10. FISH AND SHELLFISH ECOLOGY

10.1 Introduction

This chapter of the EIA Report (EIAR) assesses the abundance and distribution of fish and shellfish ecology receptors of relevance to the Project and the likely significant effects from the construction, operation, maintenance and decommissioning of the Project on these receptors. Where required, mitigation is proposed, and the residual impacts and their significance are assessed. Potential cumulative effects are also considered.

Table 10-1 below provides a list of all the supporting studies which relate to and should be read in conjunction with the fish and shellfish ecology impact assessment.

Table 10-1 Supporting studies

Details of study	Locations of Supporting Study
Benthic Survey Report (Ocean Ecology Limited, 2023)	Appendix 9-1
Sceirde Rocks Offshore Wind Farm: Underwater Noise Modelling and Assessment (Subacoustech, 2024)	Appendix 12-1

The impact assessment presented herein draws upon information presented within Chapter 9: Benthic Ecology, which assesses the potential effects on benthic habitats and species, including fish and shellfish ecology prey species.

This impact assessment informs the following impact assessments:

- Chapter 11: Marine Ornithology – assesses the indirect impacts of changes in fish and shellfish prey species on ornithological receptors;
- Chapter 12: Marine Mammals and Other Megafauna – assesses the indirect impacts of changes in fish and shellfish prey species on marine mammal receptors;
- Chapter 13: Commercial Fisheries – assesses the potential impacts on commercial fishing effort and the monetary value of fish and shellfish species.

The Natura Impact Statement (NIS) has utilised the information within this chapter full considers diadromous fish species, which can be qualifying features of Special Areas of Conservation (SACs).

10.1.1 Statement of Authority

This Chapter of the EIAR has been prepared and reviewed by Xodus Group Limited (Xodus); the qualifications and relevant experience of the authors and reviewers are detailed in Table 10-2 below. The underwater noise modelling and assessment that has informed this chapter has been prepared by Subacoustech (Appendix 12-1).

Table 10-2 Statement of authority

Name	Qualifications	Experience
Jane Gordon	BSc Hons in Zoology MSc in Environmental Science	Jane Gordon is a Lead Environmental Consultant who has been providing environmental support for offshore renewables for over five years. She has experience across various aspects and phases of offshore renewables projects, which has provided her with a holistic approach to her work and a strong technical understanding of the potential impacts of offshore energy

Name	Qualifications	Experience
		projects on the marine environment. Jane has experience conducting impact assessments for a number of EIA topics, with a recent focus on fish and shellfish ecology and commercial fisheries. Jane is working towards becoming one of Xodus' technical specialists for fish and shellfish ecology and was lead author of the fish and shellfish ecology EIA chapter for the West of Orkney Windfarm.
Jenni O'Neill	BSc Hons in Earth Science MRes in Geo-environmental engineering	Jenni is a Lead Environmental Consultant with 5 years' experience. Jenni holds a BSc in Earth Sciences from the University of Glasgow, and an MRes in Geo-Environmental Engineering from the University of Strathclyde. Prior to joining Xodus in July 2022, Jenni spent 3 years as an Environmental Consultant with Arcus Consulting (now part of the ERM group). At Arcus, Jenni work was focused managing and coordinating EIAs and planning applications for onshore renewables projects across Scotland, including onshore wind, solar PV developments, hydroelectric developments, and battery storage. Jenni therefore has gained a growing technical knowledge of the environmental sensitivities surrounding this type of development. Now with Xodus, Jenni is well versed in environmental assessments for various large-scale developments both on- and offshore.

10.2 Legislation, Policy and Guidelines

Over and above the legislation presented in Chapter 2: Background and Planning Policy, the following legislation, policy and guidance are relevant to the assessment of impacts from the Offshore Site on fish and shellfish ecology (

Table 10-3):

Table 10-3 Policy and guidance relevant to Fish and Shellfish Ecology

Policy / Guidance	Reference
Policy	
› EU Habitats Directive (Council Directive 92/43/EC) as transposed into Irish law by the European Communities (Birds and Natural Habitats) Regulations 2011, as amended (S.I. No. 477 of 2011) ('the Habitats Regulations'): › Species listed in Annex I and II of the Habitat Directive (and afforded protection under the Habitats Regulations); › Article 12 requires that the measures for the strict protection of species listed in Annex IV (a), prohibiting all forms of deliberate capture or killing, deliberate disturbance particularly during breeding, rearing, hibernation and migration, and deliberate deterioration and destruction of breeding sites or resting places;	EU Habitats Directive (Council Directive 92/43/EC)
› Wildlife Acts 1976 to 2021 confers specific protection on fish and other species, prohibiting hunting, injury, or wilful interference or destruction of the breeding place of a protected species	Wildlife Act 1976 (no. 39 of 1976)

	Wildlife (Amendment) Act 2000 (no. 38 of 2000) Wildlife (Amendment) Act 2010 (no. 19 of 2010) Wildlife (Amendment) Act 2012 (no. 29 of 2012) Heritage Act 2018 (no. 15 of 2018), Part 3 Planning, Heritage and Broadcasting (Amendment) Act 2021 (no.11 of 2021), Chapter 3
› UN Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	UN Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) (1979)
› Convention for the Protection of the Marine Environment of the Northeast Atlantic (OSPAR Convention[1]	OSPAR (1992)
› The Offshore Renewable Energy Development Plan (OREDP) (Ireland)	DCCAE (2014)
› Marine Planning Policy Statement (Ireland)	DHLGH (2019)
› National Marine Planning Framework (NMPF)	DHLGH (2021)
Guidance	
› Chartered Institute of Ecology and Environmental Management (CIEEM) - Guidelines for EIA in Britain and Ireland. Marine and Coastal, Final Document (UK and Ireland)	CIEEM (2018)
› Assessment of the environmental impacts of cables (The Convention for the Protection of the Marine Environment of the North-East Atlantic) (International	OSPAR (2009)
› Assessment of Impact of Offshore Wind Energy Structures on the Marine Environment	Marine Institute (2000)
› Guidance on Environmental Impact Statement (EIS) and Natural Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects (Ireland)	Barnes (2017)

[1] *This legislative agreement regulates international cooperation on environmental protection in the North East Atlantic. The Convention has been ratified by 15 signatory nations. The OSPAR List of Threatened and/or Declining Species and Habitats was developed to identify species and habitats in need of protection.*

Scottish Natural Heritage (SNH) - Guidance on Survey and Monitoring in Relation to Marine Renewables Deployments in Scotland Volume: Benthic Habitats (UK)	Saunders, Bedford, Trendall, & Sotheran (2011)
Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI (International)	Popper et al. (2014)
Centre for Environment, Fisheries and Aquaculture Science (Cefas) – Guidance Note for Environmental Impact Assessment in Respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) Requirements (UK)	Cefas (2004)
Cefas - Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (UK)	Judd (2012)
OSPAR - Guidance on Environmental Considerations for Offshore Wind Farm Development (UK and Ireland)	OSPAR (2008)
Guidance on Marine Baseline Ecological Assessment and Monitoring Activities for Offshore Renewable Energy Projects (Part 1 and 2). (Ireland)	DCCAE (2018a, b)

10.3 Consultation

Stakeholder consultation has been ongoing throughout the EIA and has played an important part in ensuring the scope of the baseline characterisation and impact assessment are appropriate with respect to the Offshore Site and the requirements of the regulators and their advisors. The Scoping Report was distributed to key stakeholders in August 2023. Consultees specific to the topic of fish and shellfish ecology include:

- Environmental Protection Agency;
- Galway City Council – Environment Department;
- Inland Fisheries Ireland;
- Irish Wildlife Trust;
- Marine Institute of Ireland; and
- Sea Fisheries Protection Authority.

Following receipt of scoping responses, no concerns or specific comments were raised regarding fish and shellfish ecology receptors.

10.4 Assessment Methodology

10.4.1 Data and Information Sources

10.4.1.1 Desktop Study

The existing data sets and literature with relevant coverage of the Offshore Site, which have been used to inform the baseline characterisation for the EIA, are outlined in Table 10-4 . Peer reviewed literature has been used to inform the baseline for diadromous fish.

Table 10-4 Available data and information sources for fish and shellfish ecology

Title	Description	Author	Date
Mapping the spawning and nursery grounds of selected fish for spatial planning	Spawning and nursery maps of selected fish species in UK and Irish waters.	Ellis *et al.*	2012
Fisheries sensitivities maps in British waters	Spawning and nursery maps of selected fish in British and Irish waters.	Coull *et al.*	1998
The Stock Book: Annual Review of Fish Stocks in 2022 with Management Advice for 2023	Data on fisheries resources exploited by Irish fleets.	Marine Institute	2022
Atlas of Commercial Fisheries around Ireland	Data on fishing activity around Ireland for key commercial species.	Marine Institute	2019
Shark Sightings Database and the Great Eggcase Hunt Results	Data base of sightings and case records.	Shark Trust	1994-2023
Irish Elasmobranch Group	Peer Reviewed Articles and Academic Resources on Elasmobranchs.	Irish Elasmobranch Group	1980-2023
Nephrops grounds underwater television (UWTV) survey reports - 2022	Surveyed functional units (FU) 16, 17, 19 and 22 of the Porcupine Bank[2] *Nephrops* grounds to obtain estimates of *Nephrops* burrow densities, to identify the presence of sea pens and fish species on the seabed, and to collect relative abundance and distribution of marine mammals in the area.	Aristegui *et al.*, 2021; Doyle *et al.*, 2022a; Doyle *et al.*, 2022b, on behalf of the Marine Institute	2022
Irish Groundfish Survey	Survey data from internationally coordinated survey effort from Atlantic shelf of Ireland, focusing on finding information on commercially exploited fish stocks.	Marine Institute	Various
Species Spawning and Nursery Areas	Data and various studies on the spawning and nursery grounds of commercially important species.	Marine Institute	2009
Ireland's Marine Atlas	Developed as part of Ireland's reporting for the Marine Strategy Framework Directive on the condition of the ocean. Includes relevant marine data for fisheries and aquaculture.	Marine Institute	Various
Herring Spawning Areas	Herring spawning beds and areas (i.e., adjacent spawning beds grouped into areas) based on survey data collected by the fishing industry and seabed surveys (INFOMAR).	Nolan	2023

[2] *The Offshore Site overlaps with FU 17.*

Title	Description	Author	Date
OSPAR List of Declining Species and Habitats	The list aims at providing guidance for setting priorities for the conservation and protection of marine biodiversity in implementing Annex V to the OSPAR Convention.	OSPAR	2010
Seabed habitats	The data sources listed in Chapter 9: Benthic Ecology) will also be used in the fish and shellfish ecology baseline characterisation.	Various	Various
National Parks and Wildlife Service: Maps and Data	Designated sites and NWPS Designations View.	National Parks and Wildlife Service	2022
Ireland Red List – Cartilaginous fish	List of Irish IUCN Red List threatened cartilaginous species.	Marine Institute	2016
Shellfish areas	Multiple additional data sources including: Atlas of Commercial Fisheries for Shellfish around Ireland; Shellfish Stocks and Fisheries Review 2020 (Marine Institute); Bord Iascaigh Mhara (BIM) Mussel Larvae Monitoring 2019.	Various	Various

10.4.1.2 Site Surveys

A benthic characterisation survey was completed between 9th and 20th October 2023 utilising drop-down Camera (DDC), sediment grab sampling and water sampling for water contaminants and environmental DNA (eDNA). Grab samples were successfully obtained from a total of 58 grab sample stations with a further 36 DDC transects, distributed across the Offshore Array Area (OAA) and Offshore Export Cable Corridor (OECC). Grab samples were subject to a macrofaunal analysis, chemical analysis, Particle Size Distribution (PSD) analysis and eDNA analysis. Further details on the benthic characterisation survey are provided in Chapter 9: Benthic Ecology.

Water eDNA samples were collected at 10 stations, with a single replicate at three different depths: subsurface, mid-water and 2 m above the seabed, yielding a total of 30 water samples for eDNA analysis. eDNA analysis is a non-invasive sampling method used to determine the presence of species, based on the DNA found within water samples. It involves extracting and purifying (i.e. remove Polymerase Chain Reaction (PCR) inhibitors) and amplifying the DNA from each water sample. The PCR amplification is performed for a hypervariable region of the 12S rRNA gene to target fish species. The eDNA sequences are then processed using a custom bioinformatics pipeline for taxonomic assignment (Ocean Ecology, 2023).

The results from the benthic survey have been drawn on, where appropriate, to inform the assessment of fish and shellfish ecology. The PSD results have been reviewed to determine suitability of the seabed as a spawning habitat for various species and the eDNA analysis has supplemented the desktop study in understanding the fish and shellfish species likely to be present at the Offshore Site.

10.4.2 Consideration of data sources and quality

As part of the development of the EIA chapter baseline, an extensive literature review was undertaken to define fish and shellfish presence within the Offshore Site and its surrounding marine environment.

There is generally considered to be a sufficient availability of publicly available data to enable a robust and accurate baseline characterisation for fish and shellfish ecology to be made. Site surveys, including benthic characterisation surveys and eDNA analysis were carried out to supplement the desktop study and provide an up-to-date representation of the fish and shellfish community at the Offshore Site.

10.4.2.1 Fish capture surveys

Fish surveys involving the capture of fish using mobile (e.g. trawl) or static (e.g. trap) methods were not used in baseline characterisation at the Offshore Site. Instead, desk-based review of commercial and scientific survey data, together with the non-invasive eDNA method, were considered to adequately characterise the fish and shellfish community without the requirement for invasive or mortality-inducing capture surveys, which could have greater consequences for the fish and shellfish community than the construction, operation, maintenance and decommissioning of the Offshore Site itself.

Given the detailed desktop study completed, covering a long time series and a wide variety of information sources (e.g. including scientific literature, grey literature, commercial fisheries information) and the site surveys, it is unlikely that key species have been omitted from the assessment. There is a general and wider lack of understanding of the migratory patterns and at-sea behaviours of diadromous fish. This has been considered when assessing the potential effects of the Offshore Site.

10.4.3 Likely Significant Effects Assessment Methodology

10.4.3.1 Impacts Requiring Assessment

This assessment covers all effects identified during the scoping process, as well as any further potential effects that have been highlighted as the EIAR has progressed. Table 10-5 indicates all of the direct and indirect effects assessed with regard to fish and shellfish ecology and indicates the Offshore Site phases to which they relate.

No effects have been scoped out of the assessment.

Table 10-5 Potential effects requiring further assessment

Potential effect	Description	Nature of effect
Construction/decommissioning[3]		
Disturbance or damage to fish and shellfish due to underwater noise generated from construction activities	Underwater noise disturbance to sensitive fish populations generated during construction, including disturbance to migratory fish and spawning fish species. The scale of these effects may depend on the construction methods required. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.2.1 below.	Direct
Temporary habitat loss or disturbance	The Offshore Site overlaps with the spawning and/or nursery grounds for commercially valuable or sensitive species (Table 10-11). The extent of habitat loss will depend on the equipment used. The potential for this effect to occur is assessed further in	Direct

[3] *The potential effects during the decommissioning of the Project are considered analogous with, or likely less than, those of the construction phase. Where this is not the case, decommissioning impacts have been listed separately and have been assessed in Section 10.6.4*

Potential effect	Description	Nature of effect
	the impact assessment in Section 10.6.2.2 below.	
Long-term habitat loss of fish and shellfish spawning and nursery grounds due to presence of foundations and cables on the seabed	The footprint of foundation impacts will be relatively small; however, the impacts of the OECC could have a larger impact on seabed habitats and associated fish and shellfish species. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.2.3 below.	Direct
Effects of increases in suspended sediment concentrations (SSC) and potential sedimentation / smothering on fish and shellfish during construction activities	Increased sedimentation associated with installation (e.g., jet trenching) may lead to smothering of slow moving or sessile species and also localised changes in sediment type which may potentially impact seabed dependent species. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.2.3 below.	Direct
Effects of accidental release of pollutants on fish and shellfish	Accidental releases of pollutants may arise as a result of accidental spills from vessels or other equipment and have detrimental effects on fish and shellfish.	Direct
Operational		
Habitat creation and fish aggregation	Artificial structures placed on the seabed (i.e., turbine foundations and/or cable protection) will introduce new structures for habitat creation and create artificial reef effects, with the potential for fish and predator aggregation as an indirect impact. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.3.1 below.	Indirect
Effects of increases in SSC and potential sedimentation / smothering on fish and shellfish during operational activities	Increased sedimentation associated with cable repair and reburial (e.g., jet trenching) may lead to smothering of slow moving or sessile species and also localised changes in sediment type which may potentially impact seabed dependent species. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.3.2 below.	Direct
Effects of electromagnetic fields (EMFs) from subsea cables on fish and shellfish	EMFs may impact sensitive species (such as elasmobranchs and teleost fish) by impacting foraging behaviour. The potential impacts of EMFs on sensitive species are not well understood and the level of exposure	Direct

Potential effect	Description	Nature of effect
	will depend on the cable burial and protection methods used. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.3.3 below.	
Effects of thermal emissions from subsea cables on fish and shellfish	Heat dissipated from operational subsea cables may impact sensitive species. The potential impacts of thermal load on sensitive species are not well understood and the level of exposure will depend on the cable burial and protection methods used. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.3.4 below.	Direct
Disturbance or damage to fish and shellfish due to underwater noise generated from operations	Operational noise originates from 30 Wind Turbine Generator (WTG) gearbox and generators has the potential to impact on sensitive fish and shellfish species. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.3.5 below.	Direct
Barrier effects on migratory fish from the presence of the fixed platforms and associated infrastructure	Depending on the location and scale of the development, the presence of offshore infrastructure may present a barrier to the movement of migratory fish species. The potential for this effect to occur is assessed further in the impact assessment in Section 10.6.3.6 below.	Direct
Effects of ghost fishing due to lost fishing gear becoming entangled in installed infrastructure	There is the potential for lost fishing gear to become entangled with infrastructure relating to the Offshore Site which has the potential to impact fish and shellfish species. The potential for this impact to occur is assessed further in the impact assessment in Section 10.6.3.7 below.	Direct

10.4.3.2 Assessment Methodology

10.4.3.2.1 *Characterisation of Impacts and Effects*

An assessment of potential impacts is provided for the construction (including pre-construction), operational, maintenance and decommissioning phases of the Offshore Site. The assessment for fish and shellfish ecology is undertaken following the principles set out in Chapter 4: Environmental Impact Assessment (EIA) Methodology, in line with the '*Guidelines on the Information to be Contained in Environmental Impact Assessment Reports Environmental Protection Agency'* published by the Environmental Protection Agency (EPA) in May 2022 (hereafter referred to as the EPA Guidelines) and also European Commission (2017) Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU). Potential impacts are characterised based on the following:

- **Quality of effects**: Whether an effect results in a change that improves (positive) or reduces (negative) the quality of the environment;
- **Extent**: Describes the size of the area, the number of sites and the proportion of a population affected by an effect;
- **Context**: Describes whether the extent, duration or frequency will conform or contrast with established (baseline) conditions;
- **Probability**: If effects are likely or unlikely;
- **Duration**: Describes the length of time an impact is expected to occur based on the set definitions within the EPA Guidelines;
- **Frequency**: Describes how often the effect will occur (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, annually, etc.); and
- **Reversibility**: Whether an effect can be undone, through remediation or restoration.

The criteria for the sensitivity of fish and shellfish ecology receptors are presented in Table 10-6, and the magnitude of impact in Table 10-7.

An assessment of potential impacts is provided separately for the construction (including pre-construction), operational, maintenance and decommissioning phases.

Table 10-6 Receptor sensitivity criteria

Sensitivity of Receptor	Definition
High	• No ability to tolerate a particular effect causing a significant change in individual vital rates (survival and reproduction); • No ability to adapt behaviour so that individual vital rates (survival and reproduction) are highly likely to be significantly affected; • No ability to recover from any effect on vital rate (survival and reproduction); and/or • Receptor is of conservation value on an international or national level (e.g. species on the OSPAR list of threatened and/or declining species and habitats, IUCN Red List of Threatened Species ('Red List') (near threatened, vulnerable, endangered or critically endangered), species listed on Annex II of the Habitats Directive and / or a qualifying interest of a Special Area of Conservation).
Medium	• Limited ability to tolerate a particular effect which may cause a significant change in individual vital rates (survival and reproduction); • Limited ability to adapt behaviour so that individual vital rates (survival and reproduction) may be significantly affected; and/or • Limited ability to recover from any effect on vital rates (survival and reproduction).
Low	• Some tolerance to a particular effect with no significant change in individual vital rates (survival and reproduction); • Limited ability to adapt behaviour so that individual vital rates (survival and reproduction) may be affected, but not at a significant level; and/or • Ability to recover from any effect on vital rates (survival and reproduction).
Negligible	• Ability to tolerate the effect without any impact on individual vital rates (survival and reproduction); • Ability to adapt behaviour so that individual vital rates (survival and reproduction) are not affected; and/or

Sensitivity of Receptor	Definition
	- Ability to return to previous behavioural states / activities once the impact has ceased.

Table 10-7 Impact magnitude criteria

Magnitude criteria	Definition
High	- Total loss or major alteration to the integrity or conservation status of a receptor or key features of the baseline conditions; - The effect occurs across a large spatial extent; - The effect duration is long term (i.e. 15 to 60 years) or permanent (i.e. over 60 years), with the potential to be irreversible; and/or - The effect occurs at a high intensity and/or high frequency.
Medium	- Partial change or alteration to the integrity or conservation status of a receptor or one or more key features of the baseline conditions; - The effect is medium term in duration (i.e. 7 to 15 years) and/or spans a medium spatial geographic extent; and/or - Occurring occasionally / intermittently for short periods of time but at a moderate to high intensity, or medium to high frequency and/or at moderate intensity.
Low	- Minor shift away from the baseline conditions but unlikely to have a significant effect on the conservation status or integrity of the receptor; - The effect is short term in duration (i.e. 1 to 7 years) and/or local to medium spatial geographic extent; and/or - Unlikely to occur or at a low frequency and/or intensity.
Negligible	- Very slight change from baseline condition that will not affect the conservation status or integrity of the receptor; - The effect is highly localised and temporary effect (i.e. less than a year) with full rapid recovery expected to result in very slight or imperceptible changes to baseline conditions or receptor population; and/or - The effect is very unlikely to occur and if it does will occur at very low frequency or intensity.

The consequence and significance of effect is then determined using the matrix provided in Chapter 4: EIA methodology.

10.4.3.2.2 Determining Significance of Effect

The EPA Guidelines definitions for describing significance of effect have been used for the fish and shellfish ecology impact assessment (

Table 10-8).

Table 10-8 Describing significance of effect (EPA, 2022)

Magnitude criteria	Definition	Significance
Imperceptible	An effect capable of measurement but without significant consequences.	Not significant.

Magnitude criteria	Definition	Significance
Not Significant	An effect which causes noticeable changes in the character of the environment but without significant consequences.	
Slight Effects	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.	
Moderate Effects	An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends.	Significant; tolerable.
Significant Effects	An effect which, by its character, magnitude, duration or intensity, alters a sensitive aspect of the environment.	Significant; not tolerable. Mitigation measures must be in place to prevent, reduce, or avoid the impact, and if not possible then compensatory measures are proposed.
Very Significant	An effect which, by its character, magnitude, duration or intensity, significantly alters most of a sensitive aspect of the environment.	
Profound Effects	An effect which obliterates sensitive characteristics.	

10.4.3.3 Design Parameters

Table 10-9 summarises the deisgn parameters that are used for the assessment of potential effects on fish and shellfish receptors during construction (including pre-construction), operational, maintenance and decommissioning. The full Offshore Site design is detailed in Chapter 5: Project Description.

Note that the durations of Project activities presented in this EIAR are estimates only and will depend on many factors including weather and availability of vessels.

Table 10-9 Design scenario specific to fish and shellfish receptor impact assessment

Potential effect	Design Parameter Assessed	Requirement
Construction/decommissioning		
Disturbance or damage to sensitive species due to underwater noise generated from construction activities	› Construction period is four years with works typically undertaken 24 hours a day, 7 days a week. › Seabed investigation and preparation works, including surveys (geophysical, geotechnical, and benthic), Unexploded Ordnance (UXO) clearance, boulder clearance, ground preparation (dredging, and stone bed installation), and pre-lay grapnel runs over four months; › Construction activities over 18 months involving: ○ Installation of 30 WTGs with Gravity Base Structure (GBS) foundations; ○ Installation of one Offshore Substation (OSS) with GBS foundation; ○ Installation of a single 63.5 km Offshore Export Cable (OEC); ○ Installation of a network of 73 km of Inter-Array Cables (IACs) within the OAA; and ○ Landfall installation works using Horizontal Directional Drilling (HDD); and › Movement of 23 vessels during seabed preparation and construction activities (a maximum of 11 vessels on site at any one time).	Duration and nature of noisiest construction activities, including pre-construction.
Temporary habitat loss or disturbance	› Total 1,132,151 m^2 of temporary habitat disturbance and loss associated with: › Seabed preparation activities over a four-month period, including; ○ Total volume of seabed sediment required to be dredged: 150,000 m^3; ○ Boulder clearance, controlled flow excavation (CFE) and Pre-ay grapnel PLGR) – 20 m wide disturbance corridor (no clearance activities required in OECC); ○ Two disposal sites in OAA (up to 15 disposal events): Area of Disposal Site 1 = 25,842 m^2 & Volume of dredged material to be disposed of at Disposal Site 1:	Footprint which would be affected during the construction phase.

Potential effect	Design Parameter Assessed	Requirement

	37,500 m^3. Area of Disposal Site 2: 78,229 m^2 & Volume of dredged material to be disposed of at Disposal Site 2: 112,500 m^3;
	- WTG and OSS installation (14 months);
	  ○ 30 WTG GBS foundations, and one OSS gravity base foundation;
	  ○ Floating installation (no drilling).
	- Installation of the Landfall consisting of a trenchless technology duct (0.9 km in length) including one excavated subsea emergence pit and dredged side cast material;
	  ○ trenchless technology duct = 0.9 km length / volume of exit pit = 2000 $m^{3;}$
	  ○ Area of disturbance due to side casting dredged material = 1000 m^3.
	- Inter-array (16 months) and export cable (15 months) installation
	  ○ Total length of the IAC = 73.0 km
	  ○ Total length OEC = 63.5 km
	  ○ Burial trench using jet trencher, mechanical cutting trencher and/or CFE, to a target depth of lowering of 1 m.
	  ○ Total seabed temporary disturbed by cable installation: 996,950 m^2
	- Vessel footprints of 29,120 m^2 from jack-up events for the WTGs and the OSS.
	- For the purpose of the assessment, it has been considered that 100% of the IAC (73 km) will be surface laid with hard substrate protection. This, and other cable protection and infrastructure, is considered as part of the assessment of long-term habitat loss (Section 10.6.2.3).	

Long-term habitat loss of spawning and nursery grounds	Total 1,675,691 m^2 of long-term habitat loss associated with:	Footprint which would be affected during the operational phase.

Potential effect	Design Parameter Assessed	Requirement

due to presence of foundations and cables on the seabed	- 30 WTGs and one OSS with a GBS foundations atop of stonebed material = 117,604 m^2 total;
	- Up to 110,187 m^2 of stonebed material required for jack-up vessels;
	- IACs:
	  - Cable protection footprint of 1,282,082 m^2;
	- OEC:
	  - Cable protection footprint of 165,818 m^2; and
	- Operational life 38 years.	

Temporary increases in SSC and potential sedimentation / smothering on fish and shellfish during construction activities	- Seabed preparation activities over a four-month period, including;
	  - Total volume of seabed sediment required to be dredged: 150,000 m^3
	  - Boulder clearance, controlled flow excavation (CFE) and Pre-lay grapnel (PLGR) – 20 m wide disturbance corridor (no clearance activities required in OECC).
	  - Two disposal sites in OAA (up to 15 disposal events): Area of Disposal Site 1 = 25,842 m^2 & Volume of dredged material to be disposed of at Disposal Site 1: 37,500 m^3. Area of Disposal Site 2: 78,229 m^2 & Volume of dredged material to be disposed of at Disposal Site 2: 112,500 m^3
	- WTG and OSS installation (14 months)
	  - 30 WTG GBS foundations, and one OSS gravity base foundation;
	  - Floating installation (no drilling).
	- Installation of the Landfall consisting of a trenchless technology duct (0.9 km in length) including one excavated subsea emergence pit and dredged side cast material;
		Volume of sediment released into the water column.

Accidental release of pollutants		Potential for sediment disturbance, and greatest volume sediment released into the water column. Note, there is no piling or drilling required for the installation of the WTGs as GBS foundations will be used.

Potential effect	Design Parameter Assessed	Requirement
	○ trenchless technology duct = 0.9 km length / volume of exit pit = 2000 m^3; ○ Area of disturbance due to side casting dredged material = 1000 m^3. › Inter-array (16 months) and export cable (15 months) installation ○ Total length of the IAC = 73.0 km ○ Total length OEC = 63.5 km ○ Burial trench using jet trencher, mechanical cutting trencher and/or CFE, to a target depth of lowering of 1 m. ○ Total seabed temporary disturbed by cable installation: 996,950 m^2.	
Operational		
Habitat creation and fish aggregation	1,675,691 m^2 of long-term habitat loss associated with: › 30 WTGs and one OSS with a GBS foundations atop of stonebed material = 117,604 m^2 total; › Up to 110,187 m^2 of stonebed material required for jack-up installation vessels; › IACs: ○ Cable protection footprint of 1,282,082 m^2; › OEC: ○ Cable protection footprint of 165,818 m^2; and › Operational life 38 years.	Footprint which would be affected during the operational phase that has the potential to result in artificial reef or fish / predator aggregation.
Temporary increases in SSC and potential sedimentation /	Operational life of up to 38 years. Operational works will include the following relevant campaigns:	Volume of sediment released into the water column.

Potential effect	Design Parameter Assessed	Requirement
smothering on fish and shellfish during operational activities	- Cable maintenance and repairs may also be required during the lifetime of the Project. Interventions required could include increasing the cable depth of lowering in locations along the cable route where a mobile seabed may lead to cable exposure risk. If a need for cable maintenance or repair is identified, the location, scale and type of damage will determine the repair methodology and timing. The affected area may require cable cutting, replacement and/or jointing of the cable sections and installation of additional cable protection. Major repair works may also be required throughout the operational phase. - Additionally, it is anticipated the GBS foundation will require maintenance during the Project lifetime.	

Effects of EMFs from subsea cables on sensitive species
 	
Effects of thermal emissions from subsea cables on sensitive species
	- IACs:
	  - Network of HVAC cables (66/132 kV) with a length of 73 km;
	  - Minimum depth of lowering of 1.0 m; and
	  - 1,282,082 m^2 cable protection.
	- OEC:
	  - One HVAC cable (220 kV) (single export circuit) with a length of 63.5 km;
	  - Minimum depth of lowering of 1.0 m; and
	  - 0.20km^2 cable protection.
	- Operational life of 38 years.
		Potential for EMF and thermal emissions.

Disturbance or damage to sensitive species due to underwater noise generated from operations	- Operation of 30 WTGs and one OSS; - Minimum spacing of 1,017 m between WTGs; - Estimated number of maintenance vessels expected for routine inspections, repairs and replacement:	Duration and nature of operational activities.

Potential effect	Design Parameter Assessed	Requirement
	○ Two CTVs per day with up to four daily return vessel movements; ○ One SOV per day; ○ Two annual jack up intervention campaigns (may cover more than two locations); ○ One repair platform per year; ○ One drone campaign per year; ○ Five unscheduled cable repair vessels over the lifetime; ○ Cable survey vessels required annually for the first 5 years, and one every 5 years thereafter; and ○ Oil exchange vessels required once every 10 years. › Operational life of 38 years.	
Barrier effects on migratory fish from the presence of the fixed platform and associated infrastructure	Considers the parameters above for EMF effects, underwater noise, and the following for visual effects and physical barriers: › 30 WTGs and one OSS built across the OAA; › Minimum spacing of 1,017 m between WTGs; and › Operational life of 38 years.	Parameters by which potential barrier effects would occur.
Ghost fishing due to lost fishing gear becoming entangled in installed infrastructure	› Operation of 30 WTGs and one OSS with GBS foundations; › Minimum spacing of 1,017 m between WTGs; and › Operational life of 38 years.	Extent of gear in water column.

10.4.3.4 Mitigation by Design

As described in Chapter 4: EIA Methodology, certain measures have been adopted as part of the Offshore Site design to reduce the potential for impacts to the environment. Those relating to fish and shellfish receptors are presented in Table 10-10.

Table 10-10 Mitigation measures by design, and other embedded mitigation, relevant to fish and shellfish ecology

Measure	Design Requirement
Cable burial	The use of cable protection will be minimised as far as practicable, and only used where required. Additional external cable protection (e.g., rock placement) will only be used where the minimum target burial depth cannot be achieved, for example in areas of hard ground or at third-party crossings.
Management Plans	Implementation and compliance with the Offshore Environmental Management Plan (OEMP)), including Marine Invasive Non-Native Species Management Plan (MINNSMP), and a Marine Pollution Contingency Plan (MPCP). These plans include a commitment to measures to mitigate against pollution events, biosecurity measures, waste management, measures to avoid the introduction and spread of Invasive Non-Native Species, adherence to the BWM Convention and other applicable international regulations, as well as containment procedures.
MARPOL Compliance	Marine pollution prevention under the International Convention for the Prevention of Pollution from Ships (MARPOL) convention requirements will be followed during construction, operational, maintenance and decommissioning.
Avoidance of Sensitive Habitats	The Project has completed pre-construction benthic survey and habitat mapping to inform habitat distribution and identify potential spawning or nursery habitats. This information has been taken into account for cable route refinement within the OECC to reduce the habitat loss or disturbance of potential spawning or nursery habitats, in particular for the most vulnerable species, such as herring and *Nephrops*.
Minimisation of SSC	The Project has committed to reducing SSCs through using a fall pipe located at 5 m above the seabed, instead of disposal from the sea surface, for disposal of dredged material.
Minimisation of underwater noise	Low order techniques for UXO detonation will be utilised wherever practicable to reduce underwater noise effects. See Chapter 12: Marine Mammals and Other Megafauna for further details on this.
Decommissioning Programme	Development of, and adherence to, a Decommissioning Programme prior to construction and updated throughout the Project lifespan. A Decommissioning Plan has been prepared for the Project (see Chapter 5: Project Description) the details of which will be agreed with the local authority prior to any decommissioning.
Vessels	Vessels engaged in construction works will typically be travelling at slow (<6 kts) speeds. This will reduce sound emissions relative to high-speed transiting.
Vessels	Implementation and compliance with a Vessel Management Plan (VMP) and Navigational Safety Plan (NSP).

10.5 Baseline Conditions

This section summarises current knowledge on abundance and distribution of fish and shellfish ecology within the fish and shellfish study area. The characterisation of the current environment is established from a combination of benthic site survey results and desk-based resources.

The objective of this section is to present the best available understanding of the current baseline for fish and shellfish species including identification and description of key fish and shellfish species, including detail on their ecology, conservation and commercial importance, and their wider distribution in the study area. Spawning and nursery grounds of relevance will be identified, as well as a description of migratory patterns of the diadromous fish relevant to the study area, and an identification of relevant fish and shellfish protected sites.

10.5.1 Study Area

The fish and shellfish study area is defined by the International Council for the Exploration of the Sea (ICES) rectangles[4] within which the OAA and OECC are located (i.e., 35D9, 35E0 and 34E0) as shown on Figure 10-1.

ICES rectangle 34D9 is also included due to its proximity to the Offshore Site. Although primarily designated for commercial fisheries management (including stock assessment and setting of catch limits), these four proximal ICES rectangles represent an appropriate Study Area as data collected and presented from these ICES rectangles will be highly representative of the fish and shellfish community likely to occur in both the coastal and offshore waters of the Offshore Site.

Additionally, a wider 'buffer zone' (at the scale of the North East Atlantic, but spatially undefined) is used to provide regional context for the wide degree of spatial and temporal variation in abundance and distribution of key fish and shellfish species (for instance, in relation to migratory fish species and the availability of fish spawning and nursery grounds).

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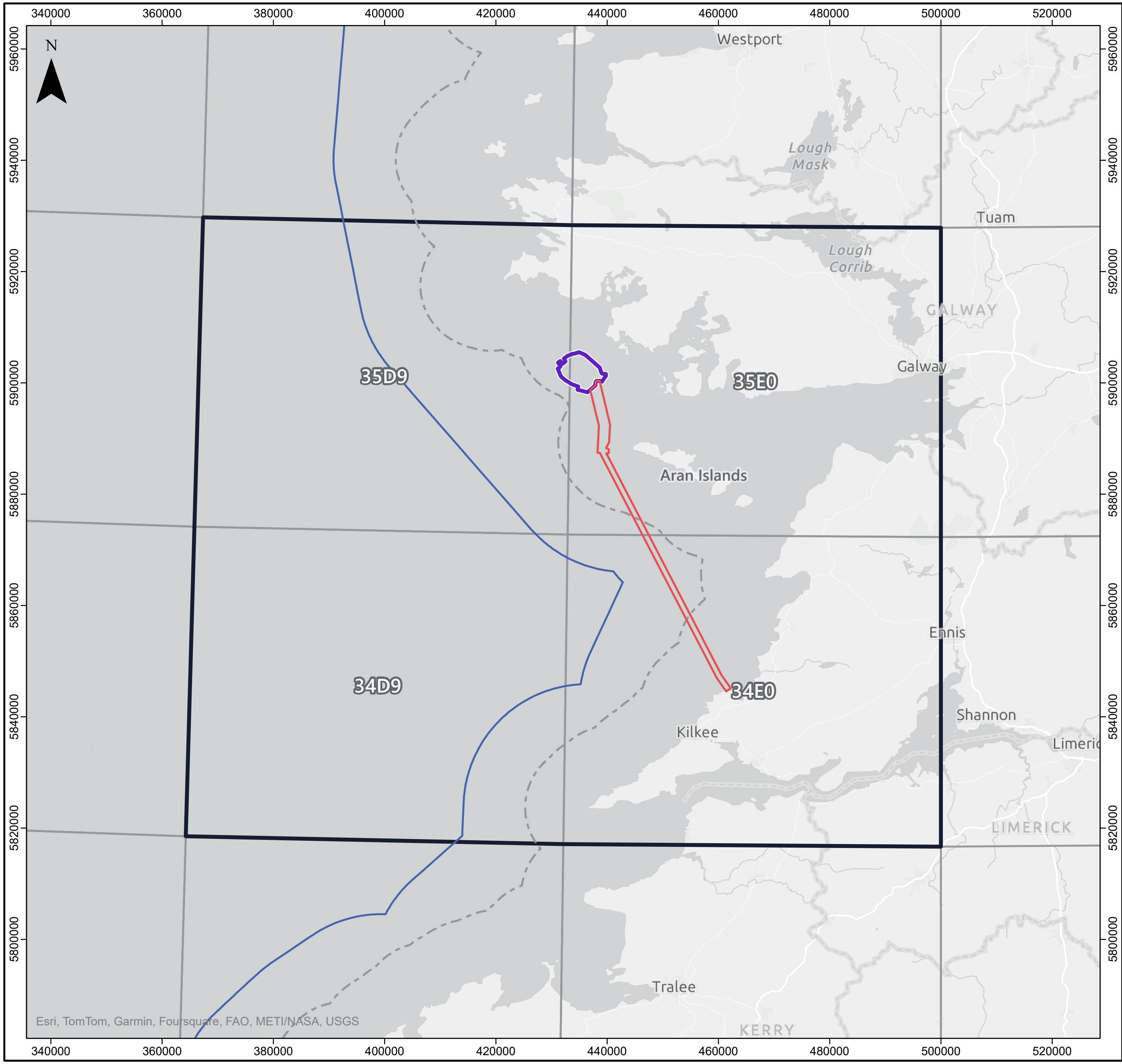
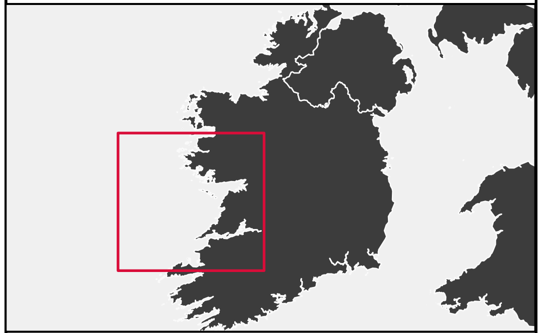
[4]Each ICES rectangle covers an area of 30' latitude by 1° longitude. The rectangles are a gridded notation system covering the north-east Atlantic region, developed by the ICES in 1970s to allow simple and controlled analysis of spatial data. Further information on ICES rectangles is available online at: https://www.ices.dk/data/maps/Pages/ICES-statistical-rectangles.aspx.



SCEIRDE ROCKS WINDFARM
Feirm Ghaoithe Charraigeacha Sceirde



LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles
- Ireland 6 NM limit
- Ireland 12 NM Limit

0 6.5 13 nm
0 10 20 km

Data Source: Contains public sector information, licensed under the Creative Commons licence v4.0; the Open Government Licence v3.0.

PROJECT TITLE
Sceirde Rocks

MAP TITLE
Fish & Shellfish Ecology Study Area

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO
Figure 10-1

SCALE	PAPER SIZE	DATUM	PROJECTION
1:1,000,000	A4	WGS 84	UTM 29N

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10.5.2 Overview

Fish and shellfish receptors relevant to the study area include marine finfish (pelagic and demersal teleost fish), shellfish (crustaceans and molluscs), elasmobranchs (sharks and rays), and diadromous fish. The distribution and composition of the fish and shellfish species identified is typical of the North Atlantic.

The seabed around Ireland gently slopes down towards a depth of around 200 m (continental shelf) after which it slopes steeply to the abyssal depth of the ocean floor. The bathymetry across the fish and shellfish study area extends to over 100 m (Marine Institute, 2024). A large number of species are recorded in the waters of the continental shelf, including *Nephrops norvegicus*, cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), megrim (*Lepidorhombus whiffiagonis*), plaice (*Pleuronectes platessa*), black sole (*Solea solea*), sandeel (*Ammodytes tobianus*) and herring (*Clupea harengus)* (Marine Institute, 2019). Along the shelf edge, species like anglerfish (*Lophiiformes*) and hake (*Merluccius merluccius*) are present as well as mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*), which migrate to the shelf edge to spawn. Blue whiting *(Micromesistius poutassou)* are mainly present in waters beyond the continental shelf slope. The spatial and temporal distribution of the fish species reflects the unique bathymetric and bioclimatic preference (Marine Institute, 2019).

The area supports important commercial fisheries (ClimeFish, 2019). The extent of commercial fishing landings indicates the study area is highly productive and of significant importance in terms of fish biomass productivity. Fish and shellfish species of commercial importance are considered as part of the baseline, provided in Section 10.5.10.

10.5.3 eDNA Analysis

The results of the eDNA analysis are described in full in Benthic Survey Report (Appendix 9-1) and summarised in Table 10-11. The most prevalent species identified, in terms of number of samples where the eDNA of the species was recorded, were European pilchard (S*ardina pilchardus*), horse mackerel and ballan wrasse (*Labrus bergylta*). Additionally, Ocean Ecology (2024) designated 20 species as of commercial importance in Europe ('commercial' in Table 10-11 below), and one species as of conservation importance (Atlantic salmon). It should be noted that 'commercial' species, that are commercially important in Europe, may not be reflective of the key commercial species for commercial fisheries within the Offshore Site (see Chapter 13: Commercial Fisheries). The lack of commercial shellfish identified through the eDNA analysis was unexpected given the commercial importance of this species within the Offshore Site. The absence of shellfish is likely to be a result of a sampling bias; eDNA from hard-shelled invertebrates is less numerous in the marine environment, as these organisms typically shed less DNA than softer-bodied organisms. It is therefore noted that the lack of shellfish eDNA in the results does not indicate the absence of this species within the fish and shellfish study area.

Table 10-11 Most relevant fish taxa identified across the survey area based on eDNA analysis (Ocean Ecology, 2024)

Fish	Common Name	Status	Number of samples in which taxon occurred
Sardina pilchardus	European Pilchard	Commercial	25
Trachurus trachurus	Atlantic Horse Mackerel	Commercial	14
Labrus bergylta	Ballan Wrasse		14
Scomber scombrus	Atlantic Mackerel	Commercial	13
Ammodytidae	Sandeel		11

Fish	Common Name	Status	Number of samples in which taxon occurred
Pollachius pollachius	Pollack	Commercial	7
Salmo salar	Atlantic Salmon	Annex II/OSPAR/Commercial	6
Trisopterus minutus	Poor Cod	Commercial	5
*Ammodytes tobianus**	Lesser Sand Eel	Commercial	5
Ctenolabrus rupestris	Goldsinny Wrasse	-	5
Labrus mixtus	Cuckoo Wrasse	-	5
Symphodus melops	Corkwing Wrasse	-	5
*Chirolophis ascanii**	Yarrell's Blenny	-	4
Taurulus bubalis	Long-Spined Bullhead	-	3
Melanogrammus aeglefinus	Haddock	Commercial	2
*Raniceps raninus**	Tadpole Fish		2
*Ciliata septentrionalis**	Northern Rockling	Commercial	2
*Molva molva**	Common Ling	Commercial	2
Belone belone	Garfish	Commercial	1
Sprattus sprattus	European Sprat	Commercial	1
*Trisopterus esmarkii**	Norway Pout	Commercial	1
Trisopterus luscus	Pouting	Commercial	1
Thunnus thynnus	Atlantic Bluefin Tuna	Commercial	1
Lepidorhombus whiffiagonis	Megrim	Commercial	1
*Scophthalmus maximus**	Turbot	Commercial	1
*Zeugopterus punctatus**	Common Topknot	Commercial	1
Salmo trutta	Brown Trout	Commercial	1
Helicolenus dactylopterus	Blackbelly Rosefish	Commercial	1
* taxa with low confidence in the identification of their Operational Taxonomic Unit (OTUs), as it was based on fewer than three matches to sequences in the reference database, and/or limited geographic occurrence records for the taxon.			

10.5.4 Spawning and Nursery Grounds

Waters off the west coast of Ireland, including the fish and shellfish study area, are potential spawning and nursery areas for a number of species of commercial and conservation importance, as indicated by fisheries sensitivity maps (Coull *et al.*, 1998; Ellis *et al.*, 2012). It should be noted that the spawning areas which have been mapped by Coull *et al.* (1998) and Ellis *et al.* (2012) represent the widest known distribution of spawning and nursery grounds based on knowledge and survey data at the time of producing these maps and should not be taken as rigid unchanging descriptions of presence or absence (Coull *et al.*, 1998). Information from a number of sources, have therefore been used in conjunction with Ellis *et al.* (2012) and Coull *et al.* (1998) to ascertain the potential for spawning and nursery grounds at a higher resolution, including data from Marine Institute (2009), and Aires *et al.* (2014).

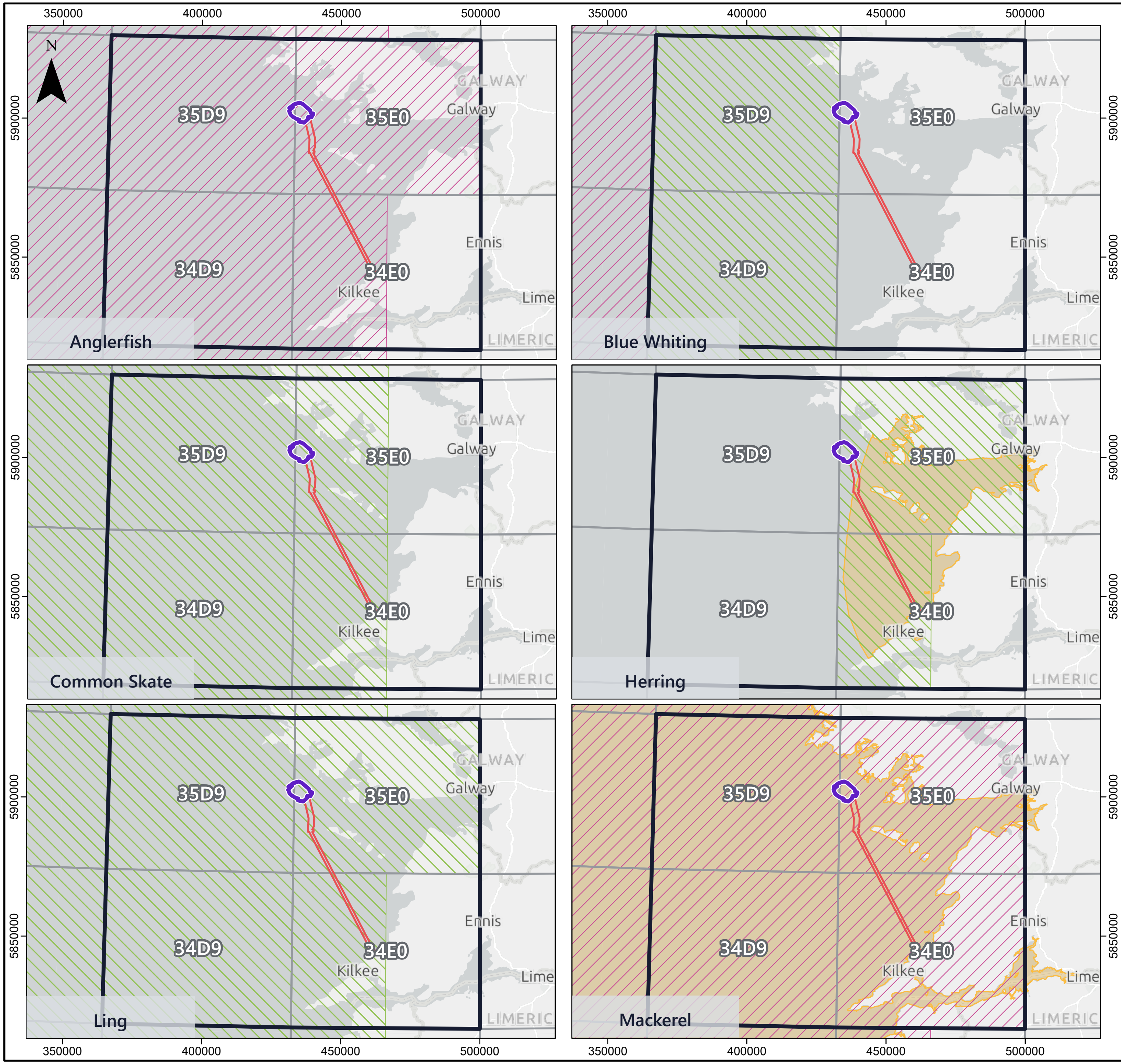
10.5.4.1 Nursery Grounds

The fish and shellfish study area overlaps with nursery grounds for anglerfish, blue whiting, common skate (*Dipturus batis*), herring, ling (*Molva molva*), mackerel, *Nephrops,* saithe (*Pollachius virens*) and spurdog (*Squalus acanthias*), as shown in Table 10-12 (Coull *et al.*, 1998; Ellis *et al.,* 2012). The spatial extent of these nursery grounds are shown in Figure 10-2 and Figure 10-3. It should be noted that anglerfish and mackerel nursery grounds are recorded at high intensity (Figure 10-2).

The nursery grounds delineated by Marine Institute (2009) also show that the study area overlaps with nursery grounds for the following species:

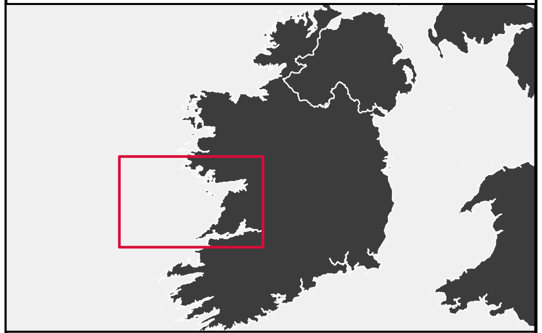
- Cod;
- Haddock;
- Hake;
- Herring;
- Horse mackerel;
- Mackerel;
- Megrim;
- Black belly angler monk (i.e. anglerfish / monkfish); and
- Whiting.

It should be noted that nursery grounds extend across much of the Irish coastline and are not local only to the study area. However, the DCCAE (2018b) highlight the importance of the Irish Biologically Sensitive Area (also known as the Irish Conservation Box) located off the southwest coast of Ireland to larval and juvenile stages of hake, cod, herring and haddock species. The northern extent of the Irish Biologically Sensitive Area overlaps the fish and shellfish ecology study area (Figure 10-4).



SCEIRDE ROCKS WINDFARM

Feirm Ghaoithe Charraigeacha Sceirde



LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles

Nursery ground intensity (Ellis et al., 2012)

- High
- Low

Nursery ground (Coull et al., 1998)

- Present

0 10 20 nm

0 25 50 km

Data Source: Contains public sector information, licensed under the Creative Commons licence v4.0; the Open Government Licence v3.0.

PROJECT TITLE

Sceirde Rocks

MAP TITLE

Ellis et al. (2012) & Coull et al. (1998) Nursery Grounds

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO

Figure 10-2

SCALE	PAPER SIZE	DATUM	PROJECTION
1:2,000,000	A4	WGS 84	UTM 29N

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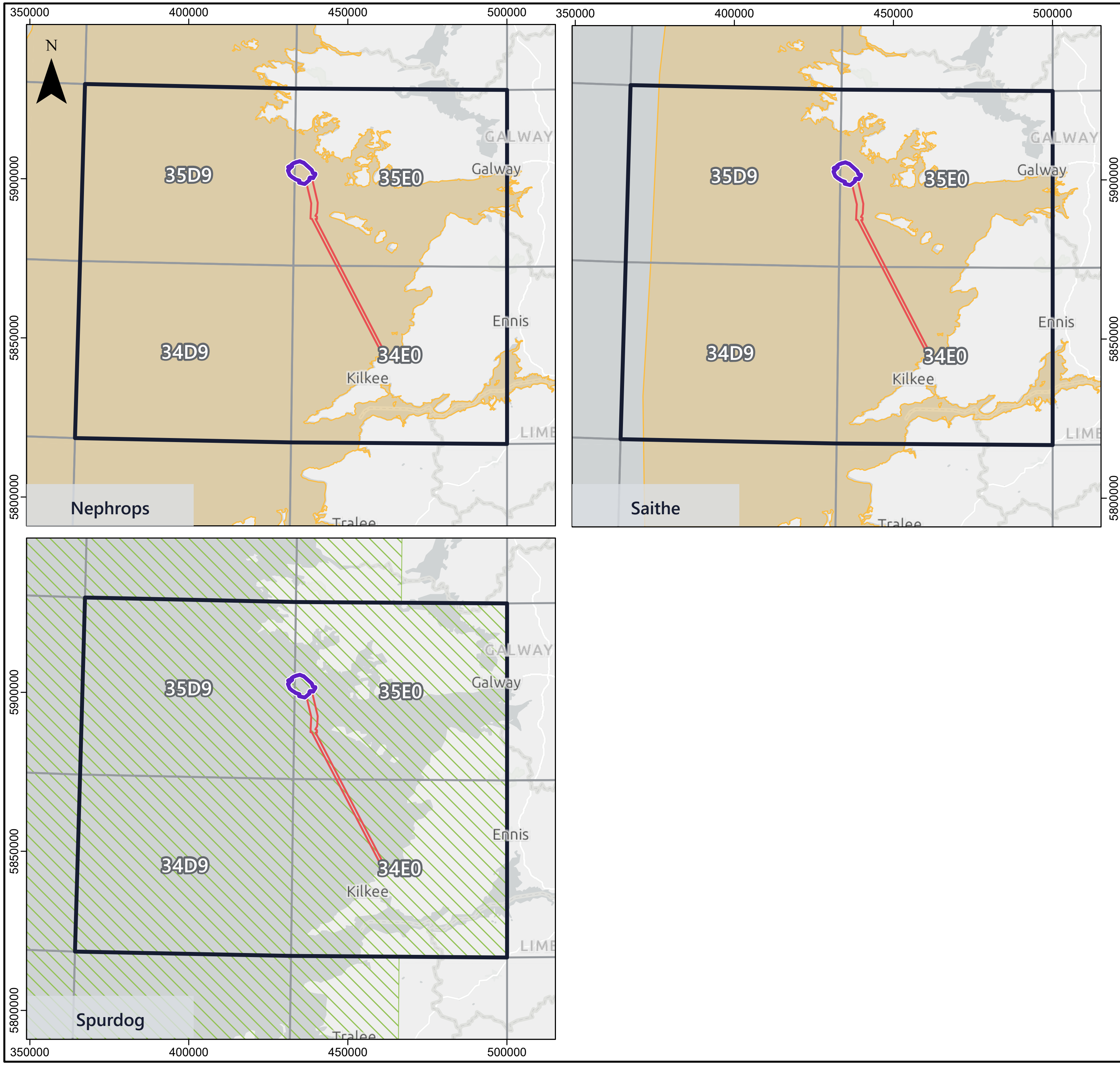

SCEIRDE ROCKS WINDFARM
Feirm Ghaoithe Charraigeacha Sceirde

LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles

Nursery ground intensity (Ellis et al., 2012)

- High
- Low

Nursery ground (Coull et al., 1998)

- Present

0 10 20 nm
0 20 40 km

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PROJECT TITLE
Sceirde Rocks

MAP TITLE
Ellis et al. (2012) & Coull et al. (1998) Nursery Grounds

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO
Figure 10-3

SCALE	PAPER SIZE	DATUM	PROJECTION
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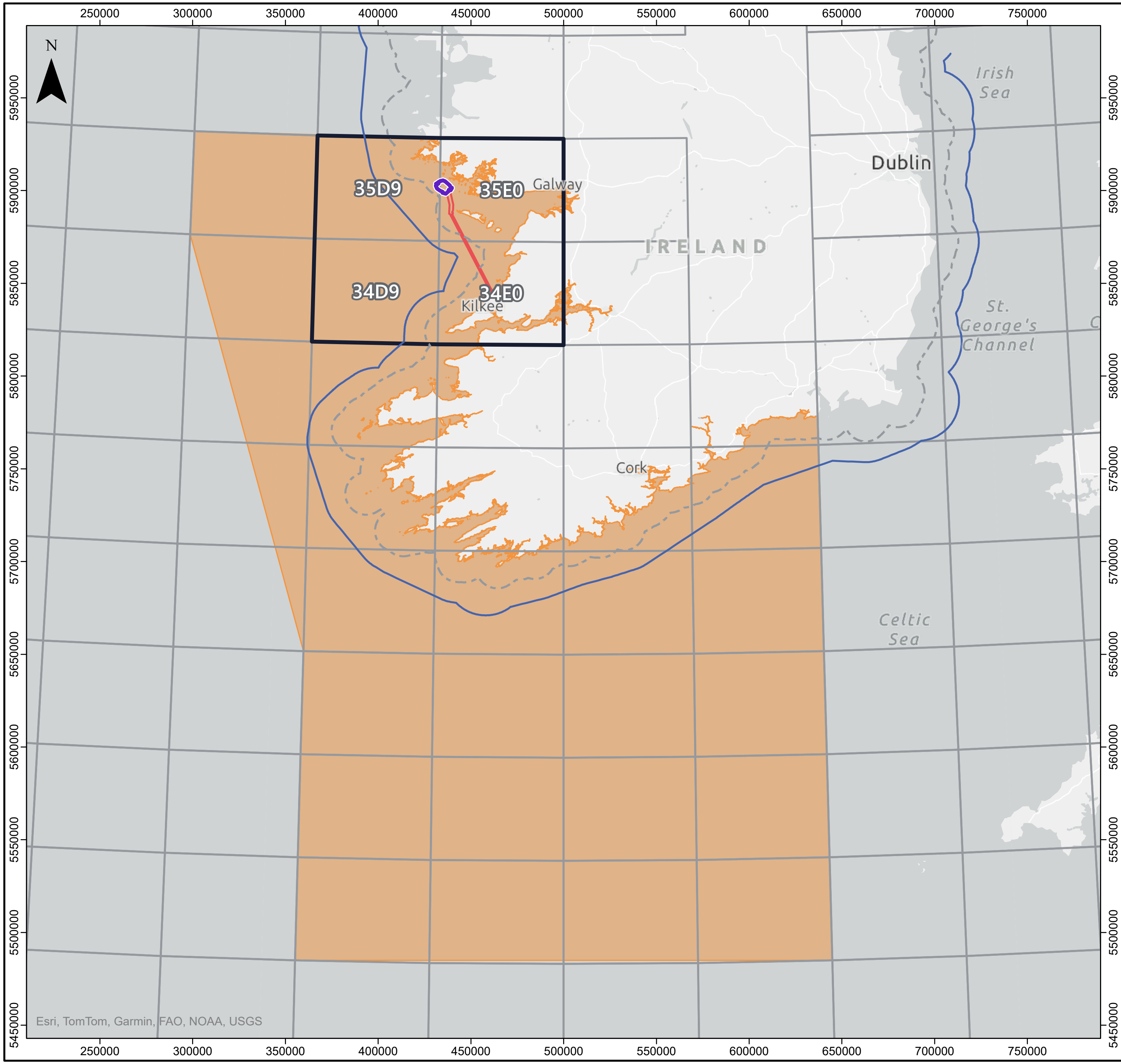

SCEIRDE ROCKS WINDFARM

Feirm Ghaoithe Charraigeacha Sceirde

LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles
- Ireland 6 NM limit
- Ireland 12 NM Limit
- Fisheries Biologically Sensitive Area

0 10 20 nm

0 30 60 km

Data Source: Contains public sector information, licensed under the Creative Commons licence v4.0; the Open Government Licence v3.0; Ireland's Marine Atlas at http://atlas.marine.ie/

PROJECT TITLE

Sceirde Rocks

MAP TITLE

Biological Sensitivity Area

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO

Figure 10-4

SCALE	PAPER SIZE	DATUM	PROJECTION
1:3,000,000	A4	WGS 84	UTM 29N

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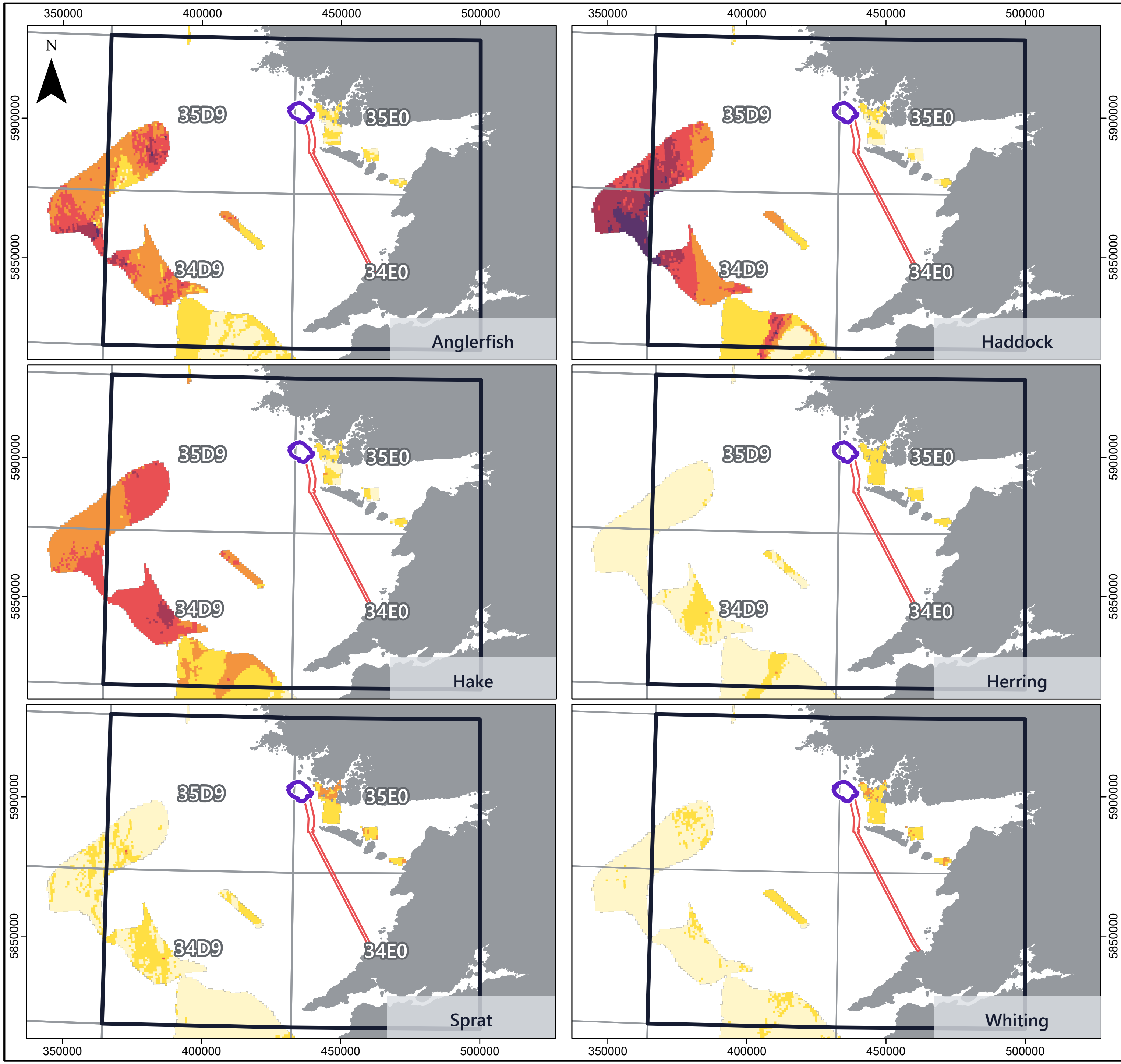
Aires *et al.* (2014) provide a review of the findings of Coull *et al.* (1998) and Ellis *et al.* (2012) alongside other datasets, including the International Bottom Trawl Survey, beam trawl survey data, and International Herring Larvae Survey reports. Aires *et al.* (2014) present a summary of the probability of aggregations of fish in the first year of their life ('0-group fish') and/or larvae of key commercial species. The probability of aggregations of 0-group-fish occurring in the fish and shellfish study area (noting that data coverage does not extend across the whole fish and shellfish study area) are illustrated in Figure 10-5 and Figure 10-6 and summarised as follows:

- Species with a low to moderate probability (0.05 – 0.2, 0.2 – 0.4) of presence of 0-group aggregations: whiting, horse mackerel, herring, and sprat; and
- Species with a moderate probability (0.4 – 0.6, 0.6 – 0.8, 0.8 – 1) of presence of 0-group aggregations: anglerfish, haddock, hake, and mackerel.

Records of 0-group aggregations in the fish and shellfish study area for the following species are absent: cod, Norway pout (*Trisopterus esmarkii*), blue whiting, and plaice (Aires *et al.* 2014).



SCEIRDE ROCKS WINDFARM
Feirm Ghaoithe Charraigeacha Sceirde

LEGEND

Offshore Array Area
Offshore Export Cable Corridor
Study Area
ICES Rectangles

Probability of aggregates of <1 year old fish
0.000001 - 0.05
0.05 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1

0 10 20 nm
0 25 50 km

Data Source: Contains public sector information, licensed under the Open Government Licence v3.0, from the UKHO and OS.
Aires, C., González-Irusta, J.M., Watret, R. (2014) Updating Fisheries Sensitivity Maps in British Waters. Scottish Marine and Freshwater Science Vol 5 No 10. Edinburgh: Scottish Government, 88pp. DOI: 10.7489/1555-1. Esri; Michael Bauer Research GmbH.

PROJECT TITLE
Sceirde Rocks

MAP TITLE
Aires Probability of Aggregates

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO
Figure 10-5

SCALE	PAPER SIZE	DATUM	PROJECTION
1:2,000,000	A4	WGS 84	UTM 29N

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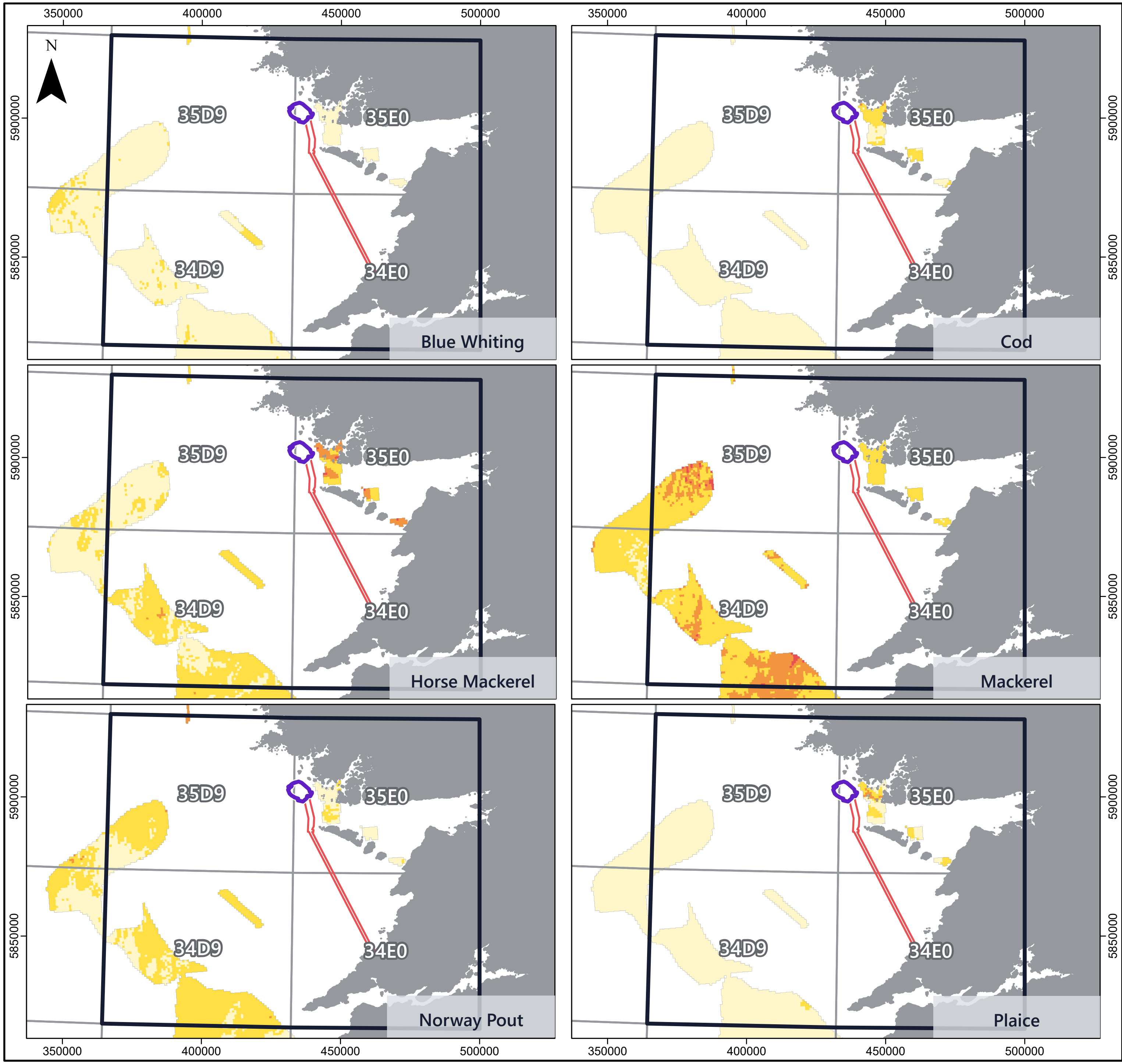

SCEIRDE ROCKS WINDFARM
Feirm Ghaoithe Charraigeacha Sceirde

LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles

Probability of aggregates of <1 year old fish

- 0.000001 - 0.05
- 0.05 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1

0 10 20 nm
0 25 50 km

Data Source: Contains public sector information, licensed under the Open Government Licence v3.0, from the UKHO and OS. Aires, C., González-Irusta, J.M., Watret, R. (2014) Updating Fisheries Sensitivity Maps in British Waters. Scottish Marine and Freshwater Science Vol 5 No 10. Edinburgh: Scottish Government, 88pp. DOI: 10.7489/1555-1. Esri; Michael Bauer Research GmbH.

PROJECT TITLE
Sceirde Rocks

MAP TITLE
Aires Probability of Aggregates

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO
Figure 10-6

SCALE	PAPER SIZE	DATUM	PROJECTION
1:2,000,000	A4	WGS 84	UTM 29N

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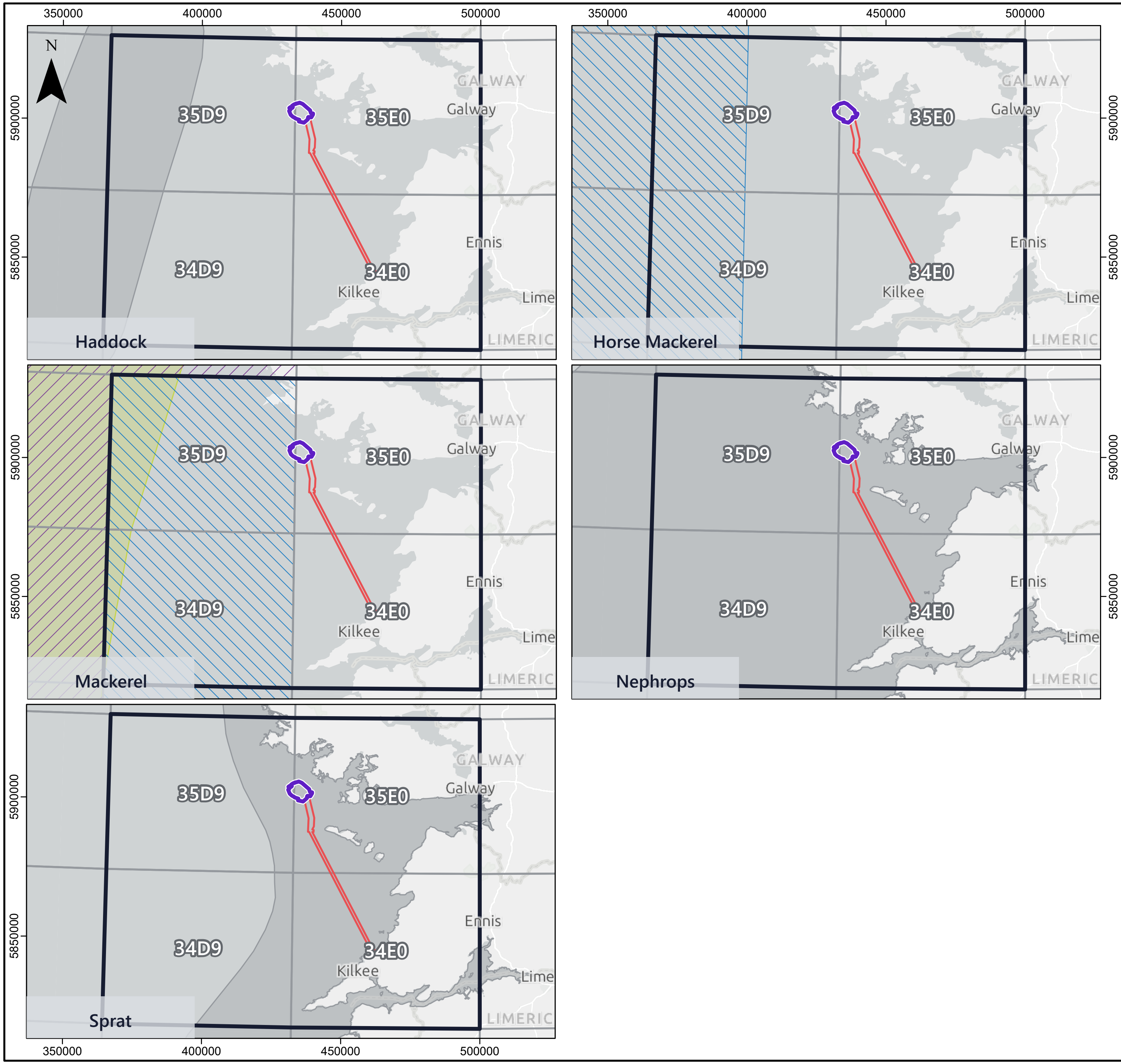
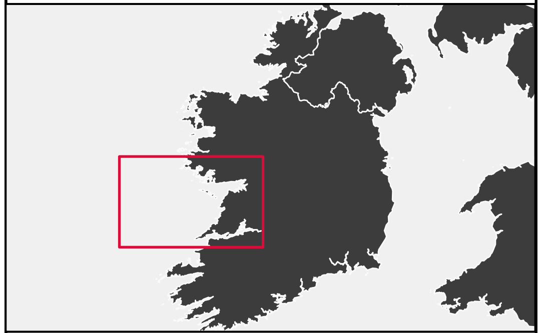
10.5.4.2 Spawning Grounds

Figure 10-7 illustrates the extent of spawning grounds within the fish and shellfish study area (Coull *et al.,* 1998; Ellis *et al.,* 2012). Spawning grounds of unidentified intensity for sprat (*Sprattus sprattus*) and *Nephrops* are located within the fish and shellfish study area and overlap the Offshore Site boundary, whilst low intensity spawning grounds for horse mackerel and mackerel, and undetermined spawning grounds for haddock, are restricted to the western edge of the study area. The areas of potential sprat and *Nephrops* spawning ground which overlap with the site boundary are a very small proportion of the overall spawning grounds for these species. The most intense spawning activity for all of these species is likely to be in the spring and early summer.



SCEIRDE ROCKS WINDFARM

Feirm Ghaoithe Charraigeacha Sceirde



LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles

Spawning ground intensity (Ellis *et al.*, 2012)

- High
- Low

Spawning ground intensity (Coull *et al.*, 1998)

- Higher intensity
- Lower intensity
- Undetermined intensity

0 10 20 nm

0 25 50 km

Data Source: Contains public sector information, licensed under the Creative Commons licence v4.0; the Open Government Licence v3.0.

PROJECT TITLE

Sceirde Rocks

MAP TITLE

Ellis et al. (2012) & Coull et al. (1998) Spawning Grounds

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO

Figure 10-7

SCALE	PAPER SIZE	DATUM	PROJECTION
1:2,000,000	A4	WGS 84	UTM 29N

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The spawning grounds delineated by Marine Institute (2009) and Nolan and Sullivan (2023) also show that the study area overlaps with spawning grounds for the following species:

- Haddock;
- Herring (spawning beds present in the south west of ICES rectangle 35E0 and the north west of ICES rectangle 45E0 around the Aran Islands);
- Horse mackerel;
- Mackerel;
- Megrim;
- Black belly angler monk (i.e. anglerfish / monkfish); and
- Whiting.

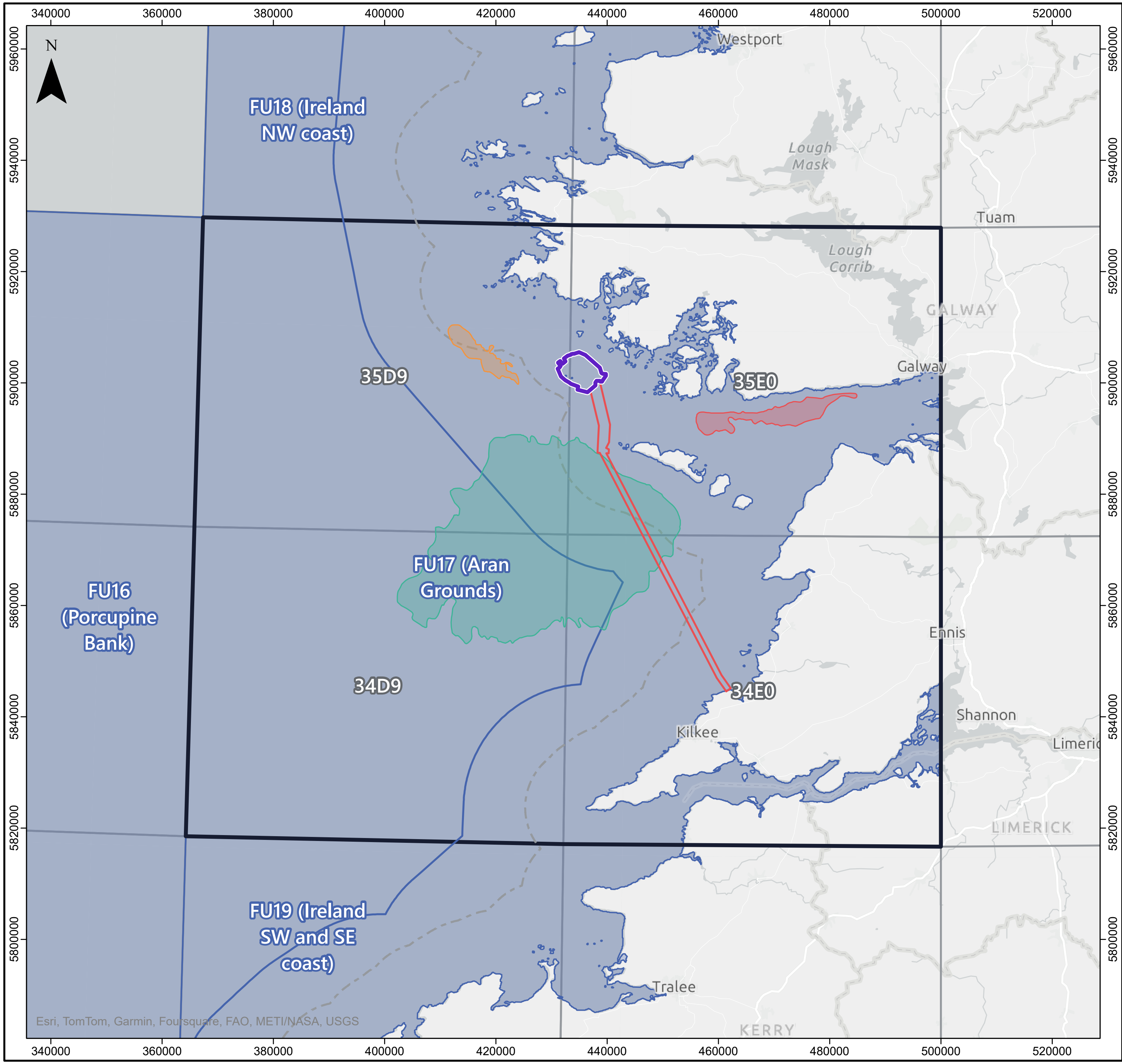
Of the species which have spawning or nursery grounds within the fish and shellfish study area as listed in Table 10-12, the majority are pelagic spawners that release their eggs into the water column (i.e. do not use the seabed to spawn) (e.g. anglerfish, blue whiting, etc.). Pelagic spawners are considered to be less vulnerable to seabed disturbance than species which spawn on the seabed.

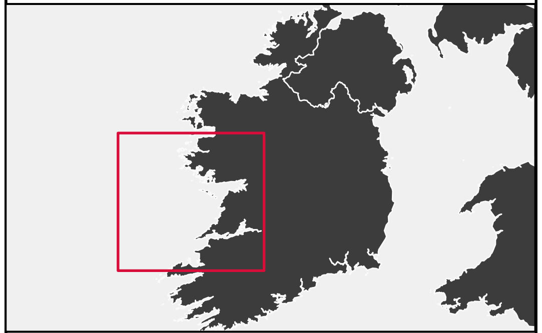
Demersal spawners, which burrow their eggs into the seabed or in nests along the bottom of the ocean, are more sensitive to seabed disturbance than pelagic spawners. Demersal spawners, including herring and sandeel, have specific habitat suitability requirements for spawning, resulting in spawning grounds that are more spatially limited than those of pelagic spawners. Nolan and Sullivan (2023) report survey records of herring spawning grounds between the Aran Islands and Galway Bay to the east of the Offshore Site, but with no direct overlap. Herring are demersal spawners, congregating together in shoals to lay dense sticky 'egg carpets' on gravel and other coarse sediments (Ellis *et al.,* 2012). Each female releases her eggs in a single batch and the resulting 'egg carpet' may be several layers thick and cover a considerable area, with eggs hatching after approximately 1 – 3 weeks (BEIS, 2022). The pelagic larvae then drift passively with the currents towards nursery grounds (Dickey-Collas *et al.,* 2015, as cited in BEIS, 2022). Sediments sampled during the site survey indicated a relatively high gravel content (average = 22.5%) and a low mud content (average = 2.8%), indicating potential suitability for herring spawning. Gravel content within the OECC was lower with a higher mud content, indicating that the sediments may be less suitable for herring spawning (Ocean Ecology, 2023).

Because *Nephrops* lay eggs on the seabed and also inhabit burrows, *Nephrops* are more vulnerable to disturbance than pelagic spawning species. Galway Bay serves as both a spawning and nursery ground for *Nephrops*. The Aran, Galway Bay and Slyne Head Grounds are an identified area of high *Nephrops* density and are classified as a functional unit (FU) for stocks (Offshore Energy SEA, 2009; Aristegui *et al.,* 2021). These FUs are shown on Figure 10-8.

It should be acknowledged that spatial data on spawning and nursery grounds mostly covers marine finfish and elasmobranch species. Most shellfish species (with the exception of *Nephrops*) are absent from these datasets. The presence of shellfish in the Offshore Site is discussed in Section 10.5.6.

SCEIRDE ROCKS WINDFARM
Feirm Ghaoithe Charraigeacha Sceirde





LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles
- Ireland 6 NM limit
- Ireland 12 NM Limit
- Nephrops Functional Unit Areas

Nephrops Grounds

- Aran Grounds
- Galway Bay
- Slyne Head

0 6.5 13 nm

0 10 20 km

Data Source: Contains public sector information, licensed under the Creative Commons licence v4.0; the Open Government Licence v3.0.

PROJECT TITLE

Sceirde Rocks

MAP TITLE

Nephrops Functional Unit Areas

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO

Figure 10-8

SCALE	PAPER SIZE	DATUM	PROJECTION
1:1,000,000	A4	WGS 84	UTM 29N

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Spawning for *Nephrops* is highly dependent on sediment type, with a preference for sediments composed of fine cohesive mud, linked to the preference for this sediment type for the burrows that this species occupy for most of their life history. Based on available information, such sediments may occur in parts of the OECC within Galway Bay and in the northern half of the cable route corridor south-east toward Liscannor Bay. The sediments sampled for the Offshore Site survey indicate a generally low mud content across most samples collected within the OAA and OECC. The main exceptions to this are stations ST042 to ST054 within the OECC where the mud content is higher (average = 25.1% compared with OECC average of 14.3% and OAA average of 2.8%) (Ocean Ecology, 2023).

Once fertilized, *Nephrops* females carry the eggs under their abdomen for the incubation period (up to 9 months), during which the females tend to remain within their burrows. Hatching of pelagic larvae occurs outside of burrows and a diel vertical migration where the larvae are dispersed by local water currents (Hill and Sabatini, 2008).

Of the remaining species listed in Table 10-12, common skate are oviparous meaning they lay eggs on the seabed in the form of egg cases. The number of eggs laid is significantly less than those released by other demersal spawning species.

Table 10-12 Summary of spawning and nursery grounds within the fish and shellfish study area

Species	Reproductive strategy[5]	Spawning				Nursery		
		Spawning period	Ellis et al (2012)	Coull et al (1998)	Marine Institute (2009)	Ellis et al (2012)	Coull et al (1998)	Marine Institute (2009)
Anglerfish	Pelagic spawner	Jan-June	-	n/a	✓	✓	n/a	✓
Blue whiting	Pelagic spawner	Feb-June	-	-	-	✓	-	-
Common skate	Oviparous	Unknown	n/a	n/a	-	✓	n/a	n/a
Haddock	Pelagic spawner	Feb-May	n/a	✓	✓	n/a	-	✓
Hake	Pelagic spawner	Jan-June	-	n/a	-	n/a	n/a	✓
Horse Mackerel	Pelagic spawner	March-July	✓	✓	✓	n/a	n/a	✓
Herring	Demersal spawner	Aug-Sept	-	-	✓	✓	✓	✓*
Ling	Pelagic spawner	Feb-May	-	n/a	n/a	✓	n/a	n/a
Mackerel	Pelagic spawner	March-July	✓	✓	✓	✓	✓	✓
Megrim	Pelagic spawner	Jan-Apr	n/a	n/a	✓	n/a	n/a	✓
Nephrops	Demersal spawner	Jan-Dec	n/a	✓	✓	n/a	✓	✓
Saithe	Pelagic spawner	Jan-April	n/a	-	n/a	n/a	✓	n/a
Sprat	Pelagic spawner	May-Aug	n/a	✓	n/a	n/a	-	n/a
Spurdog	Viviparous	All year	n/a	n/a	n/a	✓	n/a	n/a
Whiting	Pelagic spawner	Feb-June	-	✓	✓	-	-	✓
	Tick denotes records of spawning and/or nursery grounds. Dash denotes no records of spawning and/or nursery grounds. n/a = no data for species * per Nolan and Sullivan (2023)							

[5] *Demersal spawners lay eggs on the seabed. In comparison, pelagic spawners release eggs into the water column. Oviparous species reproduce by carrying eggs within their bodies which hatch within the parent.*

10.5.5 Marine Finfish

In the context of this chapter, marine finfish are defined as non-diadromous marine teleosts, including pelagic marine finfish (fish that inhabit the water column) and demersal teleost fish (bottom dwelling).

The eDNA analysis and spawning and nursery ground data provide an indication of the marine finfish species expected to be present in the fish and shellfish study area. A further indication of marine finfish species presence can be obtained through a review of the Irish Groundfish Survey (IGFS) data and commercial fisheries landings data. However, it should be noted that the IGFS surveys are conducted using demersal trawls and are therefore more likely to target demersal fish over pelagic fish. Furthermore, commercial fisheries landings also may not provide an accurate representation of species composition, as landings will be influenced by the fishing methods used, seasonality, quotas and Total Allowable Catch (TAC) limits.

The IGFS surveys have been conducted by the Marine Institute since 1990 and form part of the ICES International Bottom Trawl Surveys (IBTS). Annual survey data between 2003 and 2021 is presented on the Shiny web app[6] which can be queried by species to determine the number of individuals recorded per km^2 at the stations surveyed (Marine Institute, 2024). A summary of the data presented on the Shiny web app, and also the species-specific information on the Marine Institute (2022) species dashboard, is presented in Table 10-13 to understand the species presence in the fish and shellfish study area.

Table 10-13 Summary of marine finfish presence in the fish and shellfish study area (Marine Institute, 2022; Marine Institute, 2024)

Species	Distribution	Presence in fish and shellfish study area
Pelagic species		
Blue whiting	Distribution is generally highest on the continental shelf edge (i.e., outside the fish and shellfish study area), with the IGFS surveys recording lower densities of individuals in the inshore waters in the vicinity of the Offshore Site.	Potential – likely at low densities.
Boarfish (*Capros aper*)	Distribution is generally highest on the continental shelf edge (i.e., outside the fish and shellfish study area), with the IGFS surveys recording lower densities of individuals in the inshore waters in the vicinity of the Offshore Site.	Potential – likely at low densities.
Cod	The IGFS surveys record the highest densities in the Celtic Sea off the southeast coast of Ireland. Relatively low densities are recorded in the vicinity of the Offshore Site.	Potential – likely at low densities.
Horse mackerel	The IGFS surveys indicate a wide distribution across in both offshore and inshore Irish waters. Highest densities are recorded off the northwest and south coasts, however, this species is also recorded off the west coast of Ireland in the vicinity of the Offshore Site.	Likely.

[6] https://shiny.marine.ie/igfs/

Species	Distribution	Presence in fish and shellfish study area
Mackerel	The IGFS surveys indicate a wide distribution across Irish waters. Most adults are recorded off the north west coast of Ireland but there are relatively high densities recorded in the vicinity of the Offshore Site.	Likely.
Herring	The IGFS surveys indicate a relatively wide but patchy distribution across the north, west and south coasts of Ireland. Both juveniles and adults are recorded in the inshore waters of the west coast of Ireland in the vicinity of the Offshore Site. However, there is a high degree of inter-annual variation, with particularly high densities recorded in the vicinity of the Offshore Site for some years (e.g., 2012 and 2018).	Likely.
Sprat	Recorded in the IGFS surveys predominantly in inshore waters between 10 and 180 m. High densities are recorded in the vicinity of the Offshore Site.	Likely.
Demersal species		
Haddock	The IGFS surveys indicate that this species has a wide distribution across the north, west and south coasts of Ireland. Densities in the west coast of Ireland have generally been lower in recent years (e.g., 2018 – 2021).	Likely.
Hake	The IGFS surveys indicate that this species has a wide distribution across the north, west and south coasts of Ireland. A high density of juveniles is recorded off the southwest coast in association with key nursery grounds for this species.	Likely.
Norway pout	The IGFS surveys record lower densities on the west coast of Ireland compared with the north and south coast.	Likely – at low densities.
Pollack	Generally recorded at low densities by the IGFS surveys. Recorded off the west coast of Ireland, including in the vicinity of the Offshore Site are low. It is noted through consultation with the fishing industry that pollack is an alternative target species within the OAA.	Potential – likely at low densities.
Poor cod	The IGFS surveys indicate a wide distribution of this species across both inshore and offshore waters of Ireland.	Likely.

Species	Distribution	Presence in fish and shellfish study area
Saithe	The IGFS surveys record this species mostly off the north coast of Ireland along the continental shelf edge.	Potential – likely at low densities.
Whiting	Juveniles are mainly recorded in the IGFS surveys in inshore waters, whereas adults are present at a higher density further offshore.	Likely.
Bass (Dicentrarchus labrax)	Bass is recorded at low densities in Irish waters, concentrated off the south east coast in the Celtic Sea.	Unlikely to be present.
Black Sole	The IGFS surveys indicate a wide distribution of this species across both inshore and offshore waters, albeit at a relatively low density.	Likely – but at a low density.
Common dab (Limanda limanda)	The IGFS surveys record relatively high densities on the west coast of Ireland. This species is generally distributed in inshore waters at shallow depths.	Likely.
Plaice	Typically caught in depths out to 120 m and in areas of sandy seabed. The IGFS surveys record this species in inshore waters off the west coast of Ireland, including in the vicinity of the Offshore Site.	Likely.
John dory (Zeus faber)	The IGFS surveys indicate a wide distribution of this species across Ireland but at relatively low densities.	Likely – but at a low density.
Grey gurnard (Eutrigla gurnardus)	The IGFS surveys indicate that this species has a wide distribution across the west coast of Ireland, with relatively high densities recorded in the vicinity of the Offshore Site.	Likely.
Megrim	The IGFS surveys indicate a wide distribution of this species, with consistently high catches on the west coast of Ireland. Generally found at depths from 120 m to 600 m.	Likely.

Table 10-14 summarises the 2021 landings for the top finfish species by value (€) and weight (kg) reported by the An Bord Iascaigh Mhara's (BIM) (2023) and Sea Fisheries Protection Authority (SFPA) (see Chapter 13: Commercial Fisheries).

Table 10-14 Top finfish species landed by the Irish fleet by value and weight in 2021 (BIM, 2023)

Species	Value of landings (€M)	Live weight of landings (kg)
Mackerel	75	60,000,500
Blue whiting	12.5	2,500,000
Monkfish	12.5	2,500,000
Horse mackerel	10.5	19,000,000
Hake	10.5	4,000,000
Haddock	10.5	6,000,000

The key pelagic fish species recorded within the fish and shellfish study area include herring, mackerel, horse mackerel, European pilchard, sprat, blue whiting and boarfish. These species are either recorded within the eDNA analysis, have spawning or nursery grounds present in the fish and shellfish study area or are expected to be present based on IGFS surveys and/or commercial fisheries landings data. The most abundant demersal shelf-water fish species recorded within the fish and shellfish study area are haddock, megrim, hake, and whiting. Also likely to be found are common dab, plaice, anglerfish, pollack, poor cod, and grey gurnard (Marine Institute, 2019; Marine Institute, 2024; Marine Institute, 2022).

10.5.6 Shellfish

Shellfish are aquatic invertebrates bearing an exoskeleton. The group includes various molluscs, crustaceans, and echinoderms. Commercial fisheries landing data can be used as a proxy to identify the shellfish present in the vicinity of the fish and shellfish study area, which include Dublin Bay prawn (*Nephrops norvegicus*; referred to hereafter as *Nephrops*), scallops (Pectinidae spp.), European lobster (*Homarus gammarus*), crayfish/spiny lobster (*Palinurus elephas*), and crab species including the common shore crab (*Carcinus maenas*) and the brown crab (*Cancer pagurus*) (Brown *et al.,* 2001; AFBI, 2021; see Chapter 13: Commercial Fisheries).

Table 10-15 summarises landings findings by value and weight reported by the BIM (2023) for the top shellfish species by the Irish fleet in both value (€) and weight (tonnes) in 2021. As with Table 10-13, the landings by value have been estimated and reported by BIM (2023) and SFPA. Further detail on species of commercial importance, including commercially important shellfish, is detailed in Section 10.5.10.

Table 10-15 Top shellfish species landed by the Irish fleet by value and weight in 2021 (BIM, 2023)

Species	Value of landings (€M)	Live weight of landings (tonnes)
Nephrops	82	6,200
Crab (including brown, velvet)	25	7,200
Scallop	11.5	2,500
Lobster	11	600

10.5.6.1 *Nephrops*

Nephrops is a slim, orange pink lobster which grows up to 25 cm long and is considered to be the most commercially valuable crustacean in Europe (Bell *et al.*, 2006). *Nephrops* have a distinct preference for muddy seabed habitat, and therefore distribution patterns are determined by presence of suitable substrate, with higher abundances found on more favourable substrate. Their preference is to predominantly inhabit muddy seabed sediments, particularly with more than 40% silt and clay (Bell *et al.* 2006). *Nephrops* are considered to be opportunistic predators, mainly feeding on crustaceans, molluscs, and worms. They build and spend significant amount of time in semi-permanent burrows, which typically are 20 to 30 cm in depth (Dyebern and Hoisaeter, 1965).

Female *Nephrops* mature by three years old and will reproduce every year after. Mating begins in the early summer and spawning occurs shortly after in September. During spawning, females carry their eggs under their tails until they hatch in April or May. The larvae develop into plankton before settling into the seabed six to eight weeks later (Coull *et al.*, 1998). *Nephrops* have nursing and spawning grounds (of an undetermined intensity) located within the fish and shellfish study area (as shown in Figure 10-3 and Figure 10-7), and notably according to a study by McGeady *et al* (2019), larval retention in Aran Islands was unusually low in 2018. A OEC Trawling Activity Report, included as Appendix 13-1, demonstrates that there is minimal overlap of key *Nephrops* trawling grounds along the western boundary of the OECC, perhaps suggesting that the Offshore Site (and OECC in particular) is not an important area of habitat for *Nephrops*.

The FUs within the fish and shellfish study area are shown in Figure 10-8. The Offshore Site overlaps with an area of suitable *Nephrops* habitat that is managed under FU 17 known as Aran, Galway Bay and Slyne Head (Aristegui *et al.*, 2021). It has been recorded that FU 17 accounts for almost 50% of the total annual Irish fleet *Nephrops* landings and consists of three main fishing grounds; The Aran, Galway Bay and Slyne Head Grounds, of which the Aran is the most productive (BIM, 2017).

In 2022, the Marine Institute surveyed *Nephrops* grounds within FUs 16, 17, 19 and 22 to obtain estimates of *Nephrops* burrow densities, to identify the presence of sea pens and fish species on the seabed, and to collect relative abundance and distribution of marine mammals in the area (Aristegui *et al.,* 2021; Doyle *et al.,* 2022a; Doyle *et al.,* 2022b). The reports state that the prevalence of *Nephrops* landings is likely associated with the Aran, Galway Bay and Slyne Head *Nephrops* grounds which the fish and shellfish study area overlaps (Aristegui *et al.*, 2021). In 2021 *Nephrops* fisheries in ICES sub-area 7[7] totalled landings worth €54 million in Ireland, largely from the Porcupine Bank shelf (Aristegui *et al.,* 2021; Doyle *et al.,* 2022a; Doyle *et al.,* 2022b). Observed burrow densities have fluctuated a lot over time in this area. Although the abundance shows an overall decreasing trend over time, the density of burrows has slightly increased from 2021 to 2024 (Aristegui *et al.*, 2024).

10.5.6.2 Lobster

European lobster is predominantly found on rocky coastlines through the UK and Ireland, down to water depths of 60 m. Lobsters are solitary species and inhabit holes and tunnels that they build within rocks and boulders (Wilson, 2008). Lobsters live for at least 20 years and possibly to 50 years of age. Lobsters at the minimum landing size may vary in age from 4-8 years. Growth rate is variable and occurs incrementally during moults (which occur each year, or more in the case of larger individuals; Tully *et al.*, 2006). Adult lobsters have few natural predators, octopus being one. Natural mortality mostly occurs during moulting when the shell is soft, and cannibalism may occur. However, natural mortality rates are probably low (Tully *et al.*, 2006).

Lobsters may produce eggs every year but again this is size related and depends on the frequency of moulting. Eggs are carried externally from September to April or May when hatching occurs. Moulting cannot occur when the female lobster is carrying eggs as the eggs will be lost. Lobster larvae swim freely in the water column for about 30-40 days depending on temperature. Larvae occur mainly close to the sea surface where they can be preyed upon by seabirds and fish. Lobster larvae are the largest crustacean larvae and have a strong swimming ability (Tully *et al.*, 2006).

According to Tully (2017), the geographic distribution of lobster fishing is closely associated with the coastline close to the Offshore Site. Lobster fishing effort is mostly likely to occur within the OAA and less so within the OECC (except where it comes close to the Aran Islands – another area where lobster fishing is known to occur) (Tully, 2017).

The size composition of the landings partly reflects recent levels of fishing effort but may also be due to differences in environment. A summary of lobster management from 2004 noted that lobsters in the western region of Ireland are smaller than those from other areas around the coast (Tully, 2004).

[7] *ICES sub-area 7 is inclusive of Irish Sea, West of Ireland, Porcupine Bank, Eastern and Western English Channel, Bristol Channel, Celtic Sea North and South, and Southwest of Ireland - East and West*

10.5.7 Elasmobranchs

Elasmobranchs are a cartilaginous fish group comprising of sharks, rays and skates. There is potential for several elasmobranch species to be present in the fish and shellfish study area, including blue skate (*Dipturus batis*), spotted ray (*Raja montagui*), spurdog, and tope shark (*Galeorhinus galeus*) (Ellis *et al.,* 2012, MarLIN, 2020). Some of these species are of conservation concern; the common skate (now recognised as two different species; blue skate and flapper skate (*Dipturus intermedius*) is listed as Critically Endangered whilst the spurdog is listed as vulnerable on the IUCN Red List.

The Irish Elasmobranch Group (2023a) states that there are 30 species of shark recorded in Irish territory, and 33 species of skates and rays (2023b). Some species may be locally common and found only in discrete populations, whereas they may be uncommon in other divisions of the region.

The Shark Trust sightings database and the results of the Great Eggcase Hunt have been reviewed to understand the key elasmobranch species potentially present in the fish and shellfish study area (Shark Trust, 2022a; 2022b). Sightings data from IWDG (2023) around the OAA, including the OECC and a 20 km buffer showed 13 confirmed common basking shark sightings in 2023, displaying feeding behaviour. The egg cases of the following species have been recorded in the vicinity of the fish and shellfish study area (ordered from most common sightings to least common sightings) (Shark Trust, 2022b):

- Small-spotted Catshark/Lesser Spotted Dogfish (*Scyliorhinus canicula*);
- Thornback Ray/Skate (*Raja clavata*);
- Spotted Ray/Skate;
- Common/Flapper Skate (*Dipturus intermedius*);
- Blonde Ray/Skate (*Raja brachyura*);
- Nursehound/Bull Huss (*Scyliorhinus stellaris*);
- Undulate Ray/Skate (*Raja undulata*);
- White Skate (*Rostroraja alba*); and
- Blackmouth Catshark (*Galeus melastomus*).

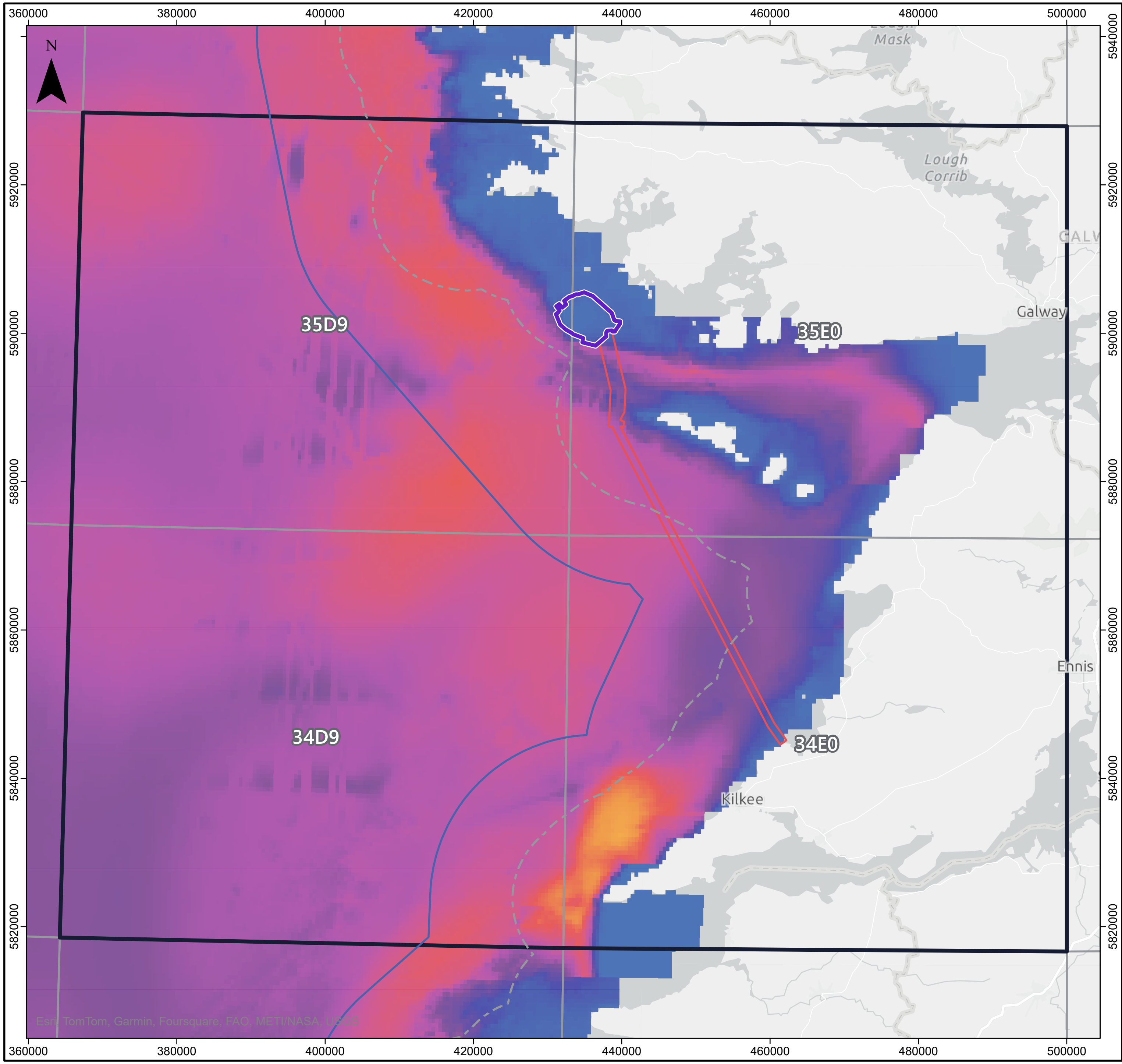
Inland Fisheries Ireland have published data from their Marine Sportfish Tagging Programme which shows records of elasmobranch species per decade and per sub-ICES rectangle (Inland Fisheries Ireland, 2023a). The records for 2010 are summarised in Table 10-16.

Table 10-16 Summary of 2010 elasmobranchs tagging record per sub-ICES rectangle (Inland Fisheries Ireland, 2023b)

ICES Rectangle	ICES Sub Rectangle	Species						
		Blue Shark	Porbeagle Shark	Tope	Common Skate Species Complex	Painted Ray	Thornback Ray	Bull Huss
34D9	34D92	1	-	-	-	-	-	-
	34D95	1	-	-	-	-	-	-
	34D98	3	-	-	-	-	-	-
34E0	34E02	19	1	-	-	-	-	-
	34E05	-	-	-	3	-	-	-
34D9	34D93	2	-	-	-	-	-	-
	34D96	8	1	-	-	-	-	-
	34D99	45	1	1	1	2	-	-
34E0	34E03	42	3	75	12	-	1	-
	34E06	-	-	73	-	-	32	2

	There were no records documented for the following sub-ICES rectangles: 35D94, 35D9, 35E01, 35D98, 35E02, 35E05, 35E08, 35D99, 35E03, 35E06, 35E09, 34E04, 34E09, and 34E08.

A recently published distribution model by McGeady *et al.* (2022) indicates that the OECC has a relatively high potential for common skate presence, with a lower probability within the OAA (Figure 10-9). Importantly, this is in the context of areas of much higher probability of presence further west in the east of ICES rectangle 35D9.



SCEIRDE ROCKS WINDFARM

Feirm Ghaoithe Charraigeacha Sceirde

LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles
- Ireland 6 NM limit
- Ireland 12 NM Limit

Probability of presence of common skate

- 1 - More Probable
- 0 - Less Probable

0 5 10 nm

0 9.5 19 km

Data Source: Contains public sector information, licensed under the Creative Commons licence v4.0; the Open Government Licence v3.0. Spatio-temporal dynamics of the common skate species complex: Evidence of increasing abundance © 2022 Ryan McGeady, Sophie L. Loca, Chris McGonigle

PROJECT TITLE

Sceirde Rocks

MAP TITLE

Common Skate Distribution 2018 - 2020

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO

Figure 10-9

SCALE	PAPER SIZE	DATUM	PROJECTION
1:750,000	A4	WGS 84	UTM 29N

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High bycatch rates have recently been observed for some elasmobranch species which are of conservation concern in the Celtic Sea, particularly in trawl gears and nets (ICES, 2023). Although there are no quotas, spatial restrictions, and prohibited listings for these species, several of them remain vulnerable to existing fisheries.

There are no specific fisheries for these species, however most of these species have commercial value, but not locally to the fish and shellfish study area. Some of these species of elasmobranch have nursery grounds in or in close proximity to the fish and shellfish study area, as shown in Table 10-12 (Ellis *et al.*, 2012).

It should be noted that, whilst classified as an elasmobranch fish, basking shark are considered within Chapter 12: Marine Mammals and Other Megafauna, due to its ecology (and thus potential for impacts) being more akin to that of a cetacean than other elasmobranch fish.

10.5.8 Diadromous Fish

Diadromous fish are fish that are highly mobile and migrate between fresh water and the marine environment to fulfil their lifecycles. There are several forms of diadromy, however, here a focus is placed on anadromy – where a species migrates from marine waters to freshwater to spawn (Salmonoids (*Salmonidae*) and lampreys (*Petromyzontiformes*)) and catadromy – where a species migrates from freshwater to oceans and seas to spawn (European eel; *Anguilla anguilla*).

There is the potential for diadromous fish species to migrate to and from Irish rivers in the vicinity of the Offshore Site. Whilst empirical data is limited for the presence, origin and distribution of diadromous fish within the fish and shellfish study area, for the purposes of the impact assessment it is assumed that these diadromous fish species have the potential to migrate through the Offshore Site. As shown in Table 10-11, no evidence of diadromous fish has been identified through eDNA analysis across the survey area. This is not considered unusual as it is understood these species migrate through the Offshore Site and are therefore transient, and so the absence of eDNA data does not indicate the absence of this species within the fish and shellfish study area.

Several diadromous fish species may occur in marine and coastal waters west of Ireland including the sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*), allis shad (*Alosa alosa*), twaite shad (*Alosa fallax*), European eel, sea trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*). Sea lamprey, river lamprey, allis shad, twaite shad, and Atlantic salmon are classed as Annex II species on the Habitats Directive.

10.5.8.1 Lamprey Species

There are three species of lamprey, including river, sea, and brook lamprey (*Lampetra planeri*). Lamprey species are listed as Annex II species on the Habitats Directive, and sea lamprey are listed on the OSPAR list of threatened and/or declining habitats and species. River and sea lamprey are diadromous, spawning in freshwater environments and migrating out to sea as juveniles – both are recorded to be present in the fish and shellfish study area. Brook lamprey are exclusively a freshwater species, inhabiting brooks, streams, rivers and occasionally lakes.

River lamprey spawn in rivers, and typically inhabit coastal and estuarine habitats for approximately one to two years following their migration to sea. Spawning typically occurs in autumn and spring, and migration out to sea occurs from late autumn onwards (Maitland, 2003). River lamprey are not considered to be at risk in Ireland (Inland Fisheries Ireland, 2023b).

Sea lamprey migrate further offshore than river lamprey for approximately 18 to 24 months before returning to rivers in spring / early summer to spawn (NatureScot, 2022a). Adult sea lamprey die after spawning, and their carcasses can sometimes be seen in rivers. Sea lamprey do not display a homing[8] behaviour (Waldman *et al*., 2008). Sea lamprey are classified as having a near threatened conservation status in Ireland (Inland Fisheries Ireland, 2023b), and are threatened by pollution, construction work in river channels, and migratory barriers (e.g. dams).

The at-sea behaviour and migratory behaviour of lamprey remains relatively unknown (Malcom *et al.,* 2010). Adult sea and river lamprey are external parasites that attach to host fish or megafauna with their oral disc to feed on their flesh and blood (NatureScot, 2022a).

10.5.8.2 Allis Shad

Allis shad are invertebrate feeders; mainly feeding on plankton and small fish in coastal waters. When spawning in rivers, the species often swims a great distance upstream and spawns only once.

Whilst Allis shad are native to Ireland, the species occurs in very low numbers in coastal waters. There is no recent evidence of Allis shad spawning in Irish waters, therefore it is assumed that all individuals caught likely originated from European populations. There is lack of sufficient data to gauge conservation status of Allis shad in Irish waters. They are threatened by commercial fisheries which often capture Allis shad as by-catch (Inland Fisheries Ireland, 2023b).

10.5.8.3 Twaite Shad

Twaite shad are also native to Ireland and are found in coastal waters as well as southeast estuaries. Their geographic range includes the coastal waters and inflowing rivers of the Atlantic coast of Europe and the Mediterranean Sea. Twaite shad have a similar diet to Allis shad, feeding on invertebrates, plankton and small fish. In Ireland, Twaite shad travel up into the lower reaches of main river channels and larger tributaries for spawning, which usually takes place in early summer at night over clean gravels. They typically survive after spawning and may spawn multiple times. Records of Twaite shad indicate rare presence, and they are classified as a vulnerable species (Inland Fisheries Ireland, 2023b).

Twaite shad and Allis shad are very similar in appearance, and the two species can interbreed.

10.5.8.4 Eels

European eel is native to the North Atlantic ocean and river system of Ireland and are catadromous (i.e. migrating down rivers to the sea to spawn). Eels spend most of their life in freshwater and once mature subsequently migrate to the Sargasso Sea to breed, over a distance of 5,000 to 10,000 km (Aarestrup *et al*., 2009). Eels are thought to spawn only once and die shortly afterwards.

European eels are recorded in the fish and shellfish study area, likely using the area for migration (Wright *et al*., 2022).

European eels are critically endangered according to IUCN red list of threatened species, on the OSPAR list of threatened and/or declining species and habitats.

10.5.8.5 Trout

Sea trout are the anadromous (i.e. migrating up rivers from the sea to spawn) form of brown trout. They are found in rivers and streams preferring well-oxygenated upland waters. Sea trout are also host species of protected freshwater pearl mussels (*Margaritifera margaritifera*) (see Section 10.5.8.7) Sea trout spawn in rivers and streams with swift currents, usually characterised by downward movement of

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[8] Homing behaviour occurs when a species, such as salmon, undertake migrations across far distances to return to their river of origin.

water into gravel, favouring large streams in the mountainous areas with adequate cover in the form of submerged rocks, undercut banks, and overhanging vegetation (Fishbase, 2023). Sea trout conduct outward marine migrations as smolts and return to native rivers to spawn as adults, following a period at sea (NatureScot, 2022b). Smolts typically migrate out to the marine environment between April and May (Ferguson *et al.*, 2019) and may still migrate through the fish and shellfish study area to feeding grounds in June.

There is a considerable variation in timing and duration for adult homeward migration, in which individuals known as 'finnock' return to their native rivers in July and September of the same year as their seaward migration and other individuals known as 'maidens' may return after a migration duration of over 12 months (NatureScot, 2022b). The peak for homeward migration is usually between May and July. There is limited information regarding sea trout migration patterns, however available information suggests predominantly inshore and local (to the river) use of the marine environment (Malcolm *et al.*, 2010). Sea trout migrate to/from a number of rivers in the vicinity of the fish and shellfish study area; however, sea trout mainly stay close to the coastline and do not travel very far from the estuaries of their natal rivers.

Considering the above, sea trout are likely to be present within the fish and shellfish study area at some point over the course of a year, likely in the spring months. Given their relatively localised migratory patterns (compared to species like salmon), they may be more limited to areas within the fish and shellfish study area proximal to the coast.

10.5.8.6 Atlantic Salmon

Atlantic salmon spawn in riverine environments, and after maturing to become parr at approximately 10 cm, the salmon goes through a transformation to enable survival in saline conditions (smoltification) and once in the marine environment, Atlantic salmon become post-smolts. Following smoltification, Irish salmon migrate from Ireland to feeding grounds in the Norwegian Sea and coast of Greenland for one or more winters at sea, before returning to the rivers in which they were born. Atlantic salmon homeward migrations back to freshwater is dictated by hormones and can occur during any month of the year. In Ireland, juvenile salmon remain in the river for two to three years while they develop into parr. Parr feed on freshwater invertebrates.

A recent study conducted in 2021 (Lilly *et al.*, 2023) tagged over 1000 wild and ranched Atlantic salmon smolts at rivers in England, Scotland, Northern Ireland and Ireland, with receiver arrays in the Irish Sea. Results show rapid initial coastal migrations with a preference for migrating within a west-north-west current direction through the Irish Sea, aligning with a favourable direction towards the continental shelf edge. Overall, the results indicate that post-smolts engage in directional swimming, have a sense of migration direction and can use a range of environmental cues to orientate their direction (Lilly *et al.*, 2023).

A recent study involving tagging 204 salmon kelts (i.e. post-spawning adults) and tracked their oceanic migration. The study showed most individual salmon migrated to polar ocean frontal areas. Irish salmon migrated primarily westwards towards South and East Greenland, whilst Norwegian and Danish salmon migrated north and north-west towards the North Atlantic Ocean, between Iceland and Svalbard. Due to these different feeding locations, Irish salmon therefore experienced much warmer temperatures, ranging from 5 to 16°C, than Norwegian and Danish salmon which experienced temperatures ranging from 0 to 11°C. These differences not only contribute to variation in growth and survival across populations, but also are likely to affect Atlantic salmon populations differently with changing climate (Rikardsen *et al.*, 2021).

Based on current knowledge, there is no existing research on the migration of post-smolts on the west coast of Ireland.

Atlantic salmon is an Annex II species under the Habitat Directive, on the OSPAR list of threatened and/or declining species and habitats, and is of cultural, recreational and commercial importance in

Ireland. Their conservation status in Ireland is classed as vulnerable, resulting from a decline in abundance due to mortality at sea, habitat loss, barriers to migration, poor water quality, overfishing and sea lice.

Lough Corrib is the second largest lake in Ireland, situated in County Galway within the River Corrib catchment. The mouth of the River Corrib is located 57 km from the Offshore Site at the nearest point. Lough Corrib is a designated SAC, designated for Atlantic salmon, freshwater pearl mussel and Brook lamprey. Further detail about connectivity and interaction with Lough Corrib SAC is provided in Section 10.5.9.

10.5.8.7 Freshwater Pearl Mussel

Atlantic salmon and sea trout are host species for freshwater pearl mussels during a critical parasitic phase of the mussel's lifecycle, when they live on the gills of Atlantic salmon or sea trout as parasites (NatureScot, 2022b). The freshwater pearl mussel larvae spend less than a year attached to the gills, and then detach and fall onto the riverbed and remain in the river habitat. Therefore, the Offshore Site only has the potential to impact freshwater pearl mussels indirectly through effects on Atlantic salmon or sea trout.

10.5.9 Protected Sites and Species

10.5.9.1 Species of Conservation Importance

There are several fish and shellfish species known to be present in the fish and shellfish study area which are protected under international and national conservation legislation or policy, including 25 Irish species which must be afforded protection under the EU Habitats Directive. Table 10-17 outlines species thought to be present in the fish and shellfish study area and the relevant protections under which they are afforded:

- Habitats Directive Annex II and Annex IV Species;
- OSPAR list of threatened and/or declining species;
- Bonn Convention Appendix I and II species;
- Bern Convention Appendix II and III species;
- Irish Red List; and
- IUCN Red List.

Table 10-17 Summary of relevant key fish and shellfish species protected by national and international policy or legislation

Common name	Latin name	Habitats Directive Annex II and Annex IV Species	OSPAR list of threatened and/ or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Irish Red List	IUCN Red List [9]
Marine finfish							
Ballan wrasse	*Labrus bergylta*						LC (?)
Cod	*Gadus morhua*		✓				VU (-)
Common dab	*Limanda limanda*						LC (↑)
European pilchard	*Sardina pilchardus*						LC (?)
Grey gurnard	*Eutrigla gurnardus*						n/a
Haddock	*Melanogrammus aeglefinus*						VU (-)
Hake	*Merluccius merluccius*						LC (?)
Herring	*Clupea harengus*						LC (↑)
Horse mackerel	*Trachurus trachurus*						VU (↓)
Mackerel	*Scomber scrombus*						LC (↓)

[9] *IUCN Red List defined as 'CR'= Critically Endangered, 'EN' = Endangered, 'VU' = Vulnerable, 'NT' = Near Threatened, 'DD' = Data Deficient, and 'LC' = Least Concern. Population trends are defined in brackets as '↑' = increasing, '↓' = decreasing, '↔' = stable, '-' = unspecified, '?' = unknown.*

Common name	Latin name	Habitats Directive Annex II and Annex IV Species	OSPAR list of threatened and/ or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Irish Red List	IUCN Red List [9]
Plaice	*Pleuronectes platessa*						LC (↑)
Pollack	*Pollachius pollachius*						n/a
Poor cod	*Trisopterus minutus*						n/a
Saithe	*Pollachius virens*						n/a
Sandeel	*Ammodytidae*						LC (?)
Sprat	*Sprattus sprattus*						LC (?)
Whiting	*Merlangius merlangus*						LC (?)
Shellfish							
Common shore crab	*Carcinus maenas*						n/a
Crayfish / spiny lobster	*Palinurus elephas*						VU (↓)
Brown crab	*Cancer pagurus*						n/a
European lobster	*Homarus gammarus*						LC (↔)
Nephrops	*Nephrops norvegicus*						LC (↔)

Common name	Latin name	Habitats Directive Annex II and Annex IV Species	OSPAR list of threatened and/ or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Irish Red List	IUCN Red List [9]
Scallops	*Pectinidae sp.*						n/a
Elasmobranchs							
Common skate	*Dipturus batis*		✓		✓	✓	CR (↓)
Lesser Spotted Dogfish	*Scyliorhinus canicula*					✓	CR (↓)
Flapper skate	*Dipturus intermedius*				✓	✓	CR (↓)
Porbeagle shark	*Lamna nasus*				✓	✓	CR (↓)
Spotted ray	*Raja montagui*		✓			✓	LC (↔)
Spurdog	*Squalus acanthias*		✓			✓	EN (↓)
Thornback ray	*Raja clavata*		✓			✓	LC (↓)
Tope shark	*Galeorhinus galeus*				✓	✓	CR (↓)
White skate	*Rostroraja alba*				✓	✓	CR (↓)
Diadromous fish							
Atlantic salmon	*Salmo salar*	✓	✓				LC (-)

Common name	Latin name	Habitats Directive Annex II and Annex IV Species	OSPAR list of threatened and/ or declining species	Bonn Convention Appendix I and II species	Bern Convention Appendix II and III species	Irish Red List	IUCN Red List [9]
European eel	*Anguilla anguilla*		✓	✓			CR (↓)
Freshwater pearl mussel	*Margaritifera margaritifera*	✓			✓		EN (↓)
River lamprey	*Lampetra fluviatilis*	✓					LC (?)
Sea lamprey	*Petromyzon marinus*	✓	✓		✓		LC (↔)

10.5.9.2 Protected Sites

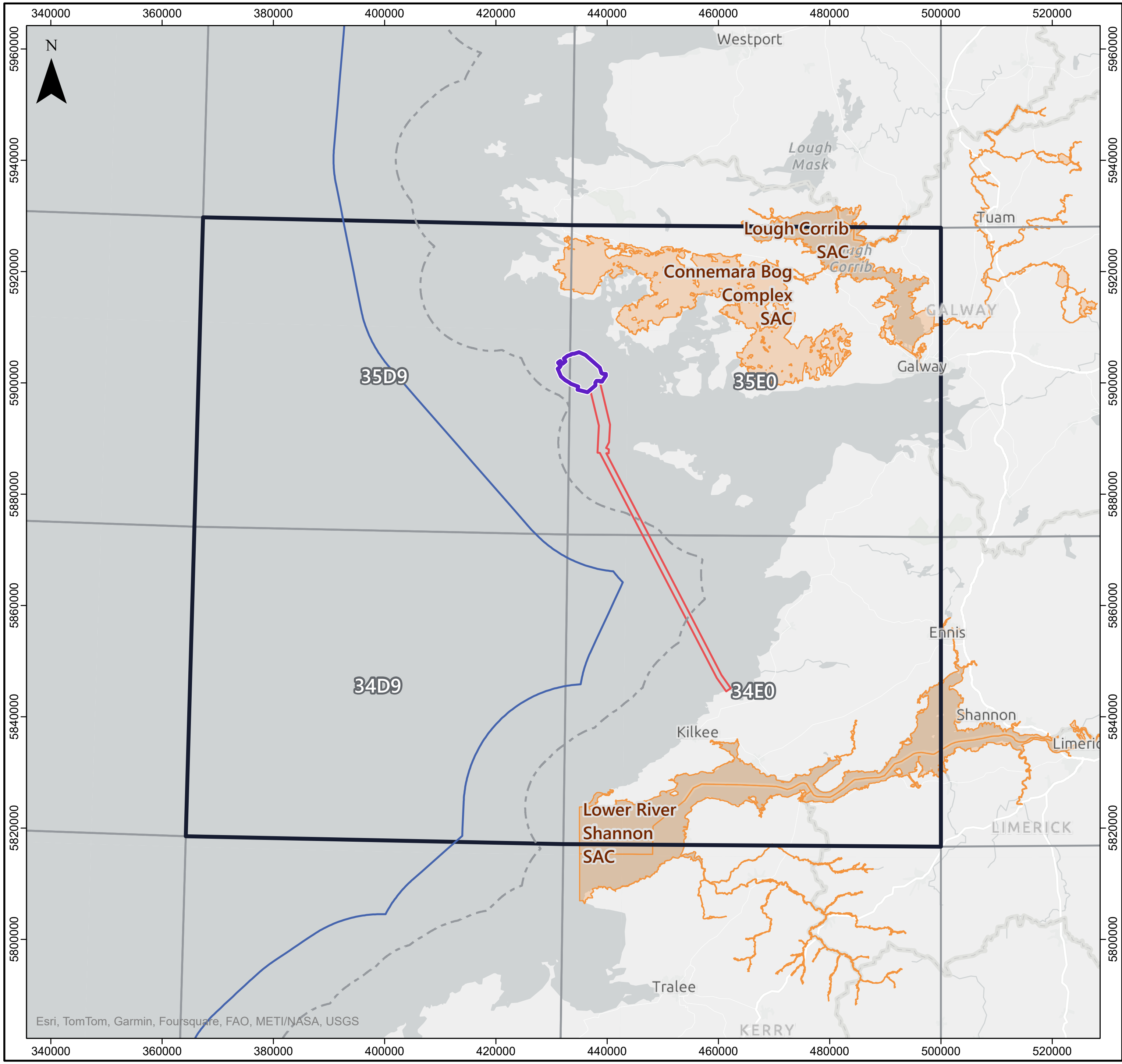
SACs designated for fish and shellfish species within the vicinity of the fish and shellfish study area that have the potential to be impacted by the Offshore Site are shown in Table 10-18 and Figure 10-10 below. There are no SACs designated for fish and shellfish species which directly overlap the Offshore Site, however there are three located within the fish and shellfish study area.

The closest relevant SACs to the Offshore Site are the Connemara Bog Complex SAC (of which Atlantic salmon are a designated species), located 6 km from the Offshore Site, and within the fish and shellfish study area. Atlantic salmon (and freshwater pearl mussel[10]) migrate between the river and the Atlantic Ocean prior to maturation and spawning. Atlantic salmon are known to occur in many of the rivers within the Connemara Bog Complex SAC; the Cashla river (which flows out of Glenicmurrin Lough) and Owenmore (Ballynahinch) river systems are acidic spate rivers which support the species. There are also known spawning sites for the species within the Connemara Bog Complex SAC. The three lamprey species and Atlantic salmon have all been observed spawning in the Lower River Shannon SAC or its tributaries. The Fergus estuary is a freshwater lower reach of this SAC and is important as a lower reach for spring salmon.

Table 10-18 SACs within fish and shellfish study area designated for fish and shellfish features

European site	Designated species or feature	Location from Offshore Site (km)	Location from study area
Connemara Bog Complex SAC	Atlantic salmon	8.3	Within study area
Lough Corrib SAC	Atlantic salmon Freshwater pearl mussel Brook lamprey	35.9	Within study area
Lower River Shannon SAC	Brook lamprey Sea lamprey River lamprey Atlantic salmon Freshwater pearl mussel	8.8	Within study area

[10] *Atlantic salmon are also host species for freshwater pearl mussel.*



SCEIRDE ROCKS WINDFARM

Feirm Ghaoithe Charraigeacha Sceirde

LEGEND

- Offshore Array Area
- Offshore Export Cable Corridor
- Study Area
- ICES Rectangles
- Ireland 6 NM limit
- Ireland 12 NM Limit
- Designated SACs

0 6.5 13 nm

0 10 20 km

Data Source: Contains public sector information, licensed under the Creative Commons licence v4.0; the Open Government Licence v3.0

PROJECT TITLE

Sceirde Rocks

MAP TITLE

Fish & Shellfish Ecology Designated SACs

VER	REMARKS	DATE	Drawn	Approved
1	DRAFT	06/12/2024	BQ	EE

DRAWING NO

Figure 10-10

SCALE	PAPER SIZE	DATUM	PROJECTION
1:1,000,000	A4	WGS 84	UTM 29N

This map is produced by Fuinneamh Sceirde Teoranta (FST).
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10.5.10 Species of Commercial Importance

There are several fish and shellfish species of commercial importance within the fish and shellfish study area. From the landings data (2018 – 2022), the highest average annual landings by species were *Nephrops*, followed by mackerel, monks/anglers and megrim (see Figure 13-5 in Chapter 13: Commercial Fisheries).

Nephrops comprise the majority of landings in ICES rectangle 34E0 in the southeast of the fish and shellfish study area and ICES rectangle 34D9 in the southwest. In ICES rectangle 34D9, following *Nephrops* are notable landings of monks/anglers and megrim. Mackerel landings are predominant in ICES rectangle 35D9 in the northwest, with smaller proportions of *Nephrops*, horse mackerel, megrim and monks/anglers.

The main species fished by the inshore fisheries include lobster (*Homarus gammarus*), brown crab, spider crab (*Maja branchydactyla*), crayfish (*Palinurus elephas*), velvet crab (*Necora puber*), shrimp (*Penaeus spp.*) and wrasse species.

Wrasse species in particular, are utilised for parasite control in aquaculture (Gonzalez and de Boer, 2017). The species have a preference for shallow waters and are typically found in habitats such as rocky shores in proximity to hard substrate (Bussmann, Utne-Palm, and de Jong, 2020). They have no known structural mechanism for the enhancement of sound pressure perception, and therefore are not considered to be vulnerable to underwater noise impacts (Cruz and Lombarte, 2004).

Chapter 13: Commercial Fisheries provides further information and assessment on species of commercial importance.

10.5.11 Summary of Baseline Environment

Multiple fish and shellfish receptors have potential sensitivities to the Offshore Site which have been identified as requiring further consideration within this impact assessment. A summary of the key issues for fish and shellfish ecology, based on the baseline outlined above, is presented below:

- Presence of spawning habitat for demersal spawners, primarily herring and *Nephrops*;
- Presence of species of conservation importance (as shown in Table 10-17) or commercial importance (*Nephrops,* crab, crayfish, lobster, and wrasse);
- Presence of European protected sites designated for fish and shellfish species; and
- Diadromous fish migrating through the Offshore Site (Atlantic salmon and indirectly freshwater pearl mussel, lamprey species, and European eel).

10.6 Likely Significant Effects and Associated Mitigation Measures

10.6.1 Do Nothing Scenario

The 'do nothing' scenario is a consideration of the baseline if the Offshore Site was not developed. This section therefore predicts the future baseline scenario for the fish and shellfish study area in the absence of the Offshore Site.

The abundance and distribution of fish and shellfish continuously changes in response to environmental and anthropogenic pressures, which may alter their future distributions across the study area. Key drivers of change include climate change, predator-prey interactions, and fishing activities.

Distribution of species will change in response to warming waters over the next few decades. Evidence has been recorded noting a northward shift of population boundaries for a number of species (Perry *et al.*, 2005; Wright *et al.*, 2020), indicating regional shifts of species into deeper and colder waters as a result of warming. Declines in population numbers (e.g. reduced recruitment rates[11]) may occur if these environments do not contain the specific habitat requirements of some species. EEA (2022) conducted an analysis of trawl survey data over a 45-year period, which has demonstrated that the number of warmer-water (Lusitanian) species has increased in the North Sea, Baltic Sea and Celtic Seas, and the number of colder-water (Boreal) species has decreased. Shifts in migratory timings, or other life history stages, that are influenced by environmental cues such as temperature, may also occur (Wright *et al.*, 2020).

It is acknowledged that there is a level of natural variation within the climate and sea temperatures. Therefore, it is not appropriate to assume all observed changes in fish and shellfish communities to anthropogenic climate change (Wright *et al.*, 2020). It is also extremely difficult to predict climate change impacts on fish and shellfish populations, and therefore, an accurate future baseline for the fish and shellfish ecology offshore study area cannot be provided.

It is likely that demersal stocks will continue to exhibit long term downward trends due to excessive fishing pressure, undesirable fishing patterns (i.e. too much fishing on young fish and discarding) and poor recruitment, likely related to reduced spawning stock biomass and aforementioned unfavourable environmental changes (Marashi, 1996). Changes in fishing patterns may also alter the fish and shellfish populations within the fish and shellfish study area. Elasmobranchs that have a slow growth rate and low fecundity are particularly sensitive to overfishing.

Climate change effects are difficult to predict, and the complex relationship between anthropogenic impacts and marine fauna make it difficult to have accurate predictions on changes to the current baseline description over the Offshore Site's life cycle.

10.6.2 Construction Phase

10.6.2.1 Disturbance or Damage to Fish and Shellfish due to Underwater Noise Generated from Construction Activities

An increase in sound emissions from survey equipment, site investigation activities, and construction activities can have mortality, physical injury or behavioural effects on fish and shellfish receptors, at an individual or population level. Behavioural effects, such as disturbance or displacement, may impact acoustic communication in fish, reproductive success, foraging, predator avoidance and navigation (Radford *et al.*, 2014; De Jong *et al.*, 2020; Hawkins and Myrberg, 1983).

Underwater sounds can be categorised as either impulsive (e.g. piling, survey equipment); or non-impulsive (or continuous) in nature (e.g. those generated by cable laying, trenching and from vessel operations). The potential impacts of anthropogenic underwater sound on fish and shellfish receptors are influenced by the characteristics of the sound (i.e., determined by the frequency and intensity of the sound source), the duration of the sound against baseline background levels and the sensitivity of the species.

Underwater sound has both a pressure and particle motion component, and the majority of research on the impact of underwater sound on the marine environment focuses on the former (Nedelec *et al.*, 2016). Sound pressure changes may be detected by fish with a swim bladder, as the gas within the swim bladder changes as a result of changing sound pressure. If the swim bladder is near the ear or connected to the hearing system, the hearing sensitivity is even greater (Popper *et al.*, 2014). Fish

[11] *Recruitment refers to the number of fish surviving in the first years of life.*

without a swim bladder cannot detect sound pressure. However, most fish species are expected to be able to detect particle motion.

Particle motion has a directional component and attenuates differently in the marine environment than sound pressure (Hawkins and Popper, 2017). Fish and shellfish may not only detect changes in particle motion in the water column, but those in close contact with the seabed may also detect particle motion in the substrate (Popper and Hawkins, 2018). Fish detect particle motion through otolithic organs in the inner ear which are of a greater density than the surrounding tissues and also through sensory hair cells in the lateral line (Popper and Hawkins, 2018). The hearing system of shellfish is uncertain. However, it is likely that they can only detect particle motion, potentially via sensory cells associated with hairs or statocyst or through vibrations of exoskeletons (Popper and Hawkins, 2018).

The most relevant criteria for considering potential impacts on fish and shellfish are considered to be those provided in the Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.*, 2014). Fish species are grouped into hearing sensitivity categories defined by a number of factors such as their hearing anatomy, particle motion detection, the use of sound during navigation or mating and the presence or absence of a swim bladder, as summarised in Table 10-19 below. Note, no explicit threshold criteria are available for shellfish and therefore the assessment is based on available literature as detailed in the '*Assessment Summary*' of Section 10.6.2.1.2.

Table 10-19 Fish species grouped into sensitive categories (Popper et al., 2014)

Group 1: Fishes that do not have a swim bladder	These species are likely to only use particle motion (and not sound pressure) for sound detection, and therefore only show sensitivity to a narrow band of frequencies (< 400 Hz). This group includes all elasmobranchs (sharks, skates and rays) and flatfish.
Group 2: Fishes with swim bladders that do not appear to play a role in hearing	These species are likely only to be sensitive to particle motion but could be susceptible to barotrauma. They only show sensitivity to a narrow band of frequencies (<1000 Hz). This group includes salmonids, e.g. Atlantic salmon.
Group 3 and 4: Fishes with swim bladders (or other structure containing gas) that are connected to the ear.	These species are sensitive to both particle motion and sound pressure extending up to around 500 Hertz (Hz) and in some cases, several kHz. This group includes Atlantic cod, herring and other clupeids.

10.6.2.1.1 Description of Effect

Impact pile driving is considered to be one of the principal sources of underwater construction noise associated with offshore wind farm development; however, impact pile driving is not a construction method proposed as part of this Project, and as such there is a very limited risk of physiological impacts of construction noise on fish and shellfish ecology receptors. However, some construction activities do generate underwater sound, albeit at a lower amplitude ("loudness") than impact piling. As outlined in Underwater Noise Modelling and Assessment (Appendix 12-1), the activities with the potential to generate underwater sound during the pre-construction and construction phases, include:

- UXO clearance;
- Vessel operations;
- Dredge and disposal activities; and
- Seabed preparation activities and cable installation activities (including dredging at foundation locations,, cable laying, trenching and the placement of cable protection).

It is also recognised that trenchless technology operations at the Landfall will also generate underwater noise that could displace diadromous fish, either commencing or terminating their migration through the marine environment. However, existing studies into the sound profile of HDD operations within shallow, riverine waters concluded that, in the absence of vessel noise, HDD produced a maximum unweighted Sound Pressure Level (SPL) of 129.5 dB re 1 µPa (Nedwell, Brooker, and Barham, 2012), when drilling below the riverbed. Erbe and McPherson (2017) reported an SPL of 142-145 dB rms re 1 µPa at 1 m, generated by a jack-up drilling rig undertaking geotechnical drilling in shallow water in western Australia. It is assumed that sound from HDD operations would be similar to this geotechnical drilling. At an offshore HDD emergence location, it is most likely that vessel noise would comprise the dominant contribution to the soundscape. The sound pressure levels associated with HDD are not of a level which could introduce a risk of injury or disturbance to diadromous fish and owing to the short term and transient nature of this activity, no impacts from HDD operations on diadromous fish species are anticipated and this underwater sound source has not been considered further in this assessment.

The following sections provide a description of the key underwater noise sources relevant to the construction phase.

UXO Clearance

UXO clearance has been identified as a possible noise source. The presence of potential UXO (pUXO) will be determined prior to construction. The pUXO will be investigated to verify the identification, and if required, the confirmed UXO (cUXO) will be cleared. Based on the results of pre-construction surveys, and a subsequent UXO risk assessment, there is expected to be a very low likelihood of finding UXO within the Offshore Site, as the west coast of Ireland was not subject to a high degree of bombing during World War II (WWII). Therefore, UXO clearance at the Offshore Site is very unlikely to be required.

In the extremely unlikely event that a UXO clearance operation is required, clearing of UXOs would result in a momentary (seconds) increase in underwater noise (i.e. sound pressure levels and particle motion). Underwater sound levels will be temporarily elevated, and this may result in injurious or temporary behavioural effects on fish and shellfish species. Whilst the presence of UXO is considered unlikely, this assessment represents the scenario that a UXO is identified and requires clearance (e.g. cannot be avoided).

Vessel Sound (including dredge and disposal)

There will be up to 23 vessels associated with the pre-construction and construction phases of the Offshore Site. Of these, only 11 will be on the Offshore Site at any given time. The Offshore Site vessels will primarily produce low-frequency continuous sound and will temporarily elevate underwater sound levels when present at the Offshore Site (Popper and Hawkins, 2019). The temporary introduction of continuous sounds can result in changes in fish and shellfish behaviour, masking of biologically relevant sounds, and hearing impairments (de Jong *et al.*, 2020).

Seabed Preparation and Cable Installation

During the construction phase, seabed preparation (within the OAA and along the OECC, where required) and cable installation activities (including cable laying, trenching and the placement of cable protection) will also produce continuous sounds, temporarily elevating underwater sound levels. As such, there is the potential for behavioural, physiological and masking effects on fish and shellfish.

10.6.2.1.2 *Characterisation of Unmitigated Effect*

UXO Clearance

Underwater noise modelling for UXO clearance has been undertaken by Underwater Noise Modelling and Assessment (Appendix 12-1) for the following clearance methods and charge weights:

- The scenario of high-order clearance of a 25 to 800 kg charge weight (+ donor charge); and
- Low-order deflagration of any charge using a 0.5 kg donor charge to vaporise the explosive material in the UXO.

The underwater noise modelling utilises the Popper *et al.* (2014) quantitative guideline values for risk of mortality and potentially mortal injury. The Popper *et al.* (2014) criteria states that for all fish species, mortality and potential mortal injury is expected to occur between 229 – 234 dB. The results of the underwater noise modelling indicate that for mortality or potential mortal injury to occur, fish would need to be within 560 – 930 m of a UXO device, assuming the highest charge weight (800 kg). Therefore, only fish in close proximity to the UXO device would be at risk.

Qualitative guidelines for the risk of recoverable injury, Temporary Threshold Shift (TTS), masking and behavioural effects associated with explosions are also available through Popper *et al.* (2014) (

Table 10-20). Qualitative guidelines present the risk of effect in relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (N, i.e. in the tens of metres), “intermediate” (I, i.e. in the hundreds of metres) or “far” (F, i.e. in the thousands of metres) which are independent of source level.

There is a high risk of recoverable injury and TTS within near distances of the source (i.e. tens of metres). For most fish groups, the risk of recoverable injury reduces to low at hundreds of metres from the source and the risk of TTS reduces to low at thousands of metres from the source.

For the purposes of the assessment, Table 10-20 groups fish species into hearing sensitivity categories, defined by a number of factors such as their hearing anatomy, particle motion detection, the use of sound during navigation or mating and the presence or absence of a swim bladder.

There is a high risk of masking within near distances of the source for all fish groups and a high risk of behavioural effects for Group 3 and 4 fish in this range. The risk of masking remains high at hundreds of metres from the source and is reduced to moderate at thousands of metres of the source for all groups except eggs and larvae which are less sensitive according to the Popper *et al.* (2014) criteria. The risk of behavioural effects remains as moderate for all groups at hundreds of metres from the source and is reduced to low at thousands of metres from the source.

It should be noted that the increase in underwater noise as a result of detonation is short term (seconds), where levels are temporarily elevated.

Table 10-20 Risk of recoverable injury, TTS, masking and behaviour impacts from UXO clearance (Popper et al., 2014)

Type of animal	Recoverable injury	TTS	Masking	Behaviour
Group 1: Fish with no swim bladder (particle motion detection)	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	(N) High (I) High (F) Low	(N) High (I) High (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low

Type of animal	Recoverable injury	TTS	Masking	Behaviour
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	(N) High (I) High (F) Low	(N) High (I) High (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Vessel Sound (including dredge and disposal)

Whilst studies have shown that some fish demonstrate avoidance behaviour on exposure to sound from approaching vessels, by diving to the seafloor or moving away from the vessel path (Ona *et al.,* 2007), there is minimal evidence in literature showing injury (to ear or non-auditory tissues) or mortality in fish (Popper *et al*., 2014) from this type of sound. Despite a lack of experimental examples of sound causing death or injury to fishes, there is the potential that low levels of anthropogenic sound may cause temporary hearing impairment, behavioural and physiological changes, and masking (Popper *et al*., 2014). Though masking effects would be short-lived due to the transient nature of the vessels as they move across the Offshore Site, it has the potential to mask signal detection for fish species that use sound for communication.

Underwater noise modelling for vessel sounds has been undertaken by Subacoustech (Underwater Noise Modelling and Assessment, Appendix 12-1), utilising the Popper *et al.* (2014) guidelines for shipping and other continuous sound (as detailed in Table 10-21). Quantitative guideline values are only available for recoverable injury and TTS for Group 3 and 4 fish. For all other groups of fish and all other impairments, only qualitative guidelines for risk are available, which are independent of source level (Popper *et al*., 2014).

In accordance with the Popper *et al.* (2014) qualitative guidelines, the risk of mortality and potential mortal injury is low at tens of metres from the source. The underwater noise modelling results indicate that for recoverable injury and TTS to occur, Group 3 and 4 fish would need to be within 10 m of the vessel. For all other groups, based on the Popper *et al* (2014) qualitative guidelines, the risk of recoverable injury is low at tens of metres from the source and the risk of TTS reduces to low at hundreds of metres from the source. The risk of masking remains as high at hundreds of metres from the source for Group 1 and Group 2 fish, reducing to moderate at thousands of metres from the source. For Group 3 and 4 fish, the risk of masking remains as high out to thousands of metres from the source. The risk of behavioural effects is moderate out to hundreds of metres from the source, reducing to low at thousands of metres from the source for all groups.

Table 10-21 Risk of mortality and mortal injury, recoverable injury, TTS, masking and behaviour impacts from shipping and other continuous noise (Popper et al., 2014)

Type of animal	Mortality and potential mortal injury	Recoverable injury	TTS	Masking	Behaviour
Group 1: Fish with no swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Group 2: Fish with swim bladder not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Group 3 and 4: Fish with swim bladder involved in hearing (primarily sound pressure detection)	(N) Low (I) Low (F) Low	170 dB rms for 48 hours	158 dB rms for 48 hours	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Seabed Preparation and Cable Installation

There is limited evidence available on the potential effects of seabed preparation and cable installation on fish and shellfish. The underwater noise modelling for vessel sounds undertaken by Subacoustech (Underwater Noise Modelling and Assessment, Appendix 12-1) for cable laying, trenching and rock placement utilises the same Popper *et al.* (2014) criteria described above for vessel noise. The modelling results indicate that for recoverable injury or TTS to occur, Group 3 or 4 fish would need to remain within 10 and 20 m of the activity, respectively. The Popper *et al.* (2014) qualitative guidelines for vessel sounds described above, would also apply to seabed preparation and cable installation activities.

Assessment Summary

Overall, it is assessed that the underwater noise generated during the pre-construction and construction phase has the potential to adversely affect a small proportion of the local fish and shellfish population for a short-term period (i.e. the duration of the construction period). It is predicted that the impact would affect the receptor directly.

As described above, mortal and potential mortal effects will only occur to fish within close proximity to the UXO clearance. Recoverable injury, TTS, masking and behavioural effects may occur over larger ranges, however, a degree of recovery would be expected for these sub-lethal effects with no material effects on the fish and shellfish community predicted. Any effects associated with vessel sound and cable installation would be short-term (the duration of the construction period), highly localised, intermittent / transient, and all effects are predicted to be recoverable. It should also be noted that the underwater noise modelling results assume that individuals remain stationary in respect of the noise source, which is highly unlikely to occur. In reality, most fish and shellfish will be able to vacate areas experiencing high levels of underwater sound to reduce their potential susceptibility to injury. Overall, the magnitude of effect is **low.**

Of the above groups, fish with a swim bladder involved in hearing (i.e. Group 3 and 4) are the most vulnerable to impacts from underwater sound (e.g. herring, and gadoids such as haddock, whiting and cod). Several of these species have spawning or nursery areas which overlap with the fish and shellfish study area and many of these species are of commercial value (Chapter 13: Commercial Fisheries). However, their spawning and nursery grounds are typically very large and widespread, relative to any transient, short duration and highly localised underwater noise generated during pre-construction and construction. The main exception to this is herring that have more spatially restricted spawning grounds due to their specific spawning habitat requirements.

Fish with a swim bladder that is involved in hearing (i.e. Group 3 and 4 fish) are deemed to be of high vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be **medium**.

Fish without swim bladders and fish with a swim bladder that is not involved in hearing (i.e. Group 1 and 2 fish) are deemed to be of low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be **low.**

There are no specific threshold criteria available to assess the effects of underwater sound on shellfish. However, available literature show mixed results for physiological or behavioural responses to underwater sound, depending on the experimental design and species. Scott *et al.* (2020) conclude that the understanding of potential physiological or behavioural effects from underwater noise on shellfish is limited and there is insufficient evidence to understand whether any underwater noise effects could result in detrimental effects at any sufficient scale or not. Shellfish are not able to detect sound pressure but may detect particle motion (Roberts *et al.,* 2016). Overall, shellfish are deemed to be of medium vulnerability, high recoverability and high commercial value. The sensitivity of the receptor is therefore, considered to be **medium.**

10.6.2.1.3 Assessment of Significance Prior to Mitigation

Underwater noise during construction will have an adverse, direct, likely, temporary, intermittent and reversible impact on fish and shellfish receptors. When combined with the medium sensitivity of shellfish and fish with a swim bladder involved in hearing, it is concluded that underwater noise during construction will have a **slight negative effect** on these receptors. Taking the low sensitivity of fish without swim bladders and fish with a swim bladder that is not involved in hearing, it is concluded that underwater noise during construction will have a **slight negative effect** on these receptors, which is Not Significant.

10.6.2.1.4 Mitigation

The following measures will be adhered to:

- Use of GBS foundations which avoids the requirement for impact piling, which generates high-amplitude impulsive sound which would have far greater effects on acoustically sensitive species than those predicted for the Offshore Site;

- Low order deflagration will be the preferred clearance method used, where clearance of any size of UXO is done using a special donor charge of 0.5 kg which vaporises the explosive material without explosion (see Chapter 12: Marine Mammals and Other Megafauna for further details on this);
- Vessels engaged in construction works will be required to operate at slow (<6 kts) speeds within the Offshore Site. This will reduce sound emissions relative to high-speed transiting and reduce the underwater noise effects associated with vessel sounds; and
- Implementation and compliance with a Vessel Management Plan (VMP) and Navigational Safety Plan (NSP).

10.6.2.1.5 *Residual Effect Following Mitigation*

Taking the embedded mitigation into account, no long-term impacts on the fish and shellfish community are anticipated. Therefore, the residual effect of underwater noise during construction is concluded to be a **slight negative effect** on shellfish and fish with a swim bladder that is involved in hearing and a **not significant negative effect** on fish without swim bladders and fish with a swim bladder that is not involved in hearing, which is Not Significant for all receptors.

10.6.2.2 Temporary Habitat Loss or Disturbance

10.6.2.2.1 *Description of Effect*

During the pre-construction and construction phases of the Offshore Site, temporary habitat loss or disturbance may occur as a result of the following activities:

- Landfall installation;
- Seabed preparation activities (UXO clearance, boulder clearance, bedform clearance, seabed drilling / cutting, and pre-lay grapnel runs); and
- Installation of the cables (trenching, laying, burial and protection).

Temporary habitat disturbance or loss may affect individuals directly through injury or physical harm and also indirectly through the disturbance or loss of nursery and spawning habitats.

It should be noted that although the habitat loss or disturbance associated with the installation of stone beds and cable protection will initially occur during the construction phase when the infrastructure is installed, the effects will continue to be realised through to the operational phase. Therefore, the habitat loss associated with the installation of stonebeds and cable protection is considered under the assessment of long-term habitat loss in Section 10.6.2.3.

10.6.2.2.2 *Characterisation of Unmitigated Effect*

As described in Section 10.4.3.1, 1,132,151 m^2 of temporary habitat loss and disturbance may occur during the construction phase, intermittently over a period of 41 months (including pre-construction activities e.g., UXO and boulder clearance).

A total of 1,132,151 m^2 of temporary habitat loss or disturbance will occur as a result of the construction phase of the Project (including pre-installation works such as seabed preparation works at the stonebed placement areas, including boulder clearance, pre-lay grapnel run, controlled flow excavation), this includes:

- 104,071 m^2 of temporary disturbance that will occur from the dredge and disposal activities across two sites;

- 29,120 m^2 of temporary disturbance that will occur as a result of the jack-up vessels for the GBS installations (31 in total);
- 996, 950 m^2 from installation of a single OEC (length 63.5 km); and
- 2,000 m^2 as a result of the Landfall installation, associated with the HDD exit pit and the dredged sidecast material.

Up to 996,950 km^2 of temporary habitat loss or disturbance is expected to result from seabed preparation works and the installation of the OEC. Trenching and burial of the cables will occur within the area previously disturbed during seabed preparation activities, therefore there will be areas of localised repeat disturbance within the 20 m wide corridor required for the installation of the OEC. For the purpose of the assessment, it has been considered that 100% of the IAC (73 km) will be surface laid with hard substrate protection, so the overall area of disturbance will not be increased. It should be noted that the installation of hard substrate protection is considered within the assessment of long-term habitat loss in Section 10.6.2.3.

The Project benthic ecology survey established that the sediment consisted mostly of coarse and sandy sediments within the OAA, with a low mud content. Within the OECC, sediments were dominated by sand but with a higher proportion of mud (Ocean Ecology, 2023). A review commissioned by The Crown Estate (RPS, 2019) on seabed recovery post-installation of cables associated with offshore windfarms in the UK found that sandy sediments recover quickly following cable installation; with sediment infilling occurring rapidly. In coarse and mixed sediments and muddy sediments, remnant cable installation trenches were conspicuous for several years after installation. However, these remnant trenches constituted shallow depressions which were of limited depth (i.e. tens of cm) when compared against the surrounding seabed (RPS, 2019). Given the sediment type in the Offshore Site, there is likely to be some limited evidence of disturbance after installation activities have concluded.

This disturbance will occur intermittently over a period of 41 months during construction, inclusive of seabed preparation in advance of construction. Activities, from seabed preparation to completion of installation, will not all occur at the same time, although some activities may overlap and occur simultaneously for a period of time. Given the intermittent nature of the activities, only a small area of seabed is expected to be disturbed at any one time.

Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings (marine finfish, shellfish, and elasmobranchs, diadromous fish (including freshwater pearl mussels)).

Marine Finfish

Temporary habitat loss or disturbance is predicted to have an adverse effect on marine finfish receptors due to the temporary loss or disturbance of functional habitats (e.g. nursery and spawning grounds). It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,132,151 m^2), short term duration (over 41 months with recovery occurring over several years), intermittent frequency and high reversibility. The magnitude is therefore considered to be **low**.

Many other fish are predicted to utilise the fish and shellfish ecology offshore study area, including demersal marine finfish that are in close contact with the seabed. However, any temporary habitat disturbance or loss is unlikely to affect the long-term functioning of these species, as the majority of other marine finfish are mobile species and able to avoid injury or physical harm associated with temporary habitat disturbance or loss (EMU, 2004). These species also spawn into the pelagic environment with a wide availability of alternative spawning grounds.

The marine finfish most vulnerable to any temporary habitat loss or disturbance are those which spawn on or near the seabed and have a demersal egg phase. Herring, as demersal spawners, are sensitive to such disturbance. As noted in 10.5.4.2, there is no evidence that herring utilise the Offshore Site as spawning grounds. However, there are spawning beds predicted to be present between the Aran

Islands and Galway Bay, and the sediments at the OAA represent potentially suitable herring spawning habitat. Herring spawning grounds are more spatially limited due to the specific habitat requirements for this species. Herring also lay demersal eggs which may be vulnerable to damage or loss as a result of seabed disturbance.

Several marine finfish have spawning or nursery grounds that overlap the fish and shellfish study area and many of these species are of a high commercial value (Chapter 13: Commercial Fisheries). Most marine finfish are considered to be of a low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be **low.** Herring are considered to be of a high vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be **medium.**

Shellfish

A number of commercially important shellfish species are known to inhabit the fish and shellfish study area such as *Nephrops*, scallops, European lobster, crayfish/spiny lobster, and crab species including the brown crab (Brown *et al.,* 2001; AFBI, 2021). Of these, *Nephrops* are predicted to use the fish and shellfish study area for spawning (Coull *et al.,* 1998). Shellfish have a more limited mobility when compared with fish and are potentially vulnerable to habitat loss and disturbance during the construction phase.

Temporary habitat loss or disturbance is predicted to have an adverse effect on shellfish receptors due to the temporary loss or disturbance of functional habitats. Immobile shellfish may also be vulnerable to physical abrasion. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,132,151 m^2), short term duration (over 41 months with recovery occurring over several years), intermittent frequency and high reversibility. The magnitude is therefore considered to be **low**.

Larger crustacea (e.g. *Nephrops* and European lobster) are classed as equilibrium species (Newell *et al.*, 1998) and are only capable of recolonising an area once the original substrate type has returned. Furthermore, larvae of *Nephrops* generally remain in the hatching areas of adults and are not transported long distances by hydrographic processes. *Nephrops* typically inhabit areas characterised by muddy sediments. As described in Section 10.5.4.2, most of the OAA contains a relatively low mud content, with higher mud content recorded in the OECC. As the recoverability of *Nephrops* is dependent on the recovery of the sediment, timescales of recovery for the species are likely to align with what is expected of the sediments across the fish and shellfish area. Based on the above, recoverability of *Nephrops* populations to substratum loss is considered moderate (Sabatini and Hill, 2008).

All other shellfish species are considered to be less vulnerable to habitat loss. Scallops are known to show a preference for sand, fine and sandy gravel and muddy sand, and are therefore, more versatile in terms of their habitat preferences when compared with *Nephrops*. Furthermore, European lobster, spiny lobster and brown crab typically inhabit hard substrata, and are therefore not dependent on softer sediments. Only a change from rock to sediment would result in loss of suitable habitat and loss of species from the affected area. Consequently, changes to sediment type (as might occur during pre-installation and construction activities) are not considered relevant to these species.

Some shellfish species at certain stages of their life cycle show a degree of mobility (e.g. scallop jet propulsion), whereas others are predominantly immobile (e.g. 'berried' female crabs, and lobsters). Immobile shellfish may be vulnerable to physical abrasion of the seabed. 'Berried' female crabs and lobsters carry their eggs under their abdomen and are often found buried under sediment. During this time when they are relatively immobile, any disturbance could result in the damage to these females and/or their egg masses (Neal and Wilson, 2008).

Shellfish communities associated with mud or sand habitats have been shown to return to baseline species abundance after a number of months, indicating a degree of recoverability and as such effects are anticipated to be short term (Newell *et al.*, 1998). These habitats are characteristic of the southern extent of the fish and shellfish study area.

Shellfish are commercially valuable within the fish and shellfish study area. Shellfish are judged to be of a medium vulnerability, high recoverability and high value. Therefore, shellfish are assessed as being of **medium sensitivity**.

Elasmobranchs

The fish and shellfish study area overlaps with nursery grounds of common skate and spurdog. Common skate lay egg cases which are deposited on the seabed, and there may be other oviparous elasmobranchs that utilise the fish and shellfish study area. Due to their reproductive method, these species are vulnerable to seabed disturbance. During the juvenile and adult phase of their lifecycle, they are less vulnerable.

Temporary habitat loss or disturbance is predicted to have an adverse effect on elasmobranch receptors due to the temporary loss or disturbance of functional habitats (e.g. nursery and spawning grounds). Any egg cases laid on the seabed may also be vulnerable to physical abrasion. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,132,151 m^2), short term duration (over 41 months with recovery occurring over several years), intermittent frequency and high reversibility. The magnitude is therefore considered to be **low**.

Adult common skate are considered to be of low vulnerability to substratum loss and are expected to exhibit high recoverability (Neal and Pizzolla, 2006). However, the egg cases laid by common skate are considered to be vulnerable to surface abrasion due to the potential disturbance to egg cases (Scottish Government, 2023). This is likely to be analogous for other species which lay egg cases.

Elasmobranchs are not of a high commercial value within the fish and shellfish study area but are of a high conservation value, with several elasmobranch species being listed as critically endangered on the IUCN red list (see Table 10-17). Generally, elasmobranchs reach sexual maturity after a number of years, exhibit relatively low fecundity, and have long gestational periods. Therefore, they are likely to take some time to recover in the wake of disturbance and loss of spawning grounds. However, elasmobranch species are likely to recover and return to the area once installation activities are complete.

Consequently, elasmobranchs are deemed to be of medium vulnerability, high recoverability and very high value (internationally important). The sensitivity of the receptor is therefore, considered to be **medium**.

Diadromous Fish

There is the potential for diadromous fish to utilise the habitats present at the Offshore Site for feeding or for diadromous fish to pass through the Offshore Site during migrations to and from Irish rivers, including those identified as SACs. However, as diadromous fish do not rely on specific seabed habitats and are highly mobile, temporary habitat disturbance of limited spatial footprint is not likely to affect this species.

Temporary habitat loss or disturbance is predicted to have an adverse effect on diadromous fish receptors due to the temporary loss or disturbance of feeding habitats. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,132,151 m^2), short term duration (over 41 months with recovery occurring over several years), intermittent frequency and high reversibility. The magnitude is therefore considered to be **low**.

Diadromous fish are not of commercial importance, although salmon angling is an important recreational activity in Ireland. Diadromous fish are highly protected and are considered to be internationally important. Diadromous fish species are considered to be of negligible vulnerability, high recoverability and very high value (internationally important). The sensitivity of the receptor is therefore, considered to be **low**.

10.6.2.2.3 Assessment of Significance Prior to Mitigation

Marine Finfish

Temporary habitat loss or disturbance during construction will have an adverse, direct, likely, short-term, intermittent and reversible impact on marine finfish receptors. Combined with the low sensitivity of marine finfish (except herring), it is concluded that temporary habitat loss or disturbance during construction will have a **not significant negative effect** on marine finfish (except herring). For herring, due to the medium sensitivity of this receptor, temporary habitat loss or disturbance during construction will have **a slight negative effect**, which is Not Significant

Shellfish

Temporary habitat loss or disturbance during construction will have an adverse, direct, likely, short-term, intermittent and reversible impact on shellfish receptors. Combined with the medium sensitivity of shellfish, it is concluded that temporary habitat loss or disturbance during construction will have a **slight negative effect** on shellfish, which is Not Significant.

Elasmobranchs

Temporary habitat loss or disturbance during construction will have an adverse, direct, likely, short-term, intermittent, and reversible impact on elasmobranch receptors. Combined with the medium sensitivity of elasmobranchs, it is concluded that temporary habitat loss or disturbance during construction will have a **slight negative effect** on this receptor, which is Not Significant.

Diadromous Fish

Temporary habitat loss or disturbance during construction will have an adverse, direct, likely, short-term, intermittent and reversible impact on diadromous fish receptors. Combined with the low sensitivity of diadromous fish, it is concluded that temporary habitat loss or disturbance during construction will have a **not significant negative effect** on this receptor, which is Not Significant.

10.6.2.2.4 Mitigation

Pre-construction benthic survey and habitat mapping has been undertaken to inform habitat distribution and identify potential spawning or nursery habitats. This information has been taken into account for cable route refinement within the OECC to reduce the habitat loss or disturbance of potential spawning or nursery habitats, in particular for the most vulnerable species, such as herring and *Nephrops*.

10.6.2.2.5 Residual Effect Following Mitigation

Taking the embedded mitigation described above into account, the residual effect of temporary habitat loss or disturbance during construction is as follows:

- **Marine finfish (except herring):** not significant negative effect;
- **Herring:** slight negative effect;
- **Shellfish:** slight negative effect;
- **Elasmobranchs:** slight negative effect; and
- **Diadromous fish:** not significant negative effect.

Effects on all species are assessed to be Not Significant.

10.6.2.3 Long-term Habitat Loss

10.6.2.3.1 *Description of Effect*

Long term habitat loss will occur in areas where foundation structures (WTGs and the OSS), stonebeds and cable protection are located. The OEC and IACs will be buried where possible to reduce any potential long-term habitat loss. Stonebed areas and cable protection will be decommissioned *in situ*, and therefore, this represents a permanent effect beyond the operational period of the Project. Further details on the decommissioning approach are included in Section 10.6.4 and in Chapter 5: Project Description.

10.6.2.3.2 *Characterisation of Unmitigated Effect*

As detailed in Table 10-9, the total long term seabed footprint of the Offshore Site is 1,675,691 m^2, representing 1.5% of the Offshore Site. It should be noted that this habitat loss will initially occur during the construction phase (including pre-installation) when the infrastructure is installed. However, an extent of the effects will continue to be realised through to the operational phase.

The WTGs and the one OSS will be placed on GBS foundations installed on stonebeds with a total footprint of 117,604 m^2. Where target burial depth cannot be achieved, cable protection may be required, which is expected to account for 1,282,082 m^2 of habitat loss for the IACs and 165,818 m^2 of habitat loss for the OECC. Up to 110,187 m^2 habitat loss is also assumed to occur for the establishment of stonebeds for up to 11 jack-up placements (10 for the WTGs and one for the OSS).

Temporary habitat loss and disturbance will also occur during the operational phase as a result of seabed disturbance associated with the requirement for jack-up vessel interventions and cable repair or replacement activities. This temporary disturbance would occur intermittently over the 38-year operational phase. However, the spatial extent would be highly localised and will be significantly less than the effects determined for the construction phase. Therefore, as a very conservative approach, the sensitivity and magnitude ratings for temporary habitat loss and disturbance during the construction phase are also considered applicable to the operational phase.

Marine Finfish

The introduction of infrastructure on the seabed will result in a physical change in the seabed and a loss of marine finfish spawning and nursery habitat. It is predicted that this impact will have an adverse effect on marine finfish receptors. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,675,691 m^2), permanent duration, continuous frequency and low reversibility. However, when the footprint of permanent habitat loss is placed in the context of the comparable habitats throughout the Offshore Site and the wider region, the magnitude is considered to be **low**.

As described for construction (Section 10.6.2.2), the majority of marine finfish species have a low vulnerability to habitat loss and disturbance as they are not dependent on the seabed during their life cycle. The main exception to this is herring that are highly dependent on specific seabed habitats for spawning. However, it is important to note that despite the potential suitability of the habitat for herring spawning, there are no recorded herring spawning grounds that directly overlap the Offshore site.

Analogous evidence from windfarms throughout the North Sea suggests that the presence of operational wind farm structures does not lead to adverse effects on fish populations and assemblages (Stenberg *et al.*, 2011; van Deurs *et al.*, 2012; Degraer *et al.*, 2020). With regards to introduction of hard substrates, in Belgian waters Degraer *et al.* (2020) found that there was some evidence of increases in numbers of species associated with these types of substrates, including sea bass and common squid.

Most marine finfish are considered to be of a low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be **low.** Herring are considered to be of a high vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be **medium.**

Shellfish

It is predicted that this impact will have an adverse effect on shellfish receptors due to the permanent loss of functional habitats (e.g. nursery and spawning grounds). However, some shellfish species may benefit from an increase in hard substrate through the provision of refuge areas. For instance, Krone *et al.* (2017) demonstrated that monopile foundations with scour protection were associated with approximately 5,000 brown crabs per foundation (twice as much as foundations with no scour protection) in the German Bight, North Sea.

It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,675,691 m^2), permanent duration, continuous frequency and low reversibility. Furthermore, this footprint of impact will be split between exposed rock substrate and sediments within the Offshore Site. Therefore, this area of impact will not be entirely within a single substrate type. When the footprint of permanent habitat loss is placed in the context of the comparable habitats throughout the Offshore Site and the wider region, the magnitude is considered to be **low**.

Most shellfish receptors present within the fish and shellfish study area have limited mobility, including lobster and scallops, making them potentially vulnerable to long term habitat loss. Shellfish are judged to be high value, as they are not protected but are of commercial importance in the region, and of medium vulnerability, due to their low mobility, and medium recoverability. Additionally, as noted in Section 10.5.6.1, *Nephrops* have a preference for muddy seabed sediments, and therefore are reliant on muddy sediments for their burrows. This can result in a higher vulnerability to long term habitat loss and disturbance. Overall, shellfish are judged as being of **medium sensitivity**.

Elasmobranchs

As some elasmobranch species have an oviparous reproductive strategy, the main risk associated with habitat loss is the loss of suitable egg laying grounds for these species. The Offshore Site is predicted to overlap with nursery ground for common skate which employ an oviparous reproductive strategy.

Egg laying habitat may be affected by the footprint of the long-term infrastructure, and therefore, permanent habitat loss represents an adverse effect. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,675,691 m^2 across a variety of substrate types within the Offshore Site, only some of which will be utilised by elasmobranch species), permanent duration, continuous frequency and low reversibility. When the footprint of long-term habitat loss is placed in the context of the comparable habitats throughout the Offshore Site and the wider region, there are wide areas of the Offshore Site where no infrastructure will be placed on the seabed (assessed as 98.5% of the Offshore Site). Beyond the Offshore Site, there is also greater availability of habitat. Therefore, the magnitude is considered to be **low**.

Common skate are categorised as having a low sensitivity to physical change to another seabed type (Scottish Government, 2023). As highly mobile species, elasmobranchs will be able to avoid the hard substrate and the habitat lost does not constitute a significant loss in the context of wider available habitat. Habitat that may be used for egg laying could be lost under the footprint of the Offshore Site infrastructure. Elasmobranchs have a relatively low fecundity making them potentially vulnerable to loss of egg laying grounds.

Elasmobranchs are deemed to be of high vulnerability, low recoverability and very high value. However, they are highly mobile and able to accommodate a change in substrate by utilising other available habitat. The sensitivity of the receptor is therefore, considered to be **medium**.

Diadromous Fish

As for construction, it is unlikely that migrating fish species will utilise the Offshore Site beyond passing through and potentially for feeding. It is predicted that the long-term habitat loss will have an adverse effect on diadromous fish. The impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,675,691 m^2), permanent duration, continuous frequency and low reversibility. The loss of habitat associated with the proposed cable protection and WTG and OSS foundations will constitute a small loss of feeding grounds in the wider regional context. Therefore, the magnitude is considered to be **low**.

As these species are highly mobile, they can avoid areas which have undergone seabed changes and no longer constitute suitable feeding grounds. Diadromous fish species are considered to be of low vulnerability, high recoverability and of a very high value. The sensitivity of the receptor is therefore, considered to be **low**.

10.6.2.3.3 Assessment of Significance Prior to Mitigation

Marine Finfish

Long term habitat loss during operational will have an adverse, direct, likely, permanent, continuous and irreversible impact on marine finfish receptors. Combined with the low sensitivity of marine finfish (except herring), it is concluded that long term habitat loss during will have a **slight negative effect** on marine finfish (except herring). For herring, which have a medium sensitivity, long term habitat loss will also have a **slight negative effect**, which is Not Significant.

Shellfish

Long term habitat loss during operational will have an adverse, direct, likely, permanent, continuous and irreversible impact on shellfish receptors. Combined with the medium sensitivity of shellfish, it is concluded that long term habitat loss will have a **slight negative effect** on shellfish, which is Not Significant.

Elasmobranchs

Long term habitat loss during operational will have an adverse, direct, likely, permanent, continuous and irreversible impact on elasmobranch receptors. Combined with the medium sensitivity of elasmobranchs, it is concluded long term habitat loss will have a **slight negative effect** on this receptor, which is Not Significant.

Diadromous Fish

Permanent habitat loss during operational will have an adverse, direct, likely, permanent, continuous and irreversible impact on diadromous fish receptors. Combined with the low sensitivity of diadromous fish, it is concluded that permanent habitat loss will have a **slight negative effect** on this receptor, which is Not Significant.

10.6.2.3.4 Mitigation

The following measure will be adhered to:

- Pre-construction benthic survey and habitat mapping has been undertaken to inform habitat distribution and identify potential spawning or nursery habitats. This information has been taken into account for cable route refinement within the OECC to reduce the habitat loss or disturbance of potential spawning or nursery habitats, in particular for the most vulnerable species, such as herring and *Nephrops*.

10.6.2.3.5 Residual Effect Following Mitigation

Taking the embedded mitigation described above into account, the residual effect of long-term habitat loss during operational is as follows:

- **Marine finfish (except herring):** not significant negative effect;
- **Herring:** slight negative effect;
- **Shellfish:** slight negative effect;
- **Elasmobranchs:** slight negative effect; and
- **Diadromous fish:** not significant negative effect.

Effects on all species are assessed to be Not Significant.

10.6.2.4 Temporary Increase in SSC

10.6.2.4.1 Description of Effect

Increased SSC will occur during the construction phase of the Offshore Site as a result of seabed disturbance caused by the following activities:

- Landfall installation;
- Seabed preparation activities (CFE or jet trenching during seabed preparation (OAA only));
- Installation of GBS foundations;
- Installation of the IACs and OEC (trenching, laying, burial and protection); and
- Releases of drilling fluids during the Landfall construction.

The deposition of the suspended sediments may result in localised changes to the sediment type and burial of specific habitats used by fish and shellfish receptors. In addition, increased SSC can result in reduced feeding success of visual predators due to decreased visibility, and mortality of eggs and larvae which are intolerant to increased sediment loads. Less mobile species can be affected through clogging of respiratory apparatus. Additionally, the disturbance of sediments during the above activities can result in the potential release of contaminants within the sediment.

Dredging, CFE, and jet trenching during seabed preparation (occurring within the OAA only) will generate some of the greatest disturbance to the seabed compared to PLGR or boulder clearance activities. During installation of hard substrate (for example, stonebed installation or rock protection) are considered to produce considerably lower levels of SSC than that associated with dredging, CFE and jet trenching. Should installation of hard substrate occur concurrently with the CFE, jet trenching or dredging activities, it is considered that the effects from the hard substrate installation would be minimal in comparison to the disturbance generated from the seabed preparation or cable trenching, only increasing SSC by a small proportion of only a few milligrams per litre (mg/l). Given this, SSC due to dredged disposal by TSHD and CFE for seabed clearance (OAA only) and cable trenching and installation are assessed here as the parameters likely to generate the maximum effect compared to other proposed installation methods named above.

The assessment presented here focuses on the proportion of fine grain sediment (approximately 10% of the bulk) which will be suspended in the water column upon disturbance. CFE and dredging activities have the potential to generate a sediment plume. The potential plume associated with the fine sediment fraction has been assessed analytically within Chapter 7: Marine Physical and Coastal Processes, based on the sediment settling velocity for silt (0.0001 m/s), with respect to the range of current flow speeds (0.2 m/s to 0.8 m/s) which are characteristic of the Offshore Site.

The potential increases in SSC associated with seabed clearance, trenching in the OECC and OAA, disposal of dredged materials (within the OAA through a fall pipe at 5 m above the seabed) and OECC trenchless technology activities at the Landfall are considered in this assessment.

10.6.2.4.2 Characterisation of Unmitigated Effect

Temporary increases in SSC and associated deposition have the potential to constitute a direct adverse effect on fish and shellfish receptors. The relevant activities during the construction period which could result in increased SSC include:

- Pre-construction seabed levelling and clearance in the OAA only;
- Cable installation via trenching from the CFE and dredging in the OAA;
- Disposal of dredged material in the OAA; and
- HDD at the Landfall within the OECC.

Please note that the below assessment has been summarised from Chapter 7: Marine Physical and Coastal Processes, and Chapter 8: Water and Sediment Quality.

Dredge and disposal activities

Up to 15 disposal events of the dredged material are expected in two locations within the OAA, with plumes occurring from each disposal event (with a hopper capacity of up to 100,000 m^3). No dredge material is to be released from the sea surface, instead material will be released at a maximum height of 5 m above the seabed, therefore minimising the dispersion effects of the disposal process. At 5 m above the seabed, based on the release rate, the instantaneous SSC could be very high on the order of hundreds of thousands (to millions) of mg/l at the fall pipe. However, the high SSC would quickly reduce to thousands of mg/l from the release site based on the deposition of the majority of the sediment bulk, with only a smaller proportion of the sediment fraction developing into a plume. Based on the fall pipe release height at 5 m above the seabed, as committed to by the Project (see Chapter 5: Project Description), the fine sediment could remain in suspension for up to 14-hours before resettling (i.e. just over a flood – ebb tidal cycle, reaching the maximum tidal excursion extent (estimated to be up to 15 km) on either the flood or ebb tidal cycle), depending on the time of release. However, dilution would occur with distance from the release site resulting in further reduction of the SSC to hundreds and tens of mg/l. The finest sediment fraction will become readily incorporated into the surrounding seabed and consequently will become part of the sediment transport regime. This process will redistribute sediments throughout the Offshore Site area and beyond, which would occur regardless of deposition induced by construction activities.

Cable installation using CFE

Use of CFE for cable installation is a much more targeted and focussed activity occurring at the seabed. Consequently, releases will likely occur closer to the seabed, to retain the majority of the sediment within the cable trench. Based on the same silt settling velocity of 0.0001 m/s, releases at 1 m above the seabed could remain in suspension for up to 3 hours. Fine sand which may be disturbed during the process, may travel up to 80 m from the location of the activity. At this distance, the thickness of deposition is again very thin at 0.002 m (i.e. all but undetectable). Changing flow speeds and directions over the course of a tidal cycle will ultimately limit the extent of plumes to the mean annual tidal excursion extent (as a maximum).

Landfall installation

Trenchless technology will be used to install the OEC from the Onshore Landfall Location (OLL) to the exit pit within the OECC (approximately 1 km offshore). The exit pit in the OECC has a total area of 0.001 km^3 and an associated excavated volume of 2000 m^3, with excavated material being stored alongside the pit as a sediment berm. The increases in SSC associated with the excavation is likely to be similar or less than that described for the seabed clearance activities above.

At each exit pit drilling fluid (PLONOR in nature) could be released at the exit location, comprising 90 % water and approximately 10 % bentonite clay, for which medium silt is applied as a proxy. Based on an assumed near-bed release height of 0.5 m, deposition thickness associated with the solids could be up to 0.05 m for the exit pit, associated with a release during the slowest neap flows. In this instance it is most likely that any sedimentation would occur directly within the exit pit and a plume would not form.

Summary

As summarised above, sediment disturbed as a result of the construction activities has the potential to form a plume that would be extremely transient within the fish and shellfish study area. Due to the current flow regime within the Offshore Site, sediment would quickly settle out and SSC would return back to ambient concentrations after a short duration (less than a day). Any deposition via THSD (within the OAA only) at the deposition zones, will result in an average thickness of 1.5 m.

The effect from increases in SSC from all Offshore Site activities is predicted to be of very local spatial extent (several kilometres from the disturbance location), only of short-term in duration (less than 1 day), continuous throughout the duration of the activities but highly reversible, returning to baseline SSCs following cessation of activity, and therefore, is unlikely to materially alter water quality within the fish and shellfish study area to an extent that would significant impact fish and shellfish receptors. Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings (marine finfish, diadromous fish, shellfish, and elasmobranchs).

Marine Finfish

The installation activities will generate localised increases in SSC which will subsequently deposit on the seabed. This impact will occur intermittently over a period of 41 months. This impact will adversely affect marine finfish receptors both directly and indirectly. The effect would be of local spatial extent, short term duration, intermittent frequency and high reversibility. The magnitude is therefore considered to be **low**.

Adult marine finfish generally have a low vulnerability to this impact, due to their ability to avoid areas affected by increased SSC (EMU, 2004). Juveniles have a lower mobility and are therefore potentially more vulnerable to this impact. However, it would be expected that juveniles would have a degree of tolerance, as periods of increased SSC will naturally occur, for example during winter storm events.

Appleby and Scarratt (1989) suggest that the development of eggs and larvae can be affected by SSC when concentrations reach thousands of mg/l. Therefore, it is reasonable to expect any SSC generated by Offshore Site activities may affect the development of eggs and larvae. However, these high SSCs are expected to be highly localised in the immediate vicinity of the release site, and therefore any effect would be spatially restricted. Subsequently, successive tides will further dissipate the plume of disturbed material. The increases in SSC associated with the Offshore Site are anticipated to be within natural variability and will reduce to background concentrations within a short period (< 1 day).

Generally, adult marine finfish are not dependent on the seabed during their lifecycle, and are therefore, largely tolerant of sediment deposition, with the exception of demersal spawners. Deposition of the sediments once they fall out of suspension is unlikely to affect those species which spawn pelagically. As their eggs are released into the water column, they will not be affected by processes occurring on the seabed.

As stated in Section 10.5.4.2, herring are the only demersal spawning fish species predicted to utilise the fish and shellfish study area for spawning. Herring are therefore considered to be more vulnerable to changes in sediment attributed to deposition compared with other marine finfish species due to the potential vulnerability of demersal eggs. Although tolerant of short-term increases in SSC (Messieh *et al.*, 1981; Kiørboe *et al.*, 1981), herring eggs are considered vulnerable to smothering by sediment deposition if the sediment is not rapidly incorporated into the sediment regime (Birklund and Wijsman, 2005). As detailed in the sections above, any deposition via THSD (within the OAA only) at the deposition zones, will result in an average thickness of 1.5 m and deposition thickness associated with the Landfall installation could be up to 0.05 m for the exit pit.

Marine finfish (with the exception of herring) are deemed to be of low vulnerability, high recoverability and of a high value. The sensitivity of the receptor is therefore, considered to be **low**.

Herring are deemed to be of a medium vulnerability, high recoverability and of a high value. The sensitivity of the receptor is therefore, considered to be **medium**.

Shellfish

Increases in SSC and associated sediment deposition will adversely affect shellfish receptors both directly and indirectly. The effect would be of a local spatial extent, temporary duration, intermittent frequency and high reversibility. The magnitude is therefore considered to be **low**.

Generally, mobile shellfish species are known to be tolerant of increased SSC and smothering and are able to move away from areas of increased SSC. The exception to this is during times when species are berried (i.e. carrying eggs). At this time, eggs require regular aeration which may be impeded by increased SSC.

Nephrops, which are known to be found in the Offshore Site (Sections 10.5.4 and 10.5.6.1), are considered tolerant of increases in SSC and smothering. As scavengers, they are not dependent on suspended sediment for food availability (Sabatini and Hill, 2008). Furthermore, as a burrowing species, they will be able to excavate any sediment re-deposited as a result of Offshore Site activities.

Most crab and lobster species are able to escape from under silt and migrate away from an area. Smothering is unlikely to cause mortality therefore a high tolerance to this impact has been recorded (Neal and Wilson, 2008). However, it has been noted that crab have been reported to avoid areas of spoil dumping, possibly due to SSC or decreased macrofauna. This species relies on visual acuity to find prey which could also contribute to their avoidance of such conditions. Berried crabs and lobsters have a lower mobility and are therefore, less able to migrate away from areas of increased SSC and heavy sediment loads.

Increased SSC may also adversely impair the feeding capabilities of scallops, although individuals are capable of moving away from areas with higher sediment loads. Smothering impacts may be avoided, as scallops can lift themselves clear of the newly deposited sediment layer (Marshall & Wilson, 2008).

Shellfish are deemed to be of medium vulnerability, high recoverability and of high value. The sensitivity of the receptor is therefore, considered to be **medium.**

Elasmobranchs

Elasmobranchs are considered highly mobile (McInturf *et al.,* 2023) and therefore are not considered vulnerable to SSC increases and subsequent deposition. Elasmobranch species with demersal reproductive strategies, such as common skate, may be more susceptible to SSC and deposition impacts. Increases in SSC and associated sediment deposition will adversely affect elasmobranch receptors both directly and indirectly. The effect would be of a local spatial extent, short term duration, intermittent and high reversibility. The magnitude is therefore considered to be **low**.

Common skate, which are known to utilise the fish and shellfish study area as nursery grounds, are not considered to be sensitive to smothering. Neal and Pizzolla (2006) predict that some stress may be caused due to loss of food and energetic costs of migrating to new foraging areas. Furthermore, considering the limited spatial extent of potential sediment plumes and associated deposition, the degree of avoidance by elasmobranchs is unlikely to be significant. Egg cases on the seabed may be more sensitive to smothering impacts. However, as noted for marine finfish, the increases in SSC associated with the Offshore Site are anticipated to be within natural variability and will reduce to background concentrations within a short period as demonstrated in the sections above.

Elasmobranchs are deemed to be of medium vulnerability, high recoverability and of very high value. The sensitivity of the receptor is therefore, considered to be **medium**.

Diadromous Fish

While salmonids can be sensitive to increased SSC through reduced visual ability to detect prey (Abbotsford, 2021), effects will be limited to times when they pass through during migrations. The effect would be of a local spatial extent, short term duration, intermittent frequency and high reversibility. The magnitude is therefore considered to be **low**.

Diadromous fish species are generally expected to have some tolerance to elevated SSC, given their migration routes typically pass through estuarine habitats which are often characterised by more turbid waters. Additionally, migratory salmonids tend to swim within the top 5 m of the water column (Godfrey *et al.*, 2015).

As much of the immediate disturbance associated with Offshore Site activities will occur at the seabed (cable installation, WTG and OSS placement), and SSC will be highest here and dissipate further up the water column, species like salmon are unlikely to encounter plumes.

Diadromous fish are deemed to be of low vulnerability, high recoverability and of very high value. The sensitivity of the receptor is therefore, considered to be **low**.

10.6.2.4.3 Assessment of Significance Prior to Mitigation

Marine Finfish

Temporary increases in SSC and associated deposition during construction will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on marine finfish receptors which constitutes a low magnitude of effect. Combined with the low sensitivity of marine finfish (except herring), it is concluded that temporary increases in SSC and associated deposition during construction will have a **slight, negative effect** on this receptor, which is Not Significant. For herring, even with medium sensitivity, considering the availability of spawning grounds in the wider area, temporary increases in SSC and associated deposition will only have a **slight negative effect**, which is Not Significant.

Shellfish

Temporary increases in SSC and associated deposition during construction will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on shellfish receptors which constitutes a low magnitude of effect. Combined with the medium sensitivity of shellfish, it is concluded that temporary increases in SSC and associated deposition during construction will have a **slight negative effect** on this receptor, which is Not Significant.

Elasmobranchs

Temporary increases in SSC and associated deposition during construction will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on elasmobranch receptors which constitutes a low magnitude of effect. Combined with the medium sensitivity of elasmobranchs, it is concluded that temporary increases in SSC and associated deposition during construction will have a **slight negative effect** on this receptor, which is Not Significant.

Diadromous Fish

Temporary increases in SSC and associated deposition during construction will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on diadromous receptors which constitutes a low magnitude of effect. Combined with the low sensitivity of diadromous fish, it is concluded that temporary increases in SSC and associated deposition during construction will have a **slight negative effect** on this receptor, which is Not Significant.

10.6.2.4.4 *Mitigation*

Mitigation by design has been incorporated throughout the Offshore Site. The use of gravity base foundations avoids the need for drilling of foundations which can cause localised high SSC. Therefore, the highest concentrations are limited to surface release(s) of dredged material by a dredger hopper, as discussed above. Nonetheless, the Project has committed to releasing dredged material through a fall pipe at a height of 5 m above the seabed (rather than at sea surface) which significantly reduces the potential for dispersion of sediment and resettlement time.

Pre-construction benthic survey and habitat mapping has been undertaken to inform habitat distribution and identify potential spawning or nursery habitats. This information has been taken into account for cable route refinement within the OECC to reduce the habitat loss or disturbance of potential spawning or nursery habitats, in particular for the most vulnerable species, such as herring and *Nephrops*.

The use of trenchless technologies at the Landfall location will minimise the extent of seabed disturbance, thereby reducing elevated SSC in the water column. The implementation of an EMP prior to construction to will also serve as mitigation in ensuring that the discharges at the exit point are suitable for release into the marine environment.

10.6.2.4.5 *Residual Effect Following Mitigation*

Temporary increases in SSC and associated deposition during construction will result in highly localised, short-term and recoverable effects. Taking the embedded mitigation described above into account, the residual effect of temporary habitat loss or disturbance during construction is as follows:

- **Marine finfish (except herring)**: slight negative effect;
- **Herring:** slight negative effect;
- **Shellfish:** slight negative effect;
- **Elasmobranchs:** slight negative effect; and
- **Diadromous fish:** slight negative effect.

Effects on all species are therefore assessed to be Not Significant.

10.6.2.5 Accidental Release of Pollutants

10.6.2.5.1 *Description Of Effect*

There is a risk of accidental pollution release during the construction phase, from sources such as vessels and equipment. This has the potential to have detrimental effects on fish and shellfish receptors by damaging individuals themselves or the habitats on which they rely.

10.6.2.5.2 *Characterisation of Unmitigated Effect*

Vessels involved with the installation and construction activities will discharge liquid effluents into the sea during operations which are compliant with appropriate anti-pollution regulations (e.g. MARPOL). All routine discharges will be rapidly dispersed by water currents and will not result in any significant reduction in the sediment or water quality in the Offshore Site and surroundings.

Accidental release of pollutants is predicted to have an unlikely adverse effect on fish and shellfish receptors. It is predicted that the impact will affect the receptor both directly and indirectly. An accidental event such as a vessel collision has the potential to result in the release or spillage of fuel or other contaminants from vessels. The initial result of such a spill or leakage would likely include physical disturbance at the discharge location. Based on the unlikely event that a pollution event will take place combined with the area being a high energy environment, any spills or leakages are likely to disperse rapidly, and the impact will be highly localised. The effect would be of a local spatial extent, long term, rare frequency / one off with a low reversibility. If severe, it is predicted that the effect could result in a partial or alteration to the integrity of the fish and shellfish population. The magnitude is therefore considered to be **medium**.

Marine finfish, elasmobranchs and diadromous fish are considered very mobile species and therefore considered to be of low vulnerability to pollution given their mobility to avoid areas of release. Shellfish are considered to be more vulnerable due to their lower level of mobility. However, it should be noted that contamination of marine prey including plankton and small fish species may lead to aromatic hydrocarbons accumulating in the food chain for all receptors.

Fish and shellfish species undertake osmoregulation to stabilise an internal environment, despite changes in composition of the external water. This can help them cope with fluctuations in water quality resulting from pollution and provides them with a resilience against accidental releases (Romano and Zeng, 2012; Nisembaum, *et al.,* 2021; Lillywhite and Evans, 2021).

Shellfish are judged to have a medium vulnerability, due to their low mobility, medium recoverability, and a high value. Shellfish are therefore considered to be of **medium** sensitivity, where marine finfish, elasmobranchs and diadromous fish are considered to be of **low** sensitivity due to their low vulnerability, medium recoverability and high value.

10.6.2.5.3 *Assessment of Significance Prior to Mitigation*

Accidental release of pollutants during construction will have an adverse, direct, unlikely, long term, one-off and irreversible impact on fish and shellfish receptors. Combined with the medium sensitivity of shellfish, it is concluded that the accidental release of pollutants will have a **moderate negative effect** on this receptor, which is Not Significant. For marine finfish, elasmobranchs and diadromous fish, due to the low sensitivity of these receptors, accidental release of pollutants will have a **slight negative effect,** which is Not Significant.

10.6.2.5.4 *Mitigation*

As described in Section 10.4.3.4, all Project activities will comply with marine pollution prevention measures required under the International Convention for the Prevention of Pollution from Ships

(MARPOL) convention (see Chapter 8: Water and Sediment Quality for further information). The Project will implement and comply with a MPCP which will outline measures for pollution prevention and waste management.

In this manner, accidental release of potential contaminants from construction vessels will be strictly controlled and procedures will be in place to minimise the impact of any accidental release if it occurs.

10.6.2.5.5 *Residual Effect Following Mitigation*

With the implementation of measures commitment to within the MPCP, the risk of accidental releases of pollution is extremely low, and as a result the risk of adverse effects on fish and shellfish receptors is equally low. The residual impact is considered to be extremely unlikely, long term, one-off and irreversible. Combined with the medium sensitivity of shellfish, it is concluded that the residual effect of accidental release of pollutants is considered to be an unlikely **slight negative effect** on this receptor, which is Not Significant. For marine finfish, elasmobranchs and diadromous fish, due to the low sensitivity of these receptors, the residual effect of accidental release of pollutants is considered to be an unlikely **not significant negative effect,** which is Not Significant**.**

10.6.3 Operational Phase

10.6.3.1 Habitat Creation and Fish Aggregation

10.6.3.1.1 *Description of Effect*

In addition to habitat loss, the presence of up to 30 WTG, one OSS GBS foundation structures and external cable protection (e.g. rock) may introduce new structures for habitat creation and create artificial reef effects, with the potential for fish and predator aggregation as an indirect impact. The introduction of hard infrastructure alters previously soft sediment habitat areas, which can attract new species and increase the habitat complexity and biodiversity of the area (Degraer *et al.,* 2020) and may result in the provision of shelter and increased food availability, especially for higher trophic level species (Degraer *et al.*, 2020).

10.6.3.1.2 *Characterisation of Unmitigated Effect*

Inger *et al.,* (2009) pose the concern that Fish Aggregating Devices (FADs), such as subsea infrastructure from offshore wind farms, focus fish stock in a specific region without necessarily enhancing productivity. Nonetheless, there is evidence indicating that artificial reefs formed by marine structures could offer both a food source and shelter, potentially increasing the productivity of an area (Langhamer and Wilhelmsson, 2009; Wilhelmsson *et al.,* 2006; Linley *et al.,* 2007). The amplification of the reef or aggregation effect is anticipated to be most pronounced in uniform sandy regions where WTGs are installed. In contrast, in areas with a more diverse substrate, the installation of WTGs is expected to result in less aggregation. Reef and aggregation effects are expected to be greater in areas of homogeneous sands, and as the substrate becomes more heterogeneous the aggregation effect decreases as a result of WTG installation (Xoubanova and Lawrence, 2022). As described in Chapter 9: Benthic Ecology, the seabed present in the OAA and OECC is relatively heterogenous, consisting of a mosaic of rocky and sediment habitat types.

Xoubanova and Lawrence (2022) summarise the current understanding regarding the reef and fish aggregation effects associated with offshore renewable developments. Post-construction monitoring at operational UK offshore wind farms has not produced definitive conclusions regarding the potential for reef or aggregation effects. Nevertheless, extended monitoring at European Union windfarms suggests alterations in fish communities within operational wind farm areas. For instance, a study (Stenberg et al., 2011; 2015) at the Horns Rev 1 offshore windfarm in Danish waters, where fishing activity is restricted at operational windfarms, revealed no adverse impacts on fish communities. Instead, it observed a higher abundance of fish within the wind farm area, increased diversity near the WTGs, and no decline in the abundance of sandeels, a species favouring sandy sediments that may be displaced with the introduction of hard substrate.

Up to 1,675,691 m^3 of hard substrate will be introduced across the Offshore Site. However, it should be noted that as the infrastructure is three dimensional, the area available for colonisation for artificial reef creation will be greater than this. The stonebed areas and cable protection will be installed in discrete locations across the Offshore Site, rather than a continuous area.

Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings (marine finfish, diadromous fish, shellfish, and elasmobranchs).

Marine Finfish

Whilst the introduction of hard substrate can create artificial reef effects and provide food and shelter, there is the potential for displacement of finfish that prefer sandy substrates (e.g. sandeel). This impact can either have a positive or adverse effect on marine finfish. A positive impact could occur for a particular species if fish aggregation results in an increase in prey. However, for prey species, there is the potential for increased predation. It is predicted that the impact will affect the receptor both directly and indirectly. The adverse impact is considered habitat loss, an assessment for which is presented in Section 10.6.2.3.

Considering the heterogenous seabed across the Offshore Site, the introduction of hard substrate is considered unlikely to result in any substantial reef or aggregation effects. If reef or aggregation effects do occur, these will be in discrete areas only (< 50 m) (Methratta, 2021). Therefore, the effect would be of local spatial extent (1,675,691 m^2), permanent duration, continuous frequency and low reversibility. Overall, the magnitude is considered to be **low**.

Studies monitoring the potential effects of offshore wind farms on reefs and aggregations suggest that adverse impacts on marine finfish species are unlikely to occur (Methratta and Dardick, 2019). Marine finfish are considered to have a low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore considered to be **low**.

Shellfish

An increase in hard substrate and creation of refuge areas may be advantageous for certain shellfish species. Krone *et al.* (2017) demonstrated that monopile foundations with scour protection in the German Bight, North Sea, were associated with approximately 5,000 brown crabs per foundation—twice as many as foundations without scour protection. The wind farm also served as a nursery ground for brown crab (Krone *et al.,* 2017). An exception to this may be scallops, which are typically found in clean sand, fine, or sandy gravel.

This impact can either have a positive or adverse effect on shellfish depending on the species' position in the food chain. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,675,691 m^2), permanent duration, continuous frequency and low reversibility. Overall, the magnitude is considered to be **low**.

Shellfish are considered to have a low vulnerability, high recoverability and high value. Consequently, shellfish are therefore assessed as having **low sensitivity**.

Elasmobranchs

Many elasmobranch species are carnivorous and therefore feed on benthic invertebrates and fishes. These species may benefit from the provision of shelter and increased food availability. However, similar to marine finfish above, monitoring studies indicate that the potential adverse effects, including those related to reef and aggregation impacts, including predators, from offshore wind farms are unlikely (Methratta and Dardick, 2019).

This impact can either have a positive or adverse effect on shellfish depending on the species' position in the food chain. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,675,691 m^2), permanent duration, continuous frequency and low reversibility. Overall, the magnitude is considered to be **low**.

Elasmobranchs are considered to be of a low vulnerability, high recoverability and very high value. Therefore, elasmobranchs are assessed to have a **low sensitivity**.

Diadromous Fish

Species in higher trophic levels are considered to be most likely to benefit from potential reef and aggregation effects (Degraer *et al.*, 2020). This is demonstrated by Reubens *et al.* (2013a; 2013b) which studied cod catches at an operational wind farm in the Belgian North Sea. The study found an increase of cod catches (a piscivorous species) in areas adjacent to the WTGs as the cod aggregated around the foundations and over areas of hard substrate. Evidence also shows that individual harbour seals use wind farms for foraging likely due to artificial reefs on the WTG and OSS foundations (Russell *et al.* 2014). Therefore, there is a potential for an increase in presence of piscivorous fish and other predators at the Offshore Site, leading to an increased risk of predation on diadromous fish during their migration through the area. Whilst exact migratory patterns to and from rivers on the west coast of Ireland are unclear (Section 10.5.8), there is the potential of Atlantic salmon migration through the Offshore Site.

Fish and predator aggregation could result in increased Atlantic salmon predation. Predation of post-smolts during the early stages of migration could result in a substantial degree of mortality and impact adult returns (Gillson *et al.,* 2022) and impacting wider population levels.

This impact can either have a positive or adverse effect on diadromous fish, depending on their position in the food chain. It is predicted that the impact will affect the receptor both directly and indirectly. The effect would be of local spatial extent (1,675,691 m^2), permanent duration, continuous frequency and low reversibility. Overall, the magnitude is considered to be **low**.

Overall, diadromous fish are considered to exhibit some vulnerability to this impact, due to the potential for increased predation on juveniles which can have wider impacts on adult returns, although given the potential scale at which aggregation may occur, the extent of predation is not likely to be substantial. Diadromous fish are also thought to be of medium recoverability and very high value. Therefore, diadromous fish are assessed to be of a **medium sensitivity**.

10.6.3.1.3 *Assessment of Significance Prior to Mitigation*

Marine Finfish

Habitat creation during operational will have an adverse or positive, direct, likely, permanent, continuous and irreversible impact on marine finfish receptors. Combined with the low sensitivity of marine finfish, it is concluded that habitat creation will have a **not significant positive or slight negative effect** on this receptor, which is Not Significant.

Shellfish

Habitat creation during operational will have a low magnitude, adverse or positive, direct, likely, permanent, continuous and irreversible impact on shellfish receptors. Combined with the low sensitivity of shellfish, it is concluded that habitat creation will have a **not significant positive or slight negative effect** on this receptor, which is Not Significant.

Elasmobranchs

Habitat creation during operational will have a low magnitude, adverse or positive, direct, likely, permanent, continuous and irreversible impact on elasmobranch receptors. However, when consideration is given to the low sensitivity of elasmobranchs, it is concluded that habitat creation will have a **not significant positive or slight negative effect** on this receptor, which is Not Significant.

Diadromous Fish

Habitat creation during operational will have a low magnitude, adverse or positive, direct, likely, permanent, continuous and irreversible impact on diadromous fish receptors. Combined with the medium sensitivity of diadromous fish, it is concluded that habitat creation will have a **slight positive or negative effect** on this receptor, which is Not Significant.

10.6.3.1.4 *Mitigation*

The following measures will be adhered to:

- Pre-construction benthic survey and habitat mapping has been undertaken to inform habitat distribution and identify potential spawning or nursery habitats. This information has been taken into account for cable route refinement within the OECC to reduce the habitat loss or disturbance of potential spawning or nursery habitats, in particular for the most vulnerable species, such as herring and *Nephrops*.

10.6.3.1.5 *Residual Effect Following Mitigation*

Taking the embedded mitigation described above into account, the residual effect of habitat creation and fish aggregation during the operational phase is as follows:

- **Marine finfish:** not significant positive or slight negative effect;
- **Shellfish:** not significant positive or slight negative effect;
- **Elasmobranchs:** not significant positive or slight negative effect; and
- **Diadromous fish:** not significant positive or slight negative effect.

Effects on all species groups are assessed to be Not Significant.

10.6.3.2 Temporary Increase in SSC

10.6.3.2.1 *Description of the Effect*

Cable repair and reburial events may result in short-term increases in suspended sediments during the operational phase. As described in Section 10.6.2.4, the deposition of the suspended sediments may result in localised changes to the sediment type and burial of specific habitats used by fish and shellfish receptors. In addition, increased SSC can result in reduced feeding success of visual predators due to decreased visibility, and mortality of eggs and larvae which are intolerant to increased sediment loads.

10.6.3.2.2 *Characterisation of the Unmitigated Effect*

The requirement for repair and reburial cannot be foreseen and may take place at any time of the year across the Offshore Site's life cycle. However, any impact during operational is anticipated to be less than that described for construction in Section 10.6.2. Therefore, taking a very conservative approach, the magnitude of impact is predicted to be comparable to construction and is judged to be **low** for all receptors.

The sensitivity of fish and shellfish receptors is as described previously for the construction phase in Section 10.6.2.1

10.6.3.2.3 Assessment of Significance Prior to Mitigation

Marine Finfish

Temporary increases in SSC and associated deposition during the operational phase will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on marine finfish receptors. Combined with the low sensitivity of marine finfish (except herring), it is concluded that temporary increases in SSC and associated deposition during the operational phase will have a **slight negative effect** on this receptor, which is Not Significant. For herring, due to the medium sensitivity of this receptor, temporary increases in SSC and associated deposition will have **a slight negative effect**, which is Not Significant.

Shellfish

Temporary increases in SSC and associated deposition during the operational phase will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on shellfish receptors. Combined with the medium sensitivity of shellfish, it is concluded that temporary increases in SSC and associated deposition during the operational phase will have a **slight negative effect** on this receptor, which is Not Significant.

Elasmobranchs

Temporary increases in SSC and associated deposition during the operational phase will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on elasmobranch receptors. Combined with the medium sensitivity of elasmobranchs, it is concluded that temporary increases in SSC and associated deposition during the operational phase will have a **slight negative effect** on this receptor, which is Not Significant.

Diadromous Fish

Temporary increases in SSC and associated deposition during the operational phase will have an adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible impact on diadromous receptors. Combined with the low sensitivity of diadromous fish, it is concluded that temporary increases in SSC and associated deposition during the operational phase will have a **slight negative effect** on this receptor, which is Not Significant.

10.6.3.2.4 Mitigation

Pre-construction benthic survey and habitat mapping has been undertaken to inform habitat distribution and identify potential spawning or nursery habitats. This information has been taken into account for cable route refinement within the OECC to reduce the habitat loss or disturbance of potential spawning or nursery habitats, in particular for the most vulnerable species, such as herring and *Nephrops*.

10.6.3.2.5 Residual Effect Following Mitigation

Temporary increases in SSC and associated deposition during the operational phase will result in highly localised, short-term and recoverable effects. Taking the embedded mitigation described above into account, the residual effect of temporary habitat loss or disturbance during the operational phase is as follows:

- **Marine finfish (except herring):** slight negative effect;

- **Herring:** slight negative effect;
- **Shellfish:** slight negative effect;
- **Elasmobranchs:** slight negative effect; and
- **Diadromous fish:** slight negative effect.

Effects on all species are therefore assessed to be **Not Significant.**

10.6.3.3 Electromagnetic Field Effects

10.6.3.3.1 *Description of Effect*

The operation of the cables will result in emission of localised EMFs. This could potentially affect the sensory mechanisms of certain fish and shellfish species. Elasmobranchs, diadromous fish and lobsters and crabs in particular are known to be electrosensitive (CMACS, 2003; Hutchison *et al.*, 2021).

10.6.3.3.2 *Characterisation of Unmitigated Effect*

The operation of the cables as outlined in Table 10-9, will result in emission of localised EMFs which have the potential to alter the behaviour of marine organisms that are able to detect electric (E-fields, measured in volts per metre (V/m)) or magnetic (B-field, measured in micro Tesla (μT)) components of the fields. The B-field penetrates most materials, and therefore, is emitted into the marine environment, thus resulting in an associated induced electric (iE)-field. When relative motion is present between B-fields and a conductive medium (e.g. sea water), iE-fields are produced. The direct E-fields are blocked by the use of conductive sheathing within the cable, and hence are not considered further. Earth has its own natural geomagnetic field (GMF) with associated B and iE-fields which species rely on for navigation (Gill and Desender, 2020; Winklhofer, 2009). The natural iE-fields result from sea water interacting with the natural GMF, due to relative motion caused by the Earth's rotation, and tidal currents (Gill and Desender, 2020).

A number of fish and shellfish species are able to detect EMFs and use them for various different reasons. Particular focus has been placed on assessing the response of crustaceans, elasmobranchs and salmonids to EMF (Hutchison *et al.*, 2020; Copping *et al.*, 2020; 2021). Generally, electrosensitive species are mainly responsive to both Direct Currents (DC) and Alternating Currents (AC), low intensity electric fields between 0.02 microvolts (μV) cm−1 and 100 μV cm−1 and frequencies of 0–15 Hertz (Hz) (Tricas and Sisneros, 2004; Stoddard, 2010; Hutchison *et al.*, 2020).

Marine renewable energy researchers, developers, and regulators widely agree that EMFs transmitted via cables from individual or a small number of devices are likely to exhibit comparatively low intensities. As a result, the extent of their impact is very localized, posing minimal risk to sensitive marine species due to the low potential for encounters with these animals.

In terms of the source of EMF from the Offshore Site, this will comprise:

- A network of IAC HVAC cables (66 kV), with a length of 73 km;
- One Offshore Export HVAC Cable (the OEC) (220 kV) with a length of 63.5 km.

Numerical modelling studies show that EMFs decrease with distance from the cable core (Hutchison *et al.*, 2021; Chainho *et al.*, 2021). Cable burial and protection can provide some distance between the EMF source and the receptor species, though it is acknowledged that shelter-seeking species (such as crustacea) may utilise cable protection as habitat, therefore increasing their risk of EMF exposure (Albert *et al.*, 2020). Whilst the minimum depth of lowering is 1.0 m (Table 10-9), it is likely that the cable will be buried or protected to a depth, there will always be, regardless of cable protection measures, a degree of separation of fish and shellfish receptors from the source of EMF emissions, minimising the field strength likely to be encountered.

An initial EMF assessment has been undertaken to ascertain the likely EMF strengths (B-fields only) at varying points across the OAA and OECC, as detailed in Chapter 5: Project Description. For the IAC, the maximum B-field emissions are predicted to be 30.3 μT at the seabed surface where case iron shell protection is used (and the cable is surface laid without any external rock protection) and 17.7 μT at the seabed surface assuming 1 m depth of lowering. For the OECs, the maximum B-field emissions are predicted to be 48.3 μT at the seabed surface where case iron shell protection is used (and the cable is surface laid without any external rock protection) and 25.3 μT at the seabed surface assuming 1 m depth of lowering. The natural background GMF within the Offshore Site is predicted to be 50 μT. Therefore, the B-fields are all anticipated to be less than the natural background GMF.

Given the strength of the cable B-field at the seabed or at the surface of the cast-iron shell is below the level of natural (background) geomagnetism at the location of the OAA and OECC (NCEI, 2019), that cable electromagnetism is not likely to be detectable by fish and shellfish receptors beyond the immediate vicinity of the cable. This is considered within the assessment presented below.

Due to the different level of sensitivity of different species groups, the receptor sensitivity appraisal has been split into the key receptor groupings; marine finfish, diadromous fish, shellfish, and elasmobranchs.

Marine Finfish

Pelagic species are unlikely to encounter the EMF associated with the Offshore Site as these species are not closely associated with the seabed. Conversely, demersal species, including eggs and larvae, on or above the seabed may overlap with the EMF associated with the cables. Consequently, these species are more sensitive to EMF effects (Nyqvist *et al.*, 2020).

The impact is predicted to adversely affect marine finfish receptors directly. This impact would be continuous throughout the lifetime of the Offshore Site but is reversible upon decommissioning. This impact will occur over a local spatial extent, with EMF emissions dissipating rapidly from the source. Overall, the magnitude is therefore considered to be **low**.

Recent primary research conducted by Cresci *et al* (2020; 2022a; 2022b) reviews the impacts of EMF exposure on the larvae of haddock, herring, and lesser sandeel. Haddock larvae exhibit magneto-sensitivity (Cresci *et al.*, 2019). In a controlled laboratory environment, exposure to magnetic fields (B-fields) ranging from 50 to 150 μT did not induce significant changes in spatial distribution (i.e., no attraction effect) for haddock larvae. However, it did result in reduced swimming speeds, potentially influencing the dispersal ecology of this species (Cresci *et al.*, 2022). For Atlantic herring larvae exposed to B-fields between 48.8 and 50 μT, both *in situ* and in laboratory conditions, no alterations in orientation were observed due to EMF exposure. This suggests that, at least at this life history stage, this species does not rely on magnetic compass orientation (Cresci *et al.*, 2020). Likewise, lesser sandeel larvae exposed to B-fields ranging from 50 to 150 μT in a laboratory setting exhibited no changes in spatial distribution, swimming speed, acceleration, or distance moved (Cresci *et al.*, 2022b). It Is important to note that magnetic fields of these intensities would only be anticipated in very close proximity to the cables for the Offshore Site due to the cable being buried or protected. As detailed above and in Chapter 5: Project Description, the B-field strength expected is considered to be less than the natural background GMF with a maximum of 48.3 μT.

Overall, it is acknowledged that the evidence base for EMF effects on fish is limited and uncertain, particularly with regards to field studies. Based on the best available scientific knowledge, and understanding of EMF effects on fish behaviours, it is understood that, under laboratory conditions, potential developmental, genetic and physiological implications of exposure to B-fields only occur when exposure levels are in the range of several milli Tesla (mT), rather than μT (Gill and Desender, 2020; Copping *et al.* 2021). Generally, research findings, although limited, suggest that EMF associated with offshore renewable developments are unlikely to result in substantial impacts on marine finfish species (Gill and Desender, 2020; Copping *et al.* 2021).

Overall, marine finfish are deemed to be of low vulnerability, high recoverability and high value. The sensitivity of the receptor is therefore, considered to be **low**.

Shellfish

The body of literature on responses in shellfish to EMF is varied and the vulnerability remains relatively unknown. Recent evidence suggests that crustaceans, including lobster and crab, have been shown to demonstrate a response to B-fields (CSA, 2019).

The impact is predicted to adversely affect shellfish receptors directly. This impact would be continuous throughout the lifetime of the Offshore Site but is reversible upon decommissioning. This impact will occur over a local spatial extent, with EMF emissions dissipating rapidly from the source. Overall, the magnitude is therefore considered to be **low**.

Recent research on brown crab in laboratory conditions (Scott *et al.*, 2021), found that there were no adverse physiological or behavioural impacts at B-fields of 250 µT. At B-field levels of 500 µT and above attraction to the areas emitting EMF and increased time spent roaming was observed. Though it is important to note that while responses are observed at these elevated levels, the proposed cables for the Offshore Site would not emit magnetic fields within these magnitudes. The attraction of crabs to EMF sources is not thought to impact overall crab movements (Williams *et al.*, 2022). Research undertaken by Hutchison *et al.* (2018; 2020) on American lobster (*Homarus americanus*) observed behavioural response to EMF associated with an HVDC cable, at a B-field of 51.3 µT (similar levels to that expected for the Project). However, the response was subtle and there was no indication that the parameters were associated with zones of high or low EMF but was an overall response. Furthermore, the highest levels of EMF (associated with the OECC), are located outside of the lobster habitat (see Section 10.5.6.2).

Exposure to EMF during embryonic development was found to lead to physiological deformities and reduced swimming test success rates in lobster and brown crab larvae. However, these deformities arose in response to exposure of EMF levels of 2,800 µT (Harsanyi *et al.*, 2022). These levels are over 50 times higher than, and therefore not comparable to, EMF levels expected for the Offshore Site. Scott (2019) also found that EMF exposure during development resulted larvae which were significantly smaller than the controls. However, there were no difference in the number of hatched larvae, mortality or fitness. Overall, research since 2016 concerning invertebrates generally supports previous studies that demonstrated no or minor effects of encounters with EMFs (Albert *et al.*, 2020). Considering this, no substantial physiological or behavioural effects are expected.

Shellfish species are therefore deemed to be of low vulnerability to EMF effects, high recoverability and of a high value. The sensitivity of the receptor is therefore, considered to be **low**.

Elasmobranchs

Elasmobranchs detect magnetic fields directly, due to their possession of specialist magnetic receptor cells. It is widely accepted that they are more responsive to magnetic fields in comparison to other species (Gill *et al.*, 2005; Hutchison *et al.*, 2020). Gill *et al.* (2009) reported that several species of elasmobranchs showed some attraction to cables and reduced swimming activity.

The impact is predicted to adversely affect elasmobranch receptors directly. This impact would be continuous throughout the lifetime of the Offshore Site but is reversible upon decommissioning. This impact will occur over a local spatial extent, with EMF emissions dissipating rapidly from the source. Overall, the magnitude is therefore considered to be **low**.

Gill and Taylor (2001) found that spurdog, which are likely to be found within the fish and shellfish study area, avoided electrical fields at 10 µV/cm. Gill *et al.* (2009) found that lesser spurdog and thornback ray responded to B-fields of 8 µT and iE-fields of 2.2 µV/m, but noted that the observed response was unpredictable and, in some instances, did not occur altogether. Hutchison *et al.* (2018; 2020) also demonstrated that little skate (*Leucoraja erinacea*), a north American species, showed an increased exploratory behaviour in response to EMF exposure. But ultimately, the cable did not represent a barrier to little skate movement (Hutchison *et al.*, 2018).

Overall, the extent of EMF influence on elasmobranchs is variable. However, the consensus from much of the literature appears to suggest that EMF levels higher (2,800 µT, Harsanyi et al., 2022) than those expected of the Offshore Site (maximum of 48.3 µT) would be required to cause behavioural and ecological change in individuals. Elasmobranchs are deemed to be of medium vulnerability, high recoverability and a very high value. The sensitivity of the receptor is therefore, considered to be **medium**.

Diadromous Fish

Contained within the skeletal structure of diadromous fish is magnetically sensitive material which enables them to use EMFs as a navigational tool during migration (Gill and Bartlett, 2010). Consequently, the introduction of anthropogenic EMF into the marine environment has the potential to alter these migratory behaviours, potentially resulting in increased energy expenditure. Although the extent of the effect of EMF on migratory species in unclear (Gill and Bartlett, 2010).

Atlantic salmon, sea trout, sea lamprey, river lamprey, and European eel may pass through the fish and shellfish study area during migrations (Section 10.5.8). While exact migration pathways are little understood and are likely to be diffuse across the fish and shellfish study area, rivers important to such species are present along the coastline.

The impact is predicted to adversely affect diadromous fish receptors directly. This impact would be continuous throughout the lifetime of the Offshore Site but is reversible upon decommissioning. This impact will occur over a local spatial extent, with EMF emissions dissipating rapidly from the source. Overall, the magnitude is therefore considered to be **low**.

No field studies are available on the response of Atlantic salmon to EMF. Wyman *et al.* (2018) investigated the effect of EMF from a DC undersea cable near San Francisco, California on Chinook salmon (*Oncorhynchus tshawytscha*). It was concluded that the EMF emitted did not affect salmon migration and survival, although slight deviation from typical migratory routes was observed. In a laboratory setting, Armstrong *et al.* (2015) also did not find any physiological or behavioural response of Atlantic salmon to B-fields at intensities of 95 µT and below, noting that the expected B-field magnitude for the Project would be a maximum of 48.3 µT.

Most migratory salmonids swim within the top 5 m of the water (Godfrey *et al.*, 2014). Therefore, they would not be affected by EMF emitted from buried cables, given the limited influence of EMF within a matter of metres of the seabed. Conversely, other species such as eels, may be found throughout the water column, including near the seabed.

Studies on European eel have concluded that subsea cables did not pose a prohibitive barrier to crossing (Hvidt *et al.*, 2003); however, some individuals did show limited effects on directional movement (Westerberg and Begout-Anras, 2000) and speed (Westerberg and Langenfelt, 2008). However, these were not strong avoidance behaviours, nor were they judged likely to influence overall migration (Westerberg and Begout-Anras, 2000; Westerberg and Langenfelt, 2008). Under laboratory conditions, Orpwood *et al.* (2015) observed no change in the movement or behaviour of European eels as a result of EMF.

Diadromous fish species are deemed to be of low vulnerability, high recoverability and of very high value. The sensitivity of the receptor is therefore, considered to be **low**.

10.6.3.3.3 Assessment of Significance Prior to Mitigation

Marine Finfish

EMF effects during the operational phase will have an adverse, direct, likely, long term, continuous and reversible impact on marine finfish receptors. Combined with the low sensitivity of marine finfish, it is concluded that EMF effects will have a **not significant negative effect** on this receptor, which is Not Significant.

Shellfish

EMF effects during the operational phase will have an adverse, direct, likely, long term, continuous and reversible impact on shellfish receptors. Combined with the low sensitivity of shellfish, it is concluded that EMF effects will have a **not significant negative effect** on this receptor, which is Not Significant.

Elasmobranchs

EMF effects during the operational phase will have an adverse, direct, likely, long term, continuous and reversible impact on elasmobranch receptors. Combined with the medium sensitivity of elasmobranchs, it is concluded that EMF effects will have a **slight negative effect** on this receptor, which is Not Significant.

Diadromous Fish

EMF effects during the operational phase will have an adverse, direct, likely, long term, continuous and reversible impact on diadromous fish receptors. Combined with the low sensitivity of diadromous fish, it is concluded that EMF effects will have a **not significant negative effect** on this receptor, which is Not Significant.

10.6.3.3.4 Mitigation

The key mitigation by design to reduce the EMF effects on fish and shellfish receptors is cable burial to a minimum depth of 1.0 m, where possible, and the installation of cable protection. There will be a degree of separation of fish and shellfish receptors from the source of EMF emissions, minimising the field strength likely to be encountered. Where cables are not buried, additional protection will be used in the form of cast-iron shells.

Furthermore, the direct E-fields are blocked by the use of conductive sheathing within the cable, and hence are not considered within this assessment as there is no pathway for impact.

10.6.3.3.5 Residual Effect Following Mitigation

Taking the embedded mitigation described above into account, the residual effect of EMF during the operational phase is as follows:

- **Marine finfish:** not significant negative effect;
- **Shellfish:** not significant negative effect;
- **Elasmobranchs:** slight negative effect; and
- **Diadromous fish:** not Significant negative effect.

Effects on all species are therefore assessed to be Not Significant.

10.6.3.4 Thermal Emissions from Operational Cables

10.6.3.4.1 *Description of Effect*

Subsea power cables generate and dissipate heat into the marine environment which may directly adversely affect fish and shellfish receptors.

The IACs and OEC will not be able to heat the overlying seawater, due to water's high specific heat capacity. Therefore, only sediments along the proposed OECC may be subject to potential heating.

10.6.3.4.2 *Characterisation of Unmitigated Effect*

Thermal emissions from cables increase the temperature of the surrounding sediments. Taormina *et al.* (2018) found that a maximum increase of 2.5°C occurs 50 cm directly below the cable. Emeana *et al.* (2016) determined that heat transfer was dependent on sediment type, and that coarse silts experience the greatest temperature change. Coarser sediments had a lower temperature change but were affected over a greater distance. The impact is predicted to be of highly localised spatial extent, long term duration, continuous and reversible upon decommissioning of the Offshore Site. The magnitude is considered to be **low.**

It is expected that due to the highly localised nature of any sediment heating, that only demersal marine finfish, elasmobranchs and shellfish would likely be affected. However, given the mobile nature of these receptors, combined with the localised nature of this impact, the vulnerability is considered to be low. Combined with a high recoverability and high value, the sensitivity is assessed as **low**.

10.6.3.4.3 *Assessment of Significance Prior to Mitigation*

Thermal emissions from operational cables during the operational phase will have an adverse, direct, likely, long term, continuous and reversible impact on marine finfish, elasmobranchs, and shellfish receptors. However, the effect will be highly localised. Combined with the low sensitivity of fish and shellfish receptors, it is concluded that thermal emissions form operational cables during the operational phase will have a **slight negative effect** on this receptor, which is Not Significant.

10.6.3.4.4 *Mitigation*

The key mitigation by design to reduce the thermal emissions on fish and shellfish receptors is cable burial to a minimum depth of 1.0 m, where possible, and the installation of cable protection. There will be a degree of separation of fish and shellfish receptors from the source of thermal emissions.

10.6.3.4.5 *Residual Effect Following Mitigation*

The residual effect of thermal emissions from operational cables during the operational phase is concluded to be an **imperceptible negative effect** and is Not Significant.

10.6.3.5 Underwater Noise

10.6.3.5.1 *Description of the Effect*

Underwater noise during operation may be generated from the operation of WTGs and the OSS. Studies have shown that operational noise impacts are considered highly unlikely to cause physical damage to fish or shellfish species (Nedwell *et al.*, 2007; MMO, 2015). Any disturbance to fish would be limited to only the immediate vicinity of the WTGs and OSS and given the mobile nature of fish and shellfish species is therefore considered highly unlikely.

10.6.3.5.2 Characterisation of Unmitigated Effect

Continuous low frequency underwater noise may result from the operation of the 30 WTGs and one OSS. The underwater noise levels generated by the operational WTGs has been estimated by Subacoustech (Underwater Noise Modelling and Assessment, Appendix 12-1), using the Popper *et al.* (2014) quantitative criteria for shipping and other continuous noise sources, as outlined in Section 10.6.2.1. It was predicted that fish with a swim bladder involved in hearing would have to remain within 10 m of each operational WTG for a 24-hour period to exceed the Popper *et al.* (2014) thresholds for recoverable injury and TTS (Appendix 12-1).

As noted above, the level of noise generated by the operational WTGs and OSS is likely to be low (Nedwell *et al.*, 2007; MMO, 2015) and effects would only occur if fish species remained within immediate vicinity of the source (i.e. within metres) for an extended period of time, which is unlikely to occur. The evidence base suggests that the level of operational noise is significantly less than construction noise and detectable only at short ranges from each WTG or OSS.

Based on the location of the Offshore Site and the ambient noise generated from local fishing and shipping activities, the operational phase of the Offshore Site is not likely to surpass existing ambient noise. Given an individual receptor would need to approach the WTG to experience operational noise, this is not considered a viable pathway for injury or significant disturbance impacts due to underwater noise.

This impact is predicted to adversely affect fish and shellfish receptors directly. This impact would be continuous throughout the lifetime of the Offshore Site but is reversible upon decommissioning. The effect will occur over a very local spatial extent, and no perceptible change to the baseline is expected. Overall, underwater noise during operation is predicted to be of a **negligible** magnitude.

Receptor sensitivity for fish and shellfish receptors with the potential to be impacted by underwater noise during operation are the same as stated for during construction. This assessed as follows as outlined in Section 10.6.2.1 above:

- Fish without swim bladders and fish with a swim bladder that is not involved in hearing: **low**;
- Fish with a swim bladder that is involved in hearing: **medium**; and
- Shellfish: **medium**.

10.6.3.5.3 Assessment of Significance Prior to Mitigation

Underwater noise during the operational phase will have an adverse, direct, likely, long term, continuous and reversible impact on fish and shellfish receptors. However, this is not expected to result in a perceptible change to the baseline. When combined with the low sensitivity of fish without swim bladders and fish with a swim bladder that is not involved in hearing, it is concluded that underwater noise during the operational phase will have an **imperceptible negative effect** which is Not Significant. For receptors which are of a medium sensitivity (i.e. fish with a swim bladder that is involved in hearing, and shellfish), operational underwater noise is considered to have a **not significant negative effect**, which is Not Significant.

10.6.3.5.4 Mitigation

No mitigation is deemed necessary for this impact, owing to the low levels of continuous noise expected from the operation of the WTGs and OSS.

10.6.3.5.5 *Residual Effect Following Mitigation*

As no mitigation is considered necessary for this impact, the residual effect following mitigation aligns with the assessment of significance prior to mitigation.

10.6.3.6 Barrier Effects

10.6.3.6.1 *Description of the Effect*

If fish species display avoidance behaviours as a result of the presence of offshore infrastructure, there is the potential for barrier effects to adversely impact the movement of migratory fish, such as lamprey species, shad species, eels, trout and Atlantic salmon that are known use the fish and shellfish study area. The assessment for salmonids is also relevant to freshwater pearl mussel who may be indirectly affected by effects on these species.

As stated in Section 10.5.8, whilst empirical data is lacking to demonstrate the distribution and migration patterns of diadromous fish within the fish and shellfish study area, it is assumed that that these diadromous fish species have the potential to migrate through the Offshore Site.

10.6.3.6.2 *Characterisation of Unmitigated Effect*

The key impacts on diadromous fish during the the operational phase with the potential to result in avoidance behaviours are considered to be EMF effects (Section 10.6.3.3), underwater noise (e.g. the combined sound associated with the operational noise of multiple WTGs) (Section 10.6.3.5) and visual effects. However, it should be noted that there is currently no available evidence of an offshore wind farm posing a barrier to diadromous fish, from any plausible impact pathway. The potential effect of EMF and underwater noise on diadromous fish is assessed in Sections 10.6.3.1 and 10.6.3.5 respectively, and it is concluded that there will be no significant effects from these pathways. Considering the highly localised extent of these impacts, the potential for a barrier effect to occur on diadromous fish is low.

In terms of visual effects, the majority of available research focusses on artificial light. For instance, exposure to street lights during downstream migration of Atlantic salmon smolts at the River Itchen, England, resulted in a more random timing of migration compared with non-lit years when migration was correlated to sunset (Riley *et al.*, 2012). Similarly, downstream migrating European eel were less likely to migrate down an artificially lit route option than an unlit route option (Vowles and Kemp, 2021). Furthermore, at fish farms, exposure to submerged artificial light has been observed to increase swimming depths by Atlantic salmon (Juell *et al.*, 2003). Atlantic salmon and sea trout are commonly found near the sea surface, and therefore, may be receptive to visual stimuli associated with the Offshore Site. However, considering the distance of the blades of the Offshore Site above the sea surface and in the context of other visual stimuli, such as cloud cover and distortions of the water surface, it is considered unlikely that any visual stimuli associated with the Offshore Site will have any adverse effects on diadromous fish. Furthermore, the Offshore Site is located far from the coast where visual or olfactory stimuli for returning to natal rivers are expected to play a more important role in navigation for Atlantic salmon (Keefer and Caudill, 2014). Considering the above, visual effects are considered unlikely to result in a barrier effect to diadromous fish.

The location of the Offshore Site, enabling passage either side of the WTGs, is unlikely to present a significant barrier to movement for migratory fish. Considering the information presented above for EMF, underwater noise and visual effects, the impact of barrier effects on diadromous fish is assessed to be continuous, of a local spatial extent and long term but is unlikely to substantially reduce the successful migrations of diadromous fish. Therefore, the magnitude is assessed as **low.**

Diadromous fish are national to internationally important receptors. Diadromous fish have some capacity to tolerate barrier effects and diversions if a successful migration can still be made. Therefore, diadromous fish are considered to have a medium vulnerability, medium recoverability, and very high value. Therefore, the sensitivity is assessed as **medium**.

10.6.3.6.3 Assessment of Significance Prior to Mitigation

Barrier during the operational phase will have an adverse, direct, likely, long term, continuous and reversible impact on fish and shellfish receptors. However, this is not expected to ultimately reduce migration success. When combined with the medium sensitivity of fish and shellfish receptors, it is concluded that barrier effects during the operational phase will have a **slight negative effect**, which is Not Significant.

10.6.3.6.4 Mitigation

The measures presented for EMF (Section 10.6.3.3.4) and underwater noise (Section 10.6.3.5.4) are applicable to this impact.

10.6.3.6.5 Residual Effect Following Mitigation

The residual effect of barrier effects during the operational phase is concluded to be a **not significant negative effect** and is therefore assessed to be Not Significant.

10.6.3.7 Ghost Fishing

10.6.3.7.1 Description of Effect

Ghost fishing may occur if discarded fishing gear becomes entangled with Offshore Site infrastructure[12] and consequently has an adverse effect on fish and shellfish species. The potential for fishing gear to become entangled with subsea structures is assessed in Chapter 13: Commercial Fisheries.

10.6.3.7.2 Characterisation of Unmitigated Effect

The assessment considers a minimum WTG spacing of 1,017m between WTGs and 610 m minimum distance between WTGs and the OSS. It is acknowledged, as stated in Chapter 13: Commercial Fisheries, that the majority of fishing that occurs within the vicinity of the Offshore Site are creelers. Pots and traps deployed by creelers are less vulnerable to entanglement, compared to vessels operating mobile gear, including demersal trawlers, seine netters and scallop dredgers, which are potentially vulnerable to gear entanglement, due to these gear types being towed behind the vessel.

As detailed in Chapter 13: Commercial Fisheries, it is assumed that fishing within and around the Offshore Site will continue the same as the pre-installation, baseline level once the Offshore Site is operational. However, the likelihood of gear entanglement (and subsequently, ghost fishing) occurring is considered to be minimal, due to the absence of mooring lines or suspended cables within the water column. If any impact is realised, it is considered that the spatial extent would be highly localised. The likelihood of this impact occurring is therefore considered to be extremely low and the magnitude of impact is considered to be **negligible**.

Considering the mobility of each species group and therefore the low likelihood of coming into contact with gear, no species group are considered particularly vulnerable to this impact. However, considering the national and international importance of some species, the sensitivity of the receptor is considered to be **low**.

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[12] *The impact of damage or loss of gear is assessed in Chapter 13: Commercial Fisheries.*

10.6.3.7.3 Assessment of Significance Prior to Mitigation

Ghost fishing during the operational phase will have an adverse, direct, unlikely, long term, intermittent and reversible impact on fish and shellfish receptors. Combined with the low sensitivity, it is concluded that temporary habitat loss or disturbance during construction will have an **imperceptible negative effect** on this receptor, which is Not Significant.

10.6.3.7.4 Mitigation

Additionally, there are numerous embedded mitigation measures proposed to reduce the likelihood of gear entanglement (see Chapter 13: Commercial Fisheries), including but not limited to:

- Ongoing communication with the fishing industry (e.g. NtMs) to provide notice of any operational phase activity, and 500 m safety zones will be in place during major maintenance works;
- Additionally, there will be ongoing monitoring of cable protection so that notices will be issued within 24 hours of any damage, destruction or decay of cables that could result in exposed cable;
- There will be procedures in place for dropped objects and claim processes for loss or damage of fishing gear;
- Guard vessels and an OFLO (where required) will onsite, where appropriate, during major maintenance works to aid offshore communications and warnings of any hazards.

10.6.3.7.5 Residual Effect Following Mitigation

The residual effect of ghost fishing effects during the operational phase is concluded to be an **imperceptible negative effect** , which is Not Significant.

10.6.4 Decommissioning Phase

A Rehabilitation Plan has been prepared for the Project (see Chapter 5: Project Description). The Rehabilitation Plan will be updated prior to the end of the operational period in line with decommissioning methodologies that may exist at the time and will be agreed with the competent authority at that time. The decommissioning activity will resemble the reverse of the installation and therefore the potential impacts associated with the decommissioning phase are considered to be analogous or likely less than that of the construction phase.

The decommissioning base locations will be out of Foynes, Cork and/or Belfast. Up to 3 vessels will be used for WTG removal and up to 4 tugs for foundation removal. For infrastructure removal the installation process is reversed using vessels to remove the WTGs and then to de-ballast the foundations and wet tow them from the site. Rock protection used for cables and/or seabed preparation material (e.g. stonebeds) is assumed to be left *in situ*. Decommissioning of the cables will involve removal of any exposed or unburied cable that is accessible. All rock berms will remain undisturbed. This method has the lowest environmental impact. Further information on the decommissioning process is detailed in Chapter 5: Project Description.

Taking this into consideration, along with the embedded mitigation in Section 10.4.3.4 which will also be applicable to decommissioning, the effects associated with the Decommissioning Phase will be at most, a **slight negative effect**, which is Not Significant for all fish and shellfish receptors.

10.7 Residual Effects

10.7.1 Construction and Decommissioning Phase

Table 10-22 Residual effect of construction and decommissioning phase impacts on fish and shellfish receptors

Impact	Receptor	Magnitude	Sensitivity	Significance Prior to Mitigation	Mitigation	Residual Effect
Underwater noise	Fish without swim bladders	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.1.4.	Not significant negative effect; Not Significant.
	Fish with a swim bladder that is not involved in hearing	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.1.4.	Not significant negative effect; Not Significant.
	Fish with a swim bladder involved in hearing	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.1.4.	Slight negative effect; Not Significant.
	Shellfish	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.1.4.	Slight negative effect; Not Significant.
Temporary habitat loss or disturbance	Marine finfish (except herring)	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.2.4.	Not significant negative effect; Not Significant.
	Herring	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.2.4.	Slight negative effect; Not Significant.
	Shellfish	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.2.4.	Slight negative effect; Not Significant.

Impact	Receptor	Magnitude	Sensitivity	Significance Prior to Mitigation	Mitigation	Residual Effect
	Elasmobranchs	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.2.4.	Slight negative effect; Not Significant.
	Diadromous fish	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.2.4.	Not significant negative effect; Not Significant.
Long-term habitat loss	Marine finfish (except herring)	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.3.4.	Not significant negative effect; Not Significant.
	Herring	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.3.4.	Slight negative effect; Not Significant.
	Shellfish	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.3.4.	Slight negative effect; Not Significant.
	Elasmobranchs	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.3.4.	Slight negative effect; Not Significant.
	Diadromous fish	Low	Low	Slight negative effect; Not significant.	As per mitigation in Section 10.6.2.3.4.	Not significant negative effect; Not Significant.
Temporary increase in SSC	Marine finfish (except herring)	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.4.4.	Slight negative effect; Not Significant.
	Herring	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.4.4.	Slight negative effect; Not Significant.
	Shellfish	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.4.4.	Slight negative effect; Not Significant.

Impact	Receptor	Magnitude	Sensitivity	Significance Prior to Mitigation	Mitigation	Residual Effect
	Elasmobranchs	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.4.4.	Slight negative effect; Not Significant.
	Diadromous fish	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.4.4.	Slight negative effect; Not Significant.
Accidental release of pollutants	Marine finfish	Medium	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.5.4.	Not significant negative effect; Not Significant.
	Shellfish	Medium	Medium	Moderate negative effect; Not Significant.	As per mitigation in Section 10.6.2.5.4	Slight negative effect; Not Significant.
	Elasmobranchs	Medium	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.5.4	Not significant negative effect; Not Significant.
	Diadromous fish	Medium	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.2.5.4	Not significant negative effect; Not Significant.

10.7.2 Operational Phase

Table 10-23 Residual effect of the operational phase phase impacts on fish and shellfish receptors

Impact	Receptor	Magnitude	Sensitivity	Significance Prior to Mitigation	Mitigation	Residual Effect
Habitat creation and fish aggregation	Marine finfish	Low	Low	Not significant positive or slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.1.4.	Not significant positive or slight negative effect; Not Significant

Impact	Receptor	Magnitude	Sensitivity	Significance Prior to Mitigation	Mitigation	Residual Effect
	Shellfish	Low	Low	Not significant positive or slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.1.4.	Not significant positive or slight negative effect; Not Significant
	Elasmobranchs	Low	Low	Not significant positive or slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.1.4.	Not significant positive or slight negative effect; Not Significant
	Diadromous fish	Low	Medium	Slight positive or negative effect; Not Significant.	As per mitigation in Section 10.6.3.1.4.	Slight positive or negative effect; Not Significant
Temporary increase in SSC	Marine finfish (except herring)	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.2.4.	Slight negative effect; Not Significant.
	Herring	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.2.4.	Slight negative effect; Not Significant.
	Shellfish	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.2.4.	Slight negative effect; Not Significant.
	Elasmobranchs	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.2.4.	Slight negative effect; Not Significant.
	Diadromous fish	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.2.4.	Slight negative effect; Not Significant.
EMF effects	Marine finfish	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.3.4.	Not significant negative effect; Not Significant.

Impact	Receptor	Magnitude	Sensitivity	Significance Prior to Mitigation	Mitigation	Residual Effect
	Shellfish	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.3.4.	Not significant negative effect; Not significant.
	Elasmobranchs	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.3.4.	Slight negative effect; Not Significant.
	Diadromous fish	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.3.4.	Not significant negative effect; Not Significant.
Thermal emissions from operational cables	All fish and shellfish receptors	Low	Low	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.4.4.	Imperceptible negative effect; Not Significant.
Underwater noise	Fish without swim bladders	Negligible	Low	Imperceptible negative effect; Not Significant.	As per mitigation in Section 10.6.3.5.4.	Imperceptible negative effect; Not Significant.
	Fish with a swim bladder that is not involved in hearing	Negligible	Low	Imperceptible negative effect; Not Significant.	As per mitigation in Section 10.6.3.5.4.	Imperceptible negative effect; Not Significant.
	Fish with a swim bladder involved in hearing	Negligible	Medium	Not significant negative effect; Not Significant.	As per mitigation in Section 10.6.3.5.4.	Not significant negative effect; Not Significant.
	Shellfish	Negligible	Medium	Not significant negative effect; Not Significant.	As per mitigation in Section 10.6.3.5.4.	Not significant negative effect; Not Significant.
Barrier effects	Diadromous fish	Low	Medium	Slight negative effect; Not Significant.	As per mitigation in Section 10.6.3.6.4.	Slight negative effect; Not Significant.

Impact	Receptor	Magnitude	Sensitivity	Significance Prior to Mitigation	Mitigation	Residual Effect
Ghost fishing	All fish and shellfish receptors	Negligible	Low	Imperceptible negative effect; Not Significant.	As per mitigation in Section 10.6.3.7.4.	Imperceptible negative effect; Not Significant.

10.8 Cumulative Effects

10.8.1 Introduction

Potential effects from the Project have the potential to interact with those from other projects (developments), plans and activities, resulting in cumulative effects on fish and shellfish receptors. The general approach to the cumulative effects assessment (CEA) is described in Chapter 4: EIA Methodology.

The list of relevant developments for inclusion within the CEA is outlined in Table 10-24. This has been informed by a screening exercise, undertaken to identify relevant developments for consideration within the CEA for each EIA topic. The Cumulative Study Area for fish and shellfish ('the Cumulative Study Area') is defined as the fish and shellfish study area detailed in Section 10.5.1 above. It is considered that this Cumulative Study Area provides a local (i.e. within the Offshore Site) and regional context for fish species. Additionally, the Shannon Estuary has been considered as part of the CEA in consideration of the potential temporary anchorage of the GBS foundations and movement of Project vessels within the estuary.

It is important to note that there are no developments of an equivalent scale or type to the Project within the Cumulative Study Area. To date, there has been little, large-scale construction on the west coast of Ireland generally. Therefore, many of the relevant developments in Table 10-24 represent short-term, localised activities which are not generally associated with any long-term infrastructure presence.

There are 97 aquaculture sites within the Cumulative Study Area. The closest aquaculture site (the Udaras na Gaeltachta site) is located 6.3 km from the OAA. The nature of these developments is such that their associated impacts are universal between sites. While these operational developments are considered part of the baseline environment, aquaculture farms, in particular those focussing on finfish production, will discharge and deposit detritus/sediments. However, the scale of this will be minimal allowing for rapid reincorporation of sediments into the local transport regime and is therefore unlikely to result in cumulative SSC impacts on fish and shellfish receptors. Owing to the very small scale at which these deposits will occur in relation to the Project, aquaculture sites are not considered further within CEA.

A number of wave buoys, navigation buoys, and sea temperature probes are located within the Cumulative Study Area. These are grouped together given their similarities as small pieces of sea surface infrastructure. The closest navigation buoy within the Cumulative Study Area is at Killeaney. This buoy is 15.36 km from the OECC. There are 15 sea temperature probes within the Cumulative Study Area. These probes occur at a high density amongst the islands along the coast of the mainland, northeast of the OAA. The closest probe was installed in Kilkieran Bay in 2004 and is 7.97 km from the OAA. There is a single (Westwave) wave buoy located 7.66 km due west of the Landfall location. These operational buoys are considered part of the baseline environment and, though they remain present within the Cumulative Study Area, they have no associated continuous operational impact on the environment. Therefore, there is no opportunity for cumulative effects together with the impacts associated with the Project. Consequently, wave buoys, navigation buoys, and sea temperature probes are excluded from CEA.

There are a number of ferry ports located within the Cumulative Study Area. However, these ports are operational and have no associated licenced maintenance or dredging activities. Consequently, it is assumed that these port locations do not generate any impacts equivalent to those associated with the Project. Therefore, there is no opportunity for cumulative interactions. Ferry ports are therefore not considered further within the CEA.

Urban waste water treatment locations are located along the coast within the Cumulative Study Area, in particular close proximity to the Landfall. As these locations are all terrestrial and are concerned with treatment activities which occur onshore, these waste water treatment locations are not considered further in CEA. However, some water treatments are co-located with discharge points which do discharge waste water effluent directly from the coast or into estuaries and therefore have the potential to impact fish and shellfish receptors. These discharge points, and others along the coast which output directly into coastal, or estuary waters are considered further in the CEA. A total of four such discharge points are listed in Table 10-24.

Two operational wave test sites are located within 50 km of the Offshore Site. These sites are considered part of the baseline environment and, though they remain present within 50 km of the Offshore Site, they have no associated continuous operational impact on the environment. Therefore, there is no opportunity for in-combination effects together with the impacts associated with the Project. Consequently, operational wave test sites are excluded from CEA.

The Project is the only Relevant Project / Phase 1 offshore renewable development in the region with a Maritime Area Consent (MAC), the only offshore wind development in the region which was successful in Offshore Renewable Electricity Support Scheme (ORESS) 1 and the only offshore wind development in the region, which is permitted to make a planning application.

There were a number of planned offshore renewable developments (at various levels of inception) proposed to be developed off the western coast of Ireland before the State's policy changed to a plan-led regime. Current policy is such that none of these projects are permitted to seek a MAC or make a planning application. However, whether any of these offshore renewables projects progress in the future is entirely dependent on future policy decisions. Therefore, all foreshore licences related to these projects have been excluded from CEA.

The nearest licenced dumping at sea (dredge and disposal) activities occurs as part of maintenance dredging associated with the Kilrush Marina, located within the Shannon Estuary. Vessels associated with the dumping at sea activities may have a cumulative effect with the vessels associated with the Project. Therefore, licenced dumping at sea is considered within the CEA.

Table 10-24 provides the list of relevant developments screened in or out of further consideration within the CEA, with justification in support of the screening decision

Table 10-24 List of developments considered for the fish and shellfish cumulative effects assessment

Location	Development Type	Development Name	Distance to OAA (km)	Distance to OECC (km)	Status	Additional Information	Considered further
Foreshore Licence							
Galway	Cable	IRIS sub-sea fibre optic cable system	0.00	71.87	Operational	Licence for Construction of Cable. 2022- overall duration 2-3 months.	No – operational project is considered part of baseline conditions.
Galway	Scientific research	UCD Research Experiments, Inishmaan	13.12	28.21	Operational	Licence for Data Monitoring Equipment. 2022-2027.	No – operational project is considered part of baseline conditions.
Clare / Kerry	Cable	Cross Shannon Cable Project	21.54	80.04	Operational	Licence for Construction of Cable. Duration of construction 12 months.	No – operational project is considered part of baseline conditions.
Dumping at Sea							
Shannon Estuary	Dredged material / dredge and disposal	Shannon Foynes Port Company	86.61	32.48	Permit valid through 31/12/2026	Permit No. S0009-03	No – permit has no temporal overlap with the construction phase of the Project.
Discharge Points							
Kilkee	Discharge Point	Kilkee	64.40	11.90	Active	Discharge in coastal water	Yes
Kilrush	Discharge Point	Kilrush	73.21	14.85	Active	Discharge in coastal water	Yes
Ennistymon	Discharge Point	Ennistymon Waste Water Treatment Plant	53.16	25.99	Active	Discharge to estuary	No – estuaries typically experience naturally elevated levels of SSC such that any additional discharge will likely be readily incorporated into the local environment and therefore no impact on fish and shellfish

Location	Development Type	Development Name	Distance to OAA (km)	Distance to OECC (km)	Status	Additional Information	Considered further
							receptors is expected considering the intervening distance of ~26 km.
Clifden	Discharge Point	Clifden Waste Water Treatment Plant	21.37	26.79	Active	Discharge to estuary	No – estuaries typically experience naturally elevated levels of SSC such that any additional discharge will likely be readily incorporated into the local environment therefore no impact on fish and shellfish receptors is expected considering the intervening distance of ~21 km..

Considering the list of relevant developments in Table 10-24, impacts have been screened in or out of CEA. The justification for this process is provided in Table 10-24, with Section 10.8.2 onward assessing the construction, operational, maintenance and decommissioning phase impacts in turn. Impacts screened in (i.e. considered to potentially result in a cumulative impact) are considered further below.

Table 10-25 Impacts requiring consideration in CEA

Effect	Screened	Justification
Construction Phase (Section 10.8.2)		
Disturbance or damage to fish and shellfish due to underwater noise generated from construction activities	Out	There is not considered to be any sound emissions associated with the discharge points and therefore this impact pathway has been screened out for these cumulative projects.
Temporary habitat loss or disturbance	Out	The discharge points will not introduce any infrastructure or vessel activity to the extent that will result in habitat loss or disturbance. Consequently, this impact is not considered further for CEA.
Long-term habitat loss	Out	No additional permanent habitat will be introduced by the foreshore licence activities or discharge points to the extent that will result in habitat loss or disturbance. Consequently, this impact is not considered further for CEA.
Temporary increase in SSC	In	There is potential for a cumulative effect.
Accidental release of pollutants	In	There is potential for a cumulative effect.
Operational Phase (Section 10.8.3)		
Habitat creation and fish aggregation	Out	No additional infrastructure will be introduced by the discharge points to the extent that will result in habitat creation. Consequently, this impact is not considered further for CEA.
Temporary increase in SSC	In	Discharge points by their nature which output directly into coastal or estuary waters are considered further in the CEA.
EMF effects	Out	No additional cables being installed at the discharge points. Consequently, this impact is not considered further for CEA.

Effect	Screened	Justification
Thermal emissions	Out	No additional cables being installed at the discharge points. Consequently, this impact is not considered further for CEA.
Underwater noise	Out	There is not considered to be any sound emissions associated with the discharge points and therefore this impact pathway has been screened out for these cumulative projects. Therefore, this impact is not considered further for CEA.
Barrier effects	Out	No additional infrastructure being installed at the discharge points. Consequently, this impact is not considered further for CEA.
Ghost fishing	Out	No additional subsea structures are being introduced at the discharge points that would result in entanglement. Consequently, this impact is not considered further for CEA.
Decommissioning Phase (Section 10.8.4)		
Disturbance or damage to fish and shellfish due to underwater noise generated from construction activities	Out	The Project activities proposed during the decommissioning phase will result in residual effect levels the same as, or less than, those assessed for the construction phase of the Project. Therefore, there are no additional CEA considerations specific to the decommissioning phase. Consequently, decommissioning impacts are not considered further for CEA.
Temporary habitat loss or disturbance	Out	
Temporary increase in SSC	Out	
Accidental release of pollutants	Out	

10.8.2 Cumulative construction effects

10.8.2.1 Increases in SCC and accidental release of pollutants

The presence of discharge points will also result in potential increases to SSC and sediment dispersion. These discharge points are active; therefore, this activity already forms part of the baseline environmental conditions however, it is acknowledged here in the interest of acknowledging that such discharges may change over time. The discharge points at Kilkee and Kilrush discharge directly into coastal waters within 15 km of the Landfall. As noted in Chapter 7: Marine Physical and Coastal Processes, sediment plumes associated with CFE clearance activities (which may occur within the OECC), could extend up to several kilometres from the site of activity but the greatest effects will be highly localised. The discharge points will release mostly treated urban wastewater which will likely contain variable sediments/substances and have the potential to contribute to release of pollutants. It can be assumed that the extent of any sediment plumes and sediment dispersion associated with the discharge points will be on a par with, or less than that associated with construction activities. Consequently, there is no opportunity for these plumes to interact cumulatively.

The Project alone was deemed to have a residual **slight negative effect** for all receptors due to increased SSC, which is Not Significant. With regards to release of pollutants, the Project along was deemed to have a **slight negative effect** on shellfish. For marine finfish, elasmobranchs and diadromous fish, the residual effect of accidental release of pollutants is considered to be an unlikely **not significant negative** effect. This amounts to an impact which is Not Significant across all receptors.

The highly localised scale of any SSC or accidental release of pollutants from the discharge points means there is no potential for cumulative impacts with regards to these impacts, and the impacts remain Not Significant. Therefore, the impact remains as previously assessed.

10.8.3 Cumulative operation effects

As per Table 10-25, there only impact pathway identified for further consideration in the CEA for the operational phase is that of temporary increase in SSC. With regards to other activities in the area, the Kilrush and Kilkee Discharge Points (Table 10-24) may interact cumulative with the Project – therefore are assessed here.

The discharge points at Kilkee and Kilrush release into coastal waters within 15 km of the Landfall. Sediment plumes from Offshore Site operations are expected to be more localised and temporary compared to construction, except during major works where plumes could extend up to several kilometres. The discharge points are 11 km and 14 km from the Offshore Site boundary. Sediment plumes from these points are likely to be similar or less extensive than those from construction of the Offshore Site, settling within 14 hours. Furthermore, these discharge points from are for treated wastewater and therefore should contain low levels of SSC. Overlap of plumes at their widest extent is possible but would result in significantly lower SSCs than at the source, approaching background levels and therefore highly unlikely to result in adverse effects on fish and shellfish receptors. Any impact would be adverse, direct, likely, temporary, localised spatial extent, intermittent and reversible. This overlap would have a minor cumulative effect, only temporarily during major works. Given the low contamination risk of sediment, the cumulative contamination potential is negligible.

The Project alone has a **not significant negative effect** for marine finfish and diadromous fish species groups, and a **slight, negative effect** for herring, shellfish and elasmobranch species (due to their medium sensitivity), both of which are Not Significant. In the interest of taking a conservative approach, cumulative impacts are characterised as (at worst) a **slight negative effect**, which is Not Significant.

10.8.4 Cumulative decommissioning effects

The Project activities proposed during the decommissioning phase will result in residual effect levels the same as, or less than, those assessed for the construction phase of the Project. There are no additional CEA considerations specific to the decommissioning phase. Decommissioning phase activities for the Project alone were assessed to have a **slight negative effect**, which is Not Significant for all fish and shellfish receptors across all impact pathways. Considering the scale and number of other nearby developments which may coincide with the Project either spatially or temporally, there is no potential for cumulative effects. Therefore, this judgement of residual impact will not change.

10.9 Conclusion

In conclusion, the fish and shellfish ecology impact assessment has assessed potential effects resulting from: underwater noise, temporary and long-term habitat loss and disturbance, temporary increases in SSC, accidental release of pollutants, habitat creation and fish aggregation, EMF effects, thermal emissions, barrier effects and ghost fishing during construction, operational maintenance and decommissioning. A number of fish and shellfish species have been considered within the assessment including marine finfish, shellfish, elasmobranchs, and diadromous fish. Mitigation by design has been considered within the assessment including; minimisation of use of external cable protection, the production of a CEMP including measures to reduce the introduction of Invasive Non-Native Species, and the use of environmental survey data to inform cable routeing and the placement of gravity-based foundations on the seabed. The assessment has concluded that the residual effect pathway would be **Not Significant** for all fish and shellfish receptors. This includes the conclusions of the cumulative effects assessment. No additional monitoring is proposed.