The Great Grid Upgrade

Sea Link

Sea Link

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Fish and Shellfish

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3.1 Introduction

3.1.1 This chapter of the Environmental Statement (ES) presents information about the environmental assessment of the likely significant fish and shellfish effects that could result from the Proposed Project (as described in **Application Document 6.2.1.4 Part 1 Introduction Chapter 4 Description of the Proposed Project**.

3.1.2 This chapter describes the methodology used, the datasets that have informed the environmental assessment, baseline conditions, mitigation measures and fish and shellfish residual significant effects that could result from the Proposed Project.

3.1.3 The Order Limits, which illustrate the boundary of the Proposed Project, are illustrated on **Application Document 2.2.1 Overall Location Plan**. This chapter should be read in conjunction with:

- **Application Document 6.2.1.4 Part 1 Introduction Chapter 4 Description of the Proposed Project**;
- **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**;
- **Application Document 6.2.1.6 Part 1 Introduction Chapter 6 Scoping Opinion and EIA Consultation**;
- **Application Document 6.2.4.1 Part 4 Marine Chapter 1 Physical Environment**;
- **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology**;
- **Application Document 6.3.4.2.A Appendix 4.2.A Benthic Characterisation Report (Original Report)**;
- **Application Document 6.3.4.2.B Appendix 4.2.B Geophysical Survey Interpretation (Additional Surveys)**;
- **Application Document 6.3.4.2.D Appendix 4.2.D Interim Subtidal Survey Report (Additional Surveys);**
- **Application Document 6.2.4.4 Part 4 Marine Chapter 4 Marine Mammals**;
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- **Application Document 6.2.4.7.B Appendix 4.7.B Electromagnetic Deviation Study**;
- **Application Document 6.6 Habitats Regulations Assessment Report**;
- **Application Document 6.11 Marine Conservation Zone Assessment**;
- **Application Document 7.5.2 Offshore Construction Environmental Management Plan**;

- **Application Document 7.5.3.1 CEMP Appendix A Outline Code of Construction Practice;** and
- **Application Document 7.5.3.2 CEMP Appendix B Register of Environmental Actions and Commitments (REAC)**.

3.1.4 This chapter is supported by the following figures:

- **Application Document 6.4.4.3 Fish and Shellfish.**

3.1.5 This chapter is supported by the following appendices:

- **Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment.**

3.2 Regulatory and Planning Context

3.2.1 This section sets out the legislation and planning policy that is relevant to the fish and shellfish assessment. A full review of compliance with relevant national and local planning policy is provided within the Planning Statement submitted as part of the application for Development Consent.

3.2.2 Policy generally seeks to minimise fish and shellfish effects from development and to avoid significant adverse effects. This applies particularly to designated sites, including in this case several Marine Conservation Zones (MCZ) for which fish and shellfish are qualifying features, but also to other suitable fish and shellfish habitat outside of designated areas where there is an aspiration in policy terms to conserve and enhance such habitats, particularly those for which features are of high value or particularly sensitive.

Legislation

Marine and Coastal Access Act 2009

3.2.3 Marine and Coastal Access Act (2009) provides the legal mechanism to help ensure clean, healthy, safe, and productive and biologically diverse oceans and seas.

The Conservation of Habitats and Species Regulations 2017 (amended 2019)

3.2.4 The Conservation of Habitats and Species Regulations (2017) (amended 2019[1]) transposes the Habitats Directive (92/43/EEC) and implements provisions from the Birds Directive (2009/147/EC) into UK legislation out to the 12 nautical mile (NM) limit.

The Conservation of Offshore Marine Habitats and Species Regulations 2017

3.2.5 The Conservation of Offshore Marine Habitats and Species Regulations (2017) applies within the UK Offshore Marine Area (beyond the 12 NM limit).

[1] Amended in response to the UK's exit from the European Union (EU), making the Habitats (92/43/EEC) and Wild Birds (2009/147/EC) Directives, operable from 1 January 2021, and creating a UK natural site network in place of the EU Natura 2000 ecological network.

The Wildlife and Countryside Act 1981

3.2.6 The Wildlife and Countryside Act (1981) (as amended) includes provisions relating to nature conservation.

The Marine Strategy Regulations 2010

3.2.7 The Marine Strategy Regulations (2010) originally implemented the Marine Strategy Framework Directive (2008) and at the end of the Brexit transition period, the Marine Strategy Framework Regulations 2010 became retained EU law.

The Water Environment (Water Framework Directive (England and Wales)) Regulations 2017

3.2.8 The Water Environment (Water Framework Directive (England and Wales)) Regulations (2017) transposes the EU Water Framework Directive (2000/60/EC) into UK legislation as retained law from the European Union.

Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006

3.2.9 Section 41 of the NERC Act (2006) imposes a requirement on the Secretary of State to publish a list species of principal importance for the purpose of conservation of biodiversity.

The Eels (England and Wales) Regulations 2009

3.2.10 The Eels (England and Wales) Regulations (2009) implement Council Regulation (EC) No 1100/2007 (EC) No 1100/2007 establishing measures for the recovery of the stock of European eel (*Anguilla anguilla)* including providing for the free passage of eels. This is now part of the body of retained EU law.

The Salmon and Freshwater Fisheries Act 1975

3.2.11 The Salmon and Freshwater Fisheries Act (1975), which relates to consolidate the Salmon and Freshwater Fisheries Act 1923 and certain other enactments relating to salmon and freshwater fisheries, and to repeal certain obsolete enactments relating to such fisheries.

Environment Act 2021

3.2.12 The Environment Act 2021[2] sets clear statutory targets for the recovery of the natural world in four priority areas: air quality, biodiversity, water and waste, and includes the introduction of Biodiversity Net Gain (BNG).

The Infrastructure Planning (EIA) Regulations 2017

3.2.13 The Infrastructure Planning (EIA) Regulations (2017) sets out requirements relating to environmental impact assessments for nationally significant infrastructure projects.

Convention for the Protection of the Marine Environment of the North-East Atlantic (the ‘OSPAR Convention')

[2] The Act has been enshrined into law; however, it is not anticipated to come into full effect until the end of 2023 (2025 for NSIPs).

3.2.14 The OSPAR Convention, which was adopted in 1998 and amended in (Convention for the Protection of the Marine Environment of the North-East Atlantic (the ‘OSPAR Convention'), 2007)and consists of fifteen governments, to provide the protection of marine biodiversity and ecosystems from polluting and non-polluting human activities.

Conservation of European Wildlife and Natural Habitats Convention (Bern convention) 1979

3.2.15 Conservation of European Wildlife and Natural Habitats Convention (Bern convention) (1979), which was put in place as the first international treaty to provide protection for both species and habitats, and to bring countries together in decision making on nature conservation.

National Policy

National Policy Statements

3.2.16 National Policy Statements (NPS) set out the primary policy tests against which the application for a Development Consent Order (DCO) for the Proposed Project would be considered. Table 3.1, Table 3.2 and Table 3.3 below provides details of the elements of NPS for Energy (EN-1) (Department of Energy and Climate Change, 2023) NPS for Renewable Energy Infrastructure (EN-3) (Department of Energy and Climate Change, 2023) and NPS for Electricity Networks Infrastructure (EN-5) (Department of Energy and Climate Change, 2023) that are relevant to this chapter.

Table 3.1 NPS EN-1 requirements relevant to fish and shellfish

NPS EN-1 section	Where this is covered in the ES
4.5.7…“*Applicants are encouraged to approach the marine licensing regulator (Marine Management Organisation (MMO) in England and Natural Resources Wales in Wales) in pre-application, to ensure that they are aware of any needs for additional marine licenses alongside their Development Consent Order application*”.	Consultation with Marine Management Organisation (MMO), Cefas, Natural England, and the Environment Agency (EA) was undertaken during the scoping stage and Preliminary Environmental Information Report (PEIR) stage. Relevant comments are provided in **Application Document 6.2.1.6 Part 1 Introduction Chapter 6 Scoping Opinion and EIA Consultation**. Key actions arising from the consultation is also listed in section 3.3.
4.5.8…“*Applicants for a Development Consent Order must take account of any relevant Marine Plans and are expected to complete a Marine Plan assessment as part of their project development, using this information to support an application for development consent*”.	Relevant Marine Plans have been considered in section 3.2 and Table 3.5.
4.5.9…“*Applicants are encouraged to refer to Marine Plans at an early stage, such as in pre-application, to inform project planning, for example*	Relevant Marine Plans have been considered in section 3.2 and Table 3.5.

NPS EN-1 section	Where this is covered in the ES
to avoid less favourable locations as a result of other uses or environmental constraints".	
5.4.17…*"Where the development is subject to EIA, the applicant should ensure that the ES clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats".*	Details of designated sites and protected species are discussed in section 3.7. A full assessment of the impacts of the Proposed Project on these species is provided in section 3.9. A Habitat Regulations Assessment (HRA) Screening Report and a HRA Report to Inform Appropriate Assessment (RIAA) have also been conducted to assess the likely significant effects (LSEs) of the Proposed Project on European designated sites and Ramsar sites. These are provided in **Application Document 6.6 Habitats Regulations Assessment Report**.
5.4.18…*"The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Secretary of State consider thoroughly the potential effects of a proposed project".*	Consultation with Natural England was undertaken during the scoping stage and PEIR stage. Relevant comments are provided in **Application Document 6.2.1.6 Part 1 Introduction Chapter 6 Scoping Opinion and EIA Consultation**.
5.4.19…*"The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests".*	Embedded mitigation and best practice measures to conserve and enhance biodiversity are provided in section 3.8, such as the micro-siting of the export cables and only using rock placement where necessary. No additional mitigation measures have been proposed in relation to fish and shellfish ecology. However, in the Marine ornithology chapter (see **Application Document 6.2.4.5 Part 4 Marine Chapter 5 Marine Ornithology**) a seasonal restriction in the Outer Thames Estuary SPA has been proposed (1st November – 31st March). This restriction is relevant to all offshore cable installation activities, excluding the pre-lay grapnel run (PLGR). This is considered relevant to the fish and shellfish impact assessment.
5.4.35…"*Applicants should include appropriate avoidance, mitigation, compensation and*	The Proposed Project follows the mitigation hierarchy (see **Application**

NPS EN-1 section	Where this is covered in the ES
enhancement measures as an integral part of the proposed development".	**Document 6.1.2.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**) and will adopt a range of measures to conserve biodiversity as detailed in section 3.8.
5.4.22 (part)..." The design of Energy NSIP proposals will need to consider the movement of mobile /migratory species such as birds, fish and marine and terrestrial mammals and their potential to interact with infrastructure. As energy infrastructure could occur anywhere within England and Wales, both inland and onshore and offshore, the potential to affect mobile and migratory species across the UK and more widely across Europe (transboundary effects) requires consideration, depending on the location of development.	Mobile and migratory fish, including those that are features of conservation importance including designated sites and protected species have been considered in both the initial baseline (section 3.6.1) assessment of impacts and likely effects (section 3.9), as well as in **Application Document 6.6 Habitat Regulations Assessment Report**.
5.4.23 "…Energy projects will need to ensure vessels used by the project follow existing regulations and guidelines to manage ballast water".	The Proposed Project design which includes embedded measures, control and management measures is presented in section 3.8 and additional mitigation and enhancement measures required for fish and shellfish (if required) are present in section 3.10.

Table 3.2 NPS EN-3 requirements relevant to fish and shellfish

NPS EN-3 section	Where this is covered in the ES
2.8.98 'Applicants should have regard to the specific ecological and biodiversity considerations that relate to proposed offshore renewable energy infrastructure developments, namely: • *fish…'*	All potential impacts to fish and shellfish resulting from the Proposed Project are assessed in section 3.9.
2.8.101*…"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"*	An assessment of impacts to fish from all phases of the Proposed Project is provided in section 3.9.
2.8.104…"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	Consultation with statutory consultees was undertaken during the scoping and PEIR stage. Comments are provided in **Application Document 6.2.1.6**

NPS EN-3 section	Where this is covered in the ES
avoidance, mitigation and compensation options which should be undertaken".	**Part 1 Introduction Chapter 6 Scoping Opinion and EIA Consultation**.
2.8.119…"Applicant assessment of the effects of installing offshore transmission infrastructure across the intertidal/coastal zone should demonstrate compliance with mitigation measures in any relevant plan-level HRA including those prepared by The Crown Estate as part of its leasing round, and include information, where relevant, about: • any alternative landfall sites that have been considered by the applicant during the design phase and an explanation for the final choice; • any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation for the final choice; • potential loss of habitat; • disturbance during cable installation, maintenance/repairs and removal (decommissioning); • increased suspended sediment loads in the intertidal zone during installation and maintenance/repairs; • potential risk from invasive and non-native species; • predicted rates at which the intertidal zone might recover from temporary effects, based on existing monitoring data; and • protected sites".	The effects of the Proposed Development have been assessed in detail in section 3.9. Options considered for landfall sites and cable installation methods are described in **Application Document 6.2.1.4 Part 1 Introduction Chapter 4 Description of the Proposed Project**.
2.8.126…Applicant assessment of the effects on the subtidal environment should include: • loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes, e.g. sandwave/boulder/UXO clearance; • environmental appraisal of inter-array and other offshore transmission and installation/maintenance methods, including predicted loss of habitat due to predicted scour and scour/cable protection and sandwave/boulder/UXO clearance; • habitat disturbance from construction and maintenance/repair vessels' extendable legs and anchors;• increased suspended sediment loads during construction and from maintenance/repairs; • predicted rates at which the subtidal zone might recover from temporary effects; • potential impacts from EMF on benthic fauna; • potential impacts upon natural ecosystem functioning; • protected sites; and • potential for invasive/non-native species introduction".	All potential impacts including disturbance to fish and shellfish from EMF and thermal emissions, loss and disturbance of fish and shellfish habitat from construction works and placement of hard structures, and underwater sound disturbance to fish and shellfish from survey works, resulting from the Proposed Project are assessed in section 3.9. Assessments of underwater sound impacts from unexploded ordinance (UXO) clearance will be addressed in a separate marine licence application once the number and nature of UXO present in the Offshore Scheme is known.
3.8.129 "Fish in the context of this NPS also includes elasmobranchs (sharks and rays) and shellfish (e.g., crabs)."	Both elasmobranchs and shellfish have been considered in this assessment, see section 3.7 for baseline conditions for these receptors.

NPS EN-3 section	Where this is covered in the ES
3.8.130 "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."	All potential impacts to fish and shellfish resulting from the Proposed Project are assessed in section 3.9. This assessment considers migration routes, spawning areas and nursery grounds of relevant species which are included in section 3.7.
2.8.134…*"Where the assessment identifies that noise from construction and UXO clearance may reach noise levels likely to lead to noise thresholds being exceeded (as detailed in the JNCC guidance) or an offence as described in paragraph 2.8.127-129 above, the applicant will be expected to look at possible alternatives or appropriate mitigation".*	The impacts resulting from underwater noise and have been assessed in section 3.9. A separate marine licence application will be made for any UXO detonation in line with MMO advice to allow for appropriate consideration of potential UXO impacts once sufficient information is available to identify any potential UXO risk.
2.8.150… *"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;* • *migration routes; and* • *protected sites."*	Fish and shellfish species that are the most likely receptors of impacts, including those highlighted have been identified in section 3.7.
2.8.151…"*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 both sound pressure and particle motion) and EMF on sensitive fish species."*	The impacts resulting from underwater noise and electromagnetic field (EMF) emissions have been assessed in section 3.9. Prior to construction there will be a full geophysical survey to determine the presence of UXO and the need for any explosive objects to be cleared. An application for a separate Marine Licence in respect of UXO clearance will be made post submission, when the exact number and type of detonations have been established. An impact assessment of the effect of UXO detonation will be

NPS EN-3 section	Where this is covered in the ES
	undertaken when this information is available for the Marine Licence application.

Table 3.3 NPS EN-5 requirements relevant to fish and shellfish

NPS EN-5 section	Where this is covered in the ES
2.2.10 "...*As well as having duties under Section 9 of the Electricity Act 1989, (in relation to developing and maintaining an economical and efficient network), applicants must take into account Schedule 9 to the Electricity Act 1989, which places a duty on all transmission and distribution licence holders, in formulating proposals for new electricity networks infrastructure, to "have regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest … and …do what [they] reasonably can to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects".*	The project undertook a detailed routeing and siting study (**Application Document 6.2.1.3 Part 1 Introduction Chapter 3, Main Alternatives Considered**) which considered a wide range of environmental factors including biodiversity.
2.13.21 *"…The sensitivities of many coastal locations and of the marine environment as well as the potential environmental, community and other impacts in neighbouring onshore areas must be considered in the identification onshore connection points."*	Landfall design is summarised in **Application Document 6.2.1.4 Part 1 Introduction Chapter 4 Description of the Proposed Project**. Furthermore, installation methods at landfall locations have been selected to minimise effects to fish and shellfish (e.g. the use of trenchless techniques for the transition zone between the offshore and onshore elements). The Proposed Project design which includes embedded measures, control and management measures is presented in section 3.8 and additional mitigation and enhancement measures presented in section 3.10.
2.14.2...(Part) "*In the assessments of their designs, applicants should demonstrate how environmental, community and other impacts have been considered and*	Landfall design is summarised in **Application Document 6.2.1.4 Part 1 Introduction Chapter 4**

NPS EN-5 section	Where this is covered in the ES
how adverse impacts have followed the mitigation hierarchy i.e. avoidance, reduction and mitigation of adverse impacts through good design; how the mitigation hierarchy has been followed, in particular to avoid the need for compensatory measures for coastal, inshore and offshore developments affecting SACs SPAs, and Ramsar sites".	**Description of the Proposed Project** and installation methods have been selected to minimise impacts on fish and shellfish (e.g. the use of trenchless techniques for the transition zone between the offshore and onshore elements). Furthermore, the Offshore Scheme has been re-routed avoid designated sites including Margate and Long Sands Special Area of Conservation (SAC). The Proposed Project design which includes embedded measures, control and management measures is presented in section 3.8 and additional mitigation and enhancement measures presented in section 3.10.

National Planning Policy Framework

3.2.17 The National Planning Policy Framework (NPPF) as revised in December 2024 (Ministry of Housing, Communities and Local Government, 2024) sets out national planning policies that reflect priorities of the Government for operation of the planning system and the economic, social, and environmental aspects of the development and use of land. The NPPF has a strong emphasis on sustainable development, with a presumption in favour of such development. The NPPF has the potential to be considered important and relevant to the Secretary of State (SoS)' consideration of the Proposed Project.

3.2.18 Table 3.4 below provides details of the elements of the NPPF that are relevant to this chapter, and how and where they are covered in the ES.

Table 3.4 NPPF requirements relevant to fish and shellfish

NPPF section	Where this is covered in the ES
Paragraph 187 "*Planning policies and decisions should contribute to and enhance the natural and local environment by [inter alia] … protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan); … [and] recognising the intrinsic character and*	Statutory protected sites and their associated features of interest which will be impacted by project activities are considered in section 3.9.

NPPF section	Where this is covered in the ES
beauty of the countryside, and the wider benefits from natural capital and ecosystem services; … [and] minimising impacts on and providing net gains for biodiversity; …[and] preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability".	Potential impacts in relation to the biodiversity of fish and shellfish are considered in section 3.9. Relevant designated sites have been further subjected to an HRA (**Application Document 6.6 Habitat Regulations Assessment Report**).
Paragraph 188 *"Plans should: distinguish between the hierarchy of international, national and locally designated sites; allocate land with the least environmental or amenity value, where consistent with other policies in this Framework; take a strategic approach to maintaining and enhancing networks of habitats and green infrastructure; and plan for the enhancement of natural capital at a catchment or landscape scale across local authority boundaries*".	Any requirements for biodiversity net gain have been considered within section 3.10. However, it has been concluded that no additional enhancement measures are required.
Paragraph 192 *"To protect and enhance biodiversity and geodiversity, plans should: Identify, map and safeguard components of local wildlife-rich habitats and wider ecological networks, including the hierarchy of international, national and locally designated sites of importance for biodiversity; wildlife corridors and stepping stones that connect them; and areas identified by national and local partnerships for habitat management, enhancement, restoration or creation; [and] promote the conservation, restoration and enhancement of priority habitats, ecological networks and the protection and recovery of priority species; and identify and pursue opportunities for securing measurable net gains for biodiversity."*	Locally, nationally, and internationally designated sites have all been considered where relevant for benthic ecology receptors. Details for relevant designated sites is provided in section 3.7, Relevant designated sites have been further subjected to an HRA (**Application Document 6.6 Habitat Regulations Assessment Report**). Note, no additional enhancement measures specific to fish and shellfish have been identified (see section 3.10).
Paragraph 193 *"When determining planning applications, local planning authorities should apply the following principles: if significant harm to biodiversity resulting from a development cannot be avoided (through locating on an alternative site with less harmful impacts), adequately mitigated, or, as a last resort, compensated for, then planning permission should be refused; [and] development on land within or outside a Site of Special Scientific Interest, and which is likely to have an adverse effect on it (either individually or in combination with other developments), should not normally be permitted. The only exception is where the benefits of the development in the location proposed clearly outweigh both its likely impact on the features of the site that make it of special scientific interest, and any broader impacts on the national*	Potential impacts in relation to the biodiversity of fish and shellfish are considered in section 3.9. Relevant designated sites have been considered further as part of the HRA (**Application Document 6.6 Habitat Regulations Assessment Report**). With regard to Sites of Special Scientific Interest (SSSIs), there

NPPF section	Where this is covered in the ES
network of Sites of Special Scientific Interest; [and] development whose primary objective is to conserve or enhance biodiversity should be supported; while opportunities to improve biodiversity in and around developments should be integrated as part of their design, especially where this can secure measurable net gains for biodiversity or enhance public access to nature where this is appropriate."	are none designated for the protection of fish and shellfish features identified within the study area.
Paragraph 194 *"The following should be given the same protection as habitats sites: possible Special Areas of Conservation; [and] listed or proposed Ramsar sites; [and] sites identified, or required, as compensatory measures for adverse effects on habitats sites, potential Special Protection Areas, possible Special Areas of Conservation, and listed or proposed Ramsar sites."*	No possible/proposed protected sites have been identified in addition to existing designations. A full list of sites designated for the protection of benthic ecology is provided in section 3.7.

National Planning Practice Guidance

3.2.19 This Chapter has also followed National Planning Practice Guidance for the Natural Environment which describes how biodiversity and ecosystems should be taken into account, for the purpose of conserving biodiversity. This follows guidance on evidence required, such as location of designated sites and the distribution and consideration of protected and priority species. In addition, guidance has been followed applying policy to avoid, mitigate or compensate for significant harm to biodiversity, to ensure that project impacts do not cause adverse effects to fish and shellfish.

Marine Planning Policy

3.2.20 The following marine plans are relevant to fish and shellfish and have informed the assessment of preliminary effects in this chapter:

- The UK Marine Policy Statement (MPS), which was adopted in 2011 and provides the policy framework for the preparation of marine plans and establishes how decisions affecting the marine area should be made (HM Government, 2011);
- East Inshore and East Offshore Marine Plan (Defra, 2014); and
- South East Inshore Marine Plan (Defra, 2021).

These are further detailed in Table 3.5.

Table 3.5 Marine Planning Policies relevant to fish and shellfish

Marine Plan	Where this is covered in the ES
The UK MPS ensures that marine resources are used in a sustainable way by ensuring biodiversity is protected and	In line with policy objectives in the MPS, this ES Chapter has taken into consideration measures that can be taken to avoid biodiversity loss and has attached appropriate weight to the designated

Marine Plan	Where this is covered in the ES
conserved by using the precautionary principle and relying on sound evidence.	sites (e.g. MCZs) which are at risk of impact from the Proposed Project. Species and habitats of principal importance have also been considered, in addition to those which are qualifying features of the sites listed in section 3.9.
East Inshore and East Offshore Marine Plan ensures biodiversity is protected and conserved between Flamborough Head and Felixstowe.	Several policies which relate to fish and shellfish are in the Marine Plans. These state that proposals occurring within fish or shellfish habitat, or with the potential to cause adverse impacts to fish and shellfish habitat, should avoid, minimise and mitigate adverse impacts so that they are no longer significant. All preliminary impacts associated with the Offshore Scheme have been assessed in section 3.9, embedded measures and control and management measures presented in section 3.8 and additional mitigation and enhancement measures if required for fish and shellfish is presented in section 3.10.
South East Inshore Marine Plan ensures biodiversity is protected and conserved between Felixstowe and Dover.	

Local Planning Policy

3.2.21 The intertidal area of the Offshore Scheme lies within the jurisdiction of Suffolk County Council, East Suffolk Council and Kent County Council. Therefore, the Offshore Scheme also falls within the boundaries of the following relevant local plans: Suffolk Coastal Local Plan, Thanet District Council Local Plan and Dover District Local Plan.

3.3 Scoping Opinion and Consultation

Scoping

3.3.1 A Scoping Report (National Grid, 2022) for the Proposed Project was issued to the Planning Inspectorate (PINS) on 24 October 2022 and a Scoping Opinion (PINS, 2022) was received from the SoS on 1 December 2022 (**Application Document 6.2.1.6 Part 1 Introduction Chapter 6 Scoping Opinion and EIA Consultation**). Table 3.6 sets out the comments raised in the Scoping Opinion and how these have been addressed in this ES. The Scoping Opinion takes account of responses from prescribed consultees as appropriate. **Application Document 6.2.1.6 Part 1 Introduction Chapter 6 Scoping Opinion and EIA Consultation** and **Application Document 5.1 Consultation Report** provides responses to the comments made by the prescribed consultees at scoping stage and how each comment has been considered.

Table 3.6 Comments raised in the Scoping Opinion

ID	Inspectorate's comments	Response
5.3.1	The Scoping Report seeks to scope this matter [*Impacts on spawning grounds for Dover sole, lemon sole, whiting and sprat*] out on the grounds that these species are pelagic spawners which release eggs into the water column, leading to the eggs being transported away by water movement. The Inspectorate notes that these species have not been highlighted as being of particular concern by any of the consultees and therefore agrees that this matter can be scoped out of further assessment.	Impacts on the spawning grounds of these species have been scoped out of further assessment and have not been considered further within this ES Chapter.
5.3.2	The Scoping Report seeks to scope this matter [*effect of HDD drilling fluids on marine water quality*] out because the proposed mitigation measures include a commitment to only use inert, biodegradable drilling fluids which would be disposed of at a licensed disposal site. The Inspectorate agrees that this matter can be scoped out of further assessment. However, as noted in point 2.1.6 above, the ES should provide information on the mitigation measures relied on to avoid likely significant effects, including the measures which would be employed in the event of an accidental leak of drilling fluids.	The effects on marine water quality from the use of drilling fluids during construction has been scoped out and has not been assessed further. Relevant embedded measures and control and management measures presented in section 3.8 and additional mitigation and enhancement measures if required for fish and shellfish is presented in section 3.10.
5.3.3	The Scoping Report seeks to scope out this matter [*leaks and spills from vessels*] on the grounds that the measures contained in the CoCP would make the risk of accidental spills/leaks negligible. The Inspectorate agrees that, provided the measures to mitigate the risks of leaks and spills are clearly described in the ES and secured in the dDCO [draft DCO], this matter can be scoped out of further assessment.	The effects on marine water quality accidental leaks and spills from vessels, including loss of fuel oils during all phases has been scoped out and has not been assessed further. Relevant embedded measures and control and management measures presented in section 3.8 and additional mitigation and enhancement measures if required for fish and shellfish is presented in section 3.10.
5.3.4	The Scoping Report states that cable thermal emissions have been scoped in because of the potential to alter community structure within the sediment. However, it	Due to comments from the Environment Agency as part of PEIR consultation, thermal effects have now been scoped

ID	Inspectorate's comments	Response
	also then states that cables have negligible capacity to heat the overlying water column. The Inspectorate has interpreted this as meaning that effects from thermal heating of the water column would not be assessed and agrees that this matter can be scoped out of further assessment.	back in (with specific consideration to smelt migration). This assessment is presented in section 3.9.
5.3.5	The Scoping Report cites published research in support of the position that while benthic invertebrates (including shellfish) may be able to detect EMF changes, significant interaction is considered to be very unlikely. The Inspectorate agrees that this matter can be scoped out of further assessment.	EMF emissions in relation to shellfish (these species are benthic invertebrates) have been scoped out. However, consideration of EMF effects to other receptors has been assessed in section 3.9.
5.3.6	The Study Area shown on Figure 4.4.1 Study Area of the Scoping Report is stated to cover the ZoI for the Proposed Development. However, the advice from the MMO (see Appendix 2 of this Opinion) is that the spawning grounds of the Thames/Blackwater herring should also be included in the assessments in the ES. Accordingly, the Study Area for this aspect should be extended to include the spawning grounds for this species at Herne Bay and at the Eagle Bank and Osea Island in the Blackwater Estuary. The Applicant should seek to agree the extent of the Study Area with relevant stakeholders, including the MMO.	The Study Area has now been extended to cover Herne Bay, Eagle Bank, and Osea Island in the Black Water Estuary. This has been discussed in section 3.6.1. A detailed analysis of herring spawning grounds has also been undertaken (**Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**). The method for this analysis was agreed with the MMO and relevant stakeholders.
5.3.7	The Scoping Report states that in addition to the screening distance, a regional approach will also be used to scope in any designated sites beyond this distance. The Scoping Report does not explain how this regional approach would be employed to decide which additional sites could be affected. The Applicant is advised to agree which designated sites should be included with relevant stakeholders; the ES should explain how these sites have been identified. The Applicant's attention is drawn to the comments from Natural England on potential impacts on migratory fish in Appendix 2 of this Opinion.	The updated approach to screening, particularly for migratory fish species in designated sites is detailed in section 3.7 of this ES chapter. Comments from Natural England have been considered when screening in designated sites. A meeting to discuss fish and shellfish scoping opinion comments was attended on the 31 May 2023. This included engagement with the MMO, Cefas, and Natural

ID	Inspectorate’s comments	Response
		England, who agreed with the updated approach.
5.3.8	The Inspectorate notes that the advice from Natural England identifies several other species which they consider should be included in the assessment in the ES. The Applicant should seek to agree which species should be included in the assessment with relevant stakeholders; supporting evidence of this agreement should be provided in the ES.	The species identified by Natural England have been reviewed. Stakeholders have been consulted on this matter. Further information on this can be found in section 3.3.
5.3.9	The Inspectorate notes that the data referred to in identifying spawning/nursery grounds is at least 20 years old. The ES should be based on the most up to date information available – the Applicant’s attention is drawn to the advice from Natural England on this point (see Appendix 2 of this Opinion). The Applicant should seek to agree the appropriate baseline data with relevant stakeholders.	Additional, more recent available data have been considered in the identification of spawning and nursery grounds in this ES chapter (see section 3.7). A detailed spawning assessment for herring and sandeel (**Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**) has been carried out which identifies potential suitable herring and sandeel spawning ground using benthic characterisation studies and other data recommended by MarineSpace (2013a; 2013b).
5.3.10	The Applicant’s attention is drawn to the advice from the EA (see Appendix 2 of this Opinion) on the potential for onshore impacts on water quality to affect the designated shellfish waters on the North Kent coast. The Inspectorate notes that the CoCP would describe mitigation measures required to avoid likely significant effects. The ES should explain how this potential impact on shellfish waters has been addressed.	The Proposed Project design which includes embedded measures and control and management measures in relation to water quality is presented in section 3.8.
5.3.11	Natural England’s advice (see Appendix 2 of this document) identifies potential impacts on fish and shellfish populations from the colonisation of artificial substrates associated with the Proposed Development.	The ability for fish and shellfish population to colonise artificial substrates associated with the Proposed Development has been considered in section 3.7. The impacts associated with

ID	Inspectorate's comments	Response
	The Inspectorate considers that these impacts should be addressed in the ES.	the placement of artificial substrates associated with the Proposed Development have been included in section 3.9.
5.3.12	The Scoping Report provides a detailed explanation of how the significance of effects would be determined, based on the relevant guidance from the Chartered Institute of Ecology and Environmental Management (CIEEM). However, no description has been provided of the methods that will be used to assess impacts and whether these will be quantitative or qualitative. The methodologies used must be described and their use justified with reference to appropriate guidance and/or agreement with relevant stakeholders. The Applicant's attention is drawn to the advice from the MMO in Appendix 2 of this Opinion in relation to assessment of effects on herring larvae (MMO response paragraph 3.5.4) and assessment of underwater noise on fish populations (MMO response paragraph 3.5.8). The assessments in the ES should address these points.	The approach and methodology of the assessment is detailed in section 3.4 and was agreed with the MMO and Cefas during further consultation. The methodology has included MarineSpace (2013a; 2013b) guidance to herring and sandeel spawning assessment, sound impacts to fish and shellfish based on Popper et al., (2014) and Electric Magnetitic Field (EMF) based on a project specific assessment (**Application Document 6.2.4.7.B Appendix 4.7.B Electromagnetic Deviation Study**). A separate marine licence application will be made for any UXO detonation in line with MMO advice to allow for appropriate consideration of potential UXO impacts once sufficient information is available to identify any potential UXO risk.

Statutory Consultation

3.3.2 Statutory consultation for the Proposed Project took place between 24 October and 18 December 2023. A further targeted consultation exercise on the main changes to the Proposed Project introduced after the 2023 statutory consultation, was undertaken between 8 July and 11 August 2024. A summary of relevant feedback received during statutory consultation relating to fish and shellfish is provided below. Further details on how consultation responses have informed the assessment can be found in **Application Document 5.1 Consultation Report**.

3.3.3 Key actions arising from MMO feedback were:

- A detailed herring *Clupea harengus* and sandeel *Ammodytes* spawning grounds assessment has been undertaken including potential effects to these receptors

(**Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**). The assessment follows MarineSpace (2013a; 2013b) guidance and multiple data layers were used, including, but not limited to, EMODnet seabed substrate (250k) data (EMODnet, 2018), , 2008 – 2017 International Herring Larvae Survey (IHLS) data, Vessel Monitoring Systems (VMS) fishing data, (Coull, Johnstone, & Rogers, 1998) and. (Ellis, Milligan, Readdy, Taylor, & Brown, 2012), important spawning areas., for the production of 'heat maps'. One Benthic data has been used for ground-truthing but is not included within the heat map as it only comprises point data. The Regional Seabed Monitoring Plan (RSMP) data is considered to be encompassed within the One Benthic data. The project benthic survey data has also not been included within the heat map, as it does not provide a regional perspective and provides too much weight on the cable route, without providing context on other available habitats present nearby (i.e. the extension of this data).

- Sediment samples collected have been re-classified based on the methods provided by (Latto, et al., 2013) to better identify 'preferred' and 'marginal' sandeel habitat.

3.3.4 Key actions arising from Environment Agency feedback were:

- An assessment of breeding populations of smelt from the Alde and Ore waterbody has now been considered within section 3.7 and 3.9. Consideration has also been given to potential thermal plume avoidance from cables and the potential effects to fish migration and avoidance of these plumes. Target burial depth (depth of lowering (DOL)) of the cable is 1 m across the route which has been incorporated into the project design.
- Transitional (diadromous) species have been considered in section 3.7, and consideration has been made to the River Stour and Great Stour Estuary.

3.3.5 Key actions arising from Natural England feedback were:

- Further advice was sought from Cefas regarding an agreed approach for the herring and sandeel assessment.
- The impacts of prey availability to relevant Special Protection Areas have been considered in **Application Document 6.2.4.5 Part 4 Marine Chapter 5 Marine Ornithology** and **Application Document 6.6 Habitats Regulations Assessment Report.**
- Additional baseline data for brown trout swimming depth have been included in section 3.7.
- A detailed herring and sandeel spawning grounds assessment has been undertaken including potential effects to these receptors (**Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**). Indirect effects from prey items on the features of these designated sites, has been considered in the HRA (**Application Document 6.6 Habitats Regulations Assessment Report**).
- The International Herring Larvae Surveys (IHLS) data from 2008 and 2017 has continued to be used for assessing herring and sandeel spawning. Following a meeting with Cefas on 08 February 2024, the inclusion of this data and the sources used were presented and subsequently approved by Cefas.

Further Engagement

3.3.6 Further stakeholder engagement was held on 31 May 2023 with Cefas and the MMO and 08 February 2024 with Natural England, Cefas, Environment Agency and the MMO. Key actions arising from these meeting were:

- The aim was to address comments from the PEIR. However, the focus was to agree an approach for the herring and sandeel assessment within the fish and shellfish impact assessment. Cefas, were happy overall with the approach to the herring and sandeel spawning assessment, whilst the EA were informed that the potential effects to smelt from thermal impacts was considered.

Summary of Scope of Assessment

3.3.7 Following on from the PEIR and stakeholder consultations, impacts that have been assessed further are provided below for each phase of the Proposed Project. The impact pathways have been agreed with the relevant stakeholders.

3.3.8 Impact pathways scoped in for construction:

- temporary physical disturbance to fish and shellfish habitat;
- temporary increase in suspended sediment concentrations (SSC) and subsequent sediment deposition leading to contaminant mobilisation, increased turbidity and smothering effects on fish and shellfish; and
- underwater sound (excluding UXO).

3.3.9 Impact pathways scoped in for operation/maintenance:

- permanent loss of fish and shellfish habitat due to placement of hard substrates on the seabed;
- effects on fish due to subsea cable electromagnetic field (EMF) emissions;
- potential effects on fish and shellfish due to subsea cable thermal emissions; and
- potential effects on fish and shellfish as a result of maintenance activities.

3.3.10 Impact pathways scoped in for decommissioning:

- potential effects on fish and shellfish as a result of decommissioning activities.

3.4 Approach and Methodology

3.4.1 **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology** sets out the overarching approach which has been used in developing the environmental assessment. This section describes the technical methods used to determine the baseline conditions, sensitivity of the receptors and magnitude of effects and sets out the significance criteria that have been used for the fish and shellfish assessment.

Guidance Specific to the Fish and Shellfish Assessment

3.4.2 In addition to the legislation and policies outlined in section 3.2, the fish and shellfish assessment has been carried out in accordance with the following good practice guidance documents:

- Chartered Institute for Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland – Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018).
- MarineSpace Ltd Guidance on environmental effect pathways between marine aggregate application areas and Atlantic herring and sandeel potential spawning habitat (2013a; 2013b).

Baseline Data Gathering and Forecasting Methods

3.4.3 The fish and shellfish ecology baseline conditions have been established by undertaking a combination of desktop review of published information, collection of project-specific survey data, and consultation with relevant organisations. The baseline provides a robust and up-to-date characterisation of the fish and shellfish ecology in relation to the Proposed Project.

Project specific surveys

3.4.4 Project specific benthic surveys were carried out in the nearshore and offshore portions of the Study Area (defined in section 3.6) to assist in identifying suitable spawning habitat for key demersal fish species including herring and sandeel.

Subtidal Characterisation Survey 2021

3.4.5 A dedicated subtidal benthic survey was carried out between 08 September and 06 October 2021 to characterise benthic ecological conditions and map the distribution and extent of habitats along the subtidal Offshore Scheme (**Application Document 6.3.4.2.A Appendix 4.2.A Benthic Characterisation Report (Original Report)**) by MMT Ocean Infinity (MMT). A broadscale habitat map was produced and this was based on combining the grab sample data (37 sample sites, which provided Folk (1954) classifications) with drop down video (DDV) analysis and side scan sonar (SSS) seabed mosaics to classify the habitat types within MMT survey corridor in terms of biotopes, in line with the EUNIS habitat classification. These broadscale EUNIS habitats were analysed to identify areas of potential preferred and marginal spawning habitat for herring and sandeel. These areas hereafter referred to as 'MMT potential 'preferred/marginal' spawning habitat'.

3.4.6 Additionally, the grab samples taken during the Subtidal Characterisation Survey 2021 were re-analysed following stakeholder feedback to identify if these grab sample sites contained any potential suitable herring and sandeel spawning grounds, based on Reach et al., (2013) for herring and Latto et al., (2013) as described in MarineSpace (2013a; 2013b). Note, data from the Subtidal Characterisation Survey 2021 is hereafter referred to as 'MMT data'.

Geophysical Survey 2024

3.4.7 Where the Offshore Scheme Boundary deviates from the Benthic Characterisation Report 2021, a geophysical survey (**Application Document 6.3.4.2.B Appendix 4.2.B Geophysical Survey Interpretation (Additional Surveys)**) was commissioned to understand seabed morphology, shallow sediment structure, and to provide benthic characterisation (**Figure 6.4.4.2.5 Subtidal marine survey locations** located in **Application Document 6.4.4.2 Benthic Ecology**). The initial interpretations of the seabed sediments and potential sensitive habitats are based on SSS and multi-beam echo sounder (MBES) data, with further analysis anticipated to confirm findings.

Additional Subtidal Survey 2024

3.4.8 An additional benthic survey was commissioned in 2024 to assess areas of the Offshore Scheme that were not included in the original 2021 survey following consultation and a minor route change (**Application Document 6.3.4.2.D Appendix 4.2.D Interim Subtidal Survey Report (Additional Surveys)**). Prior to the sampling, side scan sonar SSS and MBES were used to collect data which informed survey locations in areas where the Offshore Scheme Boundary deviates from the Subtidal Characterisation Survey 2021 survey area. The survey comprised a total of 17 survey stations, to ensure comprehensive coverage of the targeted areas (**Figure 6.4.4.2.5 Subtidal marine survey locations** located in **Application Document 6.4.4.2 Benthic Ecology**).

3.4.9 At each of the survey stations, a drop-down camera system was deployed over a transect of 50 – 150 m to capture high-quality imagery was deployed across the survey area. At eight of the survey stations, a grab sample was collected using a dual Van veen (2 x 0.1 m^2) or a Hamon grab (0.1 m^2), for quantitative macrofaunal, particle size analysis (PSA), and sediment chemical analysis.

3.4.10 The seabed imagery, grab samples and macrofaunal data collected from this survey have been used to describe sediments in targeted areas and to highlight the potential for protected habitats and species. Grab samples, macrofaunal data, DDV and PSA have been used to classify sampled areas in line with the EUNIS classification system (EEA, 2021). Habitats were subsequently assessed in terms of their ecological and conservation importance, using current marine legislation and guidance.

3.4.1 As agreed with statutory consultees at the scoping stage, no additional site-specific surveys were undertaken for the purpose of understanding the baseline environment in relation to fish and shellfish.

Desk study

3.4.2 A comprehensive desk-based review was undertaken to inform the baseline for fish and shellfish ecology. These data sources were used to inform the understanding of the relative importance and functionality of the Study Area in the regional context of fish and shellfish populations in the wider central and northern North Sea. Key data sources used to inform the assessment include:

- FishBase (FishBase, 2024) - General fish ecology, distribution and biological information (UK data sources used where available);
- European Marine Observation Data Network (EMODnet) Seabed Habitats Project data for broad-scale habitat maps of the Study Area (EMODnet, 2021) - Provides records of rarer fish and shellfish species and broadscale benthic habitat data;
- Fisheries Sensitivity Maps in British Waters (Coull, Johnstone, & Rogers, 1998; Aires, González-Irusta,, & Watret, 2014) - Provide spatial data highlighting spawning and nursery grounds of selected fish species in British waters;
- Spawning and Nursery Grounds of Selected Fish Species in UK Waters (Ellis, Milligan, Readdy, Taylor, & Brown, 2012) - Provide spatial data regarding the location of spawning and nursery grounds of selected fish species in UK waters;

- Transitional and coastal waters (TraC) fish counts[3] (Environment Agency, 2021a) - Fish count for all freshwater species between 2003-2021 in rivers adjoining the north and central North Sea;
- National Fish Populations Database (NFPD)[4] (Environment Agency, 2021b) - Fish count for all freshwater species between 2003-2021 in rivers adjoining the north and central North Sea;
- Salmonid and fisheries statistics for England and Wales (Environment Agency, 2021c) - Information on salmonid and fisheries statistics for England and Wales;
- Salmon Stocks and Fisheries in England and Wales (Cefas, 2022) - Information on salmon stocks and fisheries for England and Wales;
- The Outer Thames Estuary Regional Environmental Characterisation (Sturt & Dix, 2009) - The Outer Thames Estuary Regional Environmental characterisation provides an environmental reference statement defining marine and seabed conditions within the Outer Thames Estuary;
- East Coast Regional Environmental Characterisation report (Limpenny S. , et al., 2011) - A detailed analysis of physical and biological features, aiming to inform sustainable management and conservation efforts in the region;
- International Council for the Exploration of the Sea (ICES) International Herring Larvae Survey (IHLS) data (ICES, 2024) - The main purpose of this programme is to provide quantitative estimates of herring larval abundance, which are used as a relative index of changes of the herring spawning-stock biomass in the assessment in the North Sea;
- The International Convention for the Conservation of Nature (IUCN) Red List of Threatened Species (The IUCN Red List of Threatened Species, 2024) - A global assessment of the population levels of both marine, terrestrial and aquatic species;
- Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring and sandeel Potential Spawning Areas (MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd, & Marine Ecological Surveys Ltd, 2013a; MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd, & Marine Ecological Surveys Ltd, 2013b) - These guidance documents provide a framework for assessing the potential impacts of marine aggregate extraction on sandeel and herring habitats, which can be applied to other marine sectors and environmental impact assessments. The methodology includes mapping and screening processes to identify and characterise sandeel and herring habitats, ensuring that marine aggregate activities are managed sustainably and minimise ecological disruption;
- Hydroacoustic seabed survey and grab sampling data (Greenstreet, et al., 2010) - To assess “local” sandeel population abundance;
- Sandeel sediment habitat preferences in the marine environment (Holland G. , Greenstreet, Gibb , Fraser, & Robertson, 2005) - Information on sandeel habitat preferences in the marine environment, and
- Publicly available and relevant academic journal papers and reports.

[3] This data is hereafter referred to simply as ‘TraC data’

[4] This data hereafter referred to simply as ‘freshwater fish data’

Assessment Criteria

3.4.3 Several factors will be considered when assessing the impacts on fish and shellfish resulting from the Offshore Scheme including sensitivity of the receptors, magnitude of the impact, and the overall significance of effects. Several considerations should be considered when assessing the preliminary effects resulting from a project, including the scale of the impact, the duration of the impact and whether the damage caused by the impact is reversible or not.

3.4.4 This chapter applies the appraisal methodology as detailed in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology** in combination with CIEEM guidelines for ecological assessment in the UK (2018), professional judgement, and the application of relevant guidance as discussed in the above sections. Thus, whilst the significance matrix is used as the basis for assigning significance to an effect, the final identification of significance also requires the application of professional judgement. This allows for a more comprehensive consideration of ecological context and the absence of defined quantitative threshold for many effects in ecological systems. Potential impacts and significance of effects is based on a discussion of receptor sensitivity, importance, and magnitude, for which assessment methodologies for each are described in further detail below.

Sensitivity of fish and shellfish receptors

3.4.5 When defining sensitivity, the criteria levels set out in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology** have been considered. To determine sensitivity of the receptor, the vulnerability of the receptor to the impact and its ability to recover and adapt were considered. Vulnerability differs between different species of fish and shellfish, for example those that rely on demersal (seabed) environments as part of their life cycle are more vulnerable to construction work on the seafloor than other highly mobile species that primarily live in the water column (also referred to as the pelagic zone) and are likely to swim away from an affected area for the duration of an impact, returning once the impact is removed. In addition, the ability to recover also differs between species, with some more likely to recover over a shorter timeframe due to increased fecundity for example. The importance, or value, of the receptor on an international, national and local scale has also been considered in assessing sensitivity.

3.4.6 When defining the sensitivity of the impact, criteria detailed in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology** has been followed: very high, high, medium, low, and negligible.

Magnitude of fish and shellfish effects

3.4.7 The magnitude of an impact that could affect fish and shellfish is influenced by several key factors, including the scale of the change (and how much the receptor is likely to be affected), the spatial extent over which the impact is likely to occur, and the duration and frequency of the impact. When considering the duration and frequency of the impact, thresholds of fish and shellfish for withstanding changes in the marine environment were also assessed.

3.4.8 When defining the magnitude of the impact, criteria detailed in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology** has been followed: large, medium, small, and negligible.

Significance fish and shellfish effects

3.4.9 As set out in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**, the general approach taken to determining the significance of effect in this assessment is only to state whether effects are likely or unlikely to be significant, rather than assigning significance levels.

3.4.10 To determine whether an effect is significant or not, the nature and anticipated timeframe of the impact has been considered, in addition to the likely sensitivity of affected receptors. The magnitude, which includes the scale of change, spatial extent, duration and frequency, of the impact have also been considered. When determining whether an effect is significant, the magnitude of impact and sensitivity of the receptor is accounted for. Professional judgement has also been applied to allow for consideration of previous project knowledge and ecological context. Additionally, a precautionary approach has been taken with the worst-case scenario assessed for each impact, in order to account for any uncertainty or lack of baseline survey data in the assessment.

3.4.11 The criteria for assessing effects and residual significance are presented in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**.

Assumptions and Limitations

3.4.12 The availability of data for fish and shellfish within the North Sea region is considered sufficient to characterise the baseline and as such provide a good understanding of the existing environment. However, due to the mobile nature of fish and some shellfish, there is potential variability in usage of the area by different species. As a result, each survey contributing to the available library of research, realistically, only provides a snapshot. Furthermore, available data is typically broad for fish and shellfish, providing only a broad indication of where species are present or absent, often relating to ICES boundaries.

3.5 Basis of Assessment

3.5.1 This section sets out the assumptions that have been made in respect of design flexibility maintained within the Proposed Project and the consideration that has been given to alternative scenarios and the sensitivity of the assessment to changes in the construction commencement year.

3.5.2 Details of the available flexibility and assessment scenarios are presented in **Application Document 6.2.1.4 Part 1 Introduction Chapter 4 Description of the Proposed Project** and **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**.

Flexibility Assumptions

3.5.3 The environmental assessments have been undertaken based on the description of the Proposed Project provided in **Application Document 6.2.1.4 Part 1 Introduction Chapter 4 Description of the Proposed Project**. To take account of the flexibility allowed in the Proposed Project, consideration has been given to the potential for effects to be of greater or different significance should any of the permanent or temporary infrastructure elements be moved within the Limits of Deviation (LoD) or Order Limits.

3.5.4 The assumptions made regarding the use of flexibility for the main assessment, and any alternatives assumptions are set out in Table 3.7 below.

Table 3.7 Flexibility assumptions

Element of flexibility	How it has been considered within the assessment?
Lateral LoD marine HVDC cable	The worst-case scenario assessed for the Offshore Scheme is one bundled HVDC (x2) and one fibre optic cable in once trench. This bundled scenario maybe placed anywhere within the Offshore Scheme Boundary.

Sensitivity Test

3.5.5 It is likely that under the terms of the draft DCO, construction could commence in any year up to five years from the granting of the DCO which is assumed to be 2026. Consideration has been given to whether the effects reported would be any different if the works were to commence in any year up to year five. Where there is a difference, this is reported in section 3.9.

3.6 Study Area

3.6.1 The Offshore Scheme extends from the Outer Thames Estuary and southern North Sea between the Suffolk and Kent coastlines. The fish and shellfish chapter Study Area is illustrated in **Figure 6.4.4.3.1. Study Area**. Following regulator feedback at the scoping stage, the Study Area for spawning has been extended to include the herring spawning ground at Herne Bay and at the Eagle Bank and Osea Island in the Blackwater Estuary. This Study Area has been selected to encompass all likely zones of influence (ZoI) for fish and shellfish, as identified in section 3.9. The largest ZoI is 17 km from the Offshore Scheme and is based on the furthest extent sediment is deposited following disturbance from installation by jetting. This ZoI is represented by a buffer area around the Offshore Scheme in **Figure 6.4.4.3.1. Study Area**.

3.6.2 A 50 km distance has been adopted as an initial screening distance for any sites designated for migratory fish. However, to ensure any fish that may pass through the Study Area are considered, a regional approach has also been adopted, scoping in any sites for which an interaction may occur but is beyond this initial screening distance. For the purposes of this report, disturbance is considered to have the potential to occur where the Study Area falls in front of a migratory route into a river. Therefore, any designated sites that lie onshore of the Offshore Scheme have also been included to consider the potential for an interaction between the Offshore Scheme and potential migration routes of migratory fish. This regional based approach takes into consideration work by ABPMer (2014) as shown in Plate 3.1 and is considered to be encompassed by the Study Area illustrated in **Figure 6.4.4.3.1. Study Area**.

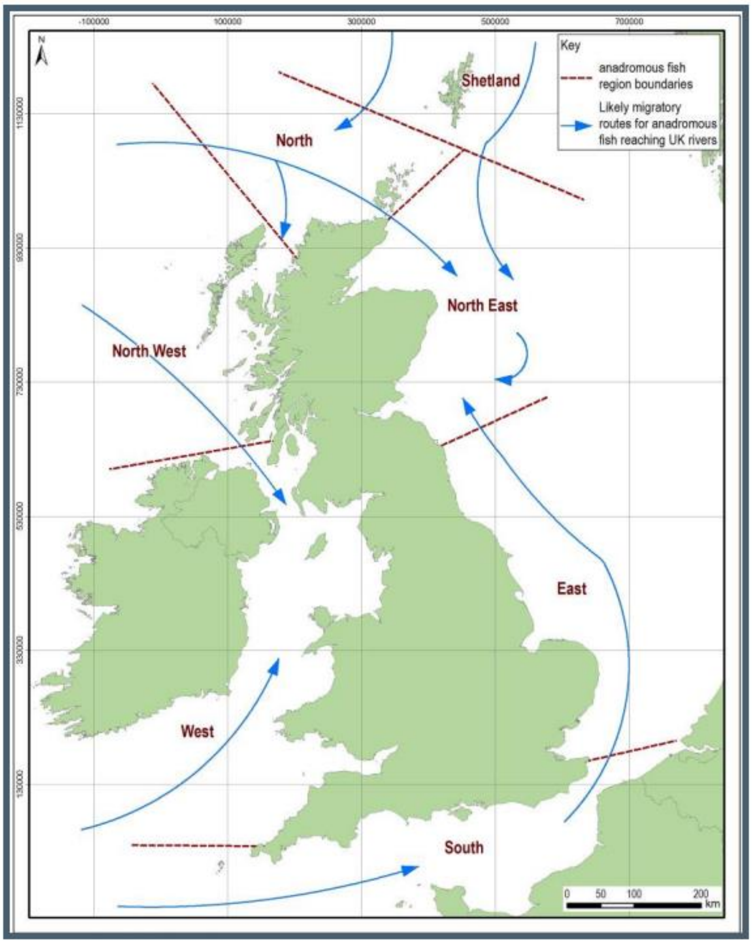

Plate 3.1 Location and extent of coastal regions to be used for screening fish qualifying interests (provided by ABPMer 2014)

3.7 Baseline Conditions

3.7.1 This section covers the fish and shellfish ecology baseline for the Offshore Scheme, with regards to the general fish and shellfish communities in the Study Area including spawning and nursery grounds, potential fish migration movements, commercial fish species (from an ecology perspective only), the relevant designated sites and species-specific information.

Protected Species and Designated Sites

Protected Species

3.7.2 There are several fish and shellfish species known to be present in the Study Area that are protected under international and national conservation legislation (Table 3.8). All species listed are also considered to be of wider ecological value as well as commercial value within the Study Area except for sandeel and the migratory fish species.

Designated Sites

3.7.3 Three designated sites for the protection of fish and shellfish are located within the 17 km of the Offshore Scheme. These are all MCZs designated for the protection of blue mussel (*Mytilus edulis*) or native oyster (*Ostrea edulis*) beds. A further four designated sites, which are either an MCZ or SSSIs, are located within 50 km of the Offshore Scheme. However, only one, the Medway Estuary MCZ, is designated for migratory fish species, for smelt (*Osmerus eperlanus*), and is considered further based on the regional approach discussed in section 3.6. The other three designated sites (Dover to Folkstone MCZ; Blackwater, Crouch, Roach and Colne Estuaries MCZ; and Folkstone Warren SSSI) are not designated for the protection of migratory fish and therefore have not been considered further. There are no SACs designated for fish or shellfish within the Study Area. Designated sites are illustrated on **Figure 6.4.4.3.2. Relevant designated sites for the protection of fish and shellfish**. Thus, the four designated sites relevant to fish and shellfish located within the Study Area are:

- **Goodwin Sands MCZ** (located partially within the Offshore Scheme boundary along the south-eastern side of the Offshore Scheme). The site is designated for the protection of blue mussel beds.
- **Thanet Coast MCZ** (located < 1 km southwest of the Offshore Scheme). The site is designated for the protection of blue mussel beds.
- **Dover to Deal MCZ** (located approximately 12 km south of the Offshore Scheme). The site is designated for the protection of native oyster and blue mussel.
- **Medway Estuary MCZ** (located approximately 42 km west of the Offshore Scheme). This site was recently designated in 2019 for smelt (*Osmerus eperlanus*), as the site is considered to provide critical habitat for this species including for feeding and post-larval development.

3.7.4 Further detail on designated sites screened into the Offshore Scheme assessment, relevant to fish and shellfish, are presented in **Application Document 6.11 Marine Conservation Zone Assessment**.

Table 3.8 Summary of relevant fish and shellfish species protected by national and international legislation or policy

Common names	Latin names	Habitats Directive Annex II and IV species	OSPAR list of threatened and/or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Wildlife and Countryside Act 1981	NERC Species of Principal Importance (SPI)	Features of Conservation Interest (FOCI)	IUCN Red List*
European eel	*Anguilla anguilla*		√	√			√	√	CR (↓)
Atlantic salmon	*Salmo salar*	√	√				√		LC (-)
Sea trout	*Salmo trutta*						√		LC (?)
Sea lamprey	*Petromyzon marinus*	√	√		√		√		LC (↔)
River lamprey	*Lampetra fluviatilis*	√					√		LC (?)
European smelt	*Osmerus eperlanus*						√	√	LC (?)
Twaite shad	*Alosa fallax*	√			√		√		LC (↔)
Allis shad	*Alosa alosa*	√			√		√		LC (?)
Herring	*Clupea harengus*						√		LC (↑)
Sprat	*Sprattus sprattus*								LC (?)
Mackerel	*Scomber scombrus*						√		LC (↓)
Sandeel	*Ammodytidae*						√[1]		LC (?)[1]
Cod	*Gadus morhua*		√				√		VU (-)

Common names	Latin names	Habitats Directive Annex II and IV species	OSPAR list of threatened and/or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Wildlife and Countryside Act 1981	NERC Species of Principal Importance (SPI)	Features of Conservation Interest (FOCI)	IUCN Red List*
Poor cod	*Trisopterus minutus*								LC (?)
Mediterranean scaldfish	*Arnoglossus laterna*								LC (?)
Whiting	*Merlangius merlangus*						✓		LC (?)
Dover sole	*Solea solea*						✓		DD (↔)
Plaice	*Pleuronectes platessa*						✓		LC (↑)
Basking shark	*Cetorhinus maximus*					✓	✓		EN (↓)
Thornback ray	*Raja clavata*		✓						LC (?)
Spotted ray	*Raja montagui*		✓						LC (↔)
Spurdog	*Squalus acanthias*		✓						VU (↓)
Tope	*Galeorhinus galeus*		✓						VU (↓)
Dog whelk	*Nucella lapillus*		✓				✓		
Native oyster	*Ostrea edulis*		✓				✓	✓	
Cephalopods	*Cephalopoda*								

Species- Specific Information

Diadromous Fish Species

3.7.5 Diadromous fish carry out seasonal migrations between bodies of freshwater and seawater. Those species known to migrate through the Outer Thames Estuary and adjacent estuaries, such as the Blackwater and the Crouch Estuary, and coastal environments (i.e. the Study Area) include European eel, Atlantic salmon, brown trout, sea lamprey and river lamprey, European smelt, Allis shad (*Alosa alosa*) and twaite shad (*Alosa fallax*).

European eel

3.7.6 The European eel is a catadromous[5] migratory species, undertaking an extensive migration to spawn in the Sargasso Sea. The newly hatched larvae, known as leptocephali, are transported to the continental shelf of the North Atlantic by the prevailing currents of the Gulf Stream, where they metamorphose into the life stage of glass eel and subsequently, in freshwater and coastal waters become pigmented 'elvers' (Aerestrup, et al., 2009; Potter & Dare, 2003).

3.7.7 Glass eels travel across shelf seas, using tidal stream transport, rising in the water column when the tide travels inwards, and settling to the bottom as the tide returns (Heessen, Daan, & Ellis, 2015). Eels migrate upstream into freshwater predominately during spring but may continue to do so until early autumn.

3.7.8 Once within freshwater habitats, eels remain for five to 15 years, transforming into yellow eels and then finally to silver eels when they begin their downstream migration through rivers and estuaries towards spawning grounds, predominately between August and December (Behrmann-Godel & Eckmann, 2003; Chadwick, Knights, & Bark, 2007). Spawning in the Sargasso Sea occurs mainly in spring (Righton, et al., 2016). However, some eels do not migrate into freshwater but instead inhabit estuaries as 'elvers' and yellow eels before returning to spawning grounds.

3.7.9 Overall, freshwater fish data reports 6,052 individuals having been recorded within the Study Area between 2010 and 2023. The highest annual record was 926 individuals in 2010 with a general decreasing trend between 2010 and 2023.

3.7.10 European eels are known to migrate into several rivers along the southeast coast of England, within the southern North Sea. These rivers include:

- River Thames: The Thames is one of the most important rivers for European eel in the UK. A recent study by Pecorelli *et al.* (Pecorelli, et al., 2019) looked at citizen science data using trap surveys collected between 2011 and 2018 as part of the Thames European Eel Project. This study aimed to assess the annual average catch per unit effort (CPUE) within the Thames River Basin District. The results showed that in 2018 European eel were recorded across the Thames River basin, with peak CPUE values typically observed in July. The Thames River Basin includes many rivers in which European eel are known to occur, including the Thames, Medway and Colne rivers, all of which ultimately outflow into the Thames Estuary. European eel was historically abundant in the Thames Estuary but with years of anthropogenic pressure from commercial fishing and habitat loss, populations of this species have

[5] A sub-category of diadromous species that migrates from freshwater to seawater to spawn

declined significantly throughout its range (Jacoby & Gollock, 2014). Environment Agency TraC data from 2013-2023 shows that European eel was mainly found in the Thames middle and upper regions with a max count of 13 elvers caught in the Middle Thames in 2014.

- River Stour (Essex): the River Stour (Essex) located on the border between Suffolk and Essex, is a major river which flows into the southern North Sea. Tributaries of the Suffolk River Stour are located within the onshore elements or the Proposed Project. It is a relatively small river, but it is an important spawning ground for European eels with trapping and tagging surveys carried out across the River Stour (Essex) in 2009 and 2010 (Wright, 2017) and while this study only assesses the behaviour of eels with respect to their interactions with man-made structures, and therefore does not provide information on where eels were found, it does at least confirm the presence of eels in the River Stour during this period. More recently, there has been evidence of European eels being present in the River Stour, as shown by the operation of a commercial glass eel fishery (Defra, 2010). In the River Stour, glass eel recruitment monitoring has been carried out to improve information on stock status (Defra, 2010) and in 2014 glass eels recruited into the river between March and August. TraC data also show that between 2013 and 2023 a total of 28 individuals were caught in the River Stour (Essex) with 13 of these being caught in 2018.
- River Stour (Kent): The River Stour (Kent) flows into Pegwell Bay adjacent to the Offshore Scheme. TraC data show that European eels have not been recorded in the River Stour (Kent) in the past ten years. However, European eels are known to be present in many marshland drainage ditches in the River Stour (Kent) catchment, but their numbers have dramatically declined (Kentish Stour Countryside Partnership, 2023). Despite the decline in numbers, a catch depletion survey as part of the Environment Agency’s National Core Fisheries Programme still recorded 94 eels in the River Stour (Kent) in 2015 (Foster, 2017).
- Blackwater River: The Blackwater River and Blackwater Estuary is another river system located in Essex, southeast England, where European eel is known to migrate. The estuary and surrounding rivers provide important habitat for European eel during its life cycle, including for feeding, growth, and migration. However, a study by Bark *et al.* (2007) found that long-term data collected by the Environment Agency between 1984 and 2005 showed a statistically significant decline in population density in the Blackwater River over the 21-year period (Bark, Williams, & Knights, 2007).

3.7.11 The TraC data recorded European eel once in the Alde River in 2018. The Alde River is situated along the coast of the northern section of the Offshore Scheme.

3.7.12 European eel is listed as ‘critically endangered’ on the IUCN Red List since 2008 and is protected under the Eels (England and Wales) Regulations (2009) and as Species of Principal Importance (SPI) under Section 41 of the Natural Environment and Rural Communities (NERC) Act. It is also included within Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendix II of the Convention on Migratory Species (CMS).

Atlantic salmon

3.7.13 Atlantic salmon is an anadromous[6] migratory species, which, during its lifecycle, uses both marine and freshwater habitats. Spawning of salmon typically occurs in November or December, in the upper reaches of rivers in gravelly substrate (Heessen, Daan, & Ellis, 2015; NASCO, 2012). The resultant larvae known as 'alevins' remain within the interstitial gravels. The transition from larvae to parr occurs in the first summer in southern streams (Potter & Dare, 2003) or up to a year in upland systems. Following the parr life stage, salmon physically and morphologically change into 'smolt'. This is preceding migration to the marine environment following one to five years spent in freshwater. The migration of smolt down-river to the ocean usually occurs from spring to early summer, generally occurring earlier in the season for larger smolt with most fish having migrated by June (Thorstad, et al., 2012). Once salmon have spent another one to five years at sea, the adults then return to their spawning rivers, which in the UK usually peaks between June to August and between October to December (Cowx & Fraser, 2003). Salmon typically spend the majority of their time (72% to 86%) in surface waters (0 m to 5 m), but often dive, sometimes to depths of > 20 m (6% to 9% of the time (Godfrey, Stewart, Middlemas, & Armstrong, 2015).

3.7.14 Salmon are mainly found along the western and northern parts of England and Wales. However, relatively low numbers of salmon are also found along the southeast coast of England (Cefas, 2022). Rivers considered to be of importance for salmon within 50 km of the Offshore Scheme are shown in **Figure 6.4.4.3.3 Rivers of known importance to migratory salmon within 50 km**. TraC data from 1992 to 2023 recorded a total of six individuals between 1992 and 1994 in the middle and upper River Thames. TraC data did not record salmon in any other rivers within the Study Area during this period. Furthermore, no records of salmon were returned from the EA NFPD freshwater fish data within the Study Area. However, anecdotal evidence suggests that salmon is known to be present in the Kent River Stour (Kent Wildlife Trust, 2021). In general, the Study Area located along the East Anglian Region is not considered to have salmon producing rivers (Cefas, 2022). The nearest designated Principal Salmon River[7] is the River Itchen, which is located more than 200 km southwest of the Offshore Scheme (Cefas, 2022). Salmon is protected as an Annex II species; however, there are no designated sites for which salmon is a qualifying feature (both primary and non-primary) within the Study Area and within a regional context.

Brown trout (Sea trout)

3.7.15 Brown or sea trout display a broad range of life history traits, with individuals that complete their lifecycle in freshwater, those that predominately inhabit estuarine waters, and those that exhibit full anadromy (Harris, 2017). Sea trout exhibit a similar life cycle to Atlantic salmon, though the adult marine stage of sea trout is shortened both spatially and temporally, with some migration back to freshwater environments after only a very short period of time feeding at sea, whilst 'maidens' only return to freshwater after a minimum of a year at sea (Gargan, Roche, Forde, & Ferguson, 2006). Adult sea trout

[6] Anadromous fish are diadromous fish that migrate from the sea into freshwater for spawning. This distinguishes them from catadromous fish, such as eels which migrate in the opposite direction, moving from freshwater to spawn in the sea.

[7] Principal Salmon Rivers consist of 64 rivers in England and Wales, designated as rivers which regularly support salmon. Salmon Action Plans have been developed for the conservation of these rivers and the management of rod catches.

returning to freshwater to spawn are more likely to stray from natal rivers compared to salmon.

3.7.16 There is limited information on swimming depths for adult sea trout, though available data suggests that while at sea, they spend most of their time at a depth of 20 m or deeper (SAMARCH, 2019). However, when migrating into river systems, they reside generally in shallow waters 0-3 m, with occasional deep dives (Kristensen, Righton, el Villar-Guerra, Baktoft, & Aarestrup, 2018). Upstream migration occurs between April and June and downstream migration through spring to early summer.

3.7.17 Sea trout are widely distributed across the UK; however, the limited literature suggests that the East Anglian population is strongly linked with the productive sea trout rivers entering the North Sea in North Yorkshire, Northumberland and East Scotland (Environment Agency, 2011). EA NFPD freshwater fish data recorded 223 brown trout using the River Stour (Kent) Catchment (including tributaries) between 2010 and 2023. The highest number of 123 individuals was recorded in 2015 and the second highest number of 46 individuals was recorded in 2011. However, in recent years this number appears to have decreased with only six individuals reported in 2022.

3.7.18 In the River Stour (Essex) Catchment (including tributaries), 1905 individuals were recorded between 2010 and 2023. The highest number of individuals was recorded in 2015 with 586 brown trout. The second highest number of 530 individuals was recorded in 2012. EA NFPD freshwater fish data also recorded brown trout in the Blackwater, Medway, Orwell, and Colne catchments.

3.7.19 TraC data from 1998 to 2021 recorded a total of 19 individuals in the south-east and Anglian region. Overall, the TraC data recorded very low numbers of brown trout in the Adur, Medway, Stour (Essex) and Thames rivers. There were no individuals recorded in the River Stour (Kent) during the same time period. The highest numbers of brown trout were recorded in the upper Thames River (a total of nine individuals recorded between 1998 and 2021). Other studies have also recorded this species migrating through other rivers in the Study Area, including the tidal Thames (Zoological Society of London, 2016). Overall, the sea trout is reported to attempt to enter most of the south coasts river (Environment Agency, 2011) although numbers are lower in recent years (Environment Agency, 2011).

Sea and River lamprey

3.7.20 Sea lamprey and river lamprey are both anadromous migratory species. After spending several years in the marine environment, adults return to freshwater to spawn in spring and early summer.

3.7.21 Sea lampreys are widely dispersed in the open sea as they are solitary feeders, being rarely found in coastal and estuarine waters (Moore, Hartel, Craddock, & Craddock, 2003). The distribution of sea lamprey is chiefly defined by their host river (Waldman, Grunwald, & Wirgin, 2008) and in offshore waters they are often found at considerable depths (Moore, Hartel, Craddock, & Galbraith, 2003).

3.7.22 In contrast, river lampreys are usually found in coastal waters, estuaries and accessible rivers and juveniles are often found in large congregations (Maitland, 2003). Distribution in the UK appears to be mainly in Wales, Northern Ireland and southern Scotland (Plate 3.2). River lamprey generally spend one to two years in estuaries, then move upstream in the autumn, between October and December (Zancolli, Foote, Seymour, & Creer, 2018).

3.7.23 Sea lamprey spawn when the water temperature reaches at least 15°C and they normally migrate into freshwater from April to June and then spawn from late May to June (Zancolli, Foote, Seymour, & Creer, 2018). The migration to sea can vary from river to river, although the metamorphosis of larvae into adults occurs between July and September (Maitland, 2003).

3.7.24 Sea lamprey and river lamprey are protected as Annex II species; however, there are no designated sites for which lamprey are a qualifying feature (both primary and non-primary) within the Study Area. Furthermore, while both species have been previously reported in low numbers within the Thames estuary (Zoological Society of London, 2016) the TraC data did not record lamprey species in any of the rivers within the Study Area between 1992 and 2023. The EA NFPD freshwater fish data recorded a total of 98 lamprey sp. within the River Stour (Kent) between 2010 and 2023. Overall low numbers were recorded each year with the highest number of 81 individuals having been recorded in 2012. In the River Stour (Essex), 941 lamprey sp. were recorded between 2010 and 2023, with the highest number of 209 individuals recorded in 2015. Lamprey were also recorded in the River Blackwater, Chelmer, Deben and Medway within the Study Area. Plate 3.2 also shows the limited distribution of both species in the south east of England, where the the Study Area is located.

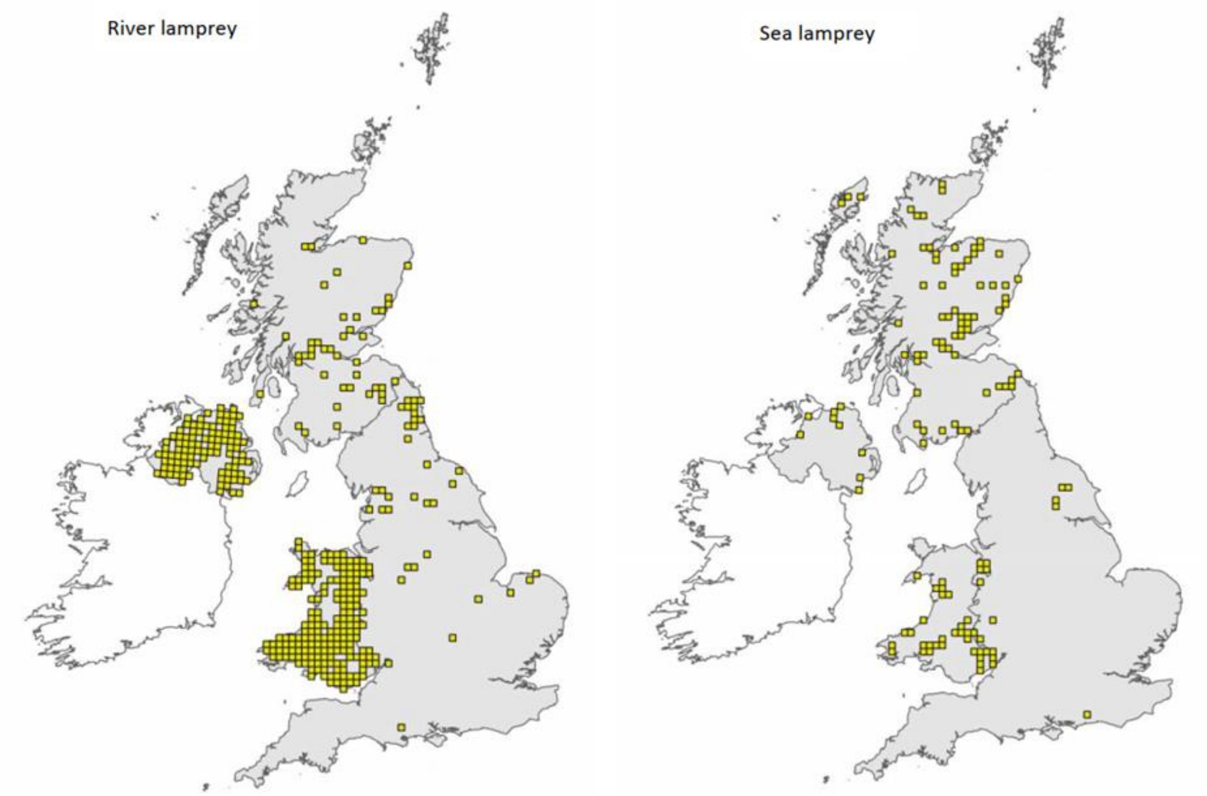

Plate 3.2 UK distribution of river lamprey and sea lamprey

European Smelt

3.7.25 The European smelt is an anadromous species that is occasionally recorded in nearshore waters but is most commonly found in lower river reaches and upper estuarine habitats (Heessen, Daan, & Ellis, 2015).

3.7.26 Smelt migrate into estuaries where they congregate in large shoals in lower reaches of an estuary to feed before moving to freshwaters to spawn in spring (Maitland, 2003);

post-larval juveniles then use estuarine nursery habitats. Smelt are thought to return to their natal river to spawn, although the degree of fidelity may not be as strong as other species such as Atlantic salmon (Torrissen, et al., 2013).

3.7.27 Once widespread in UK estuaries, the smelt is now listed as a SPI and FOCI as a result of significant population declines. Smelt is a FOCI for the Medway MCZ and is also present within the wider Thames and Swale Estuary MCZ. The Medway Estuary MCZ, which is located approximately 42 km west of the Offshore Scheme, was designated in 2019 for smelt as it is considered to provide critical habitat for this species.

3.7.28 Furthermore, within the Study Area, smelt are known to occur in a number of other river systems, including the River Thames which holds one of the largest known breeding grounds of smelt in the UK (Zoological Society of London, 2020). It is believed that adult smelt aggregate in the lower Thames estuary, in February and March, before commencing their upstream migration to spawn in March and April. Spawning is understood to occur in the area of Wandsworth Bridge, and 600 m upstream of this, before the larvae and juveniles passively move with the tide and become distributed throughout the estuary. Other rivers known to hold smelt within the Thames estuary include the River Blackwater, River Medway and River Crouch (Zoological Society of London, 2020). Furthermore, TraC data from 2013 to 2023 recorded high numbers of smelt across the Study Area, including the rivers previously mentioned, as well as River Alde and River Orwell. However, only five smelt were recorded in the River Stour (Essex) between 2013 and 2023, with no individuals recorded in the River Stour (Kent). A breeding population of smelt is also known to be present in the Ore & Alde estuary (Maitland, 2003).

Shad

3.7.29 Allis shad and twaite shad are very similar species, both members of the Clupeidae family. They occur in shallow coastal waters and estuaries but migrate further upstream to spawn in freshwater during late spring (April to June) (Maitland, 2003).

3.7.30 Spawning sites were historically recorded for allis shad in many rivers, including the Thames, although they are not thought to spawn there now (Zoological Society of London, 2020). Twaite shad is recorded as migrating through the Tidal Thames (Zoological Society of London, 2020). However, this species has been found in low abundance within the Outer Thames Estuary (Galloper Wind Farm Ltd, 2011). TraC data between 1992 and 2023 showed a single Allis shad recorded in the River Stour in 2011 and a single Twite shad recorded in the River Alde in 2011. These data suggest that both shad species are present in low abundance within the Study Area. The presence of shad at sea is very poorly understood, but the species appears to be mainly coastal and pelagic in habit (Maitland, 2003).

Pelagic fish species

3.7.31 Pelagic species are highly mobile fish that live within the water column often in large shoals. Clupeids (i.e., herring*)*, and sprat, (*Sprattus sprattus*) are the most common species within the Study Area, whilst mackerel (*Scomber scombrus*) has a seasonal presence. All three species are of commercial importance with herring and mackerel also being of national conservation importance. Clupeids possess a swim bladder which is directly involved in hearing and can make them vulnerable to anthropogenic underwater noise. Mackerel do not have a swim bladder and are therefore less sensitive to underwater noise. Other pelagic species known to be present within the Study Area include scad (*Decapterus macarellus*), lesser weever fish (*Echiichthys vipera*) and horse mackerel (*Trachurus trachurus*).

Herring

3.7.32 Herring is an important commercial species and represents a significant prey species for many predators, including large gadoids (such as cod), dogfish, sharks, marine mammals and birds (ICES, 2006a). Herring is a pelagic fish and is found mostly in continental shelf areas to depths of 200 m (Whitehead, 1986). Juveniles are generally distributed separately from adults, being found in shallower water, migrating into deeper waters to join the adult stock after two years. In the North Sea 1-group[8] herring are restricted within the 100 m depth contour and are most abundant in the south-east along the British east coast (ICES, 2006a).

3.7.33 Herring are demersal spawners, which means when spawning occurs, large numbers of eggs are released (~50,000 per female) near the seafloor, which sink and attach to gravel, stones, and shells where they form a dense mat. Herring spawning takes place in areas of well-mixed waters in open seas, coastal waters, and embayments (Heessen, Daan, & Ellis, 2015). Once they have developed into juvenile fish, herring aggregate into shoals that migrate into estuaries and shallow waters where they remain for six months to a year (Dipper, 2001). After their first year, herring move offshore, joining the adult populations as they reach maturity (Heessen, Daan, & Ellis, 2015).

3.7.34 Herring exhibit a complex population structure in the North Sea comprising three principal stocks: the Buchan/Shetland herring stock, Banks or Dogger herring stock and the Southern Bight or Downs herring stock. These stocks share foraging grounds for much of the year but are spatially and temporally differentiated by their spawning grounds and migration patterns and nursery areas (KEIFCA, 2022). The Southern Bight or Downs herring stock is located within the Study Area and is known to spawn in the English Channel from November until January (Fishsite, 2010). These three stocks represent the bulk of the North Sea herring stock, but some spawning also occurs in spring with their spawning grounds being described on a finer scale (ICES, 2006a). One of these discrete inshore herring stocks is the Blackwater and Thames stock, which is a self-contained stock located within the Study Area. Further details on the spawning and nurseries of these herring stocks are provided below and in the **Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**.

Sprat

3.7.35 Sprat is a short-lived, small-bodied pelagic schooling species that is relatively abundant in shallow waters. Sprat is an important food resource for a number of commercially important predatory fish, as well as seabirds and marine mammals.

3.7.36 Sprat are thought to be intermediate, multiple batch spawners, batches of eggs released repeatedly throughout the spawning period (Heessen, Daan, & Ellis, 2015). Spawning occurs in coastal waters up to 100 km offshore, and in deep basins (Whitehead, 1986; Nissling, Muller, & Hinrichsen, 2003). Once released, the eggs and larvae, which are pelagic, move into coastal nursery areas by larval drift (Hinrichsen, Kraus, Voss, Stepputtis, & Baumann, 2005; Nissling, Muller, & Hinrichsen, 2003).

[8] Fish in the second year of their lives, which are identified as having a winter (hyaline) otolith ring

3.7.37 The Offshore Scheme overlaps with important spawning and nursery grounds for sprat (Coull, Johnstone, & Rogers, 1998). Sprat is particularly abundant in shallow areas in the North Sea and is fished commercially, primarily for use in fish meal and as bait (ICES, 2006b). In the North Sea (ICES Subarea IIVa and IV) official landings of sprat in 2021 in the southern North Sea (ICES division IVc) totalled 3,989 tonnes which is comparatively lower than the total lands recorded in the same year in the central North Sea (75,464 tonnes in 2021) (ICES, 2022).

Mackerel

3.7.38 Atlantic mackerel (*Scomber scombrus)* is a widely distributed migratory fish and is one of the most abundant fish species in the North Atlantic (ICES, 2011). Mackerel spend their entire life in the pelagic environment and are an important food source for sharks, tuna and dolphins (Tappin, et al., 2011). This species is also exploited by commercial fisheries, which in the past has caused the collapse of abundant stocks in the North Sea (ICES, 2006c).

3.7.39 Mackerel are batch spawners and have pelagic eggs and larvae (Murua & Saborido-Rey, 2003). Mackerel in the eastern Atlantic is divided into three spawning components, the North Sea being one of these (ICES, 2011). However, the Study Area does not fall into these spawning areas (Ellis, Milligan, Readdy, Taylor, & Brown, 2012). The main spawning period for mackerel occurs between mid-May to late June, taking place particularly in the central North Sea located in deep waters outside the Study Area (Jansen & Gislason, 2011). Juveniles then remain in nursery areas in the shallow waters of the Southern Bight, which is located within the Study Area. The Study Area is therefore considered to be an important nursery ground for mackerel (Ellis, Milligan, Readdy, Taylor, & Brown, 2012).

Demersal fish species

3.7.40 Demersal species are defined as those species that live both on (epibenthic) and near (benthic or bentho-pelagic) the seabed. Sandeel, whiting, Dover sole, and plaice (*Pleuronectes platessa)* are all priority species listed under Section 41 of the 2006 NERC Act, whilst cod (*Gadus morhua)* is included on OSPAR's list of threatened/declining species and is also classified as 'vulnerable' on the IUCN Red List.

3.7.41 Whiting, Dover sole, plaice, poor cod (*Trisopterus minutus*) and European sea bass (*Dicentrarchus labrax*) are also of commercial importance. Other demersal species present within the Study Area include lesser weaver fish (*Echiichthys vipera*) and Mediterranean scaldfish (*Arnoglossus laterna*). Mention is also made of a number of other demersal species within the Study Area, including lemon sole, dab (*Limanda limanda)* and gobies *sp. (Gobiidae),* but as they are present only in low abundance a detailed baseline is not provided.

Sandeel

3.7.42 Five sandeel species occur in the North Sea, including Raitt's sandeel (*Ammodytes marinus)* which is the most common although the lesser sandeel (*Ammodytes tobianus)* and great sandeel (*Hyperoplus lanceolatus)* are also prevalent. Sandeels are an important element of the food chain in the north Atlantic, as prey for other fish species, sea birds and marine mammals (Dipper, 2001). In the central and southern North Sea (ICES Divisions IVb and IVc) sandeel fisheries have been divided into 'Sandeel Areas';

Sandeel Area 2r, in the central and southern North Sea, overlaps with the Study Area (ICES, 2022).

3.7.43 Sandeel spend a large proportion of the year buried in the sediment, only emerging into the water column to spawn briefly in winter (between November to February), and for an extended feeding period during the spring and summer months (Van der Kooij, Scott, & Mackinson, 2008). The distribution of sandeel (referring to all species within the genus *Ammodytes*) is highly patchy due to their preference for sandy habitats in well oxygenated waters, favouring coarse sand with fine to medium gravel and a low silt content (Holland G. J., Greenstreet, Gibb, Fraser, & Robertson, 2005). Populations are also associated with seabed morphological features such as subtidal sandbanks, as stated in MarineSpace et al. (2013a). Sandeel are demersal spawners; the presence of spawning grounds in the Study Area is considered below.

3.7.44 Great sandeel spawn from late spring to summer, Raitt's sandeel between November to February, whilst the lesser sandeel may spawn both in spring and autumn (Heessen, Daan, & Ellis, 2015). Once hatched, the larvae are pelagic, spending their time in the water column (undertaking vertical migrations that are influenced by light) until they develop into juveniles in the winter when they burrow into the sediment (Limpenny S. E., et al., 1966).

3.7.45 Much of the Outer Thames Estuary area is characterised (with medium confidence) by sediments representative of preferred sandeel habitat (MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd, & Marine Ecological Surveys Ltd, 2013b). These habitats include Margate and Long Sands Special Area of Conservation (SAC) which is located approximately 2 km from the Offshore Scheme and is designated for the protection of the Annex I habitat 'sandbanks which are slightly covered by sea water all the time' which is preferred sandeel habitat. However, the Offshore Scheme does not fall within the SAC. The Study Area has been identified as within an area of low intensity spawning and nursery grounds for sandeel (Ellis, Milligan, Readdy, Taylor, & Brown, 2012). Furthermore, MMT 2021 benthic characterisation surveys carried out for the Offshore Scheme identified preferred and marginal sandeel habitat which is discussed further below and in **Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**, and further information on these sites are described in **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology**.

Whiting

3.7.46 Whiting is a bentho-pelagic species found in association with a variety of seabed types including sediment and rocky areas (Barnes, 2008). Overall, whiting do not make long-distance migrations from spawning sites (Heessen, Daan, & Ellis, 2015).

3.7.47 Whiting are broadcast spawners, releasing eggs to the water column from February to June (Coull, Johnstone, & Rogers, 1998), peaking in spring in shallow waters (Wheeler, 1978). Most whiting spawning occurs in water depths less than 100 m (Heessen, Daan, & Ellis, 2015). González-Irusta and Wright (2016) states that whiting shows a high plasticity in spawning ground selection, with extensive areas of spawning occurring across the North Sea. The Study Area is located within low intensity nursery grounds for whiting (Ellis, Milligan, Readdy, Taylor, & Brown, 2012).

Dover sole

3.7.48 Dover sole is a southern species whose northern limit is in the North Sea. It favours sandy and sandy muddy substrates, within which to bury, in water depths up to 50 m.

The spatial distribution of Dover sole varies between life stages, with juveniles favouring coastal nursery grounds and older and larger individuals occupying deeper offshore waters (Teal, 2011).

3.7.49 Spawning in the North Sea typically occurs between March and June, peaking in April, in inshore areas such as estuaries (Tappin, et al., 2011). The pelagic eggs drift into high productivity shallow sandy nursery grounds, which provide a good feeding ground for juveniles (Dipper, 2001).

3.7.50 The Study Area is considered to be an area of high intensity spawning and nursery grounds for Dover sole (Ellis, Milligan, Readdy, Taylor, & Brown, 2012).

Plaice

3.7.51 Plaice are found on all UK coasts, normally on sandy substrata, as well as gravel and mud (Tappin, et al., 2011). Plaice generally spawn between January and April, at depths of between 20 m and 40 m, releasing high numbers of pelagic eggs. Following spawning, plaice reach their peak densities in May, and in June and July older fish tend to migrate offshore, whilst juveniles remain in the intertidal zone until autumn (Kuipers, 1977).

3.7.52 Coastal and inshore waters of the North Sea represent important nursery areas for plaice, although the Study Area only occurs within low intensity nursery grounds for this species. The Study Area does occur within high intensity spawning grounds though plaice are pelagic spawners, releasing eggs into the water column to be transported by water currents, not benthic spawners like herring and sandeel (Ellis, Milligan, Readdy, Taylor, & Brown, 2012).

Cod

3.7.53 Cod are widely distributed throughout the North Sea, found in shallow coastal waters to the shelf edge (200 m depth). From late winter to early spring, adult cod migrate to offshore spawning grounds, typically at depths of 20 m to 100 m in the North Sea (Dipper, 2001).

3.7.54 Modelling of spawning habitat using the abundance of spawning fish, indicated that cod spawning is widespread throughout the North Sea, associated with coarse sand and low tidal flow (González-Irusta & Wright, 2016). Cod spawning occurs between January and May in the southern North Sea, with peak spawning in February to March (Sundby, et al., 2017). The eggs and larvae of cod remain in the water column, developing into juvenile fish within six months. Juveniles then move to the seabed, often between July and August, when they become demersal (Heessen & Daan, Cod distribution and temperature in the North Sea, 1994). Juvenile cod then move into coastal nursery areas once the spawning season is over, with young cod often found in estuaries and shallow waters.

3.7.55 The Study Area is within an area of low intensity spawning and nursery grounds for cod Ellis et al., (2012). However, cod in this area is not thought to constitute a significant proportion of the UK population due to substantial stock reductions in the southern North Sea over the last 30 years (ICES, 2017).

European sea bass

3.7.56 Sea bass (*Dicentrarchus labrax*) are widely distributed across the North Sea but are primarily located in the southern North Sea (Heessen, Daan, & Ellis, 2015). This species is usually present in coastal inshore waters during the summer and uses a range of habitats including sand banks and gravel and rocky areas. In winter, seabass aggregate and migrate offshore and remain offshore throughout the winter season until they are ready to spawn in spring (between February and June). The geographic extent of spawning is thought to be bounded approximately by a minimum temperature of 9°C and can expand as the season progresses and in warmer years (Kieran , et al., 2018). The eggs and larvae of seabass are planktonic; once released, they are carried by inshore currents to nursery grounds within estuaries and shallow coastal waters.

3.7.57 The south-east coast is recognised as being important nursery grounds for sea bass. A recent study carried out by Kieran *et al.,* (2018), re-assessed existing Bass Nursery Areas (BNAs) and identified additional proposed new BNAs across England and Scotland. A number of BNAs were identified within the Study Area including:

- Alde and Ore Estuary;
- Stour and Orwell Estuary;
- Crouch and Roach Estuary;
- Thames and Medways Estuary;
- Blackwater and Clone Estuary;
- Hamford Water; and
- Grain Power Station Outfall.

3.7.58 Sea bass is a key species for both commercial and recreational fisheries. TraC data from 2013 to 2023 recorded high numbers of sea bass within the southern North Sea. The TraC data identified sea bass in a number if rivers and estuaries including the Alde and Ore Estuary, Blackwater Estuary, River Crouch, River Medway, Orwell Estuary, River Stour and Thames Estuary. The highest number of sea bass was 944 individuals caught in the middle River Thames in 2007; however, this number has significantly reduced in recent years. Due to notable stock declines in recent years, sea bass is currently under special management measures that limit the recreational fishery in the Southern North Sea (ICES Division IVc) to catch and release only during the periods 1 January to 29 February and 1 December to 31 December, whilst various restrictions have been imposed on the commercial fishery (MMO, 2021).

Lesser weever fish

3.7.59 Lesser weever fish is a venomous weever of the family Trachinidae. It is widespread across the Eastern Atlantic and North Sea (Roux, 1990). Lesser weever fish can be found in the shallow waters of the North Sea, typically at depths of up to 150 meters (Roux, 1990). They prefer sandy or muddy seabeds and can also be found near rocky areas. They are carnivorous and feed mainly on small crustaceans, such as shrimp and krill, as well as small fish and squid (Roux, 1990).

3.7.60 The breeding season of the lesser weever fish occurs from May to September (Scott & Henderson, 2016) they are pelagic spawners; however, little is known about the location of their spawning or nursery grounds.

3.7.61 TraC data from 1992 to 2023 recorded a total of 172 individuals within the south-east coast of England. However, most of these individuals were recorded far north in the Lincolnshire coast near the Humber Estuary. Small numbers (1 to 2 individuals) were recorded in the Thames Estuary, River Medway, River Stour and River Alde. This suggests that lesser weever fish may be present within the Study Area in low numbers.

Mediterranean scaldfish

3.7.62 Mediterranean scaldfish is found throughout European waters and is predominantly found along the southern and westerns coasts of UK but can also occur along the east coast of Scotland and England in smaller numbers (Ruiz, rnoglossus laterna Scaldfish. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, 2007). This species is mostly found on mixed or muddy bottoms from 10 to 200 m; however, it usually prefers the depth range of 10–100 m (Ruiz, rnoglossus laterna Scaldfish. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, 2007).

3.7.63 Although some studies have been carried out on this species for the same geographic area, there is very limited information on Mediterranean scaldfish movements, first maturity size and age, spawning or reproductive cycle of this species. This is likely because of its inferior commercial fisheries importance (i.e. it is a discard species).

Poor cod

3.7.64 Poor cod is found all around the UK coasts, with its range extending into the northern European waters such as the Baltic Sea and the North Atlantic (Ruiz, 2008). This species occurs mainly from 15 m to 200 m on sandy or muddy seabed. However, the species can also be found congregating in deeper waters around wrecks and large crevices in rocky areas (Ruiz, 2008). There is very limited information on the spawning and reproductive cycle of this species in the North Sea.

3.7.65 TraC data from the south-east coast of England recorded this species in the Orwell and Stour Estuary between 2007 and 2010, and therefore this species is known to be present within the Study Area.

Elasmobranchs

3.7.66 Elasmobranchs (i.e., sharks, skates and rays) are cartilaginous fish that form part of the mixed demersal fisheries. They are slow growing, late maturing, and possess a low fecundity compared with teleost fish. Females produce limited numbers of young which means recruitment is closely related to the numbers of adult females (Fowler, Reed, & Dipper, 2002). Many of the rajiids (skates and rays) are targeted commercially while species of the triakid sharks (e.g., tope) are important to recreational fisheries. Elasmobranchs that have been identified as being located within the Study Area include basking shark (*Cetorhinus maximus)*, thorrnback ray (*Raja clavate)*, spotted ray (*Raja montagui*) and blonde ray (*Raja brachyura)*, starry ray (*Amblyraja radiata),* Common skate (*Dipturus batis)*, cuckoo ray (*Laucoraja naevus)*, undulate ray (*Raja undulata)* and common stingray (*Dasyatis pastinca),* lesser-spotted dogfish (*Scyliorhinus canicular)*, spurdog (S*qualus acanthias)*, tope (*Galeorhinus galeus)*, smooth hound (*Mustelus mustelus)* and starry smooth hound (*Mustelus asterias)*.

Basking shark

3.7.67 The basking shark is large pelagic migratory species, listed under Schedule 5 of the Wildlife and Countryside Act 1981, with a distribution concentrated around the north and southwest coasts of the UK (Witt, et al., 2012). Basking shark are present in the North Sea, but observations are relatively rare (Witt, et al., 2012). There have been no sightings around the Southern bight, indicating negligible presence of basking shark in the Study Area. This agrees with a habitat suitability modelling study by Austin *et al.* (2019) study which identifies the Study Area as having a very low habitat suitability (<0.5) for basking shark.

Skates and rays

3.7.68 Thorrnback ray, spotted ray and blonde ray are oviparous demersal spawners, laying successive batches of eggs typically at inshore areas characterised by sandy/muddy substrates (Heessen, Daan, & Ellis, 2015). The spawning season for these species is between February and September with peak spawning for thornback ray in May and June. Peak spawning occurs slightly later in the year for the other ray species. There is insufficient information in the literature to delineate spawning grounds for these species (Ellis, Milligan, Readdy, Taylor, & Brown, 2012).

3.7.69 Thornback ray is one of the most abundant and commercially important elasmobranch species in UK waters with a large fishery operating in the Outer Thames Estuary. The Study Area overlaps with ICES rectangles 32F1, 32F2, 31F1 and 33F1 (hereafter referred to as 'relevant ICES rectangles'). UK fleet landing stock data for the relevant ICES rectangles show a total landed live weight of 148.4 tonnes of thornback ray were recorded between 2016 and 2020. Tagging work in the Thames Estuary found adults were widely distributed across the southern North Sea during the autumn and winter and favoured 20 – 35 m depth waters with small-scale seasonal movements to shallower waters (<20 m) in the Inner Thames Estuary for spawning in spring (peak May/June) (Ellis, Milligan, Readdy, Taylor, & Brown, 2012).

Dogfish and small elasmobranchs

3.7.70 The lesser-spotted dogfish is one of the most abundant shark species in the North Sea (Heessen, Daan, & Ellis, 2015). Other species known to be present, but in lower abundance, includes spurdog, tope, smooth hound and starry smooth hound. Dogfish and smooth hounds are predominately coastal species. The lesser-spotted dogfish is an oviparous demersal spawner, laying successive batches of eggs, anchoring them to macroalgae and other sessile features on the seabed. This species exhibits a protracted spawning period between November and July, peaking in June and July (Heessen, Daan, & Ellis, 2015). The spawning and nursery grounds of lesser-spotted dogfish are difficult to report due to insufficient information in the literature.

3.7.71 Spurdog, tope, smooth hound and starry smooth hound are all ovoviviparous or viviparous species (i.e., rear eggs or young within the body) and are therefore not affiliated with any particular habitat. Spawning grounds for these species are not well-defined although tope is thought to use inshore areas as nursery grounds. The Study Area occurs within low intensity nursery grounds for tope (Ellis, Milligan, Readdy, Taylor, & Brown, 2012).

Shellfish

3.7.72 Shellfish is a broad term used to describe a large group of, usually edible, marine invertebrates that possess an exoskeleton (e.g., crustaceans, molluscs, and echinoderms). Shellfish are usually benthic, demersal, subtidal and/or intertidal during their adult stages.

3.7.73 Fisheries landing data indicate that the Study Area is an important region for shellfish, notably common cockle (*Cerastoderma edule*) and common whelk (*Buccinum undatum*) which collectively comprise 57 % of the total live weight of fish and shellfish landed between 2016 and 2020 from the UK fleet landing stock data for the relevant ICES rectangles. Other commercially important and widely abundant shellfish species located within the Study Area include the great scallop (*Pecten maximus)*, native oyster (*Ostrea edulis)*, edible crab (*Cancer pagurus*) and blue mussel (*Mytilus edulis*) European lobster (*Homarus Gammarus*). Other less abundant and less commercially important shellfish species known to be present within the Study Area include queen scallops (*Aequipecten opercularis*), common razor shell (*Ensis ensis*), velvet swimming crab, (*Necora puber*), flying crab (*Liocarcinus holsatus*), spider crab (*Maja squinado*), Nephrops (*Nephrops norvegicus*) and brown shrimp (*Crangon crangon*).

3.7.74 No designated shellfish water protected areas[9] are located within the Offshore Scheme. However, a number of designated shellfish water protected areas are located within the Study Area, to the west of the Offshore Scheme: (in order of proximity) Alde (ID 8; 3.1 km), Margate (ID 29; 6.9 km), Outer Thames (ID 24; 7.8 km), Butley River (ID 9; 10.1 km) and Swalecliffe (ID 28; 11.7 km).

Common whelk

3.7.75 Common whelk is common in the North Sea and is extensively distributed along the UK coastline mainly sub tidally (Inland Fisheries and Conservation Authority, 2021). They are found primarily in muddy gravel or mud with mixed shell and is found either on the seabed surface or buried beneath the surface (Hemer, 2006). Spawning takes place from October to May and females move to hard substrate such as rocks, shells or stones to attach eggs (Inland Fisheries and Conservation Authority, 2021). UK fleet landing stock data show that a total landed weight of 5,409.9 tonnes of common whelk were recorded between 2016 and 2020 within the relevant ICES rectangles.

Common cockle

3.7.76 The common cockle is an infaunal suspension feeding bivalve that is distributed widely in estuaries and sandy bays throughout the UK, inhabiting sediments to a maximum depth of 5 cm in intertidal and subtidal areas (Seitz, Wennhage, Bergström, Lipcius, & Ysebaert, 2014). They favour clean sand, muddy sand, mud or muddy gravel and can often be found at high population densities (Tyler-Walters, Cerastoderma edule Common cockle. In: Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, Plymouth: Marine Biological Association of the United Kingdom. [Online]., 2007). Cockles reproduce by mass spawning events in late spring with spat reaching approximately 10 mm in length by the first winter.

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[9] Shellfish water protected areas designated for the protection of shellfish growth and production under Article 5 of the Shellfish Waters Directive (2006/113/EC).

3.7.77 Cockle harvesting is carried out throughout the Outer Thames Estuary and extends north along the Suffolk coastline and is divided into smaller management areas. The Study Area overlaps with several cockle management areas[10] including:

- Gunfleet Sands;
- Shingles & Long Sand;
- South Margate Sands; and
- North Margate Sand & Pan Sand.

3.7.78 Further information regarding the cockle fishery in the Outer Thames Estuary region can be found in **Application Document 6.2.4.8 Part 4 Marine Chapter 8 Commercial Fisheries.**

3.7.79 The IFCA carried out a recent study which involved carrying out targeted annual-season cockle stock surveys within a subset of the Outer Thames Cockle Management areas (IFCA, 2022). Two of the targeted survey areas fell within the Study Area. These targeted survey areas are not individually named but one is located just north of Margate approximately 12 km west of the Offshore Scheme and the other is located in Pegwell Bay located within the Offshore Scheme. Overall, the results in these two targeted survey areas showed relatively little cockle abundance in 2021 (IFCA, 2022).

3.7.80 The survey results showed that cockles were mainly distributed along the Maplin sands, which are located approximately 17 km east of the Offshore Scheme. These findings agree with longer term data from annual stock surveys carried out between 2011 and 2021 which show a similar pattern of distribution with the Maplin and Foulness Sands being the most important cockle fishing areas in the district in terms of their long-term contribution to the overall stock (IFCA, 2022). Margate and Long Sands SAC, which is located approximately 2 km from the Offshore Scheme, is also considered an important area for this species.

Blue mussel

3.7.81 Blue mussel is a commonly occurring species in the southern North Sea and the habitat ‘blue mussel beds’ is a qualifying interest feature of Goodwin Sands MCZ, Thanet Coast MCZ and blue mussels themselves are a qualifying interest species for Dover to Deal MCZ. This species was recorded during the Benthic Characterisation Survey carried out for the Offshore Scheme and was one of the top ten most abundant species recorded with a total of 4003 individuals recorded at an occurrence frequency of 15% across the survey area. Furthermore, the habitat ‘blue mussel beds’ was identified at grab sample site S007 and transects T001, T001A and T004. Further information on these sites is provided in **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology**.

Norway lobster

3.7.82 Norway lobster (*Nephrops norvegicus*) is a commercially important species that is distributed according to the extent of cohesive muddy sediments, in which they construct their burrows. The type of sediment also dictates the structure of the

[10] Cockle management areas are regulated by KEIFCA under the Thames Estuary Cockle Fishery Order (TECFO), 1994 (TECFO) and relevant byelaws. Note that there are additional cockle management areas located outside of the TECFO.

Nephrops populations, with areas of sandy mud having higher population densities. The North Sea is identified as a core habitat for Nephrops (Johnson, Lordan, & Power, 2013), however, the Study Area does not fall within ICES Nephrops 'Functional Units' (e.g. stocks) (ICES, 2022), and the Study Area does not fall within the spawning or nursery groups of this species (Ellis, Milligan, Readdy, Taylor, & Brown, 2012). Furthermore, this species was not recorded during the Subtidal Characterisation Survey 2021 carried out for the Offshore Scheme. Detailed information related to the Subtidal Characterisation Survey 2021 undertaken can be found in **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology.**

Scallop

3.7.83 In the North Sea, great scallop favour clean firm sand, fine or sandy gravel and depressions in the seabed but are occasionally found on muddy sand. They are active, epibenthic suspension feeders that occur at depths of between 10 m and 110 m, particularly in sheltered areas close to faster currents (Marshall, 2008).

3.7.84 Scallop spawning times vary from spring to autumn with some populations exhibiting two spawning peaks during this time. Larvae are planktonic for 30 days and may disperse over long distances before settling onto hydrozoans and/or bryozoans until they reach a size of approximately 1 mm to 5 mm. They then detach and settle onto the seabed (CEFAS, 2021a). Scallops are an important commercial species in the Study Area. Further detail is presented in **Application Document 6.2.4.9 Chapter 9 Part 4 Commercial fisheries.**

Native Oyster

3.7.85 Native oyster is widely distributed in UK waters and is recorded throughout the Thames Estuary and the southern North Sea. It is found within highly productive inshore waters and estuaries on firm substrates comprising of mud, muddy sand, rock, muddy gravel with shells and hard silt. Native oysters are sessile, epifaunal filter feeders found from the low intertidal to about depths of about 80 m (Perry & Jackson, 2017). Within the Study Area oysters are a designated feature of the Dover to Deal MCZ which is an important area for this species in south-east England.

3.7.86 Limited studies on the distribution of native oysters within the Study Area have been carried out; however they have been recorded within the Colne Estuary within the Blackwater, Crouch, Roach and Colne Estuary MCZ between January and November 2007 located approximately 40 km west of the Offshore Scheme (Allison, 2017).

Crabs

3.7.87 The edible crab is found in water depths between 25 m and 300 m in the North Sea, with a preference for bedrock, mixed coarse grounds, and offshore in muddy sands (Neal & Wilson, 2008). This species therefore has the potential to be present with the Study Area. Edible crabs copulate in the spring and summer, the female crabs becoming gravid, carrying their eggs under the abdomen. In the North Sea, brooding females migrate offshore to release their larvae, which once hatched remain in the water column for between 60 days and 90 days before settling. Tagging surveys off the coast of Norfolk have shown that mature females undertake long-distance northerly migrations to the Yorkshire coast, although more recent studies suggested this may be a discrete population of edible crabs. Furthermore, this species was not recorded during the Subtidal Characterisation Survey 2021 carried out for the Offshore Scheme.

Detailed information related to the Subtidal Characterisation Survey 2021 undertaken can be found in **Application Document 6.2.4.3 Chapter 3 Part 4 Benthic Ecology**.

European Lobster

3.7.88 The European lobster is generally found from the intertidal zone to depths of 60 m and therefore has the potential to be found in coarse habitats within the Study Area. This species exhibits site fidelity, although home extents can range between 2 km and 10 km (Bannister, Addison, & Lovewell, 1994). Lobsters are solitary animals and inhabit holes and tunnels that they build below rocks and boulders (Wilson, 2008). Females can spawn annually or following a bi-annual pattern, with reproduction taking place during the summer (Atema, 1986). They do not make extensive migrations when berried (carrying eggs attached to its tail or exterior part) and hatching takes place in spring and early summer on the same grounds (Pawson, 1995). They do not make extensive migrations when berried (i.e., when carrying eggs attached to the tail or exterior part) and hatching takes place in spring and early summer on the same grounds.

3.7.89 UK fleet landing stock data show that a total landed weight of 80.54 tonnes of European lobster were recorded between 2016 and 2020 within the relevant ICES rectangles. Furthermore, the Subtidal Characterisation Survey 2021 carried out for the Offshore Scheme showed areas of potentially suitable habitat for lobster with the seabed between KP 14.062 to KP 30.998 and between KP 64.599 and KP 77.500 being characterised by a high reflectivity across the majority of the section interpreted to be associated with mixed and coarse sediments (i.e., cobbles and boulders). Grab sample site S031 also contained large cobbles and boulders which may be used by European lobster. Further detailed information related to the Subtidal Characterisation Survey 2021 undertaken can be found in **Application Document 6.2.4.3 Chapter 3 Part 4 Benthic Ecology**.

Cephalopods

3.7.90 Cephalopods are divided into two superorders; the *Decapodiformes* (squid and cuttlefish) and the *Octopodiformes* (octopus). These are short-lived carnivorous invertebrates with rapid growth rates. They have only one reproductive cycle, after which they die. They play an important role in marine food webs, acting as an important prey resource for fishes, seabirds, and marine mammals (Darmaillacq, Dickel, & Mather, Cephalopod cognition., 2014).

3.7.91 The southern North Sea is not an ideal habitat for most cephalopods due to its shallow water depth (De Heij & Baayen, 2005). The only species that is regularly found in large numbers in this region is the long-finned European common squid (*Alloteuthis subulate)*, which typically migrates into the southern North Sea in the summer. This species is considered the dominant cephalopod species in the region (Jereb, et al., 2015).

3.7.92 Other species recorded in the region are:

- Long-finned squids - veined squid (*Loligo forbesii*) and European squid (*Loligo vulgaris)*;
- Short-finned squids - European flying squid (*Todaropsis eblanae)*;
- Other species of squid - clubhook squid *(Onychoteuthis banksia)*;

- Bobtail squids - Atlantic bobtail (*Sepiola atlantica)*, common bobtail (*Sepietta oweniana)* and stout bobtail (*Rossia macrosoma)*;
- Cuttlefish - common cuttlefish (*Sepia officinalis)*; and
- Octopus - curled octopus (*Eledone cirrhosa)*.

3.7.93 These species are the only cephalopods to have been encountered in the southern North Sea during International Bottom Trawl Surveys and International Beam Trawl Surveys between 1996-2003 (De Heij & Baayen, 2005).

3.7.94 The most commercially important cephalopod species in U.K. waters is the veined squid (Boyle & Pierce, 1994) but the common cuttlefish is also important (Darmaillacq, Dickel, & Mather, Cephalopod cognition, 2014). Further information in relation to commercial fisheries for cephalopods is provided in **Application Document 6.2.4.8 Part 4 Marine Chapter 8 Commercial Fisheries**.

Long-finned squid

3.7.95 Long-finned squid are neritic and demersal species associated with coastal waters. Four species of long-finned squid are found in northern European waters and are commercially important: European common squid (*Alloteuthis subulata*), veined squid, and European squid (*Loligo vulgaris*).

3.7.96 The European common squid is widely distributed in the central and southern North Sea, and it migrates into shallower water during summer and into deeper, relatively warmer waters in winter (De Heij & Baayen, 2005). The European common squid is morphologically similar to the common squid, and some studies suggest that they may be intra-specific forms rather than true, separate species (Laptikhovsky, Salman, Önsoy, & Katağan, 2002). However, their distributions overlap significantly, and common squid is not typically found as far north as the European common squid (Laptikhovsky, Salman, Önsoy, & Katağan, 2002).

3.7.97 The veined squid is the largest and most northerly distributed of the long-finned squids, preferring shallow, coastal waters and continental shelf areas (Porteiro & Martins, 1994). It tends to avoid waters cooler than 8.5°C, and it is the most commercially important squid species in UK waters (Porteiro & Martins, 1994). The veined squid is often confused with the similar European squid *(Loligo vulgaris)*, which is slightly smaller and has a distribution that rarely extends into northern UK regions (Porteiro & Martins, 1994). Maturation of veined squid takes approximately a year, and there is a single extended breeding period from December to May, usually with two pulses of recruitment during this time (Pierce & Boyle, 1994). They are terminal spawners, laying their eggs in batches before dying (Guerra, Rocha, González, & Bückle, 2001). Recent studies suggest that individuals migrate inshore from deep waters in the winter months during the peak of spawning (Young, et al., 2004).

3.7.98 The European squid is relatively scarce in the southern North Sea but is most abundant in the region in late spring to summer (Hastie, et al., 2016). It is a benthic spawner, attaching egg masses to hard substrates. The winter spawning period in the North Sea is relatively short (Hastie, et al., 2016).

Short-finned squid

3.7.99 Short-finned squid are typically found in open, oceanic waters (Arkhipkin, 1993). The European flying squid (*Todarodes eblanae*), is a predator, found in both shallow coastal and deep oceanic environments from surface waters to depths of 4,500 m (Dawe, Beck, & Drew, 2001). This species is known to undertake significant diurnal migrations, feeding near the surface at night, with spawning reported to occur at depths ranging from 70 to 800 meters (Dawe, Beck, & Drew, 2001).

Other squid

3.7.100 Common clubhook squid *(Onychoteuthis banksii*) is one of the most abundant oceanic, epipelagic squid in the world. There is very little published information on the biology and ecology of this species, but it is occasionally caught around the UK. For example, this species has been recorded in the southern North Sea during International Bottom Trawl Surveys and International Beam Trawl Surveys between 1996-2003.

Bobtails

3.7.101 Bobtail squids, which are closely related to cuttlefish, are small and stout decapods. Even the larger species do not typically exceed 65 mm in total length. Seven species of bobtail squid are present in UK waters, and while they are abundant, they are too small to be commercially exploited. These species are typically found in shallow coastal waters and continental shelf areas over sandy or muddy seabeds and are classified as neritic, benthic species.

3.7.102 The bobtail squid species found in the southern North Sea are: Atlantic bobtail (*Sepiola atlantica*), common bobtail (*Sepietta oweniana*), and stout bobtail (*Rossia macrosoma*).

Cuttlefish

3.7.103 Cuttlefish are advanced carnivorous decapods that consume small fish and crustaceans. They use a distinct structure called the cuttlebone to regulate their buoyancy and are economically valuable in various regions. In the UK's waters, there exist three cuttlefish species: the common cuttlefish, the elegant cuttlefish (*Sepia elegans*), the pink cuttlefish (*Sepia orbignyana*).

3.7.104 The common cuttlefish is both the largest (with a mantle length of up to 400 mm) and the most commonly distributed (found on all British coastlines (Hastie, Joy, Pierce, & Yau, 1994). It is a neritic, demersal species, typically found in warm, shallow coastal waters, with a significant number encountered in the southern North Sea. The lifespan of the common cuttlefish is approximately two years and the spawning season lasts from early spring to mid-summer, with spawning typically taking place in water shallower than 30 m (Hastie, Joy, Pierce, & Yau, 1994). Mature individuals move inshore to spawn, with larger females migrating earlier in the season than smaller females (Hastie, Joy, Pierce, & Yau, 1994). The black eggs are attached in bunches to substrata on the seabed, with embryo development times increasing at cooler water temperatures, taking approximately 90 days at 15°C and just 40-45 days at 20°C.

Octopuses

3.7.105 In UK waters, most octopuses belong to the non-finned (incirrate) category, with only a few species in the deep seas being finned (cirrate). Little is known about the biology of these deep-sea species. Unlike decapods such as squids, sepiolids, and cuttlefish, octopuses possess eight legs with suction cup suckers. Several species of octopuses are present in UK waters, with the curled octopus (*Eledone cirrhosa*) being the most prevalent.

3.7.106 The curled octopus, is a small bottom-dwelling octopus found in shallow coastal waters, ranging from the lower shore to depths of 300 m, and can be found on various seabed types from soft mud to rocky bottoms (Boyle & Knobloch, 1983). The species' life cycle varies across its geographical distribution, with individuals in the North Sea displaying either a one-year or a two-year cycle depending on their growth and maturation rates (Boyle & Knobloch, 1983). From July to September (Boyle & Knobloch, 1983) females spawn, with death following shortly after they have laid their eggs. The eggs usually hatch between April and July (Jereb, et al., 2015).

Spawning and nursery grounds

3.7.107 The occurrence, distribution and abundance of many fish and shellfish within the Study Area is determined by their propensity to aggregate within specific areas to spawn. 'Spawning grounds' are defined either by the species behaviour and therefore may cover a wide area, or by specific habitat preferences (e.g., gravel), which may restrict spatial extent. Fish exhibit several modes of reproduction, the most common being broadcast spawning, where eggs and sperm are released into the water column (Ellis, Milligan, Readdy, Taylor, & Brown, 2012). Other species deposit egg-cases or egg mats onto the seafloor making them more vulnerable to seabed disturbance.

3.7.108 Fisheries sensitivity maps (Coull, Johnstone, & Rogers, 1998; Ellis, Milligan, Readdy, Taylor, & Brown, 2012; Aires, González-Irusta,, & Watret, 2014) provide information on spawning grounds (the location where eggs are released) and nursery grounds (the location where juveniles are common) for selected fish and shellfish species prevalent in the Study Area (Table 3.9 and Table 3.10). These data indicate that the Offshore Scheme is located within important spawning grounds for herring, sandeel, sprat, whiting, plaice, Dover sole, and lemon sole. Of these only herring and sandeel lay their eggs on the seabed.

3.7.109 High-intensity nursery grounds of herring and Dover sole were also identified within the Study Area, as were important grounds for sandeel. Seabass nursery grounds are also known to be present within the Study Area.

3.7.110 The spawning grounds for herring and sandeel, in the context of the Offshore Scheme, are shown in **Figure 6.4.43.4. Herring larvae spawning grounds** and **Figure 6.4.4.3.6. Sandeel larvae spawning grounds**. The nursery grounds of these species, in the context of the Offshore Scheme, are shown in **Figure 6.4.4.3.5. Herring nursery grounds and 6.4.4.3.7. Sandeel nursery grounds**.

Table 3.9 Spawning grounds within the Study Area

Species	Ellis *et al.* (2012)	Coull *et al.* (1998)	Spawning Ecology
Herring	Yes[11]	Yes	Demersal
Sandeel	Low intensity	Yes	Demersal

[11] The level of intensity for herring spawning grounds is not provided by Ellis *et al*. (2012), only the location of the spawning grounds and larval data for this species are provided. The level of intensity for whiting spawning grounds is also not provided for the area in the North Sea through which the Proposed Project passes.

Species	Ellis *et al.* (2012)	Coull *et al.* (1998)	Spawning Ecology
Sprat	n/a	Yes	Pelagic
Cod	Low intensity	No	Pelagic
Whiting	No	Yes	Pelagic
Plaice	High intensity	Yes	Pelagic
Dover sole	High intensity	Yes	Pelagic
Lemon sole	n/a	Yes	Pelagic

Table 3.10 Nursery grounds within the Study Area

Species	Ellis *et al.* (2012)	Coull *et al.* (1998)
Herring	High intensity	Yes
Sandeel	Low intensity	Yes
Sprat	n/a	Yes
Mackerel	Low intensity	Yes
Cod	Low intensity	Yes
Whiting	Low intensity	Yes
Plaice	Low intensity	Yes
Dover sole	High intensity and low intensity	Yes
Tope shark	Low intensity	n/a
Thornback ray	Low intensity	n/a
Lemon sole	n/a	Yes

3.7.111 Species such as sprat, whiting, plaice, plaice, Dover sole, and lemon sole are broadcast spawners, and as such eggs, once spawned, are pelagic and distributed through the water column and will therefore be carried by ocean currents, potentially distant from the Offshore Scheme and so are unlikely to be at risk of impacts.

3.7.112 On this basis, only herring and sandeel have been taken forward for detailed assessment of potential impacts in section 3.9. The spawning times for these species within the Study Area is shown in Table 3.11.

Table 3.11 Spawning times for sensitive demersal spawners in the Study Area

Fish species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Herring (Blackwater and Thames stock)		■	■	■	■							
Herring (Southern Bight or Downs herring stock)	■										■	■
Sandeel	■	■									■	■

3.7.113 A detailed analysis of herring and sandeel spawning can be found in **Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**. This also provides further detail in terms of the data sources used and the figures presented as part of the analysis.

3.7.114 The identification of potential herring and sandeel spawning habitat was compared against the Offshore Scheme ZoIs. The following definitions for the Project ZoIs of potential seabed sediment disturbance have been used to define the area over which the confidence scores are provided (based on the ZoIs provided in Table 3.13):

- Primary Impact Zone (PIZ): The zone within which impacts resulting from the direct disturbance to seabed habitats, such as from dragging the boulder clearance plough over the seabed surface occur – also known as the direct impact zone; and
- Secondary Impact Zone (SIZ): The footprint of effects arising as a result of the proposed construction and pre-construction activities not associated with the PIZ – also known as the indirect impact zone.

3.7.115 Suitable spawning habitat for herring was identified (using the Benthic Characterisation Survey 2021 data and EMODnet seabed substrate (250k) data) in the central and southern sections of the Offshore Scheme from KP31 and KP86. Outside of this area, the Offshore Scheme passes through multiple patches of marginal and preferred habitat, becoming more sporadic in the southern section of the cable route where there is more unsuitable habitat. However, the cable route does not overlap any important spawning grounds identified by Coull et al. (1998). The VMS data showed no pelagic fishing gear being used in areas overlapping the Offshore Scheme. Although IHLS larvae data was recorded in close proximity to the Offshore Scheme, these samples were low in abundance and taken opportunistically. There is considered to be strong larval drift from the Southern Bight and Downs spawning grounds in this location, due to strong currents within the English Channel. This was noted in the most recent IHLS report (ICES, 2019) for the survey data, which stated that "*in recent years, increasing numbers of Downs larvae have drifted further north than previously observed, such as into the Skagerrak*". Overall, the Offshore Scheme is not considered to overlap important spawning grounds for herring and heat map analysis identified the cable route as overlapping predominantly low confidence herring spawning.

3.7.116 For sandeel, the Offshore Scheme overlaps with low intensity sandeel spawning grounds identified by Ellis et al (2012) and the central section of the Offshore Scheme overlaps important sandeel spawning grounds identified by Coull et al. (1998) (KP35 to KP85). This section of important spawning grounds is generally found within the Outer Thames Estuary SPA boundary from KP53 to KP83, which is known to be important for sandeel spawning. The EMODnet seabed substrate (250k) data showed that the majority of preferred sandeel spawning habitat overlapped by the Offshore Scheme was located within the SPA between KP70 and KP83. There was also a generally conformity in the use of demersal gears (as per the VMS data) within the areas of important spawning grounds, indicating the potential presence of sandeel adults and spawning. However, preferred spawning habitat and spawning grounds are widespread and located across the English Channel through to the central North Sea, including very high confidence in sandeel spawning (as per the heat map analysis).

Commercial Fisheries

3.7.117 Species of commercial importance vary along the length of the Offshore Scheme depending on location. Details on commercial fisheries within the Study Area, including information on ports and fishing fleet characteristics, is provided within **Application Document 6.2.4.8 Part 4 Marine Chapter 8 Commercial Fisheries**.

3.7.118 The Offshore Scheme passes through the jurisdictions of two Inshore Fisheries and Conservation Authorities (IFCA); Kent Essex IFCA (KEIFCA) and Eastern IFCA for Suffolk. Within these areas there are several closed areas for bottom towed fishing gear. These include the prohibited use of dredges and trawls due to the presence of sensitive features. These features are:

- East Margate Sands;
- Thanet Coast SAC; and
- Margate and Long Sands.

Summary of Receptors

3.7.119 Fish and shellfish receptors taken forward for consideration in the appraisal along with their associated value have been determined based upon potential activity/receptor interactions and professional judgement. For the appraisal, those species considered to have the greatest sensitivity to a particular effect (high or medium sensitivity rating) have been assessed at the species level, whereas those species with lower sensitivity have been assessed either at a high taxonomic level (e.g., elasmobranchs) or by functional group (e.g., demersal, pelagic and migratory) as appropriate (

3.7.120 Table 3.12).

Table 3.12 Fish and shellfish ecology receptors considered and their assigned value

Receptor group	Species	Rationale	Sensitivity/Value
Migratory species	European eel, Atlantic salmon, brown trout, sea and river lamprey, European smelt and shad	• Species of international or national conservation importance. • European eel listed as 'critically endangered' on the IUCN Red List. • Atlantic salmon and river and sea lamprey are qualifying features of designated SACs. • Species sensitive to underwater sound disturbance and Electromagnetic Field (EMF). • Some species valuable economically (commercial species).	High
Pelagic fish species	Herring	• National conservation importance. • Presence of spawning and nursery grounds. • Sensitive to habitat disturbance and underwater sound. • Commercially and ecologically (prey species) important.	Medium
	Sprat	• Presence of spawning and nursery grounds. • Sensitive to underwater sound. • Commercially and ecologically (prey species) important.	Low
	Mackerel	• Low intensity nursery grounds.	Low

Receptor group	Species	Rationale	Sensitivity/Value
		• Commercially and ecologically (prey species) important.	
Demersal fish species	Sandeel	• National conservation importance (lesser sandeel a PMF). • High/Low intensity spawning and nursery areas. • Sensitive to increased suspended sediment concentration (SSC), smothering and habitat disturbance and/or loss. • Commercially and ecologically (prey species) important).	Medium
	Cod, lesser weever fish, Mediterranean scaldfish, poor cod, European seabass, European seabass, Dover sole and plaice	• International and/or national conservation importance. • Presence of spawning and nursery grounds. • Sensitive to increased SSC and underwater sound. • Valuable economically (commercial species).	Low/Medium
Elasmobranchs	All species except basking shark	• Low intensity nursery ground for thornback ray and spurdog overlap with the Offshore Scheme. • Some species are demersal and therefore considered sensitive to increased turbidity. • Thornback ray is a demersal spawner and therefore considered sensitive to smothering and habitat disturbance and/or loss. • Sensitive to EMF effect. • Some species of national and international conservation importance, e.g., a number of ray and	Medium

Receptor group	Species	Rationale	Sensitivity/Value
		skate species are listed as an OSPAR threatened or declining species. • Some species valuable economically (commercial species).	
	Basking shark	• Wildlife and Countryside Act 1981. • NERC Species of Principal Importance (SPI).	High
Shellfish of commercial and/or conservation importance	-	• There are important shellfish areas for common cockle, common whelk within the Study Area. • Some species, such as mussels, and life stages are epibenthic or demersal and therefore sensitive to increased turbidity, smothering and EMF effects. • European lobster, crabs and scallops valuable economically (commercial species).	Medium
General fish, shellfish and cephalopod communities not included above	-	• Common, ubiquitous and of low commercial importance. • Some species and life stages are demersal and therefore considered sensitive to increased turbidity and smothering. • Considered to have a high tolerance to change given their distribution and abundance.	Low

Future Baseline

3.7.121 Fish and shellfish in the central North Sea are primarily influenced by environmental conditions and commercial fishing activity. Historically, some species have experienced decline, or fluctuations, in population due to overexploitation from commercial fisheries. This includes European eel and smelt for example.

3.7.122 The use of the marine environment in the Study Area has also changed in more recent years with increased offshore infrastructure such as offshore windfarms, and subsea cables for electricity transmission and telecommunications.

3.7.123 The baseline level of fish and shellfish in the Study Area will continue to evolve as a result of global trends including climate change, and trends associated with changes in environmental and fisheries regulations and policies. For example, as water temperatures increase, this can lead to impacts on zooplankton as a food source for some species, meaning the range of fish species may also vary and extend further north.

3.7.124 The Offshore Scheme has an operational design life of approximately 40-60 years, and therefore within its lifetime populations and/or ranges of the species discussed in section 3.7 are likely to change and shift as a result of climate change. This can include changes in the prevalence of species or timing of spawning and other important lifecycle changes. For example, changes in water temperatures may result in species moving out of the Study Area as the range for their optimal habitat increases, for example into deeper waters or further north.

3.8 Proposed Project Design and Embedded Mitigation

3.8.1 The Proposed Project has been designed, as far as possible, following the mitigation hierarchy in order to, in the first instance, avoid or minimise fish and shellfish impacts and effects through the process of design development, and by embedding measures into the design of the Proposed Project.

3.8.2 As set out in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**, mitigation measures typically fall into one of the three categories: embedded measures; control and management measures; and mitigation measures.

Embedded Measures

3.8.3 Embedded measures have been integral in reducing the fish and shellfish effects of the Proposed Project. Measures that that have been incorporated are:

- Sensitive routeing and siting of infrastructure and temporary works;
- Commitments made within **Application Document 7.5.3.2 Appendix B Register of Environmental Actions and Commitments**; and
- For red-throated diver, a full seasonal restriction (1st November – 31st March) in the Outer Thames Estuary SPA. This restriction is relevant to all offshore cable installation activities, excluding the PLGR.   A reduced seasonal restriction (1st January – 31st March) is also in place for landfall cable installation activities at the Suffolk landfall in Aldeburgh. Therefore, the Proposed Project will also avoid the seasonal period for spawning herring and sandeel of November – January and November – February (respectively) within the Outer Thames Estuary SPA with regards to cable burial activities (excluding PLGR). Although PLGR activity is discounted from the seasonal restrictions, the impact will be highly temporary and limited to the 1 - 3 m PLGR swathe.

Control and Management Measures

3.8.4 The following measures have been included within **Application Document 7.5.3.1 Appendix A Outline Code of Construction Practice** relevant to the control and management of impacts that could affect fish and shellfish receptors:

- GM01 - designated (and as minimal as possible) anchoring areas and protocols shall be employed during marine operations to minimise physical disturbance of the seabed.
- GM03 - an offshore Construction Environmental Management Plan (CEMP) including an Emergency Spill Response Plan and Waste Management Plan, Marine Pollution Contingency Plan (MPCP), Shipboard Oil Pollution Emergency Plan (SOPEP) and a dropped objects procedure will be produced prior to installation.
- LVS01 - all project vessels shall adhere to the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention).
- LVS02 - all project vessels must comply with the International Regulations for Preventing Collisions at Sea (1972) (International Maritime Organisation (IMO), 1972) regulations relating to International Convention for the Prevention of Pollution from Ships (the MARPOL Convention 73/78) (IMO, 1983) with the aim of preventing and minimising pollution from ships and the International Convention for the Safety of Life at Sea (IMO, 1974).
- LVS05 - drilling fluids required for trenchless operations will be carefully managed to minimise the risk of breakouts into the marine environment. Specific avoidance measures would include:
  - the use of biodegradable drilling fluids (PLONOR substances) where practicable,
  - drilling fluids will be tested for contamination to determine possible reuse or disposal; and
  - If disposal is required drilling fluids would be transported by a licensed courier to a licensed waste disposal site.
- BE01 - a biosecurity plan will be produced for the project, following the latest guidance on INNS from the GB non-native species secretariat.
- BE02 - all project vessels will adhere to the International Maritime Organisation (IMO) Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (Biofouling Guidelines).
- BE03 - any material introduced into the marine environment, such as rock protection material, will be from a suitable source or cleaned to ensure no INNS can be introduced.
- FSF01 - the target depth of lowering (DOL) will be between 1 m to 2.5 m (subject to local geology and obstructions).
- MM01 - adherence to JNCC guidelines for marine mammals, where appropriate, regarding the minimisation of impacts from underwater sound generated from geophysical surveys (JNCC, 2017a) and UXO detonation (JNCC, 2017b).

3.9 Assessment of Impacts and Likely Significant Effects

3.9.1 The assessment of the effects of the Offshore Scheme on fish and shellfish receptors described in this section considers the embedded, control and management measures described in section 3.8.

Table 3.13 Summary of impact pathways and maximum design scenario

Potential Impact	Maximum Design Scenario
Construction	
Temporary physical disturbance to fish and shellfish habitat	**Suffolk Landfall** Total area of 0.0002 km^2 of disturbance from use of jack-up barge (JUB) at 4 HDD entry/exit point locations (50 m^2 at each HDD entry/exit point location).
	Kent Landfall Total area of 0.020892 km^2 of disturbance from the following: • 0.02 km^2 maximum area of excavator footprint in the upper intertidal; • 0.0002 km^2 of disturbance from use of JUB or back hoe dredger at 4 HDD entry/exit point locations (50 m^2 at each HDD entry/exit point location); • 0.000032 km^2 of disturbance from the use of a cable lay barge (at each anchor worked location); • 0.0003 km^2 of disturbance from the use of a temporary cofferdam at 4 HDD entry/exit point locations (0.000075 km^2 at each HDD entry/exit point); and • 0.00036 km^2 from the placement of concrete mattresses/rock bags at HDD entry/exit points. Assumed to be five per HDD exit (Rock bags/concrete mattresses measuring 0.3 m x 3.0 m x 6.0 m or 0.45 m x 3.0 m x 6.0 m). These will be removed approximately 1 week before cable pull-in, before permanent protection will be buried

Potential Impact	Maximum Design Scenario
	at the same location, leading to the same area of temporary disturbance.
	Offshore Scheme installation A number of pre-installation and cable installation activities will temporarily disturb seabed habitats. These activities include: • 0.36 km^2 of disturbance from the pre-lay grapnel run (maximum swathe of 3 m up to a length 120 km); • 0.35 km^2 of disturbance from sandwave lowering (pre-sweeping) (maximum swathe 20 m over a length of 17.56 km between KP96.32 to KP113.883)[12]; • 3.05 km^2 of disturbance from cable trenching. This may include various methods including ploughing[13], jet trenching, and/or mechanical trenching (maximum swathe of 25 m over a length up to122 km). The total area (including landfall and cable installation activities) of temporary physical disturbance is 3.05 km^2 (3.05073 km^2). This is considered to represent the PIZ, as per the herring and sandeel spawning assessment definitions provided by MarineSpace et al. (2013a; 2013b) guidelines.
Temporary increase in SSC and subsequent sediment deposition leading to contaminant mobilisation, increased turbidity and smothering effects on fish and shellfish	Disturbed sediment has been modelled and could be deposited up to 17 km from the Offshore Scheme cable route. This is based on the dispersion of fine sediment when installing the cable using a jet trencher. However, the majority of sediment will be deposited within 100 m, with any SSC and

[12] There is no designated disposal area, the sand will be deposited within the Offshore Scheme Boundary within the area of pre-sweeping in such a way that the local currents will not backfill the pre-sweep area prior to cable installation and protection. The mechanism to infill the rock trench and allow the seabed to revert to natural bedforms is by natural backfill and sediment circulation / deposition.

[13] Displacement plough and jet plough are considered unlikely methods to be used. However, the swathe of displacement plough (up to 25 m) has been used in the assessment as a worst-case scenario

Potential Impact	Maximum Design Scenario
	deposition beyond this distance considered to be negligible and below background. 100 m is considered to represent the SIZ for the Offshore Scheme, as per the herring and sandeel spawning assessment definitions provided by MarineSpace et al. (2013a; 2013b) guidelines.
Underwater sound (excluding UXO)	Underwater sound generating activities assessed include pre-installation geophysical survey activities, pre-installation clearance, cable installation via a range of different methods including trenching, placement of cable protection and vessel movements.
Underwater sound from UXO	An application for a separate Marine Licence in respect to UXO clearance will be made post submission when the exact number and type of detonations have been established.
Operation & Maintenance	
Permanent loss of fish and shellfish habitat due to placement of hard substrates on the seabed	Total area of 0.15 km^2 of permanent loss of habitat from the following options for external cable protection: • Placement of remedial rock berms in non-high-risk areas. Rock berms will be 7 m wide (no lowering) at the base giving a total area of loss of 0.084 km^2 over a length of 12 km. • 0.017 km^2 of loss from rock backfill over a length of 38 km in high-risk trench areas (between KP35 to KP 58, and between KP81.5 to KP96.5). • 0.00036 km^2 loss from the burial of concrete mattresses at Suffolk Landfall. • 0.05 km^2 of loss from concrete mattresses/rock berm protection at cable crossings. There are ten in-service cable crossings that will require protection (maximum footprint of 0.005 km^2 per crossing).
Disturbance to fish due to subsea cable EMF emissions	The Offshore Scheme has committed to the installation of two bundled HVDC cables.

Potential Impact	Maximum Design Scenario
Potential effects on fish and shellfish due to subsea cable thermal emissions	The Offshore Scheme has committed to the installation of two bundled HVDC cables.
Maintenance effects	The Offshore Scheme is designed for a lifespan of approximately 40-60 years. The cable system installation is designed such that a regular maintenance regime is not required to maintain the integrity of the link. See route preparation and cable installation, noting that durations and extents of activities will be significantly reduced.
Decommissioning	
Decommissioning effects	Offshore and landfall working hours will be continuous (24/7). An initial decommissioning plan will be written once the final route and installation methodology is engineered by the Contractor. This will be in accordance with all applicable legislation and best practice guidance at the time of compilation. Dependent on requirements at end of asset life, the redundant cables could either be recovered for recycling (in its entirety, or in parts), or left in-situ.

Construction Phase

Temporary physical disturbance to fish and shellfish habitat

3.9.2 There are a number of landfall, route preparation and cable installation activities that will temporarily disturb seabed habitats. This disturbance will result in short term physical disturbance to, and temporary loss of, seabed habitats and in some instances physical damage of less mobile receptors (e.g., eggs, larvae or some shellfish).

3.9.3 The total area of expected temporary disturbance at the Suffolk Landfall is 0.0002 km^2 and the Kent Landfall is 0.020532 km^2, and the largest area of temporary disturbance in the Offshore Scheme associated with cable trenching is 3.05 km^2. This gives the total area of temporary disturbance from the Offshore Scheme to be 3.070732 km^2. This represents a worst-case scenario, assuming equipment with the largest footprint will be used throughout the construction phase.

3.9.4 Sensitivity to the effects of habitat disturbance varies between receptors; mobile species and life stages are considered to have greater capacity to accommodate such changes through movement to undisturbed areas while sessile or less mobile species/life stages are considered less tolerant of such disturbance which may also result in physical damage in some instances.

3.9.5 Migratory fish (e.g., salmon, sea trout, sea and river lamprey, European eel and smelt) are not considered to have functional associations with seabed habitats due to their life history strategies and transient presence within the Offshore Scheme therefore potential effects of habitat disturbance and/or loss are not considered for this receptor group.

3.9.6 Pelagic spawners known to be present within the Study Area include sprat, cod, whiting and plaice. These pelagic spawners are considered to have low sensitivity to the temporary disturbance of the cable installation activities as recruitment of these species would be largely unaffected by direct disturbance of the seabed. As no distinguishable change from baseline conditions is expected for these pelagic receptors, they are not considered further in relation to this effect.

3.9.7 The subtidal benthic habitats identified along the Offshore Scheme were generally dominated by coarse sediments and sand (further details can be seen in **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology**). The northernmost sections of the route comprise primarily sand, mixed sediments, biogenic reef and a small area of mud. The center of the route comprises predominantly coarse sediment with a few small areas of sand. The southern section of the route comprises coarse sediment and sand with a few small areas of mixed sediment (**Figure 6.4.4.2.2 Subtidal Habitat Complexes** in **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology**).

3.9.8 Demersal species and demersal life stages (e.g., eggs, larvae, juveniles) are the most sensitive to effects from physical disturbance to and/or temporary loss of seabed habitat. Displacement is considered the most likely effect to adult life stages of demersal species although some physiological damage and/or mortality of less mobile shellfish species and demersal species such as sandeel and life stages such as eggs and, to a lesser extent larva of some species which exhibit high site fidelity, is possible.

3.9.9 Herring and sandeel are likely to be particularly sensitive to removal and degradation of spawning habitat because of their specific sediment requirements. Furthermore, the high site fidelity exhibited by sandeel also increases its potential sensitivity to benthic habitat loss at sub-population levels (Jensen, Rindorf, Wright, & Mosegaard, 2011). For detailed baseline information on these species see section 3.7.

Herring

Sensitivity

3.9.10 Herring are considered to be of medium value, representing an important food source for seabirds and marine mammals. However, their spawning grounds are highly sensitive to temporary physical disturbances, as their egg mats, which are laid on the seafloor, may be removed or damaged.

3.9.11 Construction phase activities which have the potential to temporarily disturb habitat, does not overlap any important spawning grounds for herring (**Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**). Furthermore, the Offshore Scheme PIZ and SIZ, passes primarily through low confidence potential herring spawning habitat. Therefore, based on the comprehensive analysis presented in **Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**, the data provides evidence to confirm that the Offshore Scheme is not considered an important area for herring spawning.

3.9.12 Herring do not exhibit strong fidelity to specific local spawning sites, in part due to the constant movement of sediments in nearshore environments. These habitats are highly dynamic, with shifting seabed habitats driven by tides and currents, which influence herring's flexibility in choosing spawning sites. In the area where the Offshore Scheme cable route overlaps potential herring spawning grounds, the natural instability of the seabed is expected to enhance habitat recovery after any disturbances. Additionally, since the cable will be buried rather than causing permanent scarring, the seabed is likely to return to its original condition, making it suitable for herring to spawn in the next spawning period.

Magnitude of impact

3.9.13 The total area of expected temporary disturbance from the Offshore Scheme which overlaps ‘preferred’/‘marginal’ herring spawning habitat, based on the EMODnet seabed substrate (250k) data, represents an area of 1.089 km^2 and 0.368 km^2, respectively. This is based on the worst-case scenario of using a jet trencher, with a maximum swathe width of 25 m.

3.9.14 The impact of physical disturbance to and/or temporary loss of herring spawning habitat is predicted to be of low magnitude, given that the habitat overlapped by this area of physical disturbance is not considered to be important for herring spawning.

Significance of the effect

3.9.15 This disturbance is unlikely to have a significant effect on overall herring abundance given the low importance of herring spawning habitat overlapping the Offshore Scheme, the recoverability of the habitat, and the potential for spawning to occur at these locations in the subsequent spawning season. Thus, the effect is predicted to be **minor** and therefore not significant.

Sandeel

Sensitivity

3.9.16 Sandeel are considered to be of medium value, representing an important food source for seabirds and marine mammals. Furthermore, sandeel are partly benthic species, spending much of their life histories buried in the seabed, particularly in Autumn where they remain buried in the seabed, only briefly emerging to spawn between November and February. Due to their association with the seabed, including the deposition of their egg matts, sandeel are considered to have a high sensitivity to temporary physical disturbance. Furthermore, the high site fidelity exhibited by sandeel also increases its potential sensitivity to benthic habitat loss at sub-population levels (Jensen, Rindorf, Wright, & Mosegaard, 2011).

3.9.17 Construction phase activities which have the potential to temporarily disturb habitat, does overlap with important sandeel spawning grounds identified by Coull et al., (1998) (**Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**). This coincides primarily with the Outer Thames Estuary SPA, where the Offshore Scheme PIZ was also identified to intersect preferred sandeel spawning habitat.

Magnitude of impact

3.9.18 Temporary disturbance as a result of cable construction activities overlapping ‘preferred’/‘marginal’ sandeel spawning habitat based on EMODnet seabed substrate

(250k) data, represents an area of 1.073 km^2 and 0.686 km^2.This is considered small in the context of the wider availability of suitable sandeel habitat within the Study Area (which covers the majority of the southern and central North Sea). Additionally, a seasonal restriction (1st November – 31st March) on offshore cable installation in relation to red-throated diver in the Outer Thames Estuary SPA will also avoid the sandeel spawning season (November to February). This area is considered to be the focus of important sandeel spawning overlapping the Offshore Scheme. This restriction is relevant to all offshore cable installation activities, excluding the PLGR. Although PLGR activity is discounted from the seasonal restrictions, the impact will be highly temporary and limited to the 1 - 3 m PLGR swathe. Overall, the magnitude of effect to sandeel from temporary physical disturbance is considered to be low.

3.9.19 Sand is a highly dynamic sediment type (particularly in nearshore areas) and is expected to recover to normal conditions following disturbance. The cables will be buried (rather than suffer scarring, such as that associated with dredging), meaning that any sandeel habitat will return within short to medium term to previous conditions and will be available for sandeel at this location following disturbance.

Significance of the effect

3.9.20 Overall, disturbance effects to sandeel are considered to be temporary, localised and small in spatial extent compared to the wide availability of alternative habitat within the Study Area. Cable installation activities will also avoid the key spawning period for sandeel in the Outer Thames Esutary SPA, where important sandeel spawning habitat is known to be present. Therefore, the effect is predicted to be **minor** and therefore not significant.

Shellfish

Sensitivity

3.9.21 Shellfish species including scallops and crab are more limited in their mobility than fish and are often less able to avoid or move away from areas where habitat disturbance is occurring. Some species are able to disperse over very short distances, while others are sessile. Due to these physiological constraints to dispersal, shellfish at all life stages are considered to have a medium to high sensitivity to physical damage associated with the route preparation and cable installation works (Tyler-Walters, 2007; Neal & Wilson, 2008).

3.9.22 The Offshore Scheme does overlap with coarse and rocky habitat located primarily in the nearshore areas close to both landfalls which would be suitable for species such as crabs and European lobster. The Offshore Scheme also overlaps sand dominated habitats located throughout the Offshore Scheme which would be suitable for species such as scallops. Therefore, these species are susceptible to disturbance from the construction activities. Despite this, sand and rocky habitat is widespread within the Study Area, meaning that there is a wide availability of alternative habitat for shellfish species.

Magnitude of impact

3.9.23 The temporary disturbance to shellfish habitat as a result of the Offshore Scheme construction activities will be temporary and localised in nature and based on the small-scale disturbance footprint is predicted to be of low magnitude. This is compared to the wide availability of suitable shellfish habitat surrounding the Offshore Scheme.

3.9.24 Although a small proportion of shellfish habitat would be disturbed under the footprint of the construction phase works, there would be no overlap with known or designated shellfish beds and therefore the impact of cable protection on associated shellfish populations would be of negligible magnitude.

Significance of the effect

3.9.25 Due to the temporary and localised nature of construction activities and the small-scale disturbance footprint, the physical disturbance and/or temporary loss of shellfish habitat is predicted to be **negligible** and therefore not significant.

Other Marine Fish

Sensitivity

3.9.26 All remaining fish receptors are considered to have a low to very high value and low sensitivity to temporary physical disturbance.

Magnitude of impact

3.9.27 Whilst other marine fish may be present (such as demersal fish species or species which deposit egg-cases and eggs), and some temporary avoidance of the affected area around the cable preparation and installation works is expected, disturbance will be temporary, short-term and limited in spatial extent. Thus, the impact of temporary physical disturbance to habitat is predicted to be of negligible magnitude.

Significance of the effect

3.9.28 Overall, disturbance associated with Offshore Scheme construction activities will be temporary, short-term and limited in spatial extent. Thus, the impact of physical disturbance to and/or temporary loss of habitat is predicted to be **negligible** and therefore not significant.

Temporary increase in SSC and subsequent sediment deposition leading to contaminant mobilisation, increased turbidity and smothering effects on fish and shellfish

3.9.29 Seabed disturbance from pre-installation and sediment installation activities have the potential to increase SSC and turbidity, creating a sediment plume in the water column that can travel away from the Offshore Scheme before the sediment is deposited on the seabed. There are several potential effects in fish and shellfish associated with increased SSC and sediment deposition. These include the clogging of respiratory apparatus such as gills, reduced feeding success of visual predators due to decreased visibility, the clogging of feeding apparatus, the mortality of eggs and larvae which are less tolerant to turbid conditions, and effects related to toxic conditions if sediments in suspension are contaminated. The movement and migration of fish could also be impacted by SSC.

3.9.30 The largest sediment plumes and highest levels of SSC will be associated with disturbance of sediments with a high proportion of fine particulate material, such as fine sands, muds and clays, that will remain in suspension longest and settle to the seabed more slowly. In comparison, coarser materials such as sand and gravel are expected to settle more quickly within a few hours of disturbance and within only a few tens of metres from the source.

3.9.31 The sensitivity of fish species to increased SSC and deposition varies depending on whether they are demersal or pelagic, and their life stage. Most fish species occupying the subtidal and offshore waters along the cable route are pelagic and/or of low sensitivity to SSC. Many shellfish species, such as edible crab and scallops, have a high tolerance to SSC (MarLIN, 2023). Herring and sandeel eggs are also considered to be tolerant to increased SSC, with adaption to natural variability in turbidity. Herring eggs have been shown to continue normal embryonic development in short-term high concentrations of up to 500 mg/l (Kiørboe, 1981).

3.9.32 Modelling has been undertaken to estimate the extent of sediment dispersion before deposition as a result of cable installation activities. The method for these calculations, and the results, are reported in further detail in **Application Document 6.2.4.1 Part 4 Marine Chapter 1 Physical Environment**. Based on this modelling, the highest dispersion is associated with jetting activities during cable installation. Therefore, effects from this activity have been assessed further as a worst-case scenario.

3.9.33 The effects resulting from pre-sweeping/sandwave levelling are captured within the modelling results provided due to the comparable sediment loss rates which are within the levels of uncertainty associated with estimating these inputs.

3.9.34 The sediment dispersion modelling showed that SSC levels generally remained below 300 mg/l, with high concentration only occurring in the first 24 hours of disturbance. SSC concentration of 100 mg/l were recorded as far as 11 km for fine sand, but these distances were associated with the resuspension of sediment at multiple locations, due to tidal currents, rather than a single large plume.

3.9.35 Herring and sandeel are demersal spawners and are regarded as being moderately sensitive to smothering effects from sediment deposition, which can have implications on spawning success and recruitment (Kjelland, Woodley, Swannack, & Smith, 2015). Therefore, this assessment has focused on the results of sediment deposition.

3.9.36 The maximum deposition over a 14-day period for a deposition thickness of 0.5 mm for both mud and fine sand was used to define the extent of the sediment deposition ZoI for the Proposed Project. The maximum ZoI was calculated as 17 km for fine sand. However, this depth is considered very small and equivalent to natural variability. This depth is also very small when compared to the herring and sandeel (lesser sandeel) egg diameters, which have been reported as 1.57 - 1.91 mm and 0.85 – 1.23 mm, respectively (Perrichon, 2023; Russel, 1976). Using this as a reference for potential effects, it is considered unlikely that 0.5 mm is likely to have a detrimental effect to either of these species.

3.9.37 The maximum deposition over a 14-day period represents a worst-case cumulative depth of deposition and when looking at the ‘snapshot’ at the end of the 14-day period, there is very little sediment on the seabed at the end of the model simulation (<0.1 mm). Temporary deposition of 0.5 - 10 mm was modelled as occurring within 2 km of the southern modelling sites (R5 and R6). However, any accumulation of sediment (which is generally only present for the first 24 hours) will be rapidly resuspended or swept away by tidal currents over very short timescales and returned to negligible levels within a maximum of 14-days.

3.9.38 On this basis, effects from sediment deposition have focused on coarser sediment types (medium sand, coarse sand, and gravel), which will deposit in higher depths but close to the cable route installation activities. Furthermore, gravel and sand represent the dominant sediment types which were recorded along the cable route. Coarse sediments will be deposited within a maximum distance of 20 m from the jet trencher. This is based on the known settling distance of these sediments. Some minor resuspension of sediment may occur over very short periods of time and distances, which is not captured by these settling estimates. Therefore, on a precautionary basis, the maximum distance within which potential effects from deposition may occur, is considered to be 100 m. This is the SIZ distance for the Offshore Scheme, as per the herring and sandeel spawning assessment definitions provided by MarineSpace et al. (2013a; 2013b) guidelines.

3.9.39 The potential effects on each of the fish and shellfish that have been identified within or have the potential to occur within the Offshore Scheme, are considered separately below.

Herring

Sensitivity

3.9.40 Sediment deposition on developing herring eggs has the potential to reduce oxygenation over the spawning period, with the potential to reduce the spawning success of the eggs due to limited gas exchange (Frost & Diele, 2022). Where deposition does occur on herring eggs, detrimental effects may occur (Birklund, 2005). However, areas of suitable herring habitat over which sediment may be deposited, is likely to be dynamic given its location in the nearshore and the absence of fine silts. Deposited sediment is expected to be regularly redistributed over short timescales, with herring eggs expected to be relatively tolerant of deposition within levels of natural variability. Therefore, herring are considered to have a medium sensitivity to increased sediment deposition.

Magnitude of impact

3.9.41 The SIZ area for cable preparation and construction activities (100 m distance from disturbance) as part of the Offshore Scheme represents an area of 3.649 km^2 and 2.965 km^2 identified as preferred / marginal herring spawning habitat, respectively. The Offshore Scheme is located away from the known Southern Bight herring stocks and discrete East Anglian spawning grounds to the north of the Suffolk landfall and sediment would not be deposited over known important grounds for herring spawning.

3.9.42 Furthermore, the majority of the sediment disturbed by construction and pre-construction activities will be deposited locally within 20 m (rather than up to 100 m, where there will be negligible levels of deposition) and would be redistributed to background levels between 24 hours and 14 days. The magnitude is therefore considered to be low.

Significance of the effect

3.9.43 Although the cable preparation and installation does occur within potential suitable herring spawning habitat, the secondary disturbance of these habitats from sediment will be highly localised and temporary. This disturbance is unlikely to have a significant effect on overall herring abundance given that the area is not known to be of particular importance to herring spawning habitat within the Study Area. Herring spawning is also considered to have a degree of tolerance to sediment deposition, given regular movements of sediment within this dynamic area with high tidal currents. Thus, the effect is predicted to be **minor** and therefore not significant.

Sandeel

Sensitivity

3.9.44 Sandeel eggs have the potential to be physiologically damaged due to sediment deposition and smothering with the potential for mortality to occur for eggs in the vicinity of the sediment plume.

3.9.45 However, sandeel are a burrowing species, spending the majority of the year under the surface of the sediment (Van der Kooij, Scott, & Mackinson, 2008). For example, the lesser sandeel (*Ammodytes tobianus*) spends the winter buried 20 – 50 cm deep in sand (Rowley, 2008). Eggs are also laid in the sand where they stick to sand grains, often in shallow waters (Ruiz, 2008; Rowley, 2008) where wave action is considered to regularly disturb the surrounding sediment.

3.9.46 As sandeel species spend a large proportion of time buried under sand, there is expected to be some habituation to increased levels of deposition and smothering, and habitats would recover following potential disturbance. Therefore, sandeel are considered to be a receptor of high value and their sensitivity is assessed as medium.

Magnitude of impact

3.9.47 The SIZ area for cable preparation and installation activities as part of the Offshore Scheme, overlaps an area of 8.524 km^2 and 5.611 km^2 identified as potential preferred / marginal sandeel spawning habitat, respectively. The area over which secondary disturbance effects will occur to sandeel spawning is considered small, particularly in the context of the wide availability of preferred spawning habitat across the southern and central North Sea.

3.9.48 Furthermore, a seasonal restriction (1st November – 31st March) on offshore cable installation in relation to red-throated diver in the Outer Thames Estuary SPA will avoid the sandeel spawning season (November to February). This area is considered to be the focus of important sandeel spawning overlapping the Offshore Scheme. This restriction is relevant to all offshore cable installation activities, excluding the PLGR. Although PLGR activity is discounted from the seasonal restrictions, any increase in SSC and deposition associated with the PLGR will be highly limited in volume due to the 1 - 3 m PLGR swathe. Moreover, due to the temporary nature of the PLGR any sediment deposition will likely be redistributed within 24 hours thus is not considered to impact spawning activities. All other cable installation activities will be subject to the seasonal restriction and thus any sediment deposited on important sandeel spawning habitat associated with these activities will be redistributed rapidly and so will no longer be present during the sandeel spawning season. Therefore, the magnitude is assessed as low.

Significance of the effect

3.9.49 The area of potential sandeel spawning habitat disturbed as a result of increased SSC and deposition from the construction activities is small in extent compared to the wide availability of preferred spawning habitat within the study area. Furthermore, sandeel are expected to have a degree of habituation to increased levels of SSC and smothering, particularly as the sediment to be disturbed as a result of the Proposed Project will also be predominantly sand. Overall, the impact is expected to be **minor** and not significant.

Diadromous Fish

Sensitivity

3.9.50 The Offshore Scheme located in the vicinity of several estuaries and rivers including the River Thames, Thames Estuary, River Stour (Essex and Kent), River Blackwater, River Alde and River Orewall, which are used by migratory fish such as salmon, brown trout, sea and river lamprey, European eels and allis and twaite shad and smelt. Salmonids can be sensitive to increased SSC through the reduce vision of prey (Abbotsford, 2021) whilst some species may avoid areas of high SSC and prevent fish from migrating into rivers (Kjelland, Woodley, Swannack, & Smith, 2015). Such species are considered to be of medium sensitivity to increased SSC, and of high value.

Magnitude of impact

3.9.51 The closest river to the Proposed Project is the River Stour (Kent). The River Stour flows through the onshore areas of the Proposed Project and flows into Pegwell Bay, adjacent to the Offshore Scheme. This river is known to be ultised by a number of diadromous fish species including, salmon and European eels.

3.9.52 The increase in SSC, turbidity and deposition associated with the construction activities of the Offshore Scheme therefore has the potential to be a barrier to migration between marine and freshwater environments, especially in relation to the River Stour as it is the closest river to the Proposed Project. However, the majority of these species identified as part of the baseline have been shown to spend the majority of their time in the upper reaches of the water column, so are unlikely to encounter mobilised sediment which is expected to occur closer to the seabed. Furthermore, the increase in SSC from installation will be very temporary, with most SSC returning to background conditions within 24 hours. The SSC will also be comparable to natural variations in sediment concentration in estuaries, which can be very high during periods of high turbidity. Therefore, due to the short-term nature of any increase in SSC occurring during the construction of the Offshore Scheme components, the magnitude of impacts of increased SSC on diadromous fish is predicted to be negligible.

Significance of the effect

3.9.53 The increase in SSC, turbidity and deposition associated with cable installation has the potential to be a barrier to migration between marine and freshwater environments. However, due to the short-term nature of any increase in SSC occurring during installation of the cable and the relatively low predicted concentrations of SSC compared to natural variability, the magnitude of impacts of increased SSC is predicted to be **negligible**. Therefore, the effect to migratory fish species is predicted to be not significant.

Shellfish

Sensitivity

3.9.54 Many crustacean species, including the European lobster which are present in the study area are known to have low sensitivity to, and be tolerant of, short-term increases in turbidity and SSC. Increased turbidity can affect shellfish foraging times, for example crabs have been observed spending more time searching for prey in periods of increased SSC due to decreased visual acuity (Wang, Cain, & Lohman, 2004). This can lead to avoidance behaviour when conditions become unfavourable to increase feeding success elsewhere (Neal & Wilson, 2008). Berried crustacean species including the European lobster also remain sedentary during egg-bearing, meaning they may be more sensitive to increased SSC and turbidity. During egg-bearing, avoidance of sediment disturbance may be more difficult. The eggs that are laid also require sufficient regular aeration, meaning a high level of deposition and smothering may have implications, making them likely to be highly sensitive to substantial levels of sediment deposition.

3.9.55 Mobile shellfish including crabs, scallops and lobsters are thought to tolerate a smothering depth of 5 cm over a month (Neal & Wilson, 2008). They can exhibit avoidance behaviour when conditions become unfavourable by moving away from the affected area and returning once the disturbance has stopped. Due to their mobility, adults are considered to have low sensitivity to increased SSC and its associated impacts.

3.9.56 Blue mussel beds were identified under the footprint of the Offshore Scheme (at grab sample sites and at several DDV transects at MMT-KP15.4 (**Application Document 6.3.4.3.A Benthic Characterisation Report)).** However, aggregations of this species comprised patches rather than continuous reef, and therefore, this habitat does not meet the qualifying criteria of Annex I habitat 'biogenic reefs' (1170) under the Habitats Directive (2017a). The impacts of increased SSC on blue mussel beds is assessed in **Application Document 6.2.4.3 Chapter 3 Part 4 Benthic Ecology**.

3.9.57 Overall, shellfish are considered a medium value receptor and are assessed as having a low sensitivity to increased SSC and deposition.

Magnitude of impact

3.9.58 The sediment dispersion modelling showed that SSC levels generally remained below 300 mg/l, with high concentration only occurring in the first 24 hours of disturbance. SSC concentration of 100 mg/l were recorded as far as 11 km for fine sand, but these distances were associated with the resuspension of sediment at multiple locations, due to tidal currents, rather than a single large plume. Therefore, any increase in SSC and deposition will be very temporary and unlikely will not result in a significant change compared to natural variability.

3.9.59 The overall magnitude of impacts to shellfish of commercial/conservation importance and shellfish beds created by an increase in SSC and deposition is considered to be negligible.

Significance of the effect

3.9.60 Any deposition of sediment associated with the Offshore Scheme construction activities, will be highly localised and short in duration and temporary. Shellfish species which may be present nearby will either be mobile and can move away from the area of disturbance or be habituated to sediment deposition and increased SSC, particularly those species which rely on suspension feeding. Overall, the effect is determined to be **negligible** and therefore not significant.

Other Marine Fish

3.9.61 The effects to all remaining fish and shellfish species identified in the study area, including general communities, caused by increased SSC is predicted to be of negligible magnitude for the construction phase of the Offshore Scheme. Combined with the low to medium value of fish and shellfish and low sensitivity, the duration of temporary increased SSC, and subsequent deposition of sediment, the effect is predicted to be **negligible** and therefore not significant.

Underwater sound (excluding UXO)

3.9.62 A number of activities undertaken during the construction phase of the Offshore Scheme will generate underwater sound. These will occur during pre-installation geophysical surveys, during the cable installation and may also occur for any maintenance or repair activities during the lifetime of the project. The impacts from these underwater sounds have the potential to affect fish. Note, shellfish have been scoped out at the scoping stage, as they are unlikely to be adversely impacted physiologically or behaviorally by the propagation of underwater sound and vibration (Solan, et al., 2016). Shellfish have not therefore, been included in the assessment of underwater sound.

Hearing and impacts of underwater sound in fish

3.9.63 Fish use sound for various essential functions, including communication, locating prey, and avoiding predators, making sound an important environmental cue (Fay & Popper, 2000). They perceive underwater sound through their ears and the lateral line system, also known as the acoustico-lateralis system, which is sensitive to vibrations. In some species of teleosts (bony fish), gas-filled sacs such as swim bladders play a role in sound detection (Hawkins, 1993). Sensitivity to sound differs among fish species depending on the frequency range they can detect. Their responses to sound also vary according to noise levels within these frequency ranges, with most fish unable to hear sounds above 1 kHz.

3.9.64 Fish sensitivity to underwater sound, and the potential impacts, are mainly determined by their physiology, particularly whether they have a swim bladder and whether it is specifically involved in hearing (Popper, et al., 2014). Several categories of fish, grouped according to their sensitivity to underwater noise have been developed. These are based on functional hearing groups established by Popper and Hawkins (2019) using the presence/absence of morphological features. The categories are:

- **High hearing sensitivity fish** – this group use a swim bladder or other gas volume to detect sound, perceiving both sound pressure and particle motion. These fish are vulnerable to barotrauma and sensitive to a broad frequency range (several kHz).

Species in this category within the study area include herring, Allis shad, and twaite shad;

- **Medium hearing sensitivity fish** – includes fish with swim bladders that do not aid in hearing. These species can detect particle motion but not sound pressure, and while still susceptible to barotrauma, they are sensitive to a narrower frequency range. Examples present in the study area include Atlantic salmon, sea trout, European smelt (*Osmerus eperlanus*) and European eel; and
- **Low hearing sensitivity fish** – this group lack a swim bladder or other gas chamber. They detect only particle motion and are less prone to barotrauma. Species in this category include flatfish, sharks, rays, skates, lamprey, and some species like sandeel.

3.9.65 The Study Area contains fish species which fall into all three of these categories, such as herring, protected migratory fish including salmon and smelt, and elasmobranchs, and also commercially important pelagic fish.

3.9.66 Herring is of particular importance due to it being a high hearing sensitivity fish species (Popper, et al., 2014), but also commercially and ecologically notable. Due to the presence of potential herring spawning grounds within the Study Area, the potential effect of underwater sound in spawning herring, and in eggs and larvae, are also scoped in for consideration.

3.9.67 Fish eggs and larvae are considered separately from adult fish in the threshold tables provided by Popper, et al., (2014), because of their vulnerability, reduced mobility, and small size. However, there are a few peer-reviewed papers that discuss the responses of eggs and larvae to man-made sound (Popper, et al., 2014). The available studies suggest that larvae have hearing ranges similar to adults and exhibit comparable startle responses (see Popper et al., (2014) and references therein). As larvae develop swim bladders or other gas-filled structures, they may become more susceptible to pressure-related injuries.

3.9.68 Nevertheless, the impact on eggs and larvae tends to occur over much shorter distances than adults. Studies on airgun impacts, which operate at much higher sound intensity than any activities associated with the proposed Project, indicate that mortality and tissue damage in eggs and larvae are likely only when they are in close proximity to the sound source (within 5 meters, with the most severe effects within 1.4 meters for peak sound pressure levels of 220–242 dB re 1 μPa @ 1 m) (Booman, et al., 1996). Popper (2014) also concluded that damage caused to fish eggs and larvae from geophysical surveys and impact piling is assumed to be limited to the proximity of a sound source.

3.9.69 The impact of underwater sound varies depending on several factors, including the intensity and nature of the sound produced, the distance of the receptor from the source, and environmental variable including water depth and seabed features. Potential effects have been summarised below:

- **Physical or physiological effects** – these include mortality and both recoverable and non-recoverable injuries. Physical injury, such as barotrauma (e.g., swim bladder rupture), which can be fatal, is generally limited to extreme cases where fish are exposed to very high sound pressure levels, such as produced by UXO detonations or military sonar. Recoverable injuries like haematomas or capillary dilation can still reduce fitness, making fish more susceptible to predation or disease (Popper, et al., 2014). There are however, no sound sources in the Proposed Project expected to result in such effects;

- **Auditory damage** – high-intensity or very long duration underwater sound can physically damage auditory structures, such as the inner ear, sensory hair cells, and otoliths (Parvin, Nedwell, & Workman, 2006). This can be permanent damage or injury, or it can result in a temporary threshold shift (TTS), which is a reversible increase in the threshold of audibility at a specified frequency or a portion of an individual's hearing range;
- **Masking** – underwater sound can interfere with important ecological sounds, potentially altering behavioural responses. For instance, juvenile fish may choose specific habitats based on sound cues, though the broader effects of masking on fish are not well understood; and
- **Behavioural responses** – these include changes in movement patterns, migration, feeding, breeding, and potential displacement from critical habitats

Sound Sources

3.9.70 Sound can be either impulsive in nature, such as that created by some high-resolution seabed imaging sources such as MBES and sub-bottom profiling or explosions during UXO clearance. Non-impulsive, or continuous sound sources, include cable installation activities via ploughing and dredging and sound from cable lay vessel movements including with the use of dynamic positioning (DP). The effect of man-made sounds on marine receptors depends on the intensity of the sound source (i.e., the amplitude of the sound pressure wave), the duration of the sound, the operating frequency, the surrounding environment (e.g., water depth) and the sensitivity of the receiving fauna.

3.9.71 For underwater sound impact appraisals, the metrics describing sound are sound pressure level (SPL) and sound exposure level (SEL) respectively. The SPL is a measure of the amplitude or intensity of a sound. For impulsive sound sources, SPL is typically measured as a peak value, though root-mean-square (rms) values are also often provided. In contrast, continuous or non-impulsive sounds are generally measured as rms SPL values. In contrast, the SEL is a time-integrated measurement of the sound energy, which takes account of the level of sound as well as the duration over which the sound is present in the acoustic environment.

3.9.72 The sound characteristics of the Offshore Scheme activities have been determined on the basis of a significant body of knowledge of many common sound generating activities, for which there is an extensive range of values in the literature and from previous projects (Table 3.14). Where a range of sound source levels was found a reasonable but realistic worst-case level has been assumed.

3.9.73 The sound sources produced by the Proposed Project, with their assumed sound intensity and operating frequency are given in Table 3.14 below, together with details of which sources have been scoped into the assessment for fish and shellfish.

Table 3.14 Sound source levels relevant to fish and shellfish

Survey or cable installation activity	Operating frequency (kHz)	Sound Pressure Level#	Sound source data reference	Scoped in for further assessment?
Swathe or multi-beam echo sounder (MBES)	170 - 450	221 235 (peak)	(Genesis, 2011)	**No** MBES in shallow waters (< 200 m) operates at high frequencies that fall outside the hearing range of fish, thus is not detectable and does not pose any risk of injury or disturbance.
Side scan sonar (SSS) (e.g., EdgeTech 4200 Series)	300 – 600	210 – 226	(Genesis, 2011) and equipment specification sheet	**No** Operates at high frequency, producing sound that is outside the range of hearing of all fish and so this activity can be scoped out of the assessment.
Sub-bottom profiling (SBP) (e.g., Innomar SES-2000, Edgetech Chirp & Applied Acoustics 201 boomer)	0.5 – 12	235 (peak)	Equipment specification sheets	**Yes** SBP operating frequency is within the hearing range of fish.
USBL (e.g., Kongsberg HiPAP 502)	21 – 31	192 (max)	Equipment specification sheet	**No** Operates at high frequency (>1 kHz), producing sound that is outside the range of hearing of all fish and so this activity can be scoped out of the assessment.
Cable installation	1 – 15	178	(Nedwell, Langworthy, &	**No**

Survey or cable installation activity	Operating frequency (kHz)	Sound Pressure Level#	Sound source data reference	Scoped in for further assessment?
(e.g., clearance of obstacles and debris, sand wave sweeping, ploughing, jetting and trenching)			Howell, 2003; Nedwell, Parvin, Brooker, & Lambert, 2008; Hale, 2018)	Sound measurements made during a generic cable trenching recorded a maximum unweighted Sound Pressure Level (SPL_{RMS}), of 178 dB re. 1µPa (Nedwell, Langworthy, & Howell, 2003). Thus, underwater sound generated by trenching operations will be very low, and does not pose a risk of injury or significant disturbance to fish
Rock placement	n/a	~172	Vessel Rollingstone (Barham & Mason, 2019; Nedwell, Brooker, & Barham, 2012)	**No** In four studies of rock placement, it was possible to faintly hear rocks falling through a fall tube to the seabed but the underwater sound from the operations was dominated by the sound of the vessel (Nedwell, Brooker, & Barham, 2012). An SPL_{rms} of 172 dB re. 1µPa was measured during the operation of the fall pipe vessel MV Rollingstone (Nedwell, Brooker, & Barham, 2012). Thus, the SPLs associated with this activity are not of a magnitude which poses a risk of disturbance or injury to fish or shellfish and is screened out of the assessment.
HDD (e.g., break-out)	n/a	129.5	(Nedwell, Brooker, & Barham, 2012)	**No** Sound measurements made during a generic HDD operation, in shallow riverine water recorded a maximum unweighted Sound Pressure Level (SPL_{RMS}), of 129.5 dB re. 1µPa (Nedwell, Brooker, & Barham, 2012). The Offshore Scheme Suffolk HDD breakout point will be in shallow water where sound rapidly attenuates and in the intertidal at Pegwell Bay Thus, the SPLs associated with this activity are not of a magnitude which poses a risk of disturbance or injury to fish or shellfish and is screened out of the assessment.

Survey or cable installation activity	Operating frequency (kHz)	Sound Pressure Level[#]	Sound source data reference	Scoped in for further assessment?
Cable lay vessel (e.g., ~140 m in length, operating with DP)	0.005 - 3.2	180 - 197	(Ross, 1993; AT&T, 2008)	**No** There will be a limited number of vessels associated with the installation of the cable. In comparison to background vessel activity in the Southern North Sea (**Application Document 6.2.4.7 Shipping and Navigation**) the additional vessels operating to install the Offshore Scheme is not considered to be a deviation from baseline conditions. As such, sound emissions from the installation vessels will not constitute a substantive change from the baseline soundscape including existing vessel sound, and hence there is not potential for adverse effects on fish.
Project support vessels Including medium (50 m to 100 m) and small (<50) boats	Low to high frequency	160 – 180	(Genesis, 2011; Richardson, Greene, Malme, & Thomson, 1995; OSPAR, 2009)	

[#] All sound source levels given as SPLrms unless otherwise stated. Units for all SPL values are dB re 1µP a@1m.

3.9.74 As described in Table 3.14, SBP equipment operates at frequencies <1 kHz and so is within the hearing range of fish. Therefore, impulsive sound from the operation of the SBP during the pre-installation geophysical survey has been considered further in this chapter.

3.9.75 SBP systems essentially work in a similar way to sonar, radar and other reflective positioning systems (e.g. see https://www.aaetechnologiesgroup.com/news/guide-to-sub-bottom-profiling/). Popper et al. (2014) provide threshold criteria for low frequency (≤ 1 kHz) and mid-frequency sonar (1 kHz to 10 kHz). On the basis of the most likely operating range for SBP, the threshold criteria for mid-frequency sonar can be used as a proxy.

3.9.76 The injury thresholds for fish, including mortality, potential mortal injury, recoverable injury, and TTS for medium to high hearing sensitivity fish is a SPL_{rms} of 210 dB re. 1µPa. For high hearing sensitivity fish, the behavioural response threshold is slightly lower, at a SPL_{rms} of 209 dB re. 1µPa. However, these thresholds represent the upper limits of sound levels tested, with actual injury thresholds likely to be significantly higher. In particular, no effect on the ear or non-auditory tissues was observed when the maximum received sound pressure levels were at 210 dB re 1 µPa SPL_{rms} and injury, if it occurs, would begin at higher sound levels than those tested (Halvorsen, Zeddies, Ellison, Chicoine, & Popper, 2012b). The thresholds are therefore considered to be very conservative.

3.9.77 In terms of behavioural effects, certain fish species, particularly those with specialised hearing structures like swim bladders directly involved in hearing, may respond to mid-frequency sonar. Species in the Clupeidae family, such as *Alosa* spp., can hear sounds above 2,500 Hz (Halvorsen, Zeddies, Ellison, Chicoine, & Popper, 2012b). However, studies on Atlantic herring, a member of the same family, found no significant behavioural responses, such as vertical or horizontal escape reactions, when exposed to mid-frequency naval sonar (6–7 kHz) at a received rms sound pressure level of 139–209 dB re 1 µPa (Popper, et al., 2014).

Marine Fish

Sensitivity

3.9.78 The impact of underwater sound on fish can differ based on species, the level of sound exposure, and the surrounding environment. For example, seismic airguns used in geophysical surveys have been found to cause TTS in fish hearing, which impairs their ability to detect critical sounds necessary for survival (Popper, et al., 2014). Behavioral responses exhibited by fish include avoidance the seismic sound source. For instance, whiting have been observed to move vertically in response to these sounds, although some individuals showed temporary habituation after about one hour of continuous exposure (Chapman & Hawkins, 1969). While short-term behavioral responses can occur, this response is highly variable, and the ability of fish to flee from the sound source indicates that any long-term effects may be limited (Carrol, Przeslawski, Duncan, Grunning, & Bruce, 2017).

3.9.79 There are fish species from all hearing groups found within the Offshore Scheme Study Area, and therefore the sensitivity of this receptor ranges from low to high.

Magnitude of impact

3.9.80 A standard geometric spreading calculation, using a wave mode coefficient of 15 was used to determine the propagation of underwater sound from the SBP. The distance at which the injury and behavioural disturbance threshold is met is 46 m and 54 m respectively. From these calculations, injury and disturbance ranges are extremely limited where fish more likely to be disturbed by the presence of oncoming vessels and are expected to have moved away before entering the potential injury zone.

3.9.81 The overall magnitude of impacts to marine fish from underwater sound from the operation of the SBP during the pre-installation geophysical survey is considered to be negligible.

Significance of the effect

3.9.82 There may be some minor avoidance behaviour, but the vessels will be continuously moving and so the impact zone will also be transitory. As soon as the vessel has moved away normal activity can resume. Thus, the impact is localised, temporary and reversible and so the magnitude is predicted to be negligible. Combined with the low to high sensitivity and value of the species, the effect is predicted to be **negligible** and therefore not significant.

Operation and Maintenance Phase

Permanent loss of fish and shellfish habitat due to placement of hard substrates on the seabed

3.9.83 Cable installation, and repair, may require protection measures, in the form of rock berms, rock backfill or concrete mattresses. Introduction of hard substrate would replace other natural substrates, leading to permanent loss of these habitats and associated species. The total estimated area of permanent loss of habitat of 0.15 km^2 (Table 3.13).

3.9.84 Migratory fish are not considered to have functional associations with seabed habitats due to their life history strategies and transient presence within the Offshore Scheme. Therefore, this receptor group has not been considered further for this impact pathway.

3.9.85 Herring and sandeel are considered to have high sensitivity to permanent habitat loss, as these species are demersal spawners and exhibit specific habitat requirements for spawning (i.e., gravelly sediments for herring and sandy sediments for sandeel). The adult sandeel is also sensitive to habitat loss owing to the co-location of spawning and adult habitats and sediment requirements for burrowing.

3.9.86 The exact locations where rock backfill will be placed in high-risk identified areas[14] and the placement of rock berms is currently unknown. The location of the cable crossing have been identified and have been shown in comparison with the potential areas of suitable herring and sandeel spawning habitat in **Figure 6.4.4.3.8. Areas of permanent habitat loss and herring spawning habitat** and **Figure 6.4.4.3.9. Areas of permanent habitat loss and sandeel spawning habitat**. Due to the lack of information in the location of the rock berms and backfill, it has been assumed that all permanent loss of habitat has occurred in preferred spawning habitat for each species.

[14] The high-risk areas where rock backfill are identified are presented in **Figure 6.4.4.3.8. Areas of permanent habitat loss and herring spawning habitat**, but the exact location of the rock backfill within these areas are still unknown.

This includes the cable crossings, despite being able to differentiate the known habitat (areas in unsuitable habitat have been excluded).

3.9.87 Other demersal and pelagic species known to occur within the Study Area are highly mobile, with wide distributions and broad habitat requirements meaning they have capacity to exhibit avoidance behaviour and move into alternative available habitats nearby. Thus, this group of species are considered to have negligible sensitivity to permanent loss of habitat due to placement of hard substrates on the seabed.

3.9.88 According to the Marine Evidence based Sensitivity Assessment (MarESA), commercially important shellfish such as brown crab and scallop are considered to be moderately sensitive to habitat loss (Neal & Wilson, 2008; Marshall, 2008). Some crustaceans (e.g., crab and lobster) may benefit from the addition of artificial hard substrates, providing additional refuge and new potential sources of food. For example, post-installation monitoring surveys at the Horns Rev Offshore Wind Farm found artificial hard substrates were used as a hatchery or nursery grounds for several shellfish species, notably brown crab (Vattenfall, 2006).

Herring

Sensitivity

Herring are considered to be of medium value, representing an important food source for seabirds and marine mammals. Furthermore, herring spawning grounds are considered to have a high sensitivity to permanent direct loss and physical disturbance; however, herring lack site specific fidelity to spawning sites at a local scale, meaning they can move to alternative nearby suitable habitat. Therefore, the sensitivity of spawning herring and their eggs is considered to be high.

Magnitude of impact

3.9.89 Taking a worst-case scenario, it has been estimated that 0.121 km^2 of preferred herring spawning habitat (as identified by the EMODnet seabed substrate (250k) data). This is based on the requirement for: 0.017 km^2 of rock backfill; 0.084 km^2 of remedial rock berms; and 0.02 km^2 of cable crossing rock protection.

3.9.90 The overall loss of potential herring spawning habitat is limited compared to the wider availability of herring spawning habitat in the Study Area. Furthermore, the habitat to be lost is not considered to be important for herring spawning. Thus, the direct loss of potential spawning habitat of herring associated with this activity is predicted to be of low magnitude.

Significance of the effect

3.9.91 The permanent placement of cable protection measures on the seabed leading to the loss of potential herring spawning habitat is predicted to be low in spatial extent in the context of more suitable spawning habitat to the outside of the Offshore Scheme in other known spawning areas such as the Southern Bright spawning area. Overall, the effect is predicted to be **minor** and therefore not significant.

Sandeel

Sensitivity

3.9.92 Sandeel are considered to be of medium value, representing an important food source for seabirds and marine mammals. Furthermore, sandeel are partly benthic species, spending much of their life histories buried in the seabed, particularly in Autumn where they remain buried in the seabed, only briefly emerging to spawn between November and February. During spring and summer, when sandeel are actively feeding, they tend to remain within 10 km of their grounds (Wright, Christensen, Régnier, Rindorf, & van Deurs, 2019). Due to their association with the seabed, including the deposition of their egg matts, sandeel are considered to have a high sensitivity to permanent physical loss and disturbance of habitat. The high site fidelity exhibited by sandeel also increases this species potential sensitivity to benthic habitat loss at sub-population levels (Jensen, Rindorf, Wright, & Mosegaard, 2011). Therefore, the sensitivity of sandeel spawning grounds is considered to be high.

Magnitude of impact

3.9.93 Taking a worst-case scenario, it has been estimated that 0.146 km^2 of preferred sandeel spawning habitat (as identified by the EMODnet seabed substrate (250k) data) will be permanently lost as a result of the Proposed Development. This is based on the requirement for: 0.017 km^2 of rock backfill; 0.084 km^2 of remedial rock berms; and 0.045 km^2 of cable crossing rock protection (three crossings were found to occur in marginal habitat but have been included in this calculation as a worst-case).

3.9.94 Although the Offshore Scheme overlaps with preferred habitat for sandeel, this habitat is widespread and found throughout the central and southern North Sea and extends into the English Channel. Heat maps showing confidence scores for potential sandeel spawning habitats (see **Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**) indicate that the areas with the highest confidence for sandeel spawning are located outside the Offshore Scheme. The presence of juvenile and adult sandeel in the Study Area was also found to be more concentrated further east in the North Sea and south in the English Channel, with lower concentrations within the Offshore Scheme location. Overall, the magnitude is considered to be low in the context of the wider availability of habitat.

Significance of the effect

3.9.95 Given the wider availability of potential sandeel spawning habitat within the Study Area, the placement of hard substrates on the seabed for the proposed cable protection is considered to be highly localised. The effect is predicted to be **minor** and therefore not significant.

Shellfish

Sensitivity

3.9.96 Commercially important shellfish such as brown crab and scallop are considered to be moderately sensitive to permanent habitat loss (Marshall, 2008; Neal & Wilson, 2008). Some crustaceans (e.g. crabs and European lobster) may benefit from the addition of artificial hard substrates (in the form of cable protection), providing additional refuge and new potential sources of food (Taormina, et al., 2018; Taormina, et al., 2020). Thus, the overall sensitivity of shellfish of commercial and/or conservation importance is considered to be low.

Magnitude of impact

3.9.97 The subtidal benthic habitats identified along the Offshore Scheme were generally dominated by mud, sand, and coarse sediments (Further details can be seen in **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology**). The cable protection measures will also pass through areas of sand and coarse sediment and a small area of biogenic reef (**Figure 6.4.4.2.3 Marine cable crossings and areas of rock backfill within the Offshore Scheme Boundary** in **Application Document 6.2.4.2 Part 4 Marine Chapter 2 Benthic Ecology**).

3.9.98 Therefore, shellfish species which are present in sand dominated habitats (i.e. scallops) and rocky dominate habitats (i.e. crabs and lobsters) are most likely to be present and susceptible to permanent loss of habitat and disturbance. Despite this, sand habitat is widespread within the Study Area, meaning that there is a wide availability of alternative habitat for shellfish species.

3.9.99 Although a small proportion of shellfish habitat would be lost under the footprint of the permanent cable protection, there would be no overlap with known or designated shellfish beds and therefore the impact of cable protection on associated shellfish populations would be of negligible magnitude.

Significance of the effect

3.9.100 There would be no overlap of cable protection measures with known or designated shellfish beds and any permanent loss of habitat would be highly localised compared to the wider availability of habitat and for some receptors would provide refuge and additional sources of food. Therefore, the effect of permanent loss of habitat is predicted to be **negligible** and not significant.

Other Marine Fish

Sensitivity

3.9.101 All remaining fish receptors are considered to have a low to high value and low to medium sensitivity to permanent loss of habitat.

3.9.102 For other fish species which occupy or utilise rocky habitats, studies have shown that these species may benefit from the additional of artificial substrates, most likely due to the increase in habitat complexity (i.e., refuge) and increased epifaunal communities which provide food resource (Wilhelmsson, Malm, & Ohman, 2006a; Wilhelmsson, Yahya, & Ohman, 2006b; Taormina, et al., 2018). This is particularly relevant to the Offshore Scheme, given that the majority of rock placement will occur in sandy habitats. These fish species are therefore considered to have low sensitivity to habitat loss associated with the placement of rock or concrete mattresses as subsequent habitat and food resource may be available on the structures themselves.

Magnitude of impact

3.9.103 The placement of hard substrates on the seafloor in the Offshore Scheme will result in the permanent loss of habitat for other fish and shellfish habitats and species. For example, flatfish such as plaice and sole exhibit a preference for sandy substrates, which is a sediment recorded across much of the Offshore Scheme. Other fish species, such as the elasmobranch, are known to be associated with soft sandy sediment, sometimes burrowing within the sediment. However, the extent and scale of the impact is considered to be small when considering the wider availability of suitable habitats within the Study Area, including sandy substrates which are widespread. Thus, the permanent placement of hard substrates on the seabed leading to effects to flatfish and other marine fish, is predicted to be of negligible magnitude.

Significance of the effect

3.9.104 The extent of the impact is local in comparison to the wide distribution and availability of suitable foraging grounds for fish. Therefore, the effect of permanent habitat loss on this receptor is assessed as **negligible** and not significant.

Disturbance to fish due to subsea cable EMF emissions

3.9.105 Subsea cables associated with the Proposed Project are known to generate EMF emissions (Hutchison, Gill, Sigray, He, & King, 2020), which can potentially affect the foraging, migration, and behavior of electro-sensitive species like elasmobranchs, migratory fish such as salmon, and shellfish. The impact of EMF depends on several factors, including cable design, environmental conditions like water movement, and the specific sensitivities of the affected species (Gill, Hutchison, & Desender, 2023).

3.9.106 The earth has its own ambient geomagnetic field which varies slightly with geographic location. In the UK and surrounding waters this is around 50 microtesla (µT) (EMFs, 2022; National Grid, n.d.) and hereafter, referred to as the ‘baseline EMF level’.

3.9.107 EMF will be emitted from the subsea cables for the duration of the operational life of the Proposed Project. A project-specific EMF assessment (**Application Document 6.2.4.7.B Appendix 4.7.B Electromagnetic Deviation Study**) was conducted based on the assumption that the cables will be bundled.

3.9.108 The highest magnetic fields were observed when the burial depth of the cables was shallowest. Irrespective of the burial depth the magnetic fields reduce rapidly with distance from the cables due to bundling of the cables. The maximum magnetic fields calculated for cables buried 0.5 m deep and at the seabed were 204.9 µT compared to when cables were buried 2.5 m deep, the magnetic fields were 8.3 µT suggesting only a very localised effect and levels lowered below background.

3.9.109 The average water depth exceeds 30 m for most of the Offshore Scheme. However, there is shallow water (> 10 m) as the cable route comes into the landfall locations. There is 6 km of the route towards the Suffolk landfall (between KP 1 and KP 6) and 7 km of the route towards the Kent landfall (between KP 113 and KP 120), where depths are less than 10 m. Consequently, species occupying the upper layers of the water column will not be exposed to EMFs above background levels for the majority of the cable route, with marginally elevated field strengths above ambient being present in shallow waters.

3.9.110 Artificial EMF exposure has been linked to various impacts, such as reduced swimming speeds in migrating European eels (Westerberg & Lagenfelt, 2008), attraction of sea trout larvae to magnetic fields (Formicki, Sadowski, Tański, Korzelecka-Orkisz, & Winnicki, 2004) and reduced swimming speeds in elasmobranch species (Gill A. B., et al., 2009). Elasmobranchs relying on electromagnetic perception for hunting may experience decreased foraging success due to EMF exposure.

3.9.111 Studies on the long-term effects of EMF on juvenile flounder (Bochert & Zettler, 2004) and rainbow trout embryos (Fey, et al., 2019) showed no adverse effects on development or survival. Salmon eggs exposed to an EMF of 2 mT (2,000 µT) displayed increased water permeability without detrimental impacts on embryological development (Sadowski, Winnicki, Formicki, Sobocinski, & Tanski, 2007). The EMF intensity in these experiments was significantly higher than what would result from the Offshore Scheme's HVDC cables.

3.9.112 Due to the different level of sensitivity of different species and groups of fish and shellfish the appraisal of effect of maximum EMF generated during electricity transmission is divided into the key receptor groupings, described below.

Diadromous species

Sensitivity

3.9.113 The Proposed Project is in the vicinity of several estuaries and rivers which are important habitats for migratory fish species in the Study Area (see section 3.7). Some evidence suggests diadromous fish may alter their direction or position to avoid areas within the main magnetic field of subsea cables (Klimley, Putman, Keller, & Noakes, 2021).

3.9.114 While the effects on migratory fish are not fully understood, literature suggests that significant responses are likely to be limited and confined to the immediate vicinity of the cable. Diadromous fish, such as European eels, have shown directional and behavioral changes, like reduced swimming speed, in response to magnetic fields (Westerberg & Lagenfelt, 2008; Westerberg & Begout-Anras, 2000).

3.9.115 However, studies of juvenile salmon crossing cables emitting EMF found no significant behavioral changes or impacts on migration success (Wyman, et al., 2018). Similarly, biotelemetry studies of migrating European eels indicated that subsea cables did not pose a major barrier to movement, with only minor directional shifts observed in a small number of fish (Westerberg & Begout-Anras, 2000).

3.9.116 Based on this, diadromous fish are considered to have low sensitivity to EMF exposure.

Magnitude of impact

3.9.117 The increase in background EMF resulting from the Proposed Project is expected to be confined to a very limited area around the cables. The closest migration route is via the Kent River Stour located near the landfall in Pegwell Bay. The water depth approaching Kent is approximately 0 m depth to 6 m depth from KP 120 to KP 113 respectively. Therefore, the Kent landfall and approaches are the areas where migration routes may be crossed in shallow water.

3.9.118 However, the EMF levels at 5 m water depth, based on a burial depth of 1 m, were calculated to be 1.44 µT. This is considered to be a negligible difference above baseline compared to the EMF levels at which effects to fish have been recorded (e.g. 2,000 µT causing embryological development to salmon eggs (Sadowski, Winnicki, Formicki, Sobocinski, & Tanski, 2007). Moreover, the actual EMF levels are expected to be even lower, as the Proposed Project has committed to a burial depth of 1 m to 2.5 m throughout most of the Offshore Scheme.

3.9.119 Consequently, the area where EMF emissions from the cables have the potential to affect diadromous fish is extremely limited and is not expected to cause any barriers to migration. Therefore, the overall magnitude of impact from EMF emission to fish and shellfish is considered to be negligible.

Significance of the effect

3.9.120 Considering the shallow depths in which significant changes in EMF are likely to occur, migratory fish are unlikely to demonstrate behavioural changes to EMF, particularly for those species which migrate in the upper water column. In conclusion, the effect of EMF emissions on diadromous species is considered to be **negligible** and therefore not significant.

Pelagic fish

Sensitivity

3.9.121 Pelagic species are unlikely to be affected by any localised increase in EMF around the cable, as they tend to occupy higher water columns and can easily avoid such areas. Even for benthic-feeding pelagic fish, the zone of EMF influence is limited to a few tens of meters and is not expected to restrict access to prey, as their foraging grounds are widespread. Additionally, pelagic fish typically swim continuously, covering several kilometers daily, meaning they would spend minimal time near the cables. Studies show low sensitivity to EMF in pelagic species, with no evidence that clupeids or scombrids can detect or are affected by EMF (Snyder, Bailey, Katherine, Cotts, & Olsen, 2019). Thus, the sensitivity of pelagic fish to EMF is considered to be low.

Magnitude of impact

3.9.122 The Study Area is home to several commercially important pelagic species, including herring, sprat, and smelt. Given their pelagic nature and limited interaction with the seafloor, these species are unlikely to encounter EMF levels beyond background levels near the Offshore Scheme. Thus, the magnitude of EMF impact on pelagic fish is considered negligible.

Significance of the effect

3.9.123 Due to their pelagic behavior, these species are unlikely to come into contact with or be affected by any localized increase in EMF near the cable. Therefore, the effect on pelagic fish is considered **negligible** and not significant.

Demersal fish

Sensitivity

3.9.124 Several demersal teleost species, such as sandeel, whiting, sole, plaice, and cod, are present in the Study Area (see Demersal Fish Species in section 4.7). These species spend a considerable amount of time near or on the seabed, potentially exposed to increased EMF levels from the Offshore Scheme cables (Hutchison, Gill, Sigray, He, & King, 2020).

3.9.125 Although the sensitivity of demersal species to EMF is not yet fully understood, some may even utilise magnetic fields to their advantage. For example, plaice have been shown to use magnetic fields for navigation (Metcalfe, Holford, & Arnold, 1993). Additionally, field studies near offshore wind farms in the Baltic Sea indicate that EMF does not significantly affect cod behavior, as they were observed near both active and inactive cables over time (Bergström, Sundqvist, & Bergström, 2013)

3.9.126 Overall, while some individual fish may avoid areas with elevated EMF, this response is likely to be limited. Therefore, demersal species are assigned low to medium sensitivity to EMF on a precautionary basis.

Magnitude of impact

3.9.127 The maximum EMF produced by the Proposed Project is not expected to cause major behavioural responses in demersal fish. Magnetic fields are expected to rapidly reduce as distance increased from the cable (Sinclair, et al., 2023). Therefore, any behavioural responses which do occur are expected to be minor with very localised avoidance of the immediate area of the Offshore Scheme. An EMF modelling study for the Proposed Project (**Application Document 6.2.4.7.B Appendix 4.7.B Electromagnetic Deviation Study**) showed EMF level to reach just above EMF baseline levels at 0.5 m from the cable when buried to 0.5m. However, levels below this depth are considered to be low compared to EMF levels at which effects to fish have been recorded. The Proposed Project has also committed to a deeper burial depth of 1 m, throughout most of the Offshore Scheme further reducing EMF emissions at this distance. Therefore, EMF emissions are anticipated to have little influence on demersal teleost species and therefore, the magnitude of the effect is considered to be negligible.

Significance of the effect

3.9.128 EMF emissions will have a highly localised effect, with minimal avoidance behavior from demersal fish species. However, there are some knowledge gaps and the sensitivity of demersal species to EMF emissions is unclear. Overall, it is considered that EMF generated by electricity transmission will have a **negligible** effect on demersal teleost fish populations and is therefore not significant.

Elasmobranchs

Sensitivity

3.9.129 The Study Area supports a number of elasmobranch species including lesser spotted dogfish, thornback ray, and smooth hound. Elasmobranchs are particularly sensitive to EMF due to their reliance on electrosensory systems for detecting prey, predators, and mates (Hutchison, et al., 2018).

3.9.130 Laboratory experiments showed that lesser spotted dogfish were attracted to EMF strengths resembling prey but repelled by stronger fields mimicking an active cable (Gill A. , et al., 2009; Gill & Taylor, 2001). Mesocosm experiments found that dogfish aggregated near active cables but dispersed when cables were inactive. In contrast, thornback rays showed no significant behavioral changes, indicating species-specific responses (Gill A. , et al., 2009). Also, some elasmobranchs, such as lesser spotted dogfish, cannot distinguish between natural and artificial electric fields, which may explain why they sometimes bite submarine cables (Newton, Gill, & Kajiura, 2019).

3.9.131 Other benthic elasmobranchs, such as skates and rays, are also at higher risk of EMF exposure. Studies on little skate *Leucoraja erinacea* showed varied responses, including increased distance from the cable and slower swimming speeds, though these behaviors were typical exploratory actions, and the cable did not act as a movement barrier (Hutchison, et al., 2018).

3.9.132 Pelagic species like basking sharks, and other similar elasmobranchs, face a lower risk of EMF exposure as they spend most of their time in the upper water column, away from the seabed. In shallow waters, they might encounter EMF but are expected to avoid it and seek nearby suitable habitats. However, basking shark are unlikely to be present within the Study Area.

3.9.133 In conclusion, elasmobranch species are considered to have a medium value and medium sensitivity to EMF.

Magnitude of impact

3.9.134 Behavioural responses are only expected to occur within a small area (up to 5 m of the Offshore Scheme) and therefore will be highly localised and the magnitude of impact is considered to be low. Any localised effects which do occur are not expected to interfere with any key functional activities, with only mild behavioural responses anticipated.

Significance of the effect

3.9.135 Behavioral responses are expected to occur only within a small area, approximately 5 m around the Offshore Scheme, making them highly localised. However, since elasmobranchs are particularly sensitive to EMF, the overall effect is considered **minor** and not significant.

Spawning, eggs, larvae and juvenile fish

3.9.136 The Offshore Scheme is located in spawning grounds for sandeel and herring (see **Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**). Any EMF disturbance from the cable has the potential to disrupt fish behaviour such as spawning and could have a direct impact on the eggs, larvae and juveniles of these species.

Sensitivity

3.9.137 Laboratory studies have investigated the effects of EMF exposure on eggs, larvae, and juveniles across various fish species. Bochert and Zettler (2004) found no impact on juvenile flounder survival after exposure to 3,700 µT for four weeks. Similarly, Woodruff et al. (2012) reported no significant effects on Atlantic halibut larvae survival at 3,000 µT over 27 days, and Fey et al. (2019) observed no significant effects on rainbow trout eggs and larvae exposed to 10,000 µT for 36 days.

3.9.138 The magnetic field strengths in these studies are significantly higher (by two to three orders of magnitude) than would be encountered near the cable route. A recent review (Copping, et al., 2020) supports this, suggesting that the maximum levels produced from bundled cables of the Offshore Scheme (i.e. 51.5 µT at a burial depth of 1.0 m when the receptor is at seabed level) are unlikely to deter animals from their habitats or affect migration, with no significant effects reported on eggs, larvae, or juvenile fish.

3.9.139 More recent studies found that lesser sandeel larvae exposed to magnetic fields up to 150 µT showed no changes in spatial distribution, swimming speed, or movement (Cresci, et al., 2022).

3.9.140 The highest EMF strength from the bundled cables of the Offshore Scheme is predicted to be 204.9 µT at a burial depth of 0.5 m when the receptor is at seabed level. Furthermore, the actual EMF strength at the seabed is expected to be lower (51.5 µT) due to the deeper target burial depth of 1 m. Furthermore, considering that even at higher EMF strengths, studies (Cresci, et al., 2022) have shown no significant effects on fish larvae behavior or distribution, the sensitivity of spawning, eggs, larvae, and juvenile fish to EMF exposure is assessed as low.

Magnitude of impact

3.9.141 The effects of EMF emissions are expected to be minimal and confined to a very small area around the Offshore Scheme. EMF levels dissipate quickly from the cables, and since suitable habitats for sandeel and herring are widely distributed in the Study Area and North Sea, any impact on their spawning, eggs, or larvae will be highly localised. These effects are expected to only apply to larvae within 5 meters of the cable. As a result, the magnitude of the impact is assessed as negligible.

Significance of the effect

3.9.142 Any effects to herring and sandeel spawning, eggs and larvae from EMF are expected to be highly localised and only applicable to larvae within 5 m of the Offshore Scheme. Overall, the effect is considered to be **negligible** and not significant.

Potential effects on fish and shellfish due to subsea cable thermal emissions

3.9.143 Submarine power cables generate heat during operation, which, when buried in the seabed, can raise the temperature of surrounding sediment (Emeana, et al., 2016). This temperature increase can affect fish and shellfish, particularly species that live in or on the sediment (Taormina, et al., 2018; Taormina, et al., 2020). While the full effects of these temperature changes on sediment composition and biogeochemical cycles are not well understood, early studies suggest that increased temperatures may influence temperature-sensitive bacteria, including changes in bacterial communities and nitrogen cycling in sediments (NRW, 2020; Hicks, et al., 2018).

3.9.144 Sediment particle size affects heat transfer. Coarse silts experience the greatest temperature change but over a short distance, while fine and coarse sands see smaller temperature changes over a larger area (Emeana, et al., 2016).

3.9.145 The Offshore Scheme comprises mainly coarse sediment and sand with varying smaller areas of mixed sediment and mud, and therefore the influence of thermal emissions is expected to vary but be limited overall.

3.9.146 A bundled cable will be installed for the Offshore Scheme, buried to a target depth between 1.5 – 2 m below the seabed. Heat dissipation modelling was undertaken for a similar cable installation project, the Eastern Green Link 2 submarine HVDC transmission link between Scotland and England (AECOM, 2022) for bundled cables buried at a depth of 1.5 m. The modelling indicated that within 500 mm of the seabed surface the increase in sediment temperature was limited to approximately 3°C. However, seawater at the seabed surface will have a cooling effect and will dissipate any temperature increases further.

3.9.147 Only species which have life history stages associated with the benthos are considered further in this assessment. Therefore, the focus of the assessment is on demersal spawners, herring and sandeel, as well as shellfish species as these are considered to be the receptors which have the highest potential to be affected by the effect of thermal emissions. Diadromous species have been considered as they also have the potential to be affected by the effect of thermal emissions during migration.

Diadromous species

Sensitivity

3.9.148 Diadromous species, such Atlantic salmon, European eel, and smelt, are sensitive to temperature changes, which can influence migration timing and routes (Jonsson & Jonsson, 2009; Righton, et al., 2016). However, these species usually swim in the water column, away from the seabed. Seawater at the seabed surface will have a cooling effect and will dissipate any temperature increases in the water column. Studies show that localised temperature increases near the seabed have minimal effects on diadromous species such as European eel compared to seasonal changes in water temperature and currents (Westerberg & Lagenfelt, 2008). Therefore, while the upstream migration for some diadromous species such as smelt in known to be controlled by temperature (Jörg, Bastian, Sandra, & Jens, 2007), the increase in sediment temperature from the Offshore Scheme will be minimal and extremely localised and is not expected to effect the overall surrounding water column in which diadromous species would occur. Therefore, the sensitivity of diadromous fish to subsea cable thermal emissions is considered to be negligible.

Magnitude of impact

3.9.149 The closest migration route is via the Kent River Stour located near the landfall at Pegwell Bay. The water depth approaching Kent is approximately 0 m depth to 6 m depth from KP 120 to KP 113, respectively. Therefore, the Kent landfall and approaches are the areas where migration routes may be crossed in shallow water. Smelt are known to migrate and use the River Stour, as well as other relevant rivers including River Thames, River Alde and River Orwell.

3.9.150 However, given that thermal emissions are likely to be limited to within only 50 cm of the seabed, the potential to affect diadromous fish is extremely limited (this includes smelt using the Alde-Ore estuary). No barrier effects are expected to occur, and since diadromous species primarily inhabit the upper water layers during migration, and can move freely in the water column, their exposure to such localised thermal emissions is negligible.

Significance of the effect

3.9.151 Considering the low sensitivity of diadromous species to localized and minor thermal emissions, and the negligible magnitude of impact, the overall significance of the effect on these species is considered to be **negligible** and not significant.

Herring and Sandeel Spawning Grounds

Sensitivity

3.9.152 Herring do not spend large proportions of time on the seabed, rather they lay demersal eggs, predominantly in gravelly sediments. In comparison, sandeel have a preference for habitat with a high percentage of medium to coarse sand (particle size of 0.25 mm to 2 mm) and a mud content of less than 10% (particles <63 µm) (**Application Document 6.3.4.3.A Appendix 4.3.A Herring and Sandeel Assessment**). Sandeel are typically associated with sandbanks (MarineSpace Ltd; ABPmer Ltd; ERM Ltd; Fugro EMU Ltd; Marine Ecological Surveys Ltd, 2013a) and due to their habitat preferences, their distribution is often patchy. Due to their association with the seabed, both herring and sandeel are considered to have a medium sensitivity to thermal increases.

Magnitude of impact

3.9.153 Herring and sandeel eggs are laid directly on the seabed. Any heating in the upper layers is expected to be extremely minimal and is unlikely to impact individuals or eggs in the Offshore Scheme area. Furthermore, the area containing potentially suitable spawning habitat for herring and sandeel is considered small in the context of the wider availability of suitable spawning habitat for both species. Therefore, the magnitude of thermal impacts on spawning grounds is considered to be of negligible magnitude.

Significance of the effect

3.9.154 Thermal heating is expected to be minimal in upper sediment depths greater than 50 cm, where sandeel are expected to be buried (or herring egg mats on the surface). Overall, the effect is considered to be **negligible** and not significant.

Shellfish

Sensitivity

3.9.155 Few studies have been carried out of the sensitivity of shellfish to thermal emissions however, sessile species such as blue mussel (*Mytilus edulis*) and common cockle are found in a wide range of temperatures, and thus have a high tolerance to temperature changes, with studies indicating that increased temperatures has limited impacts on the physiology of these species (Tyler-Walters, Mytilus edulis Common mussel. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, 2008). Furthermore, other mobile shellfish species, such as edible crab are also considered to have a high tolerance to temperature (Neal & Wilson, 2008), and they are also mobile so can move away freely. Therefore, the sensitivity of shellfish is considered to be low.

Magnitude of impact

3.9.156 Increased sediment temperature has the potential to affect infaunal shellfish directly. Whilst the sediment surrounding the cable may be heated, there is negligible capability to heat the overlying water column because of the very high heat capacity of water, meaning there would be no effects on epibenthic species such as crabs and lobsters.

3.9.157 Although thermal effects would be long-term and occurring continuously for the operational lifetime of the Offshore Scheme, the temperature increase is low level and likely to be only a few degrees higher than ambient at the shallow sediment depths (<20 cm) at which infauna shellfish are typically found. The latest OSPAR report states a threshold of 2^{o}C temperature increase at a sediment depth of 0.2 m will only be exceeded in rare cases and for short periods of time (OSPAR Commission, 2023). Thus, if the burial depth is increased a to a target burial depth of target 1.5 m, then any further changes to temperature are also considered to be negligible. Additionally, due to natural seasonal changes in water temperature, a temperature change of a few degrees higher than ambient is regarded as an insignificant temperature increase.

3.9.158 The common cockle was one of the main commercially important shellfish species identified within the Study Area. This species is a shallow burrower, remaining in around 1–5 cm into the sediment (Tyler-Walters, 2007). However, given the thermal changes are expected to be minimal and the area affected is very limited the overall magnitude of impact on shellfish is considered negligible.

Significance of the effect

3.9.159 Any thermal effects to the sediment as a result of the cables, will be limited to depths very close to the cable (target burial depth of 2 m and minimum burial depth of 1.5 m) and will be contained to the location of the cable route only. Thus, for all shellfish species, the effect of thermal emissions is considered to be **negligible** and therefore Not Significant.

Maintenance effects

3.9.160 The Offshore Scheme is designed for a lifespan of approximately 40-60 years. The cable system installation is designed such that a regular maintenance regime is not required to maintain the integrity of the link.

3.9.161 See route preparation and cable installation, noting that durations and extents of activities will be significantly reduced.

Decommissioning Phase

3.9.162 Following the completion of the Operational phase, the Decommissioning phase will take place. As this work is planned decades into the future, it is unknown what the exact methodology will be for decommissioning, as this will be based on the Best Available Technology (BAT) available at the time of decommissioning.

3.9.163 In the years leading up to the end of the Project’s operational life, options for decommissioning will be evaluated through integrated environmental, technical, and economic assessments. The objective in undertaking these assessments will be to minimise the short- and long-term effects on the environment, whilst ensuring that the sea is safe for other users to navigate. The level of decommissioning will be based upon the regulations, best practices, and available technology at the time of decommissioning. The principal options for decommissioning include:

- Full cable removal; and
- Leaving the cable buried *in-situ*.

3.9.164 In the event of the full removal of the cable, this would have the potential to cause similar impacts to the Construction Phase of the Proposed Project. Should the cable be left in-situ, there would likely be no impact pathways to benthic receptors. Thus, as a worst-case scenario, impacts during decommissioning may be of a similar magnitude to Construction Phase activities, depending upon the decommissioning option selected. Therefore, as a worst case, the effects to benthic ecology are predicted to be **minor** and therefore not significant.

3.10 Additional Mitigation and Enhancement Measures

3.10.1 Aside from the embedded mitigation measures, as aforementioned in section 3.8, no additional mitigation measures or monitoring have been recommended as a result of the impact appraisal.

3.11 Residual Effects and Conclusions

3.11.1 As no additional mitigation was required because there were no likely significant effects fish and shellfish identified, the residual effects of the Proposed Project remain as reported in section 3.9.

3.12 Transboundary Effects

3.12.1 A transboundary effect is any significant adverse effect on the environment resulting from human activity, the physical origin of which is situated wholly or in part within an area under the jurisdiction of another State.

3.12.2 All works associated with the Proposed Project fall within the UK jurisdiction (12 NM). Given the distance of the Proposed Project from French waters (approximately 25 km), no significant transboundary effects have been identified. Predicted disturbance from the Proposed Project is short term and local and are therefore not anticipated to be sufficient to influence fish and shellfish receptors outside UK waters, and subsequently cause transboundary effects.

Table 3.15 Summary of fish and shellfish effects

Phase	Potential Impact	Receptor	Sensitivity	Effect		Additional Mitigation Measures	Residual Effect	
				Magnitude	Significance		Magnitude	Significance
Construction Phase	Temporary physical disturbance to fish and shellfish	Herring	High	Low	Minor	No	Low	Minor
		Sandeel	High	Low	Minor	No	Low	Minor
		Other marine fish	High - low	Negligible	Negligible	No	Negligible	Negligible
		Shellfish	High - medium	Negligible	Negligible	No	Negligible	Negligible
	Temporary increase in SSC and subsequent sediment deposition leading to contaminant mobilisation, increased turbidity and smothering effects on fish and shellfish	Herring	Medium	Low	Minor	No	Low	Minor
		Sandeel	Medium	Low	Minor	No	Low	Minor
		Diadromous fish	Medium	Negligible	Negligible	No	Negligible	Negligible
		Other marine fish	Medium - low	Low	Negligible	No	Low	Negligible
		Shellfish	Low	Negligible	Negligible	No	Negligible	Negligible
	Underwater sound effects	Marine fish	High -low	Negligible	Negligible	No	Negligible	Negligible

Phase	Potential Impact	Receptor	Sensitivity	Effect		Additional Mitigation Measures	Residual Effect	
				Magnitude	Significance		Magnitude	Significance
Operational Phase	Permanent loss of fish and shellfish habitat due to placement of hard substrates on the seabed	Herring	High	Low	Minor	No	Low	Minor
		Sandeel	High	Low	Minor	No	Low	Minor
		Shellfish	Low	Negligible	Negligible	No	Negligible	Negligible
		Other marine fish	High - low	Negligible	Negligible	No	Negligible	Negligible
	Disturbance to fish due to subsea cable EMF emissions	Diadromous species	Low	Low	Negligible	No	Low	Negligible
		Pelagic species	Low	Negligible	Negligible	No	Negligible	Negligible
		Demersal species	Medium - low	Negligible	Negligible	No	Negligible	Negligible
		Elasmobranchs	Medium	Low	Minor	No	Low	Minor
		Spawning, eggs, larvae and juvenile fish	Low	Negligible	Negligible	No	Negligible	Negligible
	Potential effects on fish and shellfish	Diadromous species	Negligible	Negligible	Negligible	No	Negligible	Negligible
		Herring and sandeel	Medium	Negligible	Negligible	No	Negligible	Negligible

Phase	Potential Impact	Receptor	Sensitivity	Effect		Additional Mitigation Measures	Residual Effect	
				Magnitude	Significance		Magnitude	Significance
	due to subsea cable thermal emissions	spawning grounds						
		Shellfish	Low	Negligible	Negligible	No	Negligible	Negligible
Decommissioning Phase		Potential effects the same as route preparation and cable installation						

3.13 References

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