deposition could have potential impacts on benthic habitats and species.
Prey species	ES Chapter 12 Marine mammals (Document Reference: 3.1.14) ES Chapter 13 Offshore ornithology (Document Reference: 3.1.15)	This chapter informs Chapters 12 and 13.	Impacts on fish and shellfish ecology can have an impact on the prey resource for bird species and marine mammals.
Changes in fishing activity	ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16)	Changes in fishing activity are assessed in Section 11.6.1.7	ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16) provides an assessment of the effects on commercial fisheries. Changes in fishing activity has the potential to change fish and shellfish ecology.
Operation			
Physical disturbance, temporary habitat loss and long term habitat loss	ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12)	Impacts as a result of physical disturbance and temporary and long term habitat loss are assessed in Sections 11.6.2.1 and 11.6.2.2.	The benthic environment provides habitat and prey species for fish and shellfish receptors. Impacts on benthic ecology can have subsequent impacts on fish and shellfish
Suspended sediments and deposition	ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10)	Impacts as a result of suspended sediment and deposition are assessed in Section 11.6.2.3.	Changes in suspended sediment concentrations are assessed in ES Chapter 8 Marine Geology, Oceanography and Physical Processes (Document Reference: 3.1.10). Changes in suspended sediment concentrations and associated sediment deposition could have potential impacts on benthic habitats and species.
Re-mobilisation of contaminated sediments	ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11)	Re-mobilisation of contaminated sediments during construction is assessed in Section 11.6.2.4.	ES Chapter 9 Marine Water and Sediment Quality (Document Reference: 3.1.11) provides an assessment of the potential for contaminants to be present in the study area. Re-mobilisation of contaminated sediments and associated deposition could have potential impacts on benthic habitats and species.
Prey species	ES Chapter 12 Marine mammals (Document Reference: 3.1.14) ES Chapter 13 Offshore ornithology	This chapter informs Chapters 12 and 13.	Impacts on fish and shellfish ecology can have an impact on the prey resource for bird species and marine mammals.

Topic and description	Related chapter	Where addressed in this chapter	Rationale
	(Document Reference: 3.1.15)		
Changes in fishing activity	ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16)	Changes in fishing activity are assessed in Section 11.6.2.8	ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16) provides an assessment of the effects on commercial fisheries. Changes in fishing activity has the potential to change fish and shellfish ecology.
Decommissioning			
Interactions for impacts during the decommissioning phase will be the same as those outlined above for the construction phase.			

11.10 Inter-relationships

385. The impacts identified and assessed in this chapter have the potential to interrelate with each other. The areas of potential inter-relationships between impacts are presented in Table 11.55. This provides a screening tool for which impacts have the potential to interrelate. Table 11.56 provides an assessment for each receptor (or receptor group) as related to these impacts.

386. Within Table 11.56 the impacts are assessed relative to each development phase (Phase assessment, i.e. construction, operation or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the level of impact upon that receptor. Following this, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across all development phases.

387. None of the potential inter-relationships identified with respect to fish and shellfish ecology are expected to result in a synergistic or greater impact than those assessed in Section 11.6.

Table 11.55 Inter-relationships between impacts - screening [does impact 1 affect the same receptor as impact 2, impact 3 etc y/n]

Potential interaction between impacts							
Construction							
	Impact 1: Physical disturbance and temporary habitat loss	Impact 2: Increased SSCs and sediment re-deposition	Impact 3: Remobilisation of contaminated sediments	Impact 4: Underwater noise from piling for foundation installation	Impact 5: Underwater noise from other construction activities	Impact 6: Underwater noise from UXO clearance	Impact 7: Changes in fishing activity
Impact 1: Physical disturbance and temporary habitat loss		Yes	Yes	No	No	No	No
Impact 2: Increased SSCs and sediment re-deposition	Yes		Yes	No	No	No	No
Impact 3: Remobilisation of contaminated sediments	Yes	Yes		No	No	No	No
Impact 4: Underwater noise from piling for foundation installation	No	No	No		Yes	Yes	No
Impact 5: Underwater noise from other construction activities	No	No	No	Yes		Yes	No
Impact 6: Underwater noise from UXO clearance	No	No	No	Yes	Yes		No
Impact 7: Changes in fishing activity	No	No	No	No	No	No	

Potential interaction between impacts								
Operation								
	Impact 8: Temporary habitat loss/ physical disturbance	Impact 9: Long term habitat loss	Impact 10: Increased SSCs and re-deposition	Impact 11: Remobilisation of contamination sediments	Impact 12: Underwater noise and vibration	Impact 13: EMFs	Impact 14: Introduction of hard substrate	Impact 15: Changes in fishing activity
Impact 8: Temporary habitat loss/ physical disturbance		Yes	Yes	Yes	No	No	No	No
Impact 9: Long term habitat loss	Yes		No	No	No	No	Yes	No
Impact 10: Increased SSCs and re-deposition	Yes	No		Yes	No	No	No	No
Impact 11: Remobilisation of contamination sediments	Yes	No	Yes		No	No	No	No
Impact 12: Underwater noise and vibration	No	No	No	No		No	No	No
Impact 13: EMFs	No	No	No	No	No		No	No
Impact 14: Introduction of hard substrate	No	No	No	No	No	No		No
Impact 15: Changes in fishing activity	No	No	No	No	No	No	No	
Decommissioning								
It is anticipated that the decommissioning impacts will be similar in nature to those of construction								

Table 11.56 Inter-relationships between impacts – phase and lifetime assessment

Receptor	Highest residual significance level			Phase assessment	Lifetime assessment
	Construction	Operation	Decommissioning		
Fish and shellfish	Moderate Impact 4(ii): Underwater noise from piling for foundation installation (TTS and behavioural) for Downs Herring	Minor	Minor	No greater than individually assessed impacts **Construction** Underwater noise impacts will be greatest in spatial extent for piling and UXO clearance, but these will occur only during a short part of the construction phase and therefore there is limited potential for interaction with habitat disturbance from seabed preparation, installation of cables etc and associated effects (increased SSC and resuspension of contaminants). The effects resulting from habitat disturbance will be localised and episodic with limited potential for interaction. Any reduction in fishing effort would be beneficial to fish ecology although likely to be of low magnitude. It is therefore considered that these impacts would not interact to increase in the significance level overall. **Operation** Operational noise impacts from WTGs will be highly localised to within close proximity of each WTG, whilst the majority of disturbance to or loss of habitat for fish will also be confined to the immediate footprint of the Project infrastructure. This relates to largely the same spatial footprint. Therefore, there is no greater impact as a result of any interaction of these impacts. EMF effects and disturbance to or loss of habitat for fish will be localised to the cables and relates to largely the same spatial footprint. It is therefore considered that these impacts would not interact to increase in the significance level overall.	No greater than individually assessed impacts The greatest magnitude of impact will be the spatial footprint of construction noise (i.e. UXO clearance and piling) and the habitat disturbance from seabed preparation, installation of cables etc. Once this disturbance impact has ceased all further impact during construction and operation will be small scale, highly localised and episodic. There is no evidence of long term displacement of fish or shellfish from operational wind farms. It is therefore considered that over the Project lifetime these impacts would not combine and represent an increase in the significance level.

11.11 Potential monitoring requirements

302. No further monitoring is proposed in relation to fish and shellfish ecology. This is because the outcomes of the assessment have concluded that all of the potential impacts considered will result in either negligible or, at worse, minor adverse effects (i.e. no significant effects).

11.12 Summary

388. This chapter has provided a characterisation of the existing environment for fish and shellfish ecology. Information on fish and shellfish ecology within the commercial fisheries study area was collected through desktop review and consultation. These are summarised in Table 11.1 and Table 11.6. The baseline characterisation was used to inform the assessment of fish and shellfish assemblage present within the vicinity of the Project. Full details of the baseline characterisation can be found in ES Appendix 11.1 Fish and Shellfish Ecology Technical Report (Document Reference: 3.3.5).

389. Table 11.57 presents a summary of the potential impacts, mitigation measures and conclusion of likely significant effects in respect to fish and shellfish ecology in EIA terms. The impacts assessed include: Physical disturbance and temporary habitat loss, increased SSCs and sediment re-deposition, remobilisation of contaminated sediments, underwater noise from piling for foundation installation, underwater noise from other construction activities, underwater noise from UXO clearance and changes in fishing activity.

390. The assessment has determined that the majority of impacts on fish and shellfish ecology during the construction, operation and decommissioning phases of North Falls are considered either 'minor adverse' or 'negligible'.

391. The assessment also considered potential cumulative effects (Section 11.7), including: Physical disturbance and temporary habitat loss, increased SSCs and sediment re-deposition, underwater noise from piling for foundation installation, underwater noise from other construction activities, underwater noise from UXO clearance, and EMFs from subsea cabling. The assessment has determined that the majority of impacts were assessed as minor.

392. As fish and shellfish impact assessment has taken account of the distribution of fish stocks and populations irrespective of national jurisdictions Transboundary effects over fish and shellfish ecology have been scoped out of further assessment in accordance with the Scoping Opinion (Planning Inspectorate, 2021).

393. Effects on fish and shellfish ecology also have the potential to have secondary effects on other receptors and these effects are fully considered in the topic-specific chapters. These receptors are outlined in Table 11.54, and the topic-specific chapters below:

- ES Chapter 10 Benthic and Intertidal Ecology (Document Reference: 3.1.12);
- ES Chapter 14 Commercial Fisheries (Document Reference: 3.1.16);
- ES Chapter 12 Marine Mammals (Document Reference: 3.1.14), and

- ES Chapter 13 Offshore Ornithology (Document Reference: 3.1.15).

394. Inter-relationships between the potential impacts are outlined in Table 11.55, none of the potential inter-relationships identified with respect to fish and shellfish ecology are expected to result in a synergistic or greater impact than those assessed in Section 11.6.

395. No further monitoring is proposed in relation to fish and shellfish ecology.

Table 11.57 Summary of potential impacts on fish and shellfish receptors

Potential impact	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional mitigation	Residual impact
Construction						
Impact 1: Physical disturbance and temporary habitat loss	Fish in general	Low	Negligible	Negligible	N/A	Negligible
	Sandeels	High	Negligible	Minor	N/A	Minor
	Herring (Downs and Blackwater)	High	Negligible	Minor	N/A	Minor
	Thornback ray	Medium	Negligible	Minor	N/A	Minor
	Oysters / cockles	High	Negligible	Minor	N/A	Minor
	Shellfish in general	Medium	Negligible	Minor	N/A	Minor
Impact 2: Increased suspended sediment concentrations	Fish and shellfish in general	Low	Negligible	Negligible	N/A	Negligible
	Sandeels	Medium	Negligible	Minor	N/A	Minor
	Herring (Downs and Blackwater)	Medium	Negligible	Minor	N/A	Minor
	Other species with spawning grounds in the offshore project area	Low	Negligible	Negligible	N/A	Negligible
	Oysters / cockles	Medium	Negligible	Minor	N/A	Minor
	Shellfish in general	Low	Negligible	Negligible	N/A	Negligible
Impact 3: Remobilisation of contaminated sediments	Fish and shellfish in general	Negligible	Negligible	Negligible	N/A	Negligible
	Fish with no swim bladder	Low (General)	Negligible	Negligible	N/A	Negligible
		Medium (sandeels)		Minor	N/A	Minor

Potential impact	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional mitigation	Residual impact
Impact 4(i): Underwater noise from piling for foundation installation (mortality/recoverable injury)	Fish with swim bladder not involved in hearing	Low (General)	Negligible	Negligible	N/A	Negligible
		Medium (Gobies)		Minor	N/A	Minor
	Fish with swim bladder involved in hearing	Medium (General)	Negligible	Minor	N/A	Minor
		High (Herring)		Minor	N/A	Minor
	Eggs and larvae	High	Negligible	Minor	N/A	Minor
	Shellfish	Medium	Negligible	Minor	N/A	Minor
Impact 4(ii): Underwater noise from piling for foundation installation (TTS and behavioural) *outcomes of the assessment apply to both a fleeing animal or stationary animal modelling scenario.	Dover sole, plaice, lemon sole and mackerel	Low	Negligible	Negligible	N/A	Negligible
	Sandeels	Medium	Low	Minor	N/A	Minor
	Bass	Low	Negligible	Negligible	N/A	Negligible
	Cod and sprat	Medium	Negligible	Negligible	N/A	Minor
	Herring (Downs)	High	Negligible	Minor	N/A	Minor
	Herring (Blackwater)	High	Negligible	Minor	N/A	Minor
	Elasmobranchs	Low	Negligible	Negligible	N/A	Negligible
	Diadromous species	Low	Negligible	Negligible	N/A	Negligible
Impact 5: Underwater noise from other construction activities	Fish with no swim bladder or other gas chamber	Low (General) Medium (Sandeels)	Negligible	Negligible	N/A	Negligible
	Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume	Low (General) Medium (Gobies)	Negligible	Negligible (General) Minor (Gobies)	N/A	Negligible (General) Minor (Gobies)

Potential impact	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional mitigation	Residual impact
	Fish in which hearing involved a swim bladder or other gas volume	Medium (General) High (Herring)	Negligible	Minor (General) Minor (Herring)	N/A	Minor (General) Minor (Herring)
	Eggs and larvae	High	Negligible	Minor	N/A	Minor
	Shellfish	Medium	Negligible	Minor	N/A	Minor
Impact 6: Underwater noise from UXO clearance	Fish with no swim bladder or other gas chamber	Low (General) Medium (Sandeels)	Negligible	Negligible	N/A	Negligible
	Fish with swim bladder in which hearing does not involve the swim bladder or other gas volume	Low (General) Medium (Gobies)	Negligible	Negligible (General) Minor (Gobies)	N/A	Negligible (General) Minor (Gobies)
	Fish in which hearing involved a swim bladder or other gas volume	Medium (General) High (Herring)	Negligible	Minor (General) Minor (Herring)	N/A	Minor (General) Minor (Herring)
	Eggs and larvae	High	Negligible	Minor	N/A	Minor
	Shellfish	Medium	Negligible	Minor	N/A	Minor
Impact 7: Changes in fishing activity	Fish and shellfish in general	Low	Negligible	Negligible	N/A	Negligible
Operation						
Impact 8: Temporary habitat loss/ physical disturbance	Fish and shellfish in general	Low	Negligible	Negligible	N/A	Negligible
	Herring (Downs and Blackwater)	High	Negligible	Minor	N/A	Minor
	Sandeels	High	Negligible	Minor	N/A	Minor
	Oysters / cockles	High	Negligible	Minor	N/A	Minor

Potential impact	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional mitigation	Residual impact
	Shellfish	Medium	Negligible	Minor	N/A	Minor
	Thornback ray	Medium	Negligible	Minor	N/A	Minor
Impact 9: Long term habitat loss	Fish in general	Low	Negligible	Negligible	N/A	Negligible
	Herring, sandeel, cockles and oysters	High	Negligible	Minor	N/A	Minor
	Shellfish	Medium	Negligible	Minor	N/A	Minor
Impact 10: Increased suspended sediment concentrations and re-deposition	Fish in general	Low	Negligible	Negligible	N/A	Negligible
	Downs herring	Medium	Negligible	Minor	N/A	Minor
	Sandeels	Medium	Negligible	Minor	N/A	Minor
	Oysters / cockles	Medium	Negligible	Minor	N/A	Minor
Impact 11: Re-mobilisation of contaminated sediments	Fish and shellfish in general	Negligible	Negligible	Negligible	N/A	Negligible
Impact 12: Underwater noise and vibration	Fish and shellfish in general	Low	Low	Negligible	N/A	Negligible
Impact 13: Electromagnetic Fields (EMFs)	Fish species in general	Low	Negligible	Negligible	N/A	Negligible
	Elasmobranchs	Medium	Low	Minor	N/A	Minor
	Lamprey	Medium	Negligible	Negligible	N/A	Negligible
	European eel	Low	Negligible	Negligible	N/A	Negligible
	Salmon and sea trout	Low	Negligible	Negligible	N/A	Negligible
	Shellfish	Low	Negligible (General) Low (Crab and Lobster)	Negligible	N/A	Negligible

Potential impact	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional mitigation	Residual impact
Impact 14: Introduction of hard substrate	Fish and shellfish in general	Low	Negligible	Negligible	N/A	Negligible
Impact 15: Changes in fishing activity	Fish and shellfish in general	Low	Low	Negligible	N/A	Negligible
Decommissioning						
Impact 16: Temporary habitat loss/ physical disturbance	Fish and shellfish in general	Low to High	Negligible	Negligible to Minor	N/A	Negligible to Minor
Impact 17: Remobilisation of contaminated sediments	Fish and shellfish in general	Negligible	Negligible	Negligible	N/A	Negligible
Impact 18: Underwater noise and vibration	Fish and shellfish in general	Low to High	Negligible to Low	Negligible to Minor	N/A	Negligible to Minor
Impact 19: Changes in fishing activity	Fish and shellfish in general	Low	Low	Negligible	N/A	Negligible
Cumulative Effects						
Cumulative impact 1: Physical disturbance and temporary habitat loss during construction	Fish in general	Low	Negligible	Negligible	N/A	Negligible
	Sandeels	High	Negligible	Minor	N/A	Minor
	Herring (Downs and Blackwater)	High	Negligible	Minor	N/A	Minor
	Thornback ray	Medium	Negligible	Minor	N/A	Minor
	Oysters / cockles	High	Negligible	Minor	N/A	Minor
	Shellfish in general	Medium	Negligible	Minor	N/A	Minor
Cumulative impact 2: Increased SSCs and sediment	Fish and shellfish in general	Low	Negligible	Negligible	N/A	Negligible
	Sandeels	Medium	Negligible	Minor	N/A	Minor

Potential impact	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional mitigation	Residual impact
re-deposition during construction	Herring (Downs and Blackwater)	Medium	Negligible	Minor	N/A	Minor
	Other species with spawning grounds in the offshore project area	Low	Negligible	Negligible	N/A	Negligible
	Oysters / cockles	Medium	Negligible	Minor	N/A	Minor
	Shellfish in general	Low	Negligible	Negligible	N/A	Negligible
Cumulative impact 3: Underwater noise from piling for foundation installation during construction	Dover sole, plaice, lemon sole and mackerel	Low	Negligible	Negligible	N/A	Negligible
	Sandeels	Medium	Low	Minor	N/A	Minor
	Bass	Low	Negligible	Negligible	N/A	Negligible
	Cod and sprat	Medium	Negligible	Minor	N/A	Minor
	Downs herring	High	Negligible	Minor	N/A	Minor
	Blackwater herring	High	Negligible	Minor	N/A	Minor
	Elasmobranchs	Low	Negligible	Negligible	N/A	Negligible
	Diadromous species (Salmon and sea trout)	Low	Negligible	Negligible	N/A	Negligible
	Diadromous species (Allis and Twaite shad and European eel)	Medium	Negligible	Minor	N/A	Minor
Cumulative impact 4: Underwater noise from other construction activities during construction	As previously identified Cumulative impact 3	As previously identified Cumulative impact 3	Negligible	Negligible to Minor	N/A	Negligible to Minor

Potential impact	Receptor	Sensitivity	Magnitude	Significance of Effect	Additional mitigation	Residual impact
Cumulative impact 5: Underwater noise from UXO clearance during construction	As previously identified Cumulative impact 3	As previously identified Cumulative impact 3	Negligible	Negligible to Minor	N/A	Negligible to Minor
Cumulative impact 6: Temporary habitat loss/ physical disturbance during operation	As previously identified Cumulative impact 1	As previously identified Cumulative impact 1	Negligible	Negligible to Minor	N/A	Negligible to Minor
Cumulative impact 7: Long term habitat loss during operation	As previously identified Cumulative impact 1	As previously identified Cumulative impact 1	Negligible	Negligible to Minor	N/A	Negligible to Minor
Cumulative impact 8: Increased SSCs and re-deposition during operation	As previously identified Cumulative impact 2	As previously identified Cumulative impact 2	Negligible	Negligible to Minor	N/A	Negligible to Minor
Cumulative impact 9: Electromagnetic Fields (EMFs) during operation	Fish species in general	Low	Negligible	Negligible	N/A	Negligible
	Elasmobranchs	Medium	Negligible	Minor	N/A	Minor
	Lamprey	Medium	Negligible	Minor	N/A	Minor
	European eel	Low	Negligible	Negligible	N/A	Negligible
	Salmon and sea trout	Low	Negligible	Negligible	N/A	Negligible
	Shellfish	Low	Negligible	Negligible	N/A	Negligible
Cumulative impact 10: Temporary habitat loss / physical disturbance during decommissioning	As previously identified Cumulative impact 1	As previously identified Cumulative impact 1	Negligible	Negligible to Minor	N/A	Negligible to Minor
Cumulative impact 11: Underwater noise and vibration during decommissioning	As previously identified Cumulative impact 3	As previously identified Cumulative impact 3	Negligible	Negligible to Minor	N/A	Negligible to Minor

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