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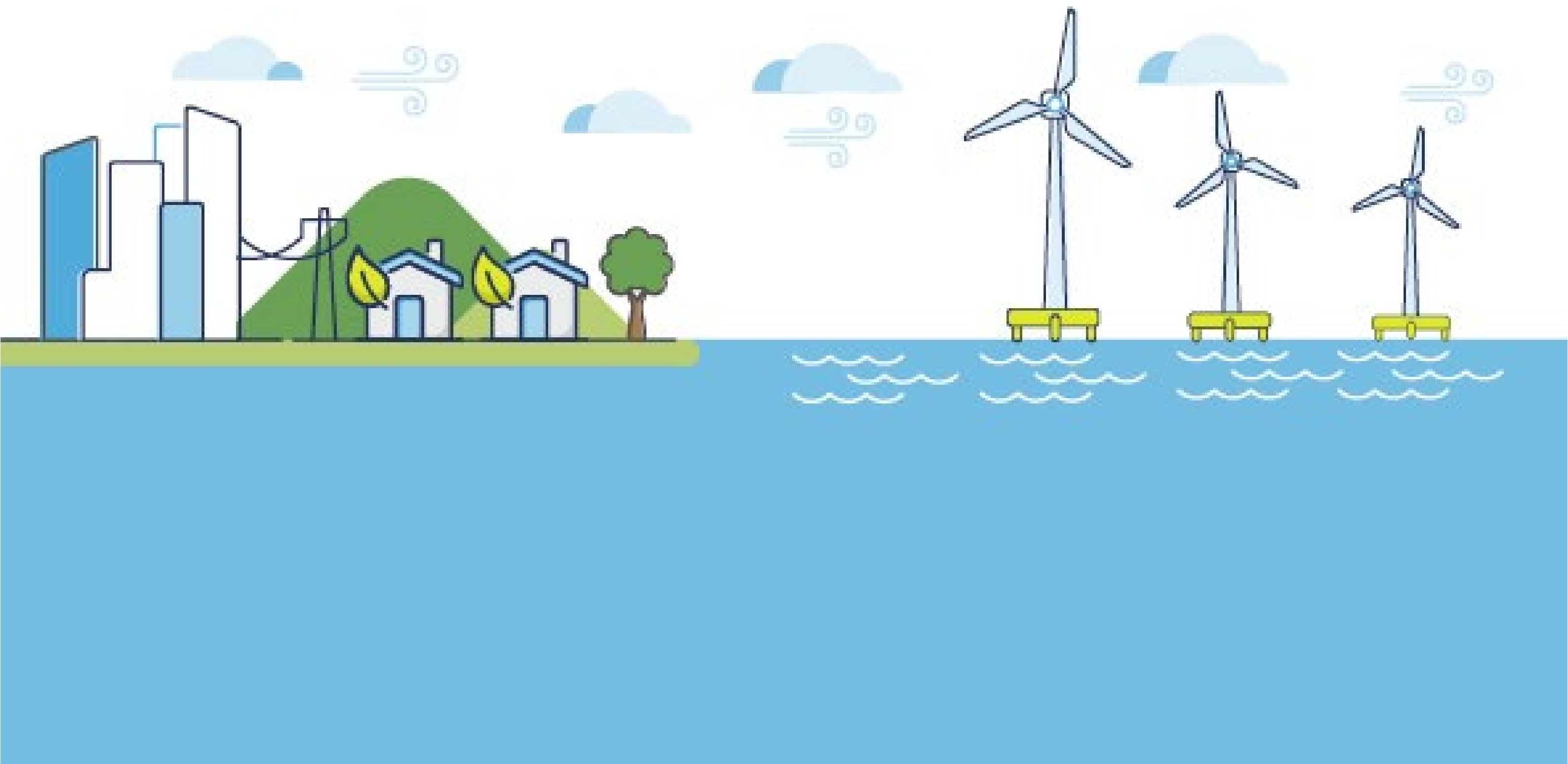
White Cross Offshore Windfarm Environmental Statement

Chapter 11: Fish and Shellfish



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Appendices

Appendix 11.A: Fish and Shellfish Technical Appendix

Glossary of Acronyms

Acronym	Definition
AfL	Agreement for Lease
ALDFG	Abandoned, Lost, or otherwise Discarded Fishing Gear
BAP	Biodiversity Action Plan
BEIS	Department for Business, Energy and Industrial Strategy
CD	Chart Datum
CEA	Cumulative Effect Assessment
Cefas	Centre for the Environment, Fisheries and Aquaculture Science
CHART	Catch and Release Tag
CITES	Convention on International Trade in Endangered Species
CMS	Convention on Migratory Species
DAS	Digital Aerial Survey
DECC	Department for Energy and Climate Change
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMF	Electromagnetic Frequency
ES	Environmental Statement
EU	European Union
EUNIS	European Nature Information System
FIRM	Fisheries and Resources Monitoring System
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Sea
IFCA	Inshore Fisheries and Conservation Authority
IUCN Red List	The International Union for Conservation of Nature's Red List of Threatened Species
MCS	Marine Conservation Society
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
NBN	National Biodiversity Network
NERC	Natural Environment and Rural Communities
NGC	National Grid Company
nm	Nautical Mile
NPS	National Policy Statement
NPPF	National Planning Policy Framework
NPPG	The National Planning Practice Guidance
O&M	Operation and Maintenance

Acronym	Definition
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWL	Offshore Wind Ltd
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PLGR	Pre-Lay Grapnel Run
PSD	Particle Size Distribution
RMS	Root Mean Square
SAC	Special Area of Conservation
SSC	Suspended Sediment Concentration
SSSI	Site of Special Scientific Interest
TTS	Temporary Threshold Shift
VMS	Vessel Monitoring System
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UWN	Underwater Noise
UXO	Unexploded Ordnance
WTG	Wind Turbine Generator
YFS	Young Fish Survey

Glossary of Terminology

Defined Term	Description
Agreement for Lease	An Agreement for Lease (AfL) is a non-binding agreement between a landlord and prospective tenant to grant and/or to accept a lease in the future. The AfL only gives the option to investigate a site for potential development. There is no obligation on the developer to execute a lease if they do not wish to.
Applicant	Offshore Wind Limited
Department for Business, Energy and Industrial Strategy (BEIS)	Government department that is responsible for business, industrial strategy, science and innovation and energy and climate change policy and consent under Section 36 of the Electricity Act.
Project Design Envelope	A description of the range of possible elements that make up the Project design options under consideration. The Project Design Envelope, or 'Rochdale Envelope' is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact parameters are not yet known but a bounded range of parameters are known for each key project aspect.
Development Area	The area comprising the Onshore Development Area and the Offshore Development Area
Environmental Impact Assessment (EIA)	Assessment of the potential impact of the proposed Project on the physical, biological and human environment during construction, operation and decommissioning.
Export Cable Corridor	The area in which the export cables will be laid, either from the Offshore Substation Platform (OSP) or the inter-array cable junction box (if no OSP), to the National Grid Company (NGC) Onshore Substation comprising both the Offshore Export Cable Corridor and Onshore Export Cable Corridor.
Landfall	Where the offshore export cables come ashore (up to MHWS)
Mean high water springs	The average tidal height throughout the year of two successive high waters during those periods of 24 hours when the range of the tide is at its greatest.
Mean low water springs	The average tidal height throughout a year of two successive low waters during those periods of 24 hours when the range of the tide is at its greatest.
Mitigation	Mitigation measures have been proposed where the assessment identifies that an aspect of the development is likely to give rise to significant environmental impacts and discussed with the relevant authorities and stakeholders in order to avoid, prevent or reduce impacts to acceptable levels. For the purposes of the EIA, two types of mitigation are defined:

Defined Term	Description
	• Embedded mitigation: consisting of mitigation measures that are identified and adopted as part of the evolution of the project design, and form part of the project design that is assessed in the EIA. Additional mitigation: consisting of mitigation measures that are identified during the EIA process specifically to reduce or eliminate any predicted significant impacts. Additional mitigation is therefore subsequently adopted by OWL as the EIA process progresses.
Offshore Development Area	The Windfarm Site (including wind turbine generators, substructures, mooring lines, seabed anchors, inter-array cables and Offshore Substation Platform (as applicable)) and Offshore Export Cable Corridor to MHWS at the Landfall. This encompasses the part of the project that is the focus of this application and Environmental Statement and the parts of the project consented under Section 36 of the Electricity Act and the Marine and Coastal Access Act 2009
Offshore Export Cable Corridor	The proposed offshore area in which the export cables will be laid, from Offshore Substation Platform or the inter-array cable junction box to the Landfall
Offshore Infrastructure	All of the offshore infrastructure including wind turbine generators, substructures, mooring lines, seabed anchors, Offshore Substation Platform and all cable types (export and inter-array). This encompasses the infrastructure that is the focus of this application and Environmental Statement and the parts of the project consented under Section 36 of the Electricity Act and the Marine and Coastal Access Act 2009
Offshore Substation Platform	A fixed structure located within the Windfarm Site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore
Project	The Project for the offshore Section 36 and Marine Licence application includes all elements offshore of MHWS. This includes the infrastructure within the windfarm site (e.g. wind turbine generators, substructures, mooring lines, seabed anchors, inter-array cables and Offshore Substation Platform (as applicable)) and all infrastructure associated with the export cable route and landfall (up to MHWS) including the cables and associated cable protection (if required).
White Cross Offshore Windfarm	100MW capacity offshore windfarm including associated onshore and offshore infrastructure
Windfarm Site	The area within which the wind turbines, Offshore Substation Platform and inter-array cables will be present
Works completion date	Date at which construction works are deemed to be complete and the windfarm is handed to the operations team. In reality, this may take place over a period of time.

11. Fish and Shellfish Ecology

11.1 Introduction

1. This chapter of the Environmental Statement (ES) presents the potential impacts of the White Cross Offshore Windfarm Project (the Offshore Project) on Fish and Shellfish Ecology. Specifically, this chapter considers the potential impact of the Project seaward of Mean High-Water Springs (MHWS) during its construction, operation and maintenance, and decommissioning phases.

2. The ES has been finalised with due consideration of pre-application consultation to date (see **Chapter 7: Consultation**) and the ES will accompany the application to the Marine Management Organisation (MMO) on behalf of the Secretary of State for Business for The Department for Business, Energy and Industrial Strategy (BEIS) for Section 36 Consent and relevant Marine Licences under the Marine and Coastal Access Act (MCAA) 2009.

3. This ES chapter:

- Presents the existing environmental baseline established from desk studies, and consultation
- Presents the potential environmental effects on Fish and Shellfish Ecology arising from the Offshore Project, based on the information gathered and the analysis and assessments undertaken
- Identifies any assumptions and limitations encountered in compiling the environmental information
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects identified in the EIA process.

11.2 Policy, Legislation and Guidance

4. **Chapter 3: Policy and Legislative Content** describes the wider policy and legislative context for the Offshore Project. The principal policy and legislation used to inform the assessment of potential impacts on Fish and Shellfish Ecology for the Offshore Project is outlined in this section.

11.2.1 National Policy Statement

The specific assessment requirements for Fish and Shellfish Ecology are set out within the overarching National Policy Statement (NPS) for Energy (EN-1) and NPS for Renewable Energy Infrastructure (EN-3) and summarised in **Table 11.1**. NPSs are statutory documents which set out the government's policy on specific types of Nationally Significant Infrastructure Projects (NSIPs) and are published in accordance with the Planning Act 2008. Although the Offshore Project is not an NSIP, it is recognised that due to its size of 100MW and its location in English waters, certain NPS are considered relevant to the Offshore Project and decision-making and are referred to in this ES.

Table 11.1 Summary of NPS EN-1 and EN-3 provisions relevant to Fish and Shellfish Ecology

Summary	How and where this is considered in the ES
"There is the potential for the construction and decommissioning phases, including activities occurring both above and below the seabed, to interact with seabed sediments and therefore have the potential to impact fish communities, migration routes, spawning activities and nursery areas of particular species. In addition, there are potential noise impacts, which could affect fish during construction and decommissioning and to a lesser extent during operation." **EN-3, Section 2.6.73**	Impacts resulting from construction and decommissioning works associated with both seabed interaction and underwater noise are considered within **Section 11.5** and **11.7**.
"The applicant should identify fish species that are the most likely receptors of impacts with respect to feeding areas; spawning grounds; nursery grounds; overwintering areas for crustaceans and migration routes." **EN-3, Section 2.6.74**	Species of fish and shellfish present within the Offshore Development Area have been identified through a desk-based assessment of data available at the time of writing, and are presented in **Appendix 11.A**.
"Where mitigation measures are applied to offshore export cables to reduce electromagnetic fields (EMF) the effects on sensitive species during operation are unlikely to be a reason for PINS to have to refuse to grant consent. Once installed, operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement. EMF during operation may be mitigated by use of armoured cable for inter-array and export cables which should be buried at a sufficient depth." **EN-3, Section 2.6.75 and Section 2.6.76**	Impacts that may result from EMF effects during the operation of the Offshore Project on fish and shellfish receptors are assessed in **Section 11.6.4**.
"During construction, 24 hour working practices may be employed so that the overall construction programme and the potential for	24-hour working practices will be employed for offshore construction.

Summary	How and where this is considered in the ES
impacts to fish communities are reduced in overall time." **EN-3, Section 2.6.77**	

11.2.2 National Planning Policy Framework

5. The National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, updated July 2021) is the primary source of national planning guidance in England. Sections relevant to this aspect of the ES are summarised below in **Table 11.2**.

Table 11.2 Summary of NPPF Policy relevant to Fish and Shellfish Ecology

Summary	How and where this is considered in the ES
"Noise resulting from a proposed activity or development in the marine area or in coastal and estuarine waters can have adverse effects on biodiversity. Anthropogenic sound has the potential to mask biologically relevant signals; it can lead to a variety of behavioural reactions, affect hearing organs and injure or even kill marine life." **Section 2.6.3.1**	Underwater noise impacts resulting from the Offshore Project have been considered within **Section 11.5.3** and **Section 11.6.3**, and within **Chapter 12 Appendix 12.A: Marine Mammal and Marine Turtle Underwater Noise Modelling Report**.
"Seabed disturbance during marine operations introduces potential risk to fish and shellfish through the suspension of sediments and associated sequestered pollutants." **Section 3.6.6**	Potential impacts relating to suspended sediment have been considered in **Section 11.5.2** and **Section 11.6.2.** The effects of sequestered pollutants are scoped out of assessment, based on findings in **Chapter 9: Marine Water and Sediment Quality**.
"Use of cable protection in areas where cable burial is not possible may impact sites designated as being of national or international nature conservation importance or other sensitive areas such as designated shell fisheries, spawning or nursery grounds for economically important fish species." **Section 3.3.30**	Potential impacts on designated sites are addressed in **Chapter 10: Benthic and Intertidal Ecology**. Potential impacts on spawning and nursery grounds for economically important fish and shellfish species have been assessed throughout **Sections 11.5, 11.6,** and **11.7**.

11.3 Assessment Methodology

11.3.1 Study Area

6. Details of the location of the Offshore Project and the offshore infrastructure are set out within **Chapter 5: Project Description.**

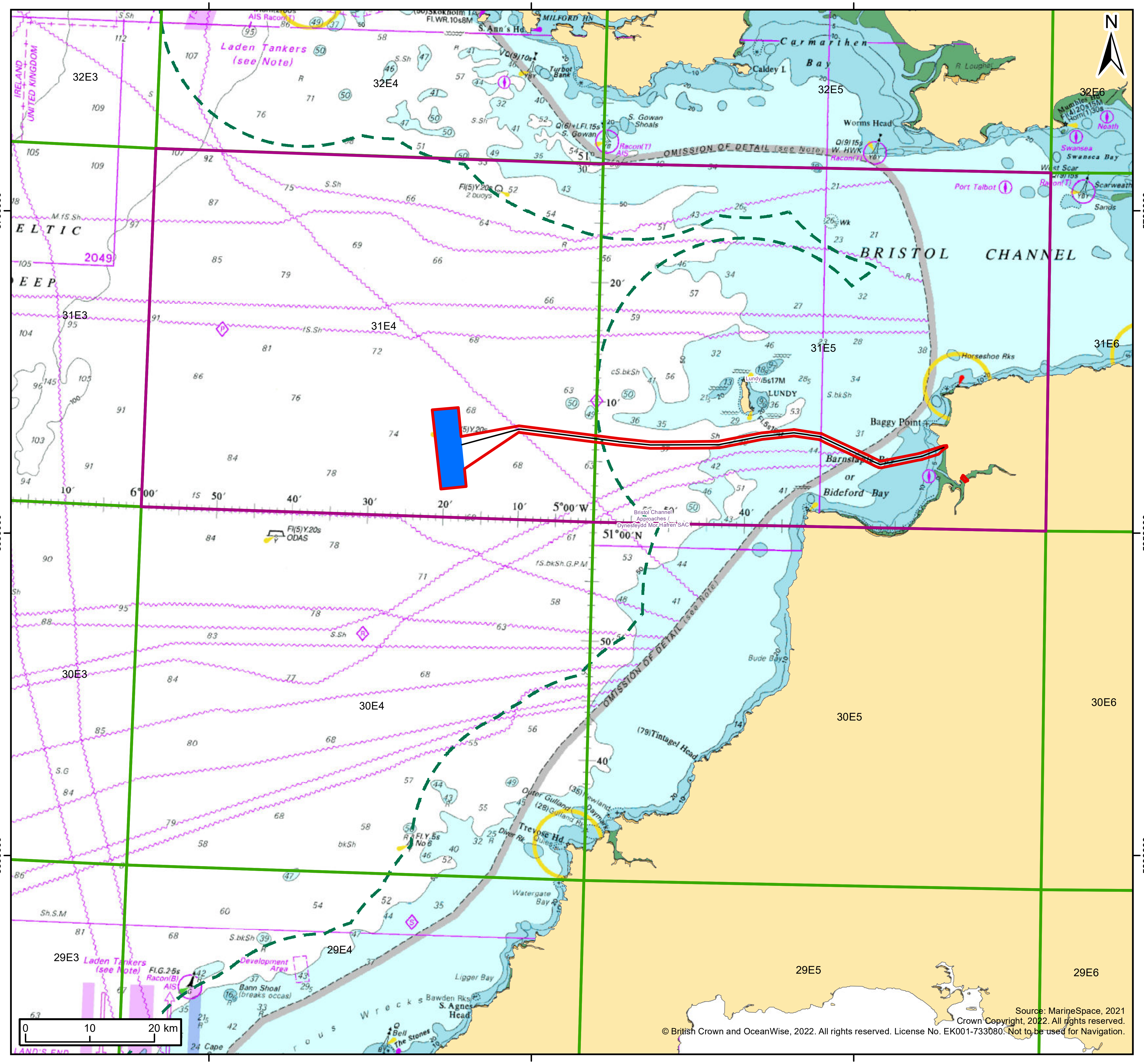
7. The Fish and Shellfish Ecology Study Area has been defined by the distance over which impacts on the fish and shellfish population from all the offshore project

elements (i.e. Offshore Export Cable Corridor, Offshore Substation Platform (OSP) and surrounding waters) may occur, and by the location of any receptors that may be affected by those potential impacts.

8. For the purposes of this report the **Fish and Shellfish Ecology Study Area** has been defined as International Council for the Exploration of the Seas (ICES) Rectangles 31E5 and 31E4 (**Figure 11.1**). This area comprises 7,426km² of marine environment. The Windfarm Site is located within the southeast corner of ICES Rectangle 31E4.

9. For some impacts on fish and shellfish receptors, assessed within this chapter, the effect was determined to be limited to within the area of seabed disturbance resulting from the Offshore Project. Therefore, a **Maximum Footprint Area** was also defined, as the combined areas of the Windfarm Site (49.4km²) and the maximum case scenario for seabed disturbance resulting from the installation of export cables (4.68km²), for a total of 54.08km².

10. The Fish and Shellfish Ecology Study Area has been established using professional judgement and is presented in **Figure 11.1**.



Legend

- Primary Fish and Shellfish Ecology Study Area
- Offshore Export Cable
- Offshore Development Area
- Windfarm Site
- ICES Rectangles
- UK 12nm limit

Client:	Project:
Offshore Wind Ltd.	White Cross Offshore Windfarm

Title: Fish and Shellfish Study Area

Figure: 11.1 Drawing No: PC2978_MSP_ZZ_XX_DR_Z_0310

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: WGS 1984 UTM Zone 30N

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11.3.2 Approach to Assessment

11. The assessment methodology for Fish and Shellfish Ecology is consistent with that presented in in **Chapter 6: EIA Methodology**.

11.3.2.1 Impact assessment criteria

12. The terms used to define sensitivity and magnitude are outlined in **Chapter 6: EIA Methodology**. Specific definitions for the Fish and Shellfish Ecology chapter are provided in **Table 11.3** and **Table 11.4**.

Table 11.3 Definition of terms relating to receptor sensitivity

Term	Definition
High	Very limited tolerance to the considered impact is displayed by a receptor of international or national importance. The receptor is unable to adapt to the impact, and will be unable to undergo a permanent recovery.
Medium	Very limited tolerance to the considered impact is displayed by a receptor of regional importance, where adaptability and/or permanent recovery to the impact is not possible. Limited tolerance to the considered impact is displayed by a receptor of international or national importance, where adaptability and recovery is limited, with return to acceptable status taking 1-5 years.
Low	Limited tolerance to the considered impact is displayed by a receptor of local importance, where adaptability and recovery is very limited, with return to acceptable status taking 5-10 years. Moderate tolerance to the considered impact is displayed by a receptor of regional importance, where adaptability and recovery is limited, with return to acceptable status taking 1-5 years. High tolerance to the considered impact is displayed by a receptor of international or national importance, where adaptability and recovery is rapid, with return to acceptable status taking 0-12 months.
Negligible	High tolerance to the considered impact is displayed by a receptor of local importance, where adaptability and recovery is rapid, with return to acceptable status taking 0-12 months. Total tolerance to the considered impact is displayed by a receptor of international, national or regional importance.

Table 11.4 Definition of terms relating to magnitude of an impact

Term	Definition
High	The impact results in a change beyond that seen through natural background variation. This change is irreversible, lasting for a period of over 10 years, and will occur throughout the lifetime of the project.

Term	Definition
Medium	The impact results in a change obvious within monitoring data, but within the range of natural background variation. This change will be reversible over a period of 5-10 years, and will occur regularly throughout the lifetime of the project.
Low	The impact results in a small but noticeable change within monitoring data, but within the range of natural background variation. This change will be reversible over a period of 1-5 years and will occur occasionally throughout the lifetime of the project.
Negligible	The impact results in an unnoticeable change within monitoring data within the range of natural background variation. This change will be reversible over a period of ≤1 year and will occur infrequently throughout the lifetime of the project.

13. The significance of the effect upon Fish and Shellfish Ecology has been determined by correlating the magnitude of the impact and the sensitivity of the receptor. The method employed for this assessment is presented in **Table 11.5**.

Table 11.5 Significance of an impact - resulting from each combination of receptor sensitivity and the magnitude of the effect upon it

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

14.

11.3.2.2 Approach to underwater noise assessment

15. The approach to underwater noise assessment differs from other impacts. An assessment of underwater noise in the marine environment, resulting from the Offshore Project, can be found in **Appendix 12.A**. Due to differences in impact pathway relevant to underwater noise effects, the receptor groups used for the underwater noise assessment on Fish and Shellfish Ecology differ from those described in Section 11.4.1. These receptor groups are described within Popper *et al*. (2014), and comprise:

- Fish with a swim bladder used in hearing
- Fish with a swim bladder not used in hearing
- Fish with no swim bladder

- Fish eggs and larvae.

16. The above list indicates the physiological features resulting in highest levels of sensitivity to underwater noise first, with sensitivity decreasing down the list, as indicated within Popper *et al*. (2014). Species most sensitive to underwater noise (those with a swim bladder used in hearing) include herring and shad, and will, therefore, be used to determine the worst-case scenario. The above receptor groups, with the exception of fish eggs, demonstrate a level of mobility that will allow for fleeing behaviour, resulting in a reduction of prolonged exposure.

Table 11.6 Indicative values of impacts on fish receptor groups assessed from underwater noise sources (Popper et al., 2014). RMS – Root Mean Square; SELcum – Cumulative Sound Exposure Level; TTS – Temporary Threshold Shift

Underwater Noise Receptor Group	Source of Noise	Mortality and Potential Moral Injury	Impairment	
			Recoverable Injury	TTS
Fish: swim bladder involved in hearing	Continuous noise sources	NA	170 dB RMS for 48 hrs	158 dB RMS for 12 hrs
	Pile driving	207 dB SELcum > 207 dB peak	203 dB SELcum > 207 dB peak	186 dB SELcum
	Explosions	229 – 234dB peak	NA	NA
Fish: swim bladder not involved in hearing	Pile driving	210 dB SELcum > 207 dB peak	203 dB SELcum > 207 dB peak	> 186 dB SELcum
	Explosions	229 – 234dB peak	NA	NA
Fish: no swim bladder	Pile driving	> 219 dB SELcum > 213 dB peak	> 216 dB SELcum > 213 dB peak	>> 186 dB SELcum
	Explosions	229 – 234dB peak	NA	NA
Eggs and larvae	Pile driving	210 dB SELcum > 207 dB peak	Moderate impact nearfield (tens of metres), low impact beyond	Moderate impact nearfield (tens of metres), low impact beyond
	Explosions	> 13 mm s-1 peak velocity	NA	NA

17. Fish with a swim bladder involved in hearing include Atlantic cod, European herring, and European eel. Fish with a swim bladder not involved in hearing include Atlantic salmon, and fish with no swim bladder include the elasmobranchs and pleuronectiformes (Popper *et al*., 2014).

11.3.3 Worst-Case Scenario

18. In accordance with the assessment approach to the Project Design Envelope, or 'Rochdale Envelope', set out in **Chapter 6: EIA Methodology**, the impact assessment for Fish and Shellfish Ecology has been undertaken based on a realistic worst-case scenario of predicted impacts. The Project Design Envelope for the Offshore Project is detailed in **Chapter 5: Project Description**.

19. **Table 11.7** presents the realistic worst-case scenario elements considered for the assessment of fish and shellfish ecology.

Table 11.7 Definition of realistic worst-case scenario details relevant to the assessment of impacts in relation to fish and shellfish ecology

Impact	Realistic worst-case scenario	Rationale
Construction		
Temporary habitat loss/physical disturbance	Installation of 8 Wind Turbine Generators (WTG) using a catenary mooring drag embedment system is 2,984m^2 per turbine totalling 23,872m^2 Installation of inter-array cables: 480,000m^2 Installation of protection material for inter-array cables: 22,400m^2 Area of sand wave excavation for inter-array cables: 12,000m^2 Area of sand wave excavation for export cables: 280,800m^2 Installation of export cables: 2 x export cables totalling 4,680,000m^2 Cable ground lay vessel anchoring: 3,600m^2 Installation of unburied export cable protection: 238,560m^2 Installation of export cable crossing protection: 14,000m^2 Total Offshore Export Cable Corridor area: 4,680,000m^2	Temporary habitat loss/physical disturbance has been assessed in terms of the area of seabed affected, as opposed to the volume of water affected. The volume of temporary habitat loss/physical disturbance within the water column has been assessed in more detail within the following Sections, which refer to potential impacts during construction. Permanent habitat loss is assessed within the operation and maintenance (**Section 11.6**) and refers to the total volume of habitat lost as a result of Offshore Project infrastructure.
Temporary increased suspended sediments and sediment deposition	Maximum displacement volume of sediment predicted to arise from jetting/ploughing, or trenching/cutting for cable installation (including sand wave removal), is 1,684,800m^3	Cable burial for two cables assuming 3m wide, 3m deep excavation for each Jetting/ploughing considered the worst case
Underwater noise and vibration	UXO Charge Weight: 309.4kg Impact piling modelling (Unweighted SEL_{cum}): 219dB Vessel movement (large): 168dB Vessel movement (medium): 161dB	Values as presented within Appendix 13.A: Underwater Noise and Vibration Technical Report

Impact	Realistic worst-case scenario	Rationale
	Backhoe dredging: 165dB Suction dredging: 186dB Cable laying: 171dB Trenching: 172dB Rock placement: 172dB Drag embedment anchors: 171dB Suction pile installation: 192dB	
Barrier Effects	Total maximum volume for floating substructures in operation: 110,000m3 Volume of 8 WTG anchors/moorings turbines using a catenary mooring with scour protection, totalling 90,478m³ Volume of suspended inter-array cables: 147 m³ - Assumes 0.18m outer diameter and 5.8km of cable in water column. Volume of protection material for inter-array cables: 23,040m³ Volume of protection material for unburied export cables: 136,320m³ Volume of protection material for export cable crossings: 14,400m³ Volume of OSP (draft fixed jacket substructure): 15,000m³ Volume of OSP scour protection: 2,513m3 Total: 391,898m2	The worst-case area of seabed predicted to be impacted during the construction phase of the Offshore Project, is limited to the immediate volume of water surrounding physical structures, including the volume of water containing the offshore OSP and floating turbine platform structures.
Operation and Maintenance		
Permanent habitat loss	Area of WTG anchors/moorings: 8 x 12MW turbines using a catenary mooring system totalling 19,392m² Area of protection material for inter-array cables: 22,400m² Area of protection material for unburied export cables: 238,560m² Area of protection material for export cable crossings: 14,000m²	This impact exclusively refers to the area of seabed loss due to the placement of infrastructure (such as buried cable routes, catenary chains on the seabed, and anchors/moorings within the seabed).

Impact	Realistic worst-case scenario	Rationale
	Area of sand wave excavation for inter-array cables: 12,000m² Area of sand wave excavation for export cables: 280,800m² Area of scour protection for inter-array cables: 60,319m² Area of scour protection for substation: 1,257m² Area of scour protection for export cables: 145,040m² Total: 950,384m²	
Temporary increased suspended sediments and sediment deposition	The magnitude of effects of increased suspended sediment concentration and sediment deposition are determined to be less than those that are predicted to arise during the construction and installation phase of the Offshore Project. Maximum displacement volume of sediment predicted to arise during the construction and installation phase of the Offshore Project is 1,684,800m³.	Cable burial for two cables assuming 3m wide, 3m deep excavation for each Jetting/ploughing considered the worst case
Underwater noise and vibration	Noise output from an 18MW turbine is predicted to be 132dB (SPLRMS) at 150m from the largest proposed turbine, for a turbine running 24hr per day. This output increases to 136dB (SPLRMS) at 100m, or 160dB (SPLRMS) at 10m. Cable 'snapping' has been identified at a rate of up to 23 snaps per day, with <10 snaps exceeding 160dB (SPL_{peak}) Total number of cable repairs of lifetime: 10 Total number of remediation events (re-burial): 40 Total area of seabed affected by remediation events: 1,500,000m².	Values as presented within Appendix 13.A: Underwater Noise and Vibration Technical Report
Electromagnetic fields	Radius of inter-array cable: 0.15m Radius of export cable: 0.15m Total length of suspended inter-array cable: 3,200m Total length of export cable: 187,200m	The spatial extent of impact has been determined as the cylindrical volume of water surrounding the cable in which EMF is elevated above baseline conditions. It has been determined that

Impact	Realistic worst-case scenario	Rationale
	Maximum detectable distance of EMF surrounding inter-array cable: 4m Maximum detectable distance of EMF surrounding export cable: 4m Maximum volume of water containing identifiable EMF from inter-array cable: 172,774m³ Maximum volume of water containing identifiable EMF from export cable (laid on the seabed surface): 5,043,384m³ Total volume: 5,216,158m³.	EMF becomes undetectable at 4m from the cable in seawater.
Barrier effects	Total maximum volume for floating substructures in operation: 110,000m3 Volume of 8 WTG anchors/moorings turbines using a catenary mooring with scour protection, totalling 90,478m³ Volume of suspended inter-array cables: 147 m³ - Assumes 0.18m outer diameter and 5.8km of cable in water column. Volume of protection material for inter-array cables: 23,040m³ Volume of protection material for unburied export cables: 136,320m³ Volume of protection material for export cable crossings: 14,400m³ Volume of OSP (draft fixed jacket substructure): 15,000m³ Volume of OSP scour protection: 2,513m3 Total: 391,898m2	The worst-case area of seabed predicted to be impacted during the construction phase of the Offshore Project, is limited to the immediate volume of water surrounding physical structures, including the volume of water containing the offshore OSP and floating turbine platform structures.
Fish aggregation effects	The worst-case scenario for fish aggregation (assumed to occur within the same volume of water as barrier effects) during the operation	Fish aggregation effects will occur in regions of water immediately surrounding introduced barriers.

Impact	Realistic worst-case scenario	Rationale
	and maintenance phase of the Offshore Project is similar to the worst-case scenario for barrier effects during the construction and operation and maintenance phases.	
Ghost fishing	Annual monitoring of anchor/moorings will be undertaken during the lifetime of the Offshore Project. Remotely operated vehicles (ROVs) will be used to identify any entanglement hazards such as ALDFG snagged on Project substructures.	A worst-case scenario for this impact is difficult to determine due to the unknown location and likelihood of lost gear entering the array at any point in time.
Decommissioning		
It is anticipated that the decommissioning impacts would be similar in nature to those of construction, although the magnitude of effect is likely to be lower.		

11.3.4 Summary of Mitigation

11.3.4.1 Embedded Mitigation

20. This section outlines the embedded mitigation relevant to the Fish and Shellfish Ecology assessment, which has been incorporated into the design of the Offshore Project (**Table 11.8**). Where other mitigation measures are proposed, these are detailed in the impact assessment.

Table 11.8 Embedded mitigation measures relevant to the fish and shellfish ecology assessment

Component/Activity	Mitigation embedded into the design of the Offshore Project
Continuous monitoring of Project substructures for the presence of ALDFG and other potential entanglement hazards	Annual monitoring of anchor/moorings will be undertaken during the lifetime of the Offshore Project. Remotely operated vehicles (ROVs) will be used to identify any entanglement hazards such as ALDFG snagged on Project substructures.
Cables and cable burial	The target burial depth is 1.5m where possible (recognised industry good practice and reducing effects of EMF), with a burial depth range of 0.5m – 3m. A detailed Cable Burial Risk Assessment (CBRA) will also be required, to confirm the extent to which cable burial can be achieved. Where it is not possible to achieve cable burial, additional cable protection (rock placement, concrete mattressing or grout bags)

Component/Activity	Mitigation embedded into the design of the Offshore Project
	may be required, and this will also increase the minimum distance between the cable and a migratory fish. Cables will be specified to reduce EMF emissions, as per industry standards and best practice, such as the relevant IEC (International Electrotechnical Commission) specifications.
Construction Noise	A draft Marine Mammal Mitigation Protocol (MMMP) (**Appendix 12.C**) has been developed and will be implemented, which will include proposals for soft start and ramp-up of piling. A soft start and ramp up protocol for pile driving would allow mobile species to move away from the area of highest noise impact. The MMMP details the required mitigation measures to minimise the potential risk of physical and auditory injury (PTS) to marine mammals as a result of underwater noise during UXO clearance and piling. Any mitigation beneficial to marine mammals would also potentially reduce impacts on fish.

21. No additional mitigation measures are recommended that relate to Fish and Shellfish Ecology.

11.3.5 Baseline Data Sources

11.3.5.1 Desktop Study

22. A desk study was undertaken to obtain information on Fish and Shellfish Ecology. Data were acquired for the Fish and Shellfish Ecology Study Area, through a detailed desktop review of existing studies and datasets. Agreement was reached via scoping (Case reference: EIA/2022/00002) with all consultees that the data collected, and the sources used to define the baseline characterisation for Fish and Shellfish Ecology, are fit for the purpose of the EIA.

23. The sources of information presented in **Table 11.9** were used to inform the Fish and Shellfish Ecology assessment.

Table 11.9 Data sources used to inform the Fish and Shellfish Ecology assessment

Source	Summary
EMODnet (2019)	Bathymetric habitat data and EUNIS classifications.
IUCN Red List	Conservation status for global and European populations.
ICES Landing Data (MMO, 2021)	Data for Statistical Rectangles 31E4 and 31E5.
Marine Life Information Network (MarLIN)	Information on the biology of species and ecology of habitats in UK seas and coasts.
Rogan *et al.* (2018)	Seasonality of basking shark observations.
Coull *et al.* (1998) and Ellis *et al.* (2012)	Spawning and Nursery habitats for fish species across UK Seas.
Barne *et al.* (1995) and Barne *et al.* (1996)	Physical and biological data for the coasts and seas of the United Kingdom.
FishBase	Taxonomic and biological data.
Peverley and Stewart, 2021; and Stewart, 2021	Local Atlantic herring spawning information.

11.3.5.2 Site Specific Survey

24. To inform the EIA, site-specific surveys were undertaken, as agreed with the statutory consultees. A summary of surveys is outlined in **Table 11.10**.

Table 11.10 Summary of site-specific survey data

Survey name and year	Summary
Annual Report – Southwest England Ornithological and Marine Mammal Aerial Survey (2022)	APEM Digital Aerial Survey (DAS) results for Offshore Wind Ltd.
Benthic Characterisation Survey, 2022 (Appendix 8.C)	25 stations (22 offshore and 3 nearshore) sampled with a 0.1m2 grab sampler with prior investigation by drop-down camera. Single Particle Size Distribution (PSD) analysis and macrobenthic samples collected from each sampling station.

11.3.6 Data Limitations

25. This baseline has been produced using publicly available data and literature of relevance to the identified receptor groups. Whilst Project-specific data have been considered in the form of sediment and DAS data, bespoke fish and shellfish surveys have not been undertaken within the Fish and Shellfish Ecology Study Area. The baseline presented has been informed using a wide range of data and literature. Whilst it is acknowledged that sources used are only representative of the

assemblage at the time of collection, every effort has been made to ensure that the baseline established is accurate.

11.3.7 Scope

26. Upon consideration of the baseline environment, the project description outlined in **Chapter 5: Project Description**, and Scoping Opinion, several potential impacts upon Fish and Shellfish Ecology have been scoped in or out. These impacts are outlined, together with a justification for why they are or are not considered further, in **Table 11.12**.

Table 11.11Summary of impacts scoped in relating to Fish and Shellfish Ecology

Potential Impact	Justification
Temporary habitat loss/physical disturbance	There is potential for temporary physical disturbance of the seabed during the construction phase activity. Anchor and mooring line installation, cable burial, cable protection installation, and associated seabed clearance may result in impacts to a range of fish and shellfish receptors.
Temporary increased suspended sediments and sediment deposition	There is potential for direct physical disturbance of the seabed habitats during construction related to suspension of sediment during cable and mooring installation work and remediation (including seabed preparation).
Underwater noise and vibration	Underwater noise generated by the construction and operation of the windfarm and its associated infrastructure has the potential to impact local fish and shellfish receptors.
Barrier effects	Barrier effects due to anthropogenic structures in the water column have the potential to occur via a number of potential pathways throughout all stages of the Offshore Project. Anchor and mooring line installation, cable protection installation, OSP installation, floating turbine platform structure installation, and associated seabed clearance may result in impacts to a range of fish and shellfish receptors.
Permanent habitat loss	Permanent habitat loss has the potential to occur during the operational phase of the Offshore Project. Seabed loss resulting from the placement of infrastructure will remove existing habitat from the region.
Electromagnetic fields	EMFs have the potential to disrupt organs used for navigation and foraging within a number of fish

Potential Impact	Justification
	and shellfish species. These will originate from both the inter-array and export cables.
Fish aggregation effects	The introduction of physical substructures associated with offshore windfarms have the potential to cause fish aggregation effects over time, which may impact local populations.
Ghost fishing	Ghost fishing is a well-known cause of mortality in all fish and shellfish receptor groups, and have the potential to occur should fishing gear become trapped on infrastructure.

Table 11.12 Summary of impacts scoped out relating to Fish and Shellfish Ecology

Potential Impact	Justification
Transboundary Impacts	The distribution of fish and shellfish species is independent of national geographical boundaries. This assessment is undertaken taking account of the distribution of fish stocks and populations, irrespective of national jurisdictions. As a result, it is considered that a specific assessment of transboundary effects is unnecessary, as determined within the Scoping Report (Reference Number: EIA/2022/00002).
Re-mobilisation of contaminated sediments	Sediment samples collected in site-specific surveys (**Chapter 8 Appendix 8.A**) indicate little to no evidence of contamination. Therefore, no pathway for this impact is present within the Fish and Shellfish Ecology Study Area, and assessment is not considered necessary.

11.3.8 Consultation

27. Consultation has been a key part of the development of the Offshore Project. Consultation regarding Fish and Shellfish Ecology has been conducted throughout the EIA. An overview of the project consultation process is presented within **Chapter 7: Consultation**. A summary of the key issues raised during consultation, specific to Fish and Shellfish Ecology, is outlined below, together with how these issues have been considered in the production of this ES (**Table 11.13**).

Table 11.13 Consultation responses

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
Cefas	14/03/2022 Formal scoping request under the Marine Works (Environmental Impact Assessment) Regulations 2007 (As Amended) for the construction of White Cross Floating Offshore Windfarm in the Celtic Sea. Reference Number: EIA/2022/00002	I suggest the applicant groups fishes according to their potential auditory sensitivity (Popper et al., 2014) in their underwater noise assessment as well as commercial importance. It is expected that some of the identified fishes, i.e., herring and cod will have higher sensitivity to sound pressure than others given that the swim bladder is also involved in their hearing mechanisms.	Separate receptor groups have been determined for Fish and Shellfish Ecology for the determination of underwater noise and vibration, as presented within **Section 11.3.2**
		The applicant has also noted that the proposed site area is commercially and ecologically important for some crab and lobster species. Currently there are no established noise criteria for crustaceans therefore, I recommend that the applicant draw on, and support their conclusions using the peer-reviewed literature.	The determination of underwater noise and vibration impacts is made within **Section 11.5.3** and **11.6.3**, with consideration given to currently available peer-reviewed literature.
		Both fishes and marine mammals were scoped into the assessment of underwater noise produced by construction. However, for fishes, I do not agree that underwater noise should be scoped out during the operational phase. Very little is known about the noise produced by floating offshore wind turbines during operation and as such the potential effects of noise on fish. The applicant is still considering different foundation types and so the conduction of noise through moorings, anchors and foundations into the water column cannot be ruled out. The proposed operational timeline of the floating windfarm is also up to 25 years, therefore any impact of operational noise would be prolonged.	This has been included, and is assessed within **Section 11.5.3** and **11.6.3**
Cefas		In answer to "To the best of your knowledge is the description of the environment and potential impacts accurate?": Generally, yes, the report provides a high-level fish ecology baseline and correctly identifies that the proposed windfarm array and offshore	Consideration is given to each of these spawning grounds throughout the

Consu ltee	Date, Document, Forum	Comment	Where addressed in the ES
		export cable corridor (ECC) are within or near to spawning grounds for several fish species. I recognise that key fish species acknowledged to inhabit or use the area as spawning/nursery habitat including, but not limited to, cod (*Gadus morhua*), sole (*Solea solea*) mackerel (*Scomber scombrus*), herring (*Clupea harengus*), sprat (*Sprattus sprattus)* and sandeels (*Ammodytes spp*.). It is notable that the footprint of the works overlaps high intensity spawning grounds for sensitive commercial species such as cod, plaice, sole and sandeel.	chapter, as defined within **Section 11.4.1**
		I note that nursery grounds for sole are classified as low intensity within the Scoping Report. However, from a review of Ellis et al. (2012) it is my understanding that this area overlaps with high intensity nursery grounds for sole. Therefore, I recommend the Applicant to review the dataset used to underpin the maps provided before the submission of the Preliminary Environmental Information Report (PEIR) or Environmental Statement (ES).	This is revised within **Section 11.4.1**
		In addition, it is recognised that the Bristol Channel is an important area for elasmobranchs including species such as thornback ray (*Raja clavata*), cuckoo ray (*Leucoraja naevus*), smalleyed ray (*Raja microocellata*) and spotted ray (*Aetobatus narinari*) as well as basking sharks (*Cetorhinus maximus*), some of which are of national significance. Data sources used to inform the assessment including Shark Trust database (Shark Trust 2021) are appropriate.	Consideration to elasmobranch species are made through the chapter as defined within **Section 11.4.1**
		I note that diadromous species present in the region include Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), shads (*Alosa spp*.) and lampreys (*Petromyzontiformes spp*.) with rivers present in the region containing the only spawning populations of twaite shad (*Alosa fallax*) known in the UK.	Consideration to migratory species are made through the chapter as defined within **Section 11.4.1**
		I appreciate the report also recognise the increase occurrence of Atlantic bluefin tuna (Thunnus thynnus) in UK waters. I have recommended additional data sources to inform the baseline assessment for these species in point 23:	Peer reviewed literature has been used to inform bluefin tuna baselines within **Section 11.4.1**

Consu ltee	Date, Document, Forum	Comment	Where addressed in the ES
		23: It is appreciated that most recent ICES report on bluefin tuna (Thunnus thynnus) (ICES, 2021) has been incorporated into the assessment. I recommend additional data sources to inform the baseline for these species including: CEFAS. 2021. Catch and Release Tag (CHART) Scientific Data Collection Programme for Atlantic Bluefin Tuna. Available from: https://www.cefas.co.uk/impact/programmes/chart/; and MMO. 2021. Bluefin Tune in the UK. Available from: https://www.gov.uk/guidance/bluefin-tuna-in-the-uk	
		The following impacts to fish ecology receptors have been scoped in for further assessment: i. Underwater noise (UWN) impacts from pile driving and anchoring activities during construction and noise and vibration generated during the operational wind turbine generators as can be conducted through the tower and foundations into the water. ii. Increased Suspended Sediment Concentrations (SSCs) related to suspension of sediment during cable and mooring installation work (including seabed preparation) and during operation/maintenance activities. iii. Re-mobilisation of contaminated sediments during construction and operation. iv. Temporary habitat loss/Physical disturbance during operation. v. Permanent habitat loss/Physical disturbance due to the presence of permanent structures on the seabed (foundations of the OSP and any cable protection above the seabed). vi. Colonisation of introduced artificial substrate during operation. vii. Electro-Magnetic Fields (EMF) from operational cables. viii. Ghost fishing caused by entangled of lost fishing gear in the mooring system during operation.	Impacts are assessed within **Sections 11.5**, **11.6** and **11.7**

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		I agree the above impacts are all appropriate. However, see some minor comments 28-32 in response to question 5. (These comments are addressed below).	
		I note that appropriate data sources have been used to inform the assessment on fish ecology and fisheries (as per table 2.11 and 2.19, scoping report). For instance: MMO landings data covering the ICES rectangles 31E4, 31E5 and 30E5 from 2009- 2019; Landings statistics by ICES rectangle for the period 2016 to 2020; Vessel Monitoring System (VMS) data, for the period 2015-2019 sourced from ICES (2017 data) and the MMO (2015-2019 data); International Bottom Trawl Survey (IBTS) from 1965-2019; Cefas Young Fish Survey (YFS) from 1981-2019; Distribution of Spawning and Nursery Grounds as defined in Coull et al. (1998) and in Ellis et al. (2012) from 1998-2010. It should be noted that 7.f and 7.g herring are data limited and Celtic Seas herring are monitored by acoustic surveys along the Irish coast (CSHAS) (ICES. 2021. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 3:12.917 pp. https://doi.org/10.17895/ices.pub.8214). Cefas fisheries advisors recommended the use of the latest data series for the IHLS; to date, up to 2020 data are publicly available through the ICES website (https://www.ices.dk/data/dataset-collections/Pages/default.aspx). Please see further recommendations for herring below: Bristol Channel Herring Project involving Devon and Severn IFCA. Available here: https://www.devonandsevernifca.gov.uk/Resource-library/G-Authority-Communications-Publications/News-Items/2019-News-Items/December-2019/Somerset-Fishermen-Undertake-Sampling-for-Bristol-Channel-Herring-Project; Peverley, M. and Stewart, J.E. (2021). Fisheries Research & Management Plan: Atlantic Herring (Clupea harengus) in the North of	The listed data sources have been used to inform the baseline described in **Section 11.4.1**, including the most recently available IHLS data (June 2022).

Consu ltee	Date, Document, Forum	Comment	Where addressed in the ES
		Devon and Severn IFCA's District. Devon and Severn Inshore Fisheries and Conservation Authority & North Devon Biosphere. 57 pp + appendices. Available here: https://www.northdevonbiosphere.org.uk/uploads/1/5/4/4/15448192/herring_frmp_final.pdf; and The Blue Marine Foundation 2020 review including available here: https://www.bluemarinefoundation.com/wpcontent/uploads/2021/01/BLUE_Review_2020.pdf.	
		In answer to: "Do you agree with the conclusions reached?": A high-level description of potential project impacts on fish receptors have been included within the scoping report. However, at this stage, I would not expect conclusions on the significance of impacts to have been reached. Therefore, once the evidence and assessment have been subsequently provided in the Environmental Statement, Cefas fisheries advisors will be able to provide an informed response to this question. As per my comment in point 18 (list of impacts to fish ecology), I agree the potential impacts scoped in for further assessment are all appropriate. However, I have added some recommendations in points 28-32 below to increase the confidence of the assessment of potential impacts on fish and fisheries during PEIR/ES stage.	Scoped in impacts are assessed within **Sections 11.5**, **11.6 and 11.7**
		Habitat loss: Please note that sandeel spawning grounds overlap with the proposed development. I recommend using the latest sediment data available to determine seabed substrate suitability for sandeel habitat within the WCOWF. See methods used by Latto et al., 2013.	The latest available sediment data has been used to determine sandeel spawning grounds using the methods described in Latto *et al.* 2013. See **Section 11.4.1**
		Underwater Noise (UWN): I appreciate that impacts of noise exposure on fish from UWN will be assessed using the criteria described in Popper et al. (2014) and Hawkins & Popper (2014). I recommend the Applicant to carry out a high-level review of studies where	Underwater noise and vibration is assessed in **Section 11.5.3 and 11.6.3,** using impact-

Consu Itee	Date, Document, Forum	Comment	Where addressed in the ES
		measurements of noise levels from pile installation within offshore wind farms have been undertaken. It should be noted that cod are sensitive to noise (group 3 species by Popper et al., 2014) and therefore potentially vulnerable during spawning periods (e.g., eggs and larvae). Sandeel are also potentially sensitive to underwater noise impacts due to their vulnerability and reduced mobility (Popper et al., 2014). I defer to Cefas Noise and Bioacoustics specialist team for further comments on the UWN assessment.	specific receptor groups as described within **Section 11.3.2**
		EMF: I appreciate the current uncertainties regarding the potential impacts of EMF on marine receptors, especially for dynamic cables which are unburied, and that there is the potential for the effects of EMF to negatively impact elasmobranchs and other electrosensitive species. As recognised by the Applicant, key sensitive elasmobranch species inhabit the area (e.g., basking shark, skate and rays). In this regard, it should be noted that, concerning proximity to cables as key factor for exposure, Hutchison et al. (2021) highlighted that the rock mattress used for the current export cables at Wave Hub might be colonised by species offering new habitat opportunities for electro sensitive species (rays and skates) in the area thus increasing the chances for these species to get closer to the cable and therefore exposition (sic) times. Recent research has demonstrated statistically significant changes in behaviour responses in electro sensitive fish species such elasmobranchs as result to exposure to EMF emissions from buried cables, even to very low intensity changes (i.e., nano to micro-Tesla), regardless of the external protection used (Hutchison et al., 2020a; 2020b; 2021). In addition, the same authors highlighted that cables located in the water column also introduce EMFs in the pelagic zone, though little is known about the extent of these impacts.	Electromagnetic field effects are assessed in **Section 11.6.4**

Consu ltee	Date, Document, Forum	Comment	Where addressed in the ES
		Furthermore, I note that due to the Government net zero strategy and the expansion of the marine renewable energy, an increased number of wind farm applications, including floating ones, are expected to emerge in following years. In this regard, is likely that any future developments will seek to use the evidence and monitoring of impacts and effects that were observed/found at demonstration sites. Therefore, following the latest recommendations by Hutchison et al. (2021), we strongly recommend making cables properties and energy transmission data available to enable more realistic modelling as the lack of evidence and poor understanding of effects might cause delays facing future offshore applications.	
		I note that permanent and temporary habitat loss and disturbance during construction have not been scoped in for further assessment. However, at this early stage, due to dependence of some fish species to the seabed (e.g., sandeel display site fidelity to the seabed during spawning events), I recommend that habitat loss and disturbance from the installations of anchors, dragging of mooring lines and seabed contact from the dynamic cables are scoped in for further assessment during all development phases (construction, operation and decommissioning).	Temporary habitat loss has been scoped into construction and decommissioning (**Section 11.5.1**), with permanent habitat loss scoped into operation (**Section 11.6.1**)
		I note that heat effects from the cable upon fish have not been scoped in/out. Please note that recent peer-reviewed literature has shown that thermal radiation from subsea cables does occur and that there can be attraction or effects upon biota, however, the extent and likelihood of this impact on fish receptors is not known and requires further study (Taormina et al., 2018). Therefore, in my opinion, this impact should at least be highlighted as a knowledge gap.	Thermal effects are considered within **Section 11.6.4**
		In response to: "Do you agree with the potential impacts that have been scoped out for each topic? If not, please provide details": I note some inconsistencies between the potential impacts described within section 2.5.2 of the scoping report and the summary table (Table 2.13) in section 2.5.5 (e.g., UWN, habitat loss). I recommend	A summary of impacts assessed within this chapter is provided in **Section 11.12**

Consu ltee	Date, Document, Forum	Comment	Where addressed in the ES
		the Applicant to update the ES report to include potential impacts scoped in and out, taking into account recommendations provided in this advice minute, to avoid misunderstanding and facilitate interpretation.	
		In response to: "Have the relevant potential cumulative effects been identified? If not, please provide details": I note that the cumulative effect assessment will be undertaken as part of the ES review which is appropriate. However, in the context of assessing cumulative effects on fish receptors no specific information on how these were or will be assessed has been provided. Therefore, I am unable to provide further comments at this stage.	Cumulative impacts are assessed within **Section 11.8**
		In response to: "Have the relevant potential transboundary impacts been identified? If not, please provide details": In the context of fish ecology, I am in agreement with the Applicant that the distribution of fish species is independent of national geographical boundaries and consequently I have no objection that a specific assessment of transboundary effects is unnecessary in relation to fish ecology. Transboundary impacts will be assessed in regard to commercial fisheries as part of the construction, operation, decommissioning which is appropriate.	Assessed within **Chapter 14: Commercial Fisheries.**
		In response to "Do you agree with that the proposed approach to assessing each impact is appropriate? If not, please provide details.": Generally, yes. However, see previous comments for further information on data sources to best assess potential impacts on fish receptors.	Impact assessment is undertaken within **Sections 11.5, 11.6** and **11.7**, with consideration for other comments.
		In response to: "Is there any further guidance relating to each topic that we should be aware of? If so, please provide details.": Not at this stage and beyond the ones provided in previous comments.	All guidance provided through consultation comments has been incorporated.
Devon and	18/03/2022 Devon and	For information on fish, the Applicant is broadly relying on large-scale survey programs for data. These large-scale surveys are useful but	Consideration to the recommended sources is

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
Severn IFCA	Severn IFCA Response to MMO Consultation for EIA/2022/0002	typically under-represent phenomena such as fish spawning in inshore areas. For example, there are thought to be herring spawning grounds inshore near to Clovelly, which are not well-represented by International Herring Larval Surveys or the distribution of spawning and nursery grounds as defined in Coull et al. (1998) and Ellis et al. (2012) (to which the Applicants refer). It would be beneficial if the Applicant considered other evidence where available. This may be particularly important for herring, which exist as several distinct spawning populations in the area. This local-scale population structuring likely increases the vulnerability of 'local' populations to exploitation and habitat disturbance. For more information, please see https://www.devonandsevernifca.gov.uk/content/download/7305/52672/version/2/file/DSIFCA_AppealRepresentation_08June2021.pdf	given within **Section 11.4.1**
		Table 2.12 of the EIA Scoping Report highlights sandeel as being of low commercial importance; however, the Applicant should also consider the ecological role of this species and others, beyond the immediate commercial importance. Though there may not be large commercial fisheries for certain species, they still serve important functions including as forage fish for commercially targeted species.	Whilst the commercial importance of the species is discussed, this does not influence determinations made on impacts to sandeel or the wider demersal fish receptor group throughout the chapter.
		The EIA Scoping Report doesn't appear to consider physical disturbance impacts of cable laying and impacts at the landfall (up to MHWS) site, which should be given further consideration – particularly on spawning grounds, sedimentation impacts on (shell)fish and disturbance to sub- and inter-tidal mussel beds. Habitat loss and physical disturbance only included in the operational impacts section; D&S IFCA would suggest that permanent and temporary physical habitat loss during the construction phase should be screened into the EIA, as should cumulative permanent habitat loss. These additional considerations would also inform the Applicant's assessment of	Addressed in **Chapter 10: Benthic and Intertidal Ecology**

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		displacement or disruption of commercially important fish and shellfish grounds.	
		The EIA Scoping Report, the Applicant uses the mobile nature of fish to justify the decision not to undertake site-specific surveys. While this is broadly true, there may be some benefit to conducting site-specific surveys (particularly for shellfish, and finfish spawning grounds) depending on where the landfall (up to MHWS) is situated. D&S IFCA is likely to be able to provide guidance and/or data depending on the choice of landfall (up to MHWS) site; for example, D&S IFCA conducts annual monitoring of mussel stocks in the Taw-Torridge estuary and so will be able to comment on this species in particular if the landfall (up to MHWS) site is placed within that system.	Data sources presented within this chapter, including ICES landings data and spawning grounds data for relevant species allows for a baseline determination to be made without bespoke site-specific surveys as determined during scoping.
Natural England	17/03/2022 EIA/2022/00002 EIA Scoping for White Cross Floating Offshore Windfarm. White Cross Floating Offshore Windfarm, Celtic Sea	Migratory fish are not an interest feature of the Taw Torridge Estuary SSSI however several Annex II species identified in the scoping report (shad, lamprey, trout and Atlantic salmon) migrate through the estuary so impacts wider than Bideford Bay and the Severn Estuary should be considered. Any assessment should acknowledgement the presence of fish, their protection, and provide suitable mitigation to avoid any adverse impacts during construction and operation e.g. avoidance of piling/disruptive construction works when the fish are travelling up river to spawn.	The migratory fish receptor group is considered throughout the chapter, with acknowledgement of the relevant described factors provided for the assessment of each impact.

11.4 Existing Environment

28. This section describes the existing environment in relation to Fish and Shellfish Ecology associated with the White Cross study area. It has been informed by a review of the sources listed in **Table 11.9**.

11.4.1 Current baseline

29. The distribution of fish and shellfish across any particular area is influenced by a combination of biotic and abiotic factors. Abiotic factors are those that characterise the physical environment, and include factors such as bathymetry, salinity, current, wind, and waves. Biotic factors, in contrast, characterise the biological environment, and may include predator-prey dynamics, competition for mates or food resources, or impacts from anthropogenic activities.

11.4.1.1 Physical Environment

30. The Fish and Shellfish Ecology Study Area is located in the southern part of the Outer Bristol Channel, west of the Devon Coast (See **Figure 11.1**). It extends seaward from the mouths of the rivers Taw and Torridge, encompassing Bideford Bay and Lundy Island. This area is an important spawning/nursery habitat for several fish species including Atlantic cod *Gadus morhua*, Dover sole *Solea solea*, mackerel *Scomber scombrus*, Atlantic herring *Clupea harengus*, sprat *Sprattus sprattus*, and sandeels *Ammodytes* spp.

31. The region is exposed to predominantly westerly prevailing winds with an average of 25 days per year with gale-force winds, mostly to the southwest of the Fish and Shellfish Ecology Study Area, occurring in the winter months (Uncles and Stephens, 2007). In this area, large waves are encountered for much of the year, due to the prevailing westerly winds and long fetch across the Atlantic Ocean. The most frequent wave direction in the Fish and Shellfish Ecology Study Area is from the southwest or south-southwest, with a mean height of approximately 1.9-2.0m (ABPmer, 2008). These are amplified close to the coast, due to the steep nearshore bathymetric gradient.

32. The main input of water into the area is from the Atlantic, though a deep-water current flowing northward from the Mediterranean also influences the region (DECC, 2009). The water mass in the region remains thermally stratified (separated) and there is a distinct thermocline that forms during the late spring and summer. The discontinuity layer (zone of mixing) is present between 100-500m depth, with a marked vertical temperature gradient. Mean salinity is typical of oceanic water, at 35‰, but freshens in the northeast, closer to the Bristol Channel. Here, freshwater

output decreases salinity, although the extent to which this occurs changes seasonally with riverine flow rates (Barne *et al.*, 1996).

33. Site-specific physical characteristics are detailed in **Chapter 8: Marine and Coastal Processes**. Depth across the Fish and Shellfish Ecology Study Area ranges from less than 5m below Chart Datum (CD) in the nearshore Landfall Area, to between 69-72m CD across the Windfarm Site.

34. Seabed sediments within the Windfarm Site are primarily sand, though coarse substrate (gravelly sand and sandy gravel) is also common across the Fish and Shellfish Ecology Study Area. Between Lundy Island and the headland at Hartland Point there is also scattered presence of rock and other hard substrate. Approximately 20km from the coast, due to the sheltering effect of Bideford Bay, seabed sediments become finer, with sand and mud more common. Mapping of average annual suspended sediment concentrations (SSC), across the UK shelf seas (1998-2015), determined that SSC at the Windfarm Site is <5 mg/l, while closer to shore SSC increases to <15 mg/l (Cefas, 2016).

35. The export cable makes Landfall between Clovelly (west) and Woolacombe (east), on the west coast of Devon. The coast is varied, characterised by high cliffs of sandstone/shale, and beaches of coarse sand and gravel. At Landfall the coast comprises sandy beach backed by sand dunes. The intertidal, infralittoral, and shallow circalittoral areas within the Fish and Shellfish Ecology Study Area are characterised as being predominantly sand, with pockets of mud and sandy mud or muddy sand (EMODnet, 2019). Annex I bedrock and/or stony reef may also be present along the coastline, where it overlaps with the ECC.

36. The Fish and Shellfish Ecology Study Area is characterised as having a high tidal range. Within the Windfarm Site, the mean range falls between 6-7 m, but increases to 7-8m at the Landfall, and even higher into the Bristol Channel and Severn estuary. Tidal water levels may be increased further during storm surges. Tidal currents are highest during mean spring tides, and across the Windfarm Site are directed approximately east-northeast on a flood tide, and west-southwest on an ebb tide. Peak flows during this period are between 0.6-0.65 m/s at the site, although higher velocities (1.3-1.4 m/s) occur between Lundy Island and Hartland Point (ABPmer, 2008). Near to shore, currents are slower and are shore-parallel.

11.4.1.2 Biological Environment

37. Food availability is a key determinant of fish and shellfish distribution within a defined area. While mobile species are able to forage large distances for food, sessile or slow-moving species are more limited in their mobility and are, therefore,

reliant on food availability within their adjacent surrounding area. Common food sources for filter-feeding shellfish and juvenile fish species may include algae, benthic detritus, and plankton. Species at higher trophic levels are more likely to feed on other fish and shellfish species, while parasitic species (such as lamprey) may rely on hosts significantly larger than themselves.

38. Fish and shellfish are a food source for numerous other species in the region, for example other fish, cetaceans, or marine birds. Fish and, to a lesser extent, crustaceans, comprise most of the diet for the most common marine mammal species in the area, the common dolphin *Delphinus delphis*. Fish species including Atlantic herring, sprat, and sandeel are key food sources for multiple marine ornithology receptors in the area, as detailed in **Chapter 13: Offshore Ornithology**.

39. While **Chapter 10: Benthic and Intertidal Ecology** details the biological habitats present within the region, the intertidal areas around the west Devon coastline include intertidal sediments, coastal saltmarshes and saline reedbeds, cliffs, estuary habitats, intertidal rock, islands, rock pools, and further offshore sponge and anthozoan communities on subtidal rocky habitats, and stony reefs.

40. Both temporal and spatial perspectives are necessary when considering distribution of receptor species within the survey area. For example, time of year is important when considering migratory species. Through a spatial view, spawning, nursery, or feeding grounds may be broadly distributed, or concentrated in defined areas. The temporal and spatial extent of overlap of the proposed development must, therefore, be considered. Further, conservation importance, in addition to commercial value/importance, must be taken into account when assessing impacts.

41. Diadromous fish spend most of their life history in either salt water (anadromous) or fresh water (catadromous) but migrate into the opposite habitat to spawn. These species are present in the northern Celtic Sea and the rivers that lead into this area, including the Taw and Torridge, which empty into the Fish and Shellfish Ecology Study Area.

42. Fish and shellfish populations in the area may be impacted by anthropogenic activities such as fishing, tourism, aquaculture, oil and gas developments, extraction/dredging, or deposition actions.

43. Commercial fisheries are an extractive human activity of commercial importance, further detailed in **Chapter 14: Commercial Fisheries**. Most important species groups (in terms of value landed), in ICES Statistical Rectangles 31E4 and 31E5 are shellfish, which includes brown crab *Cancer pagurus*, spider crab *Maja squinado*,

common whelk *Buccinum undatum*, king scallop *Pecten maximus*, queen scallop *Aequipecten opercularis*, and European lobster *Homarus gammurus*. Elasmobranchs of commercial importance include the blonde ray *Raja brachyura*, and thornback ray *Raja clavata*. Demersal species include Dover sole, lemon sole *Microstomus kitt*, bass *Dicentrarchus labrax*, turbot *Psetta maxima*, Atlantic cod, haddock *Melanogrammus aeglefinus*, pollock *Pollachius pollachius*, and plaice *Pleuronectes platessa*.

44. These species are targeted through a variety of fishing gear, from static methods such as pots or gill nets, to mobile methods such as trawls. Pelagic species, including European pilchard *Sardinia pilchardus*, mackerel *Scomber scombrus*, horse mackerel *Trachurus trachurus*, and herring *Clupea harengus* are also landed, but in smaller quantities and are, therefore, of lesser commercial importance than other species in the area.

11.4.1.3 Fish and Shellfish Species Present within the Study Area

45. Sections 11.5, 11.6, and 11.7 assesses the potential effects of the proposed development on a series of fish and shellfish 'receptor groups'. A 'long-list' of species, with potential presence within the Fish and Shellfish Ecology Study Area, has been included for each of these receptor groups, derived from the sources below. Additionally, species with commercial or conservation importance, and those with spawning or nursery grounds that overlap the Fish and Shellfish Ecology Study Area, have been highlighted in a separate 'short-list', with pertinent details for each species. Spawning areas for fish within the Fish and Shellfish Ecology Study Area, as identified within Coull *et al.*, 1998 and Ellis *et al.*, 2012, are presented in Figure 11.2, Figure 11.3, Figure 11.4, and Figure 11.6. Some receptor groups, that have been determined as having similar/identical sensitivity to impacts included in Sections 11.5, 11.6, and 11.7, have been assessed together.

11.4.1.3.1 Fish and Shellfish Species Present – Commercial Fisheries Landing Data

46. Data compiled by the MMO (MMO, 2022) were reviewed for the most recently available 5 year data period (2016-2020) and were filtered to show only landings within ICES rectangles that encompass the Fish and Shellfish Ecology Study Area (see **Figure 11.1**). The Windfarm Site is located in 31E4; the offshore export cable corridor extends from 31E4 into 31E5 to landfall (up to MHWS).

47. Based on these official landings data, the key shellfish species (determined by commercial interest) are whelk, European lobster, crab species, scallop species, and nephrops. The key finfish of commercial value include blonde rays, sole, thornback rays, pollock, bass, and turbot. For a full assessment of commercial fisheries refer

to **Chapter 14: Commercial Fisheries**, and **Appendix 14.A: Commercial Fisheries Technical Report**.

11.4.1.3.2 Published Literature

48. Sections 5.4-5.5 in Barne *et al*. (1995), and Barne *et al.* (1996), describe exploited and rare shellfish species within the wider region, encompassing the Fish and Shellfish Ecology Study Area.

49. Exploited seabed species consist of European lobster, brown crab, spider crab, crawfish *Palinurus elephas*, Norway lobster *Nephrops norvegicus*, deep water prawn *Pandalus borealis*, pink prawn *Pandalus montagui*, brown shrimp *Crangon crangon*, common cockle *Cerastoderma edule*, blue mussel *Mytilus edulis* (in Bideford Bay), native oyster *Ostrea edulis*, common periwinkle *Littorina littorea*, razor shell *Ensis* spp., king scallop, queen scallop, cuttlefish *Sepia officinalis*, squid *Loligo* spp., and whelk.

50. Rare seabed species such as the sponge crab *Dromia personata*, Cranch's spider crab *Achaeus cranchii*, and several sea slug species (fan slug *Tritonia nilsodhneri,* yellow skirt slug *Okenia elegans*, blue spot slug *Greilada elegans*, and *Trapania pallida* and *Caloria elegans*) were all found at Lundy.

51. Exploited, diadromous, and 'other protected' species of fish within the region are described in Sections 5.7-5.9 of both Barne *et al*. (1995) and Barne *et al.* (1996). While the exploited fish species are listed in sections below, diadromous species include Atlantic salmon *Salmo salar*, sea trout *Salmo trutta* m. *trutta*, European eel *Anguilla anguilla*, and twaite shad *Alosa fallax*.

52. Other migratory fish species that have been recorded in the area are river lamprey/lampern *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus*, European sea sturgeon *Acipenser sturio*, common goby *Pomatoschistus microps*, and sand goby *P. minutus*.

53. The northern Irish Sea was identified as having 3 distinct demersal assemblages, as revealed through extensive beam trawls throughout the region and surrounding waters (Ellis *et al*., 2000).

54. The demersal assemblage that characterises the Fish and Shellfish Ecology Study Area is dominated by flatfish, including common dab *Limanda limanda*, European plaice *Pleuronectes platessa*, Dover sole *Solea solea*, as well as echinoderms such as common starfish *Asterias rubens*. The *Nephrops-Glyptocephalus* assemblage, identified off the Cumbrian coast, may also be present in the waters of the Windfarm Site (Ellis *et al*., 2000). This assemblage is the most dissimilar to others and is

typified by witch *Glyptocephalus cynoglossus* and Norway lobster, but brown crab, red whelk, and sand sea star *Astropecten irregularis* are also common. It should be noted that this dataset is temporally limited, as sampling was limited to September 1998, and survey design targeted juvenile, commercially important flatfish, which likely contributed to the low number of large pelagic or littoral species in surveys (Ellis *et al.*, 2000).

55. Six distinct epibenthic assemblages were identified in the Celtic Sea, using 2m beam trawl catches (Ellis *et al.*, 2013). The Fish and Shellfish Ecology Study Area is characterised as having an 'Inner shelf' assemblage, which is dominated by species including brittle star *Ophiura ophiura*, shrimp *Crangon allmanni*, swimming crab *Liocarcinus holsatus*, yellow hermit crab *Anapagurus laevis*, and common hermit crab *Pagurus bernhardus*. Sampling for this study occurred across years, capturing inter-annual variability, but only in two dedicated months (March for 2000-2002 and November for 2003-2009).

56. Martinez *et al.* (2013) analysed commercial landings data and scientific trawl surveys to assess regional fish assemblages. The Fish and Shellfish Ecology Study Area falls within an area with shallower stations (28-90 m), and is characterised by gadoids (e.g. whiting), small-spotted catsharks, horse mackerel, and a high biomass of flatfish (common dab and European plaice), clupeids (sprat and Atlantic herring), grey gurnard *Eutrigla gurnardus*, and skate species.

11.4.1.3.3 Species and Habitats of Conservation Importance

57. A number of species present within the Fish and Shellfish Ecology Study Area are protected due to their nature conservation status. These species, and the protective measures that apply to them, are detailed in the subsequent paragraphs.

58. Species and habitats listed under Annex II of the EU Habitats Directive, transferred into UK regulations as the Conservation of Habitats and Species Regulations, can be protected through the designation of Special Areas of Conservation (SACs). There are 3 SACs within the Fish and Shellfish Ecology Study Area (Bristol Channel Approaches SAC, Lundy SAC, and Braunton Burrows SAC). However, none of these are designated for fish and shellfish species. Certain migratory fish species are also given protection, and examples of designated Annex II species found in the Fish and Shellfish Ecology Study Area are: river lamprey, sea lamprey, twaite shad, allis shad *Alosa alosa*, and Atlantic salmon. These species are all designated features of SACs in the region.

59. The UK Biodiversity Action Plan (BAP) was the first national biodiversity action plan and described the biology of the UK, as well as detailed plans for its conservation.

It was replaced by the UK Post-2010 Biodiversity Framework in 2012. The UK Post-2010 Biodiversity Framework succeeds the UK BAP, and sets out priority species and habitat for each of the four UK countries. It also provides a framework for conservation within the UK as a whole, and describes how the UK can meet the Aichi Biodiversity Targets.

60. Section 126 of the Marine and Coastal Access Act (MCAA) describes the governance duties of the MMO in relation to Marine Conservation Zones (MCZs) and Marine Licensing. There are six MCZs within the Fish and Shellfish Ecology Study Area; Hartland Point to Tintagel MCZ, North West of Lundy MCZ, Lundy MCZ, Morte Platform MCZ, Bideford to Foreland Point MCZ, and South West Approaches to the Bristol Channel MCZ. These MCZs protect a range of habitats and species, including the spiny lobster *Palinurus elephas*.

61. The Wildlife and Countryside Act 1981 legally prohibits the intentional harm of certain designated species. Species within Schedule 5 of this act, that may be present within the Fish and Shellfish Ecology Study Area, include allis and twaite shad, angel shark *Squatina squatina*, and basking shark *Cetorhinus maximus*.

62. Basking shark are protected by the Wildlife and Countryside Act 1981 to a distance of 12 nautical miles (nm) offshore. This legislation makes it an offence to intentionally or recklessly kill, injure, or take any wild animal included in Schedule 5, damage or destroy any structure or place which a wild animal in Schedule 5 uses for shelter or protection, or disturb any such animal while it is occupying said structure or place. This 12nm protection is matched by the Countryside Rights of Way Act 2000.

63. The International Union for the Conservation of Nature (IUCN) lists basking sharks as Endangered within the Northeast Atlantic ecoregion (Rigby *et al.*, 2021). Although they receive national protection through the Wildlife and Countryside Act 1981 and Countryside Rights of Way Act, the European Habitats Directive does not extend protected status to basking sharks and they are, therefore, not included among the European Protected Species (EPS). As a result, they do not qualify for protection via designation of Special Areas of Conservation (SACs).

64. Although not considered as an EPS, basking sharks are listed in Appendix II and III in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Basking sharks are also listed under Appendix 1 and 2 of the Bonn Convention on Migratory Species (CMS), and Appendix 1 of the United Nations Convention on the Law of the Sea (UNCLOS).

65. Under the OSPAR Convention, certain commercially exploited and ecologically vulnerable species, such as Atlantic cod, sea lamprey, and European eel, (all found in the region) are provided legislative protection. These species are part of a larger list of species/habitats that are threatened, or in decline, within the northeast Atlantic. This list is used by the OSPAR Commission to identify at-risk areas of biodiversity and guide recommendations for conservation and protection.

66. The proceeding sections provide additional details on the following fish and shellfish groups:

- Elasmobranchs
- Demersal fish
- Pelagic fish
- Shellfish
- Migratory fish.

67. A complete list of all fish and shellfish species expected to fall within the Fish and Shellfish Ecology Study Area can be found in **Appendix 11.A: Fish and Shellfish Baseline Report**. This section also includes details on the ecology and conservation status of these species.

11.4.1.3.4 Elasmobranchs – Background

68. The presence of elasmobranch species within the Fish and Shellfish Ecology Study Area has been informed by the sources listed above in Section 11.3.3, and in the published literature summarised within Section 11.4.1 of this report. Data have also been obtained from the ICES Fisheries and Resources Monitoring System (FIRM) elasmobranch factsheet for Area VII (FAO, 2008), and the National Biodiversity Network (NBN) Atlas (2022).

69. The FIRM elasmobranch factsheet for Area VII lists only 2 species (thornback ray and spotted ray *Raja montagui*) as stable/increasing within the Celtic Sea North area (VIIg). Elasmobranch species with recorded presence in the area are also listed in ICES Statistical Rectangles 31E4 and 31E5 (commercial landings), and in the NBN Atlas (2022) (non-commercial species).

70. The common skate *Dipturus batis* was once widely distributed across the northeast Atlantic continental shelf, but has declined severely in UK waters and beyond, to the point that it is now listed as Critically Endangered (Dulvy *et al.*, 2015). There is a single record of the species in the NBN Atlas, however this record is now over 60 years old (NBN Atlas, 2022). The species is demersal, and found in coastal waters between 10-600m depth, on the continental shelf slope or deep offshore seamount

habitats (Last *et al.*, 2016). Despite its rarity, it has been included here in the elasmobranch baseline as a precautionary measure, due to its Critically Endangered status.

71. Angel sharks were also, historically, widely distributed across the northeast Atlantic continental shelf, but have similarly declined in numbers. The angel shark is now listed as Critically Endangered on the IUCN Red List (Morey *et al.*, 2019), and is included on the OSPAR List of Threatened and Declining Species (OSPAR, 2010). In Welsh waters, the species has been in decline since the 1970s (Hiddink *et al.*, 2019), and is now heavily monitored in this region. Between 1980-2020, 1,642 individuals (including 79 juveniles) have been reported in Welsh coastal waters and the Bristol Channel (Barker *et al.*, 2020). There is less evidence of angel shark populations in English waters. However, due to the proximity of the Fish and Shellfish Ecology Study Area to the coastal waters of the Welsh Zone, past records of angel sharks within the region, and their listed status as a Critically Endangered species, this species has been included in the baseline as a precautionary measure.

72. The ICES assessment of basking sharks in the Northeast Atlantic ecoregion lists their presence in areas 1-10, 12 and 14 (ICES, 2019). Their stock assessment advises that no targeted fisheries should be permitted, and bycatch should be minimised. Landings in the last decade have been close to zero, therefore there is no estimation of current stock status or population size. Assessments of magnitude, in terms of population level impacts, will therefore be limited in the impact assessment. There are no accurate global estimates of population size; however, the public sightings scheme initiated by the Marine Conservation Society (MCS) has recorded 24,013 UK sightings between 1987-2008 (Wilding *et al.*, 2020).

73. Based on previous surveys, basking shark densities around the UK are highest around the southwest region of England, particularly the northern coast, including multiple sightings in the Fish and Shellfish Ecology Study Area and around Lundy (Witt *et al.*, 2012; Bloomfield and Solandt, 2008). Their presence follows a season pattern, with densities greatest during the summer months (Witt *et al.*, 2012; Rogan *et al.*, 2018). Lundy Island, within the Fish and Shellfish Ecology Study Area, is considered a regional sighting hotspot (Witt *et al.*, 2012).

74. Telemetry/tagging data and recorded sightings show that basking sharks are wide-ranging across UK waters and those around the Republic of Ireland, with migration routes that pass through the proposed Fish and Shellfish Ecology Study Area (Austin *et al.*, 2019; Doherty *et al.*, 2019). Ecological niche modelling performed by Austin *et al.* (2019) predicted suitable basking shark habitat across the Fish and Shellfish Ecology Study Area, especially at Lundy.

75. During digital aerial surveys (DAS), a single individual basking shark was recorded within the survey area (Windfarm Site plus 4km buffer); in January 2021 (APEM, 2022). The density of basking sharks within the area was, therefore, determined to be 0.02 per km², however this is not in line with expected distribution of these animals within the region, and cannot be considered to be representative of the basking shark population as a whole.

76. Due to the high conservation importance, size, behaviour, and life history of basking sharks, they have been described in detail within Appendix XX: Basking Sharks Technical Report. Key findings from the report have been referenced here where appropriate.

77. **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix** Table 2.1 contains the total list of elasmobranch species with confirmed presence within the Fish and Shellfish Ecology Study Area, described in terms of their ecology.

78. Sediments within the Fish and Shellfish Ecology Fish and Shellfish Ecology Study Area are primarily sand, with gravelly sand and sandy gravel also common. Most species of rays, skates, and angel sharks are benthic, and prefer soft sand or mud (Martin *et al.*, 2012). It is, therefore, expected that ray and skate species may be encountered over sandy areas, compared with harder seabed areas where they are likely to have a lower density.

79. Blue sharks are present within ICES Statistical Rectangles 31E4 and 31E5, though the sum of their landed weight between 2016-2020 was relatively low (0.13 tonnes), compared with other species. There were no sightings reported within DAS data for the Windfarm Site or buffer zone, however they are recorded within the greater Celtic Sea area, primarily in pelagic waters. They are listed as a priority species under the UK Post-2010 Biodiversity Framework.

11.4.1.3.5 Elasmobranchs – Commercial Importance

80. Multiple elasmobranch species of commercial importance were recorded within ICES Statistical Rectangles 31E4 and 31E5 between 2016-2020. A full species list is included within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**. These include (in order of highest landed value):

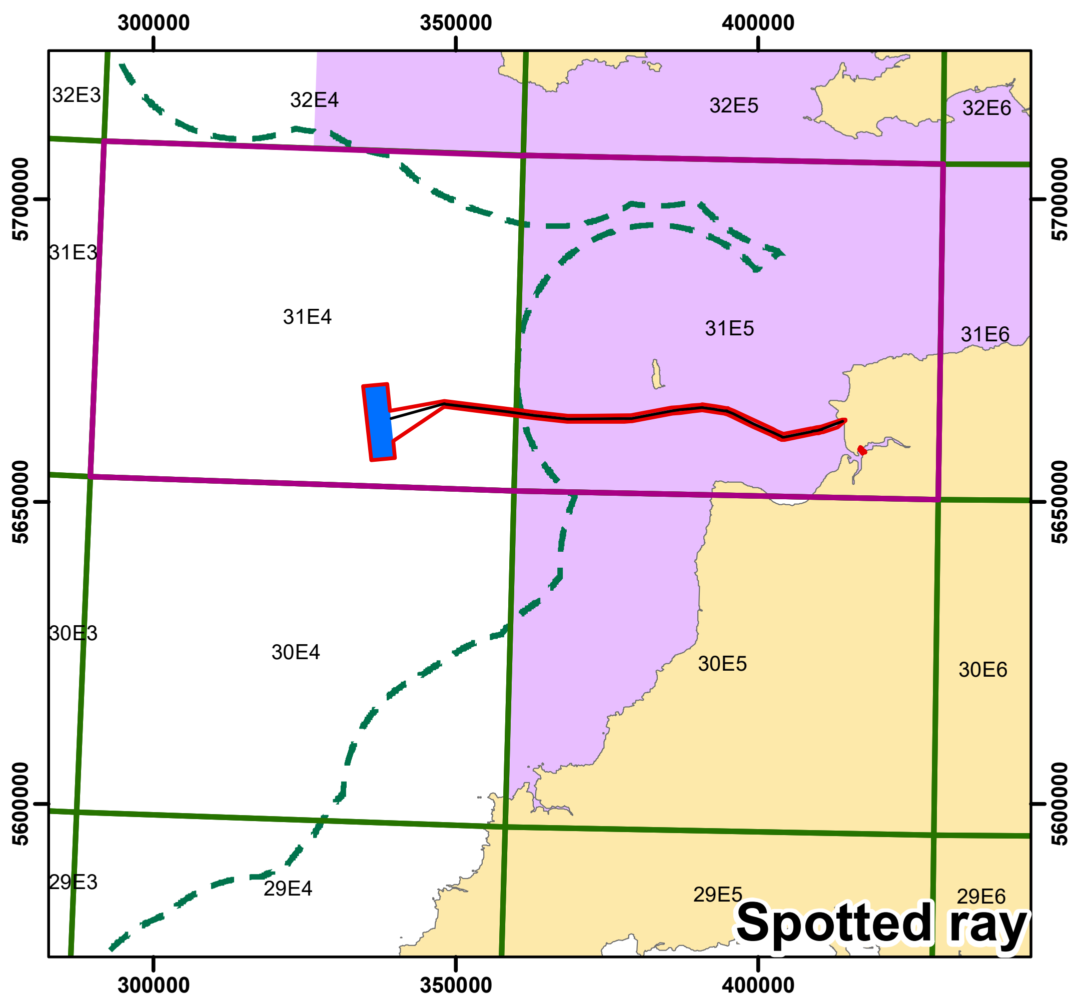
- blonde ray *Raja brachyura*
- thornback ray *Raja clavata*
- small-eyed ray *Raja microocellata*
- lesser spotted dogfish *Scyliorhinus canicula*
- smoothhound *Mustelus mustelus*
- spotted ray *Raja montagui*

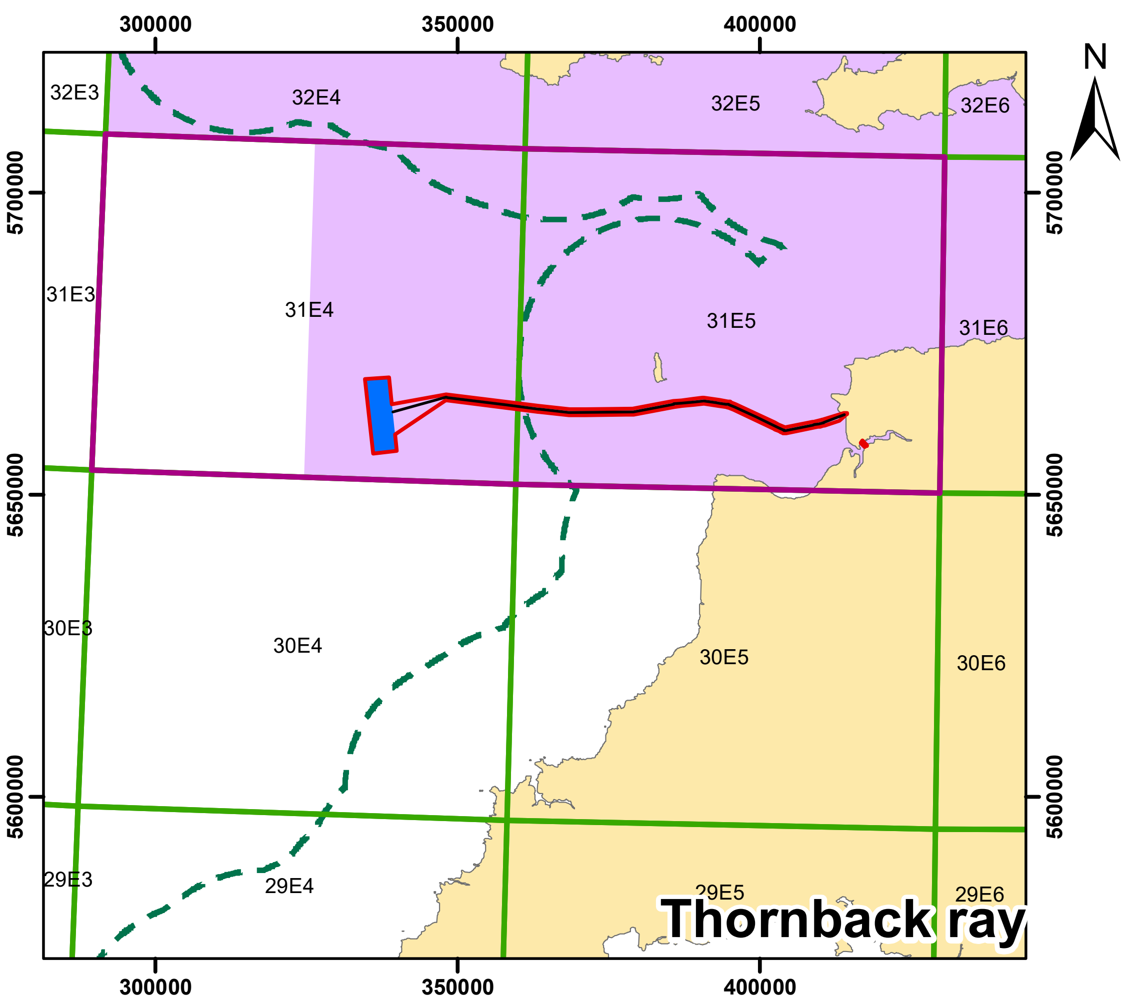
- spurdog *Squalus acanthias*
- nursehound *Scyliorhinus stellaris*
- cuckoo ray *Leucoraja naevus*
- shagreen ray *Leucoraja fullonica*
- blue shark *Prionace glauca*
- tope *Galeorhinus galeus*
- starry smooth hound *Mustelus asterias.*

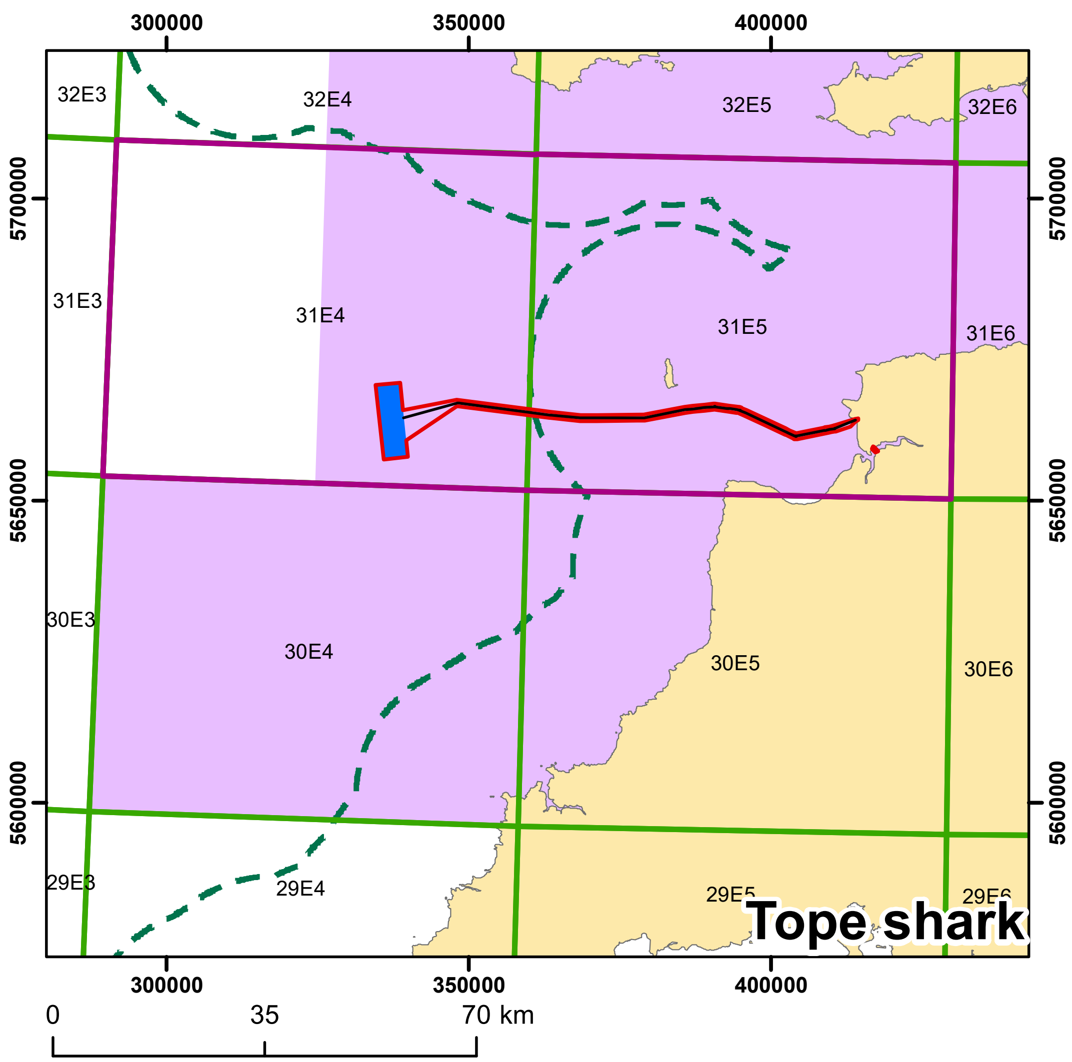
81. Blue shark and basking shark may also be considered to have commercial importance, due to the presence of tourism within the area, that caters to the sighting of these species

11.4.1.3.6 Elasmobranchs – Spawning and Nursery Grounds

82. There are no data available on spawning grounds for elasmobranch species within the Fish and Shellfish Ecology Study Area, however several species have recorded nursery grounds within the area (**Figure 11.2**). Thornback ray and tope have low intensity nursery grounds across the whole of the proposed development area (Ellis *et al.*, 2012). Spotted ray have recorded nursery grounds within the eastern two-thirds of the Fish and Shellfish Ecology Study Area (Ellis *et al.*, 2012), with a previous study also documenting nursery grounds in coastal waters within, and surrounding, Bideford Bay (Coull *et al.*, 1998).







Legend

- Primary Fish and Shellfish Ecology Study Area
- Offshore Export Cable
- Offshore Development Area
- Windfarm Site
- ICES Rectangles
- UK 12nm limit

Nursery grounds (Ellis et al, 2012)

- High Intensity
- Low Intensity

Client:	Project:
Offshore Wind Ltd.	White Cross Offshore Windfarm

Title:

White Cross OWF Elasmobranch Spawning and Nursery Areas

Figure: 11.2	Drawing No: PC2978_MSP_ZZ_XX_DR_Z_0315

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	18/08/2022	NB	xx	A3	

Co-ordinate system: WGS 1984 UTM Zone 30N

WHITE CROSS

Royal HaskoningDHV Enhancing Society Together

MarineSpace an ERM Group Company

Source: Ellis et al., 2010, Coull et al., 2019, ICES

11.4.1.3.7 Elasmobranchs – Conservation Importance

83. Almost all of the identified elasmobranch species identified within the Fish and Shellfish Ecology Study Area, either through ICES Statistical Rectangles or DAS, are of nature conservation importance. Only the starry smoothhound, cuckoo ray, and lesser spotted dogfish are listed as Least Concern on the IUCN Red List, and not protected under any UK regulatory frameworks. Angel shark, basking shark, common skate, sandy ray, and white skate are all listed as either Endangered or Critically Endangered, both globally and in Europe. The nature conservation status of each species of elasmobranch identified is presented within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**.

11.4.1.3.8 Demersal Fish – Background

84. Demersal fish comprise species with a degree of benthic association, living and/or feeding primarily on, or around, the seabed. A large number of demersal fish species have been identified as having a presence within the Fish and Shellfish Ecology Study Area. The species identified are presented within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**, alongside summary information regarding their biology and nature conservation status.

11.4.1.3.9 Demersal Fish – Commercial Importance

85. A number of species of commercial importance were identified as being present within the Fish and Shellfish Ecology Study Area between 2016 and 2020. Species are listed in full within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix** , and include, but are not limited to:

- Atlantic cod
- European bass *Dicentrarchus labrax*
- blue whiting *Micromesistius poutassou*
- European hake *Merluccius merluccius*
- gilthead seabream *Sparus aurata*
- haddock *Melanogrammus aeglefinus*
- megrim *Lepidorhombus whiffiagonis*
- European plaice *Pleuronectes platessa*
- European pollock *Pollachius pollachius*
- sand sole *Pegusa lascaris*
- turbot *Scophthalmus maximus*
- witch flounder *Glyptocephalus cynoglossus*
- wrasse *Labrus* spp..

86. Although not identified within ICES landings data, sandeel species (*Ammodytes* spp.) may also have the potential for presence within the Fish and Shellfish Ecology

Study Area. Whilst this species is of commercial importance within certain regions of the UK, landings data from the Fish and Shellfish Study Ecology Area indicates that they are not of commercial importance within the Offshore Development Area.

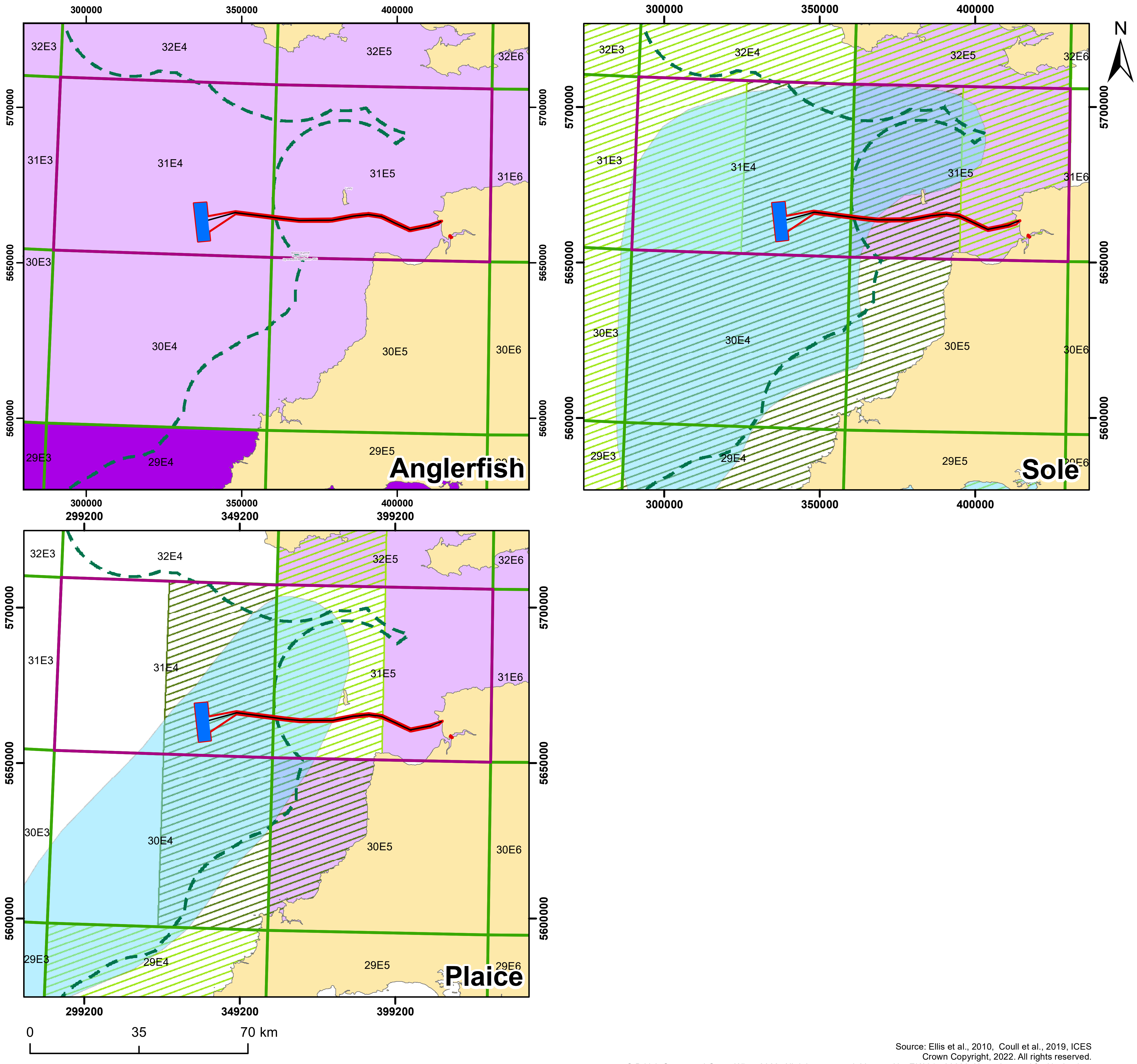
11.4.1.3.10 Demersal Fish – Spawning and Nursery Grounds

87. Spawning and nursery grounds for a number of demersal species are present within the Fish and Shellfish Ecology Study Area. Anglerfish *Lophius piscatorius*, Atlantic cod, European plaice, sandeel, sole and whiting were all identified within Ellis *et al*. (2012) and/or Coull *et al*. (1998) as having spawning or nursery grounds within the Fish and Shellfish Ecology Study Area (**Figure 11.3** and **Figure 11.4**). Each of these species had spawning areas and/or nursery grounds that directly overlapped the Windfarm Site and/or export cable corridor.

88. Sandeel species are known to be highly sensitive to seabed disturbance. Modelling of the Fish and Shellfish Ecology Study Area has been undertaken, using the approaches outlined in Latto *et al.* (2013), with results presented within **Figure 11.5**. Sandeel habitat identified within this model considers all life stages of sandeel species. Results suggest that whilst the Fish and Shellfish Ecology Study Area contains regions of high potential sandeel habitat, the Maximum Footprint Area (the area determined to undergo direct benthic disturbance) comprises of mainly medium and low potential sandeel habitat, with a small number of discrete high potential areas along the Offshore Export Cable Corridor (**Table 11.14**).These species are largely found in association with sandy seabed habitats comprising primarily of medium to coarse grain sizes, with increasing components of either finer or coarser sediments reducing the likelihood of sandeel suitability (Holland *et al*., 2005).

Table 11.14 Percentage of sandeel potential habitat area across the total Fish and Shellfish Ecology Study Area (ICES Rectangles 31E4 and 31E5) located within the Maximum Footprint Area of the Offshore Project

Sandeel potential habitat	Total area across Study Area (km²)	Area within maximum footprint area (km²)	Percentage of potential habitat across the Study Area within maximum footprint area
Low	2,772.82	1.10	0.04%
Medium	5,210.39	53.14	1.02%
High	1,817.60	0.42	0.02%



Legend

- Primary Fish and Shellfish Ecology Study Area
- Windfarm Site
- Offshore Export Cable
- Offshore Development Area
- ICES Rectangles
- UK 12nm limit
- Spawning grounds (Coull et al, 1998)

Spawning grounds (Ellis et al, 2012)

- High Intensity
- Low Intensity

Nursing grounds (Ellis et al, 2012)

- High Intensity
- Low Intensity

Client:	Project:
Offshore Wind Ltd.	White Cross Offshore Windfarm

Title:

White Cross OWF Demersal Spawning and Nursery Areas 1/2

Figure:	11.3	Drawing No:	PC2978-MSP-ZZ-XX-DR-Z-0313

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	18/08/2022	NB	xx	A3	1:1,250,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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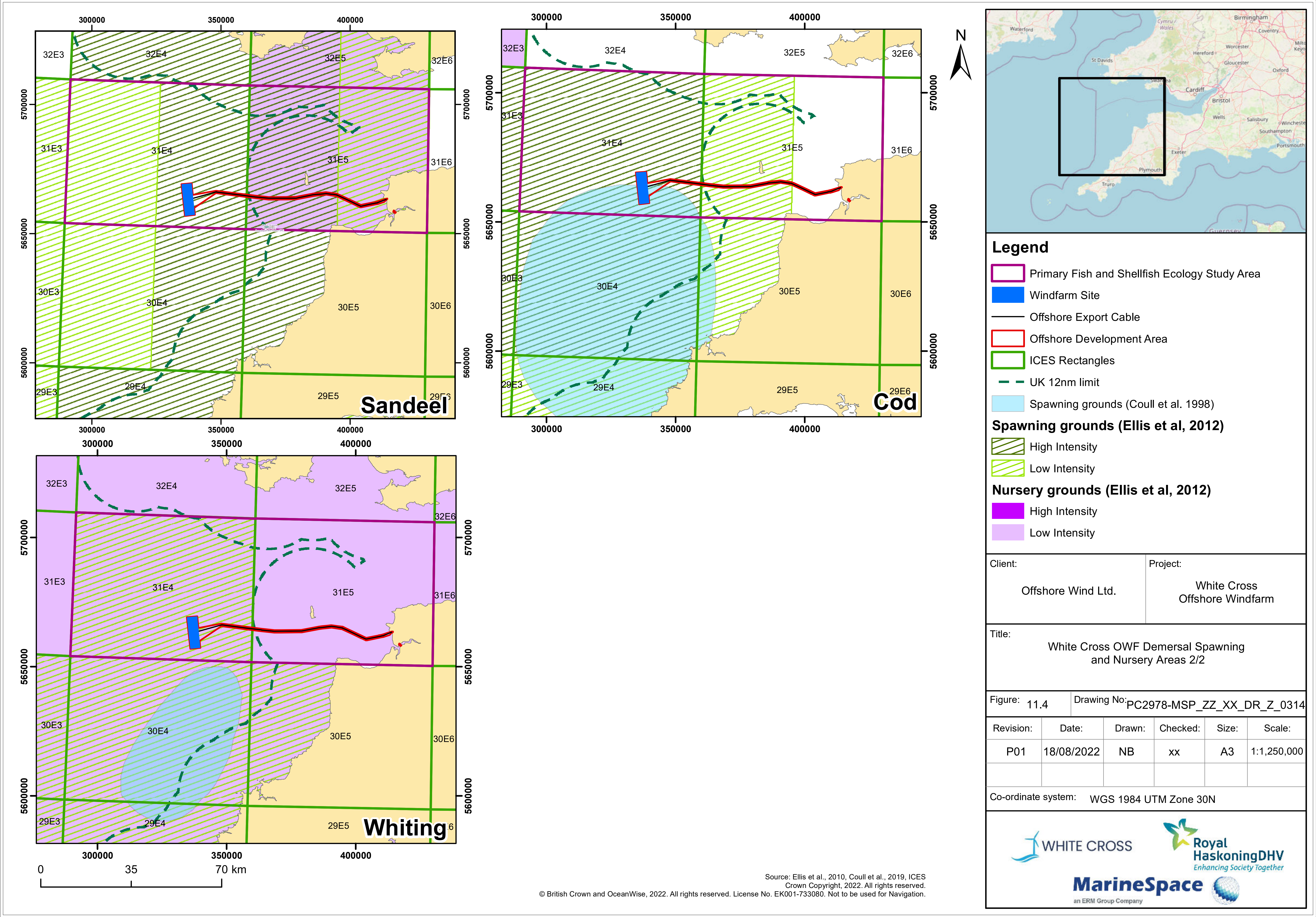
Source: Ellis et al., 2010, Coull et al., 2019, ICES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Legend
Primary Fish and Shellfish Ecology Study Area
Windfarm Site
Offshore Export Cable
Offshore Development Area
ICES Rectangles
UK 12nm limit
Spawning grounds (Coull et al. 1998)
Spawning grounds (Ellis et al, 2012)
High Intensity
Low Intensity
Nursery grounds (Ellis et al, 2012)
High Intensity
Low Intensity
Client:
Offshore Wind Ltd.
Project:
White Cross Offshore Windfarm
Title:
White Cross OWF Demersal Spawning and Nursery Areas 2/2
Figure: 11.4
Drawing No: PC2978-MSP_ZZ_XX_DR_Z_0314
Revision: P01
Date: 18/08/2022
Drawn: NB
Checked: xx
Size: A3
Scale: 1:1,250,000
Co-ordinate system: WGS 1984 UTM Zone 30N
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Source: Ellis et al., 2010, Coull et al., 2019, ICES
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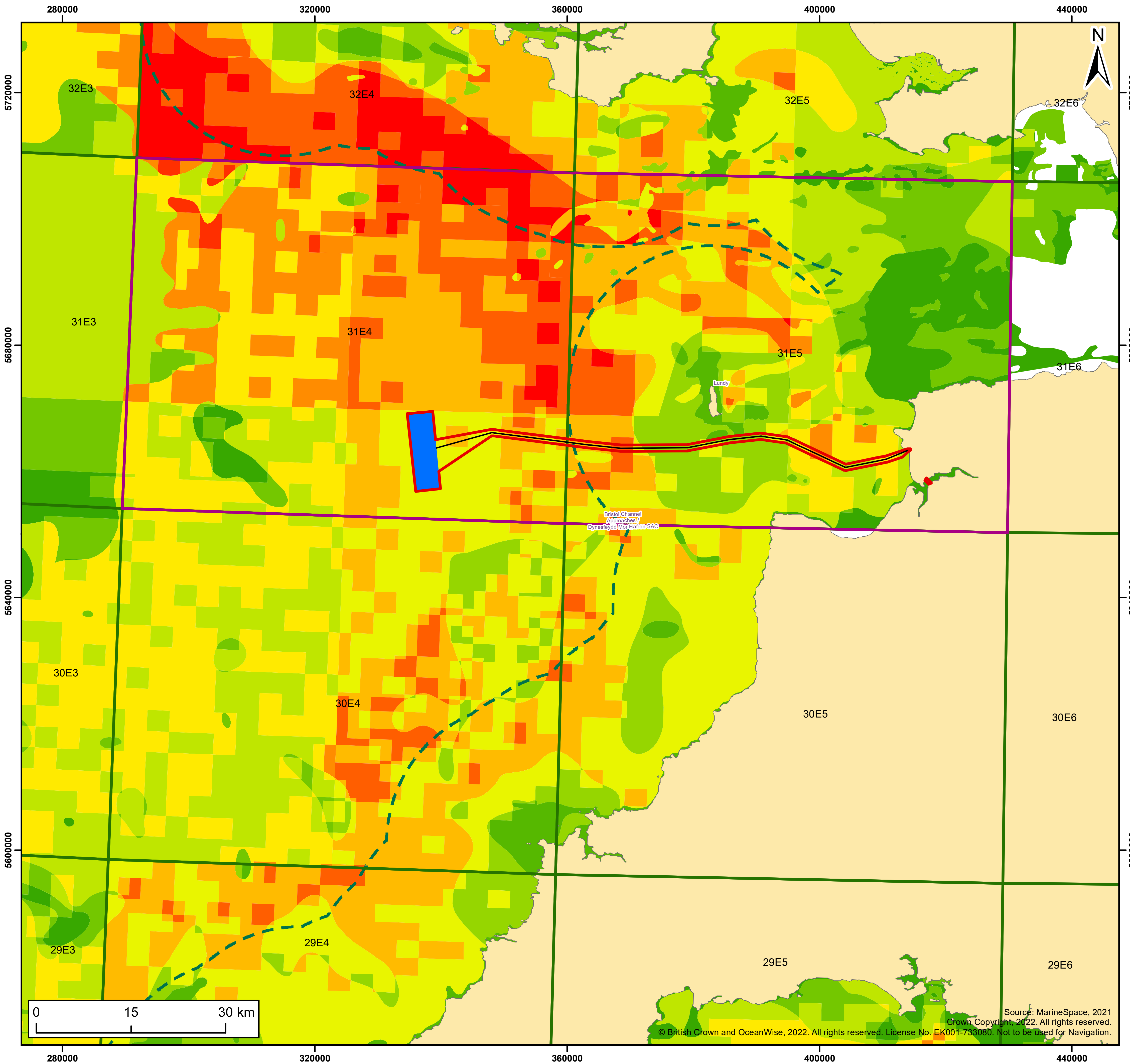

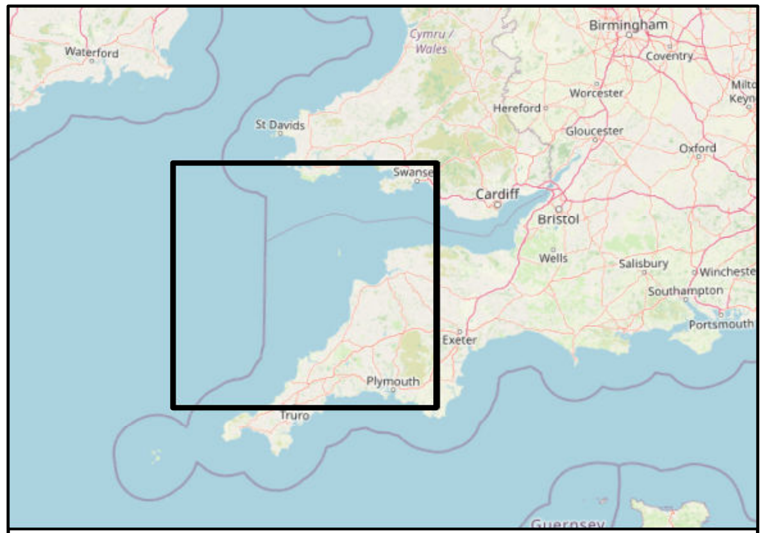

Legend

- Primary Fish and Shellfish Ecology Study Area
- Offshore Export Cable
- Offshore Development Area
- Windfarm Site
- ICES Rectangles
- UK 12nm limit

Sandeel spawning potential

- 2 (Low)
- 3 (Low)
- 4 (Low)
- 5 (Low)
- 6 (Medium)
- 7 (Medium)
- 8 (Medium)
- 9 (Medium)
- 10 (High)
- 11 (High)
- 12 (High)
- 13 (High)

Client:	Project:
Offshore Wind Ltd.	White Cross Offshore Windfarm

Title:
Areas with Potential to Support Spawning of Sandeel Populations

Figure: 11.5 | Drawing No: PC2978-MSP_ZZ_XX_DR_Z_0311

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	18/08/2022	NB	IW	A3	1:600,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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11.4.1.3.11 Demersal Fish – Conservation Importance

89. The nature conservation status of demersal fish identified within the Fish and Shellfish Ecology Study Area is presented within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**, Table 3.2. Species listed include:

- Anglerfish
- Atlantic cod
- European hake
- gilthead seabream
- megrim
- pollock
- sand sole
- witch flounder
- blue whiting.

11.4.1.3.12 Pelagic Fish – Background

90. Pelagic fish comprise species with limited association with the seabed or coastline, instead spending the majority of their life history within areas of open water. Six pelagic fish species have been identified as having a presence within the Fish and Shellfish Ecology Study Area:

- Atlantic herring *Clupea harengus*
- Atlantic horse mackerel *Trachurus trachurus*
- Atlantic mackerel Scomber scombrus
- European sprat *Sprattus sprattus*
- Atlantic bonito *Sarda sarda*
- European pilchard *Sardina pilchardus*.

91. The species identified are presented in further detail within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**, alongside summary information regarding their biology and nature conservation status.

92. In addition to these species, recent evidence suggests an increasing presence of Atlantic bluefin tuna *Thunnus thynnus* within the Celtic Sea. However, observations of the species within the Fish and Shellfish Ecology Study Area are infrequent, with the majority of sightings occurring on the south coasts of Cornwall and Ireland (Thomas *et al.*, 2021). Although sightings of this species have been recorded, there are no known spawning sites within the Fish and Shellfish Ecology Study Area.

11.4.1.3.13 Pelagic Fish – Commercial Importance

93. Of the 6 pelagic species recorded in the region, only Atlantic mackerel have been recorded within ICES catch data across all years from 2016-2020. Herring catches have been recorded across all years, with the exception of 2020. Horse mackerel and European pilchard were recorded in 3 of the 5 years. Within the ICES data European sprat were only recorded in 2018, and a single Atlantic bonito was recorded in 2020.

11.4.1.3.14 Pelagic Fish – Spawning and Nursery Grounds

94. Low intensity spawning and nursery grounds for Atlantic mackerel are present within the Fish and Shellfish Ecology Study Area and Maximum Footprint Area. Although Atlantic mackerel spawning and nursery areas are present within the Fish and Shellfish Ecology Study Area, this species is a mid-water spawner (**Figure 11.6**). This spawning strategy is displayed by the majority of pelagic species, generally resulting in an increased tolerance to impacts associated with benthic disturbance and habitat loss. Atlantic herring are an exception to this, instead laying eggs directly on the sediment surface.

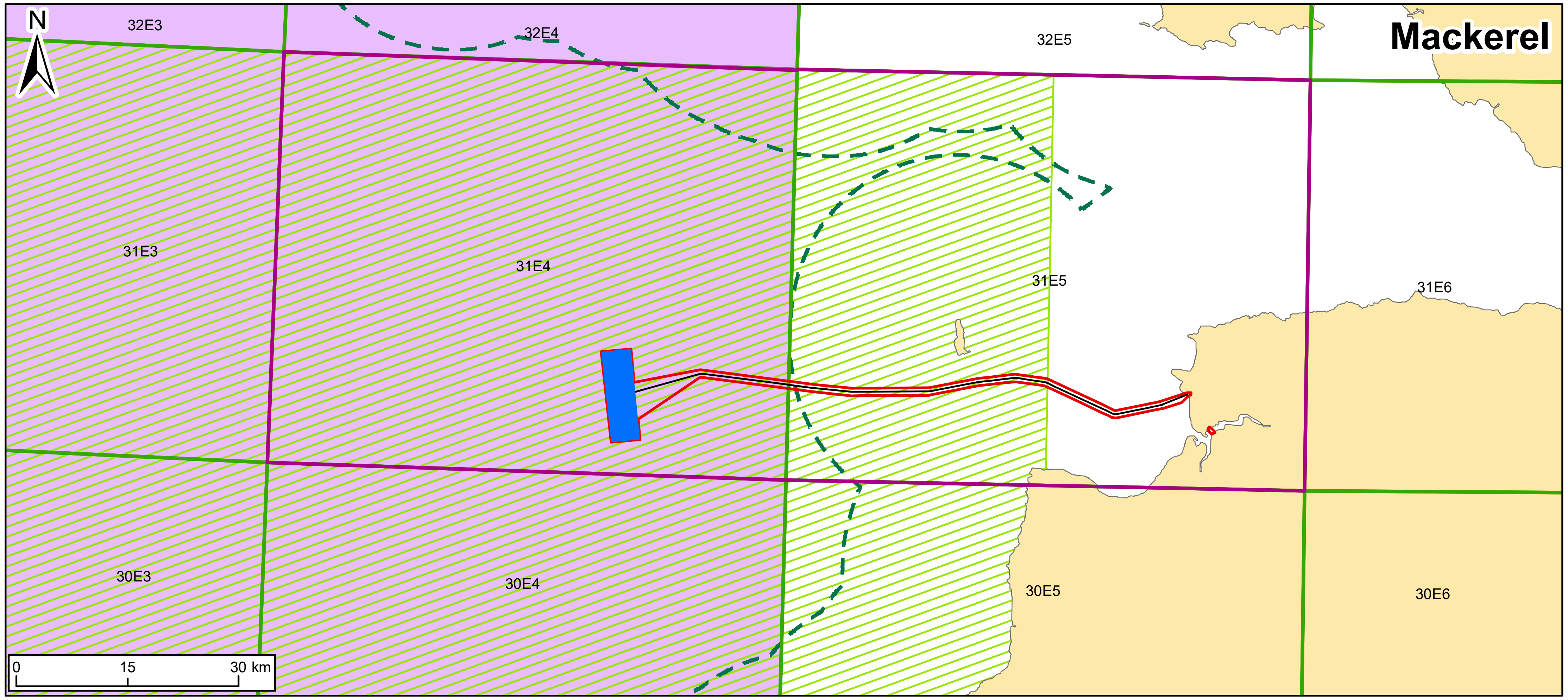
95. Atlantic herring display a strong preference for laying eggs on seabed comprising coarse gravel to stone (5-150 mm) (ICES, 2013). Herring eggs are highly sensitive to disturbance of the seabed on which they are laid. Modelling of the Fish and Shellfish Ecology Study Area has been undertaken, using approaches outlined in Reach *et al.* (2013), with results presented within **Figure 11.7**. Modelling results suggest that the majority of the Fish and Shellfish Ecology Study Area is considered to be of low spawning potential for the species (**Table 11.15**).

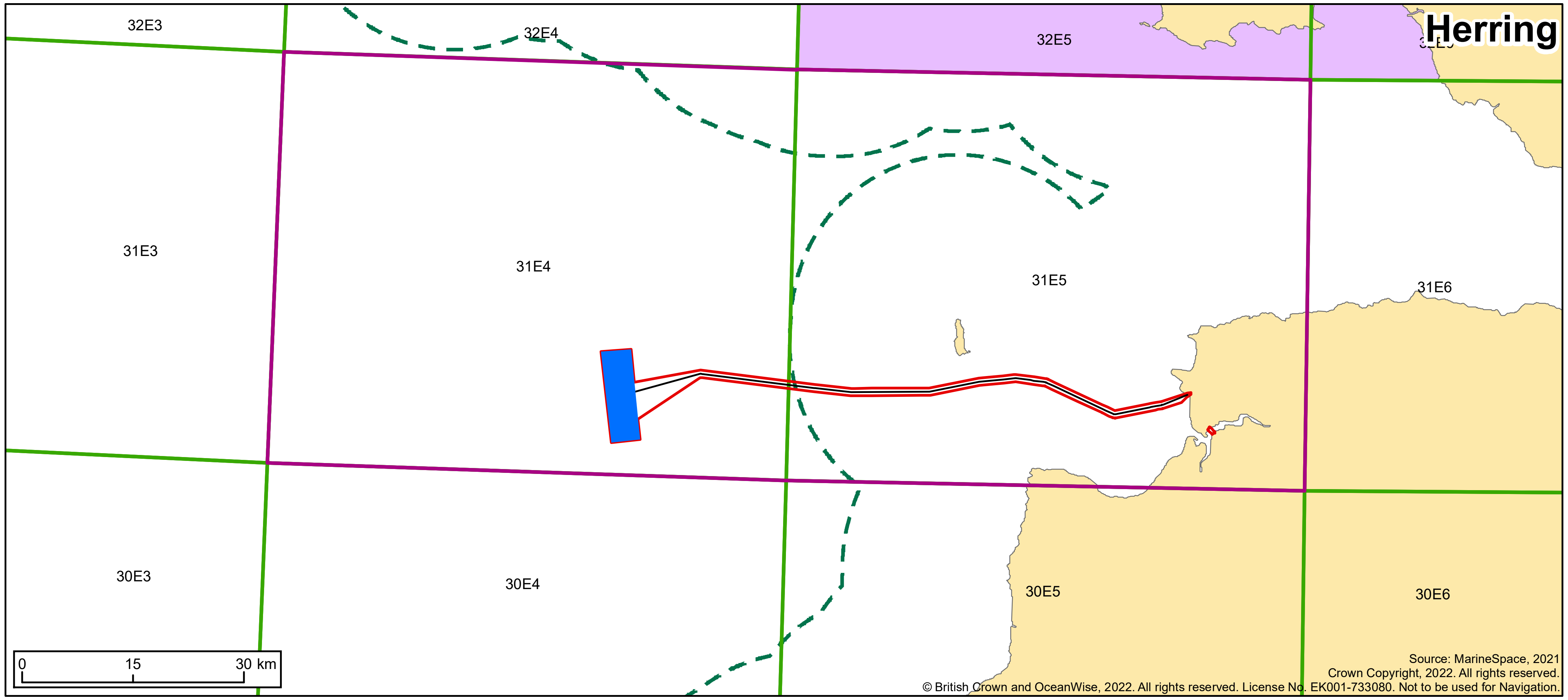
Table 11.15 Percentage of Atlantic herring potential spawning area across the Fish and Shellfish Ecology Study Area (ICES Rectangles 31E4 and 31E5) located within the Maximum Footprint Area of the Offshore Project

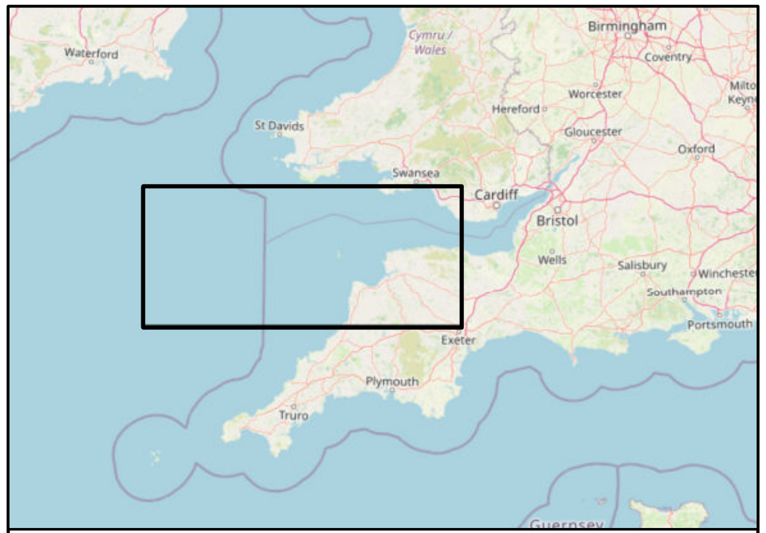
Atlantic herring potential spawning grounds	Total area across Study Area (km²)	Area within Maximum Footprint Area (km²)	Percentage of potential habitat across the Study Area within maximum footprint area
Low	5769.45	27.54	0.48%
Medium	1217.30	1.72	0.14%
High	44.91	0.00	0.00%

96. It is acknowledged that the above model likely underrepresents spawning grounds for Atlantic herring that exist within the Fish and Shellfish Ecology Study Area along the north Devon Coast, from Minehead to Clovelly (Stewart, 2021). Inshore areas may be underrepresented within wider scale data collection efforts, resulting in

these areas indicating low herring spawning potential. The population associated with the North Devon spawning ground has been determined to be genetically distinct from the wider Bristol Channel population (Clarke *et al.*, 2021; Peverley and Stewart, 2021). Consideration for this known population will be given throughout the assessment of relevant impacts within this assessment.







Legend

- Primary Fish and Shellfish Ecology Study Area
- Windfarm Site
- Offshore Export Cable
- Offshore Development Area
- ICES Rectangles
- UK 12nm limit

Nursing grounds (Ellis et al, 2012)

- High Intensity
- Low Intensity

Spawning grounds (Ellis et al, 2012)

- High Intensity
- Low Intensity

Client: Offshore Wind Ltd.

Project: White Cross Offshore Windfarm

Title: White Cross OWF Pelagic Spawning and Nursery Areas

Figure: 11.6

Drawing No: PC2978-MSP_ZZ_XX_DR_Z_0317

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: WGS 1984 UTM Zone 30N

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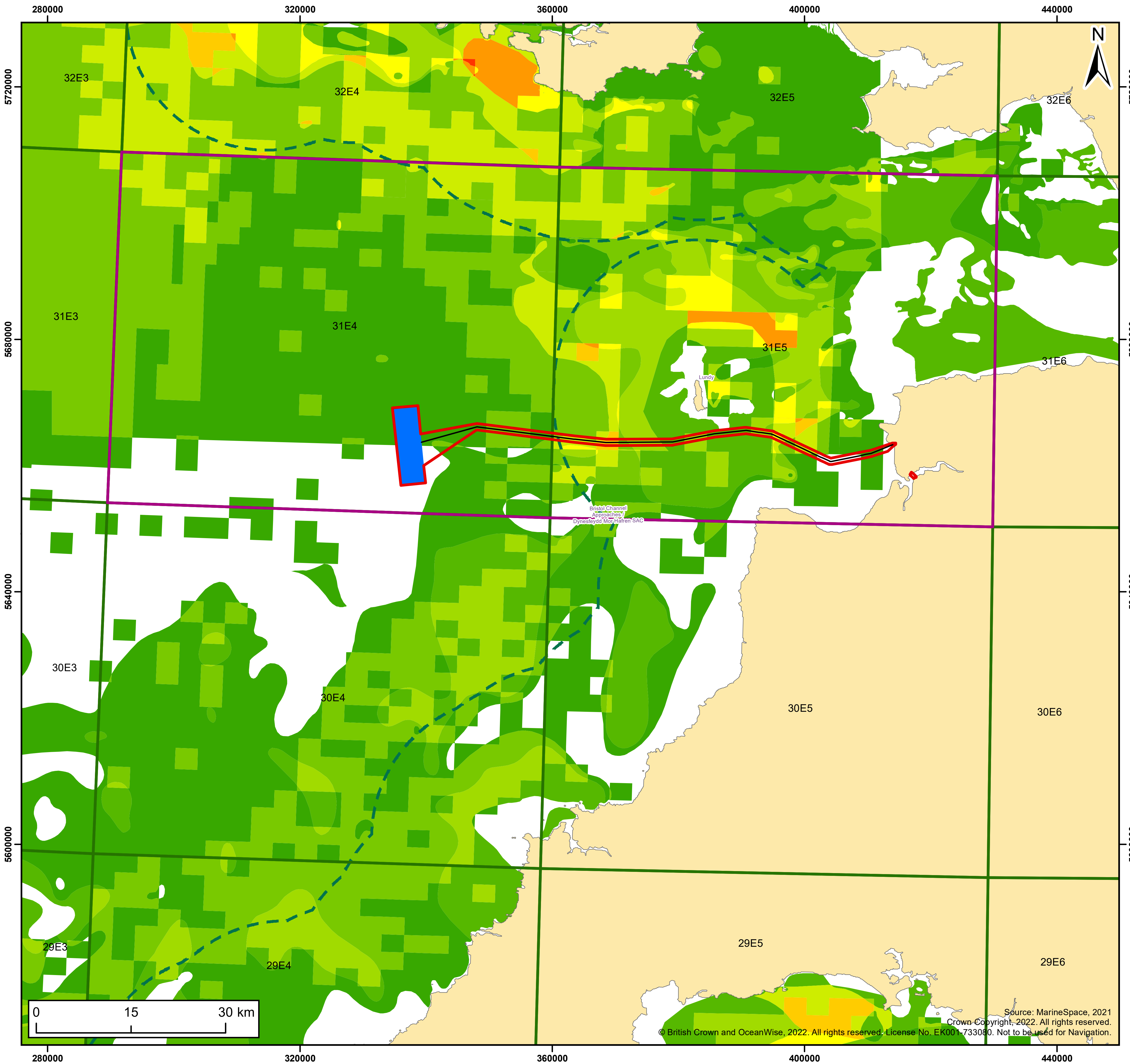

Legend

- Primary Fish and Shellfish Ecology Study Area
- Offshore Export Cable
- Offshore Development Area
- Windfarm Site
- ICES Rectangles
- UK 12nm limit

Herring spawning potential

- 2 (Low)
- 3 (Low)
- 4 (Low)
- 5 (Medium)
- 6 (Medium)
- 7 (Medium)
- 8 (Medium)
- 9 (High)
- 10 (High)
- 11 (High)
- 12 (High)

Client:	Project:
Offshore Wind Ltd.	White Cross Offshore Windfarm

Title:

Areas with Potential to Support Spawning of Atlantic Herring

Figure:	Drawing No:
11.7	PC2978-MSP_ZZ_XX_DR_Z_0312

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
P01	18/08/2022	NB	xx	A3	1:600,000

Co-ordinate system: WGS 1984 UTM Zone 30N

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11.4.1.3.15 Pelagic Fish – Conservation Importance

97. With the exception of European sprat and Atlantic bonito, each of the pelagic species identified is of nature conservation importance. Atlantic horse mackerel is listed as vulnerable at a global scale (least concern in Europe), and European pilchard is listed as Near Threatened in Europe (least concern globally). Atlantic herring, Atlantic horse mackerel and Atlantic mackerel are all listed on the UK post-2010 biodiversity framework, and are species of conservation interest that can contribute to MCZ designation. The species identified are presented in further detail within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**, alongside summary information regarding their biology and nature conservation status.

11.4.1.3.16 Shellfish – Background

98. In EIA terms, the class 'shellfish' comprises marine invertebrates and their associated commercial fisheries. This includes bivalve, crustacean and mollusc species. Further consideration is given to marine invertebrate species without associated fisheries, within **Chapter 10: Benthic and Intertidal Ecology**. A number of shellfish species are known to be present within the Fish and Shellfish Ecology Study Area. Full details of these are presented within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix** alongside summary information regarding their biology and nature conservation status.

11.4.1.3.17 Shellfish – Commercial Importance

99. A number of shellfish species have been recorded in landings data between 2016-2020, within the Fish and Shellfish Ecology Study Area:

- whelk *Buccinium undatum*
- European lobster *Homarus gammarus*
- brown crab *Cancer pagurus*
- spider crab *Maja squinado*
- velvet swimming crab *Necora puber*
- king scallop *Pecten maximus*
- queen scallop *Aequipecten opercularis*
- Norway lobster *Nephrops norvegicus*
- squid *Loligo vulgaris.*

100. Norway lobster and squid were all reported at values of over £60,000 over the 5-year period. Whelk fisheries recorded the highest landed value, at approximately £5.3m over 5 years. The Offshore Project lies within Functional Unit 22 (Celtic Sea, Bristol Channel) for Norway lobster.

11.4.1.3.18 Shellfish – Spawning and Nursery Grounds

101. As a result of their limited mobility, many shellfish species remain within a single region throughout their life history. Whilst some shellfish, including certain species of squid and prawn, may undergo seasonal migrations, for the purposes of this assessment it is assumed that the inshore waters of the Fish and Shellfish Ecology Study Area contain spawning areas for each of the identified shellfish species.

11.4.1.3.19 Shellfish – Conservation Importance

102. Nature conservation consideration is infrequently afforded to shellfish species, with many of the species identified within the ICES landings data not assessed within the IUCN Red List. Of those assessed none scored higher than 'Least concern' with the exception of European squid, which was precluded from assessment due to the lack of data for this stock. None of the species identified within the Fish and Shellfish Ecology Study Area are listed within The Habitats Directive. The spiny lobster *Palinurus elephas* is a designated feature of the Lundy and Bideford to Foreland Point MCZs. This species is listed as 'Vulnerable' within the IUCN Red List. It is also listed on the UK post-biodiversity framework as a priority species, and as a species of principal importance under the Natural Environment and Rural Communities (NERC) Act 2006. All species identified herein, are presented in further detail within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**, alongside summary information regarding their biology and nature conservation status.

11.4.1.3.20 Migratory Species – Background

103. A number of fish species adopt a diadromous life strategy, relying on access to migratory pathways between marine and freshwater environments in order to spawn. Diadromous fish can be either catadromous (migrate into marine waters to spawn, e.g. some eel species) or anadromous (migrate into freshwater to spawn, e.g. some salmonid species). Determining which rivers are important to species present within the Fish and Shellfish Ecology Study Area is valuable, to ensure consideration is given to the potential disruption to any migratory pathways.

104. The Habitats Directive provides protection to 5 species of migratory fish, each of which is covered within **Appendix 6.A Report to Inform Appropriate Assessment**. Species considered as having potential migratory pathways within the Fish and Shellfish Ecology Study Area are scoped into this assessment. These species have been determined using a range of sources, and comprise: Atlantic salmon *Salmo salar*, sea trout *Salmo trutta* m. *trutta*, European eel *Anguilla anguilla*, river lamprey *Lampetra fluviatilis*, sea lamprey *Petromyzon marinus,* allis shad *Alosa alosa*, and twaite shad *Alosa fallax* (Barne *et al.*, 1995; Barne *et al.*, 1996).

The Bristol Channel is of particular importance to shad and lamprey species, hosting significant populations of these species (Barnes *et al.*, 1996).

105. A single observation of common sturgeon *Acipenser sturio* within the Fish and Shellfish Ecology Study Area is recorded in the NBN Atlas, dating to 1948 (NBN, 2022).

106. Other migratory species within the Fish and Shellfish Ecology Study Area are likely to remain within the nearshore region of the Fish and Shellfish Ecology Study Area. Distribution of these species is often driven by the distribution of appropriate prey species. As a result, lamprey and salmonid species often remain within shallow coastal waters for the majority of their lives before migrating into fresh water to spawn. It is therefore acknowledged that there is the potential for these species to be present within the Fish and Shellfish Ecology Study Area, but they are less likely to be present within the Windfarm Site.

11.4.1.3.21 Migratory Species – Commercial Importance

107. None of the migratory species described above is landed in the marine environment, however some species are of commercial importance when present in freshwater environments. European eel, Atlantic salmon, and sea trout all have commercial importance as both food and game species, whilst lamprey are of limited commercial value. The targeted catch of shad species is illegal under Section 5 of the Wildlife and Countryside Act (1981).

11.4.1.3.22 Migratory Species – Migration, Spawning and Nursery Grounds

108. A description of the ecology of each of the migratory species described above is provided within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**. A summary of the relevant migratory factors is provided below.

109. Regarding Atlantic salmon and sea trout, the Torridge and Taw rivers fall within the Fish and Shellfish Ecology Study Area, both of which are used by these species for spawning. No deep-water feeding grounds for these species are present within the region, which are generally located in waters further north, where the mixing of Arctic and Atlantic waters results in high levels of marine productivity (Gilbey *et al.*, 2020). Whilst feeding may occur in this region, it is likely to be opportunistic, during migration between bodies of fresh and marine water. Similarly, whist the region may be used by juveniles, this use will likely be limited to transitionary periods during migration.

110. European eel are catadromous, with mature adults migrating from across the UK and Europe southwards, in order to reach spawning grounds within the Sargasso Sea. Juveniles then return to the east and northeast Atlantic, and migrate to

freshwater sites until reaching sexual maturity. Very little is known about the life history of the species. However, is it acknowledged that the Offshore Project has the potential to overlap with the species' migratory pathways. Peaks in juvenile numbers may occur during the late spring as returning juveniles begin their freshwater migration.

111. Both lamprey and shad species may be present within the Fish and Shellfish Ecology Study Area, with the Bristol Channel being a known site used by these species. These species exhibit a preference for coastal waters where prey availability is high.

11.4.1.3.23 Migratory Species – Conservation Importance

112. The species identified are presented in further detail within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix** alongside summary information regarding their biology and nature conservation status.

113. There are no Special Areas of Conservation (SACs) within the Fish and Shellfish Ecology Study Area designated for any Annex II migratory fish species. A number of SACs with migratory fish and shellfish qualifying features are present within the wider region, as identified within the Scoping Report (Reference Number: EIA/2022/00002). and **Table 11.16**. Populations of migratory fish from these sites have the potential be present within the Fish and Shellfish Ecology Study Area. Potential impacts to the qualifying features of these sites are covered within **Appendix 11.A: Fish and Shellfish Ecology Technical Appendix**.

Table 11.16: Designated sites where Annex II migratory fish species are a qualifying feature.

Special Area of Conservation (SAC)	Qualifying Migratory Fish Features
River Wye/Afon Gwy SAC	Atlantic salmon; sea lamprey; river lamprey; twaite shad.
River Usk/Afon Wysg SAC	Atlantic salmon; sea lamprey; river lamprey; twaite shad.
Severn Estuary/Môr Hafren SAC	Sea lamprey; river lamprey; twaite shad.
Severn Estuary Ramsar	Atlantic salmon; sea lamprey; river lamprey; twaite shad; allis shad; European eel.
Carmarthen Bay and Estuaries/Bae Caerfyrddin ac Aberoedd SAC	Twaite shad.
Afon Tywi/River Tywi SAC	Twaite shad.
River Slaney SAC	Atlantic salmon; sea lamprey; river lamprey; twaite shad.
River Barrow and River Nore SAC	Atlantic salmon; sea lamprey; river lamprey; twaite shad.
Lower River Suir SAC	Atlantic salmon; sea lamprey; river lamprey; twaite shad.

Special Area of Conservation (SAC)	Qualifying Migratory Fish Features
Blackwater River (Cork/Waterford) SAC	Atlantic salmon; sea lamprey; river lamprey; twaite shad.

11.4.1.3.24 Receptor Groups Used for Assessment

114. Assessment for the majority of effect pathways for fish and shellfish receptors has focussed on the following key receptor groups:

- Elasmobranchs
- Demersal fish
- Pelagic fish
- Migratory fish
- Shellfish.

115. For the assessment of underwater noise the following key receptor groups have been identified, as described within Section 11.3.2.2 Popper *et al*. (2014):

- Fish with a swim bladder used in hearing
- Fish with a swim bladder not used in hearing
- Fish with no swim bladder
- Fish eggs and larvae.

11.4.2 Do Nothing Scenario

116. The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) require that "an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of the Project (operational lifetime anticipated to be a minimum of 25 years), long-term trends mean that the condition of the baseline environment is expected to evolve.

117. Accurate and scientifically rigorous determination of baseline shift over the next 25 years, for Fish and Shellfish Ecology within the Celtic Sea, is not possible within the constraints of this assessment. Whilst global broadscale oceanographic changes, including changing sea level and temperature, may result in changes to the receptor groups considered within this chapter, these effects are unlikely to result in a significant change to the determinations made within the presented impact assessment.

11.5 Potential impacts during construction

118. The potential Project impacts, during construction, have been assessed for Fish and Shellfish Ecology receptor groups the results of which are presented in this section.

11.5.1 Impact 1: Temporary habitat loss/physical disturbance

119. Temporary habitat loss/physical disturbance has the potential to occur via a number of pathways throughout construction of the Offshore Project. Anchor and mooring line installation, cable burial, cable protection installation, and associated seabed clearance may result in impacts to a range of fish and shellfish receptors. The worst-case area of seabed predicted to be impacted by temporary disturbance during the construction phase of the Offshore Project is presented within **Table 11.17**.

Table 11.17 Worst-case extent of temporary habitat loss/physical disturbance during construction.

Potential Pathway	Worst-case Scenario
Installation of Wind Turbine Generator (WTG) anchors/moorings	8 x 12MW turbines using a catenary mooring system totalling 19,200m²
Installation of inter-array cables	744,000m²
Installation of protection material for inter-array cables	52,514m²
Area of sand wave excavation for inter-array cables	59,520m²
Area of sand wave excavation for export cables	468,000m²
Installation of export cables	2 x export cables totalling 4,680,000m²
Cable ground lay vessel anchoring	3,600m²
Installation of unburied export cable protection	131,040m²
Installation of export cable crossing protection	14,000m²
Total area[1]	6,112,354m²

120. The worst-case area of 6,112,354m² (6.11km²) represents approximately 0.12% of the Fish and Shellfish Ecology study area (7,426km²), and 11.3% of the Maximum Footprint Area (54.08km²).

[1] Temporary habitat loss/physical disturbance has been assessed in terms of the area of seabed affected, as opposed to the volume of water affected. The volume of temporary habitat loss/physical disturbance within the water column has been assessed in more detail within the following Sections, which refer to potential impacts during construction. Permanent habitat loss is assessed within the operation and maintenance (Section 11.6) and refers to the total volume of habitat lost as a result of the Project's infrastructure.

121. Temporary habitat loss/physical disturbance is most likely to impact species with demersal life stages and/or that have limited mobility. It may also impact species which do not have a direct relationship with the seabed, but prey on species that will be impacted by this effect. Following completion of construction, it is anticipated that the seabed will return to its previous condition with sediment composition unlikely to have undergone significant change and once again becoming suitable habitat. An assessment of the area of the seabed not anticipated to return to previous conditions over an extended/permanent period is covered in **Section 11.6.1**.

122. The species found across the Fish and Shellfish Ecology Study Area are typical of the species found within the Celtic Sea, and there is no evidence suggesting rare or unique habitat relating to Fish and Shellfish Ecology. Several fish and shellfish species have been identified as having spawning and nursery grounds within the Fish and Shellfish Ecology Study Area, across a number of receptor groups.

123. Consideration should be given to the differences between disturbance to adult individuals, existing eggs and larvae within spawning/nursery grounds, and the habitat within which spawning/nursery grounds have the potential to occur. Adult individuals within the fish and Shellfish Ecology receptor groups have varying degrees of mobility allowing for the avoidance of disturbed habitat. Populations are therefore unlikely to undergo any significant change, as a result of habitat loss and disturbance at the scale described within **Table 11.17**. Whilst impacts to existing eggs and larvae are more likely to affect local populations, recovery has the potential to occur rapidly. The temporary loss/disturbance of the spawning/nursery grounds themselves, are more likely to reduce the fecundity of the local population due to the multi-cohort impact that this may result in. Population level recovery will be aided by recruitment of species from surrounding areas unaffected by this impact.

124. Elasmobranch species, including spotted ray, thornback ray and tope shark are all identified within Ellis *et al.* (2012) as having low intensity spawning grounds within the Fish and Shellfish Ecology Study Area. Each of these species is also identified as having similar spawning grounds within the wider region, but outside of the Fish and Shellfish Ecology Study Area. Basking shark are highly mobile, with the distribution driven primarily by the distribution of prey species within the water column (Sims and Merrett, 1997; Sims and Quayle, 1998). If required, minor adjustments to distribution will allow basking shark to continue with established foraging behaviour.

125. Demersal species including anglerfish, cod, sole, plaice, sandeel and whiting are all indicated within Ellis *et al.* (2012), and/or Coull *et al.* (1998), to have low intensity

nursery grounds and both high and low intensity spawning grounds within the Fish and Shellfish Ecology Study Area. Each of these species is also identified as having similar spawning grounds within the wider region, but outside of the Fish and Shellfish Ecology Study Area. It should be noted that many demersal species utilise pelagic or broadcast spawning strategies, releasing eggs into the water column where they are carried by local currents before hatching. Anglerfish, cod, sole, plaice, and whiting all employ this spawning strategy. Of the benthic species identified within Ellis *et al.* (2012), and Coull *et al.* (1998) as having nursery and/or spawning grounds withing the Fish and Shellfish Ecology Study Area, only sandeel lay their eggs directly on the seabed.

126. Sandeel species burrow into specific substrata, consisting of medium to coarse grain size (Holland *et al.*, 2005) associated with sand substrate types (Folk, 1954) characteristic of the Fish and Shellfish Ecology Study Area. However, as identified within the Section 11.4.1, the secondary study area comprises mainly low to medium sandeel potential habitat, modelled using methodology by Latto *et al*. (2013).

127. Pelagic species including Atlantic horse mackerel, Atlantic mackerel, European sprat, Atlantic bonito, and European pilchard have pelagic spawning strategies and are, therefore, not impacted by temporary habitat loss/physical disturbance. Atlantic herring is a pelagic species with a demersal spawning strategy and, therefore, requires assessment. Low Atlantic herring potential spawning habitat dominates the Fish and Shellfish Ecology Study Area and the Maximum Footprint Area, as modelled using the methodology in Reach *et al*. (2013) within Section 11.4.1. However, there are isolated pockets of medium Atlantic herring potential spawning habitat within the Maximum Footprint Area.

128. Migratory species including Atlantic salmon, sea trout, European eel, river lamprey, sea lamprey, allis shad, and twaite shad are diadromous and, mostly, anadromous; therefore no spawning grounds are located within the Fish and Shellfish Ecology Study Area and the Maximum Footprint Area. European eel are catadromous, however their spawning grounds are in the Sargasso Sea, and not within the Fish and Shellfish Ecology Study Area and the Maximum Footprint Area.

129. Shellfish species have varied spawning strategies, however, due to their limited mobility in comparison to fish species, all species within the receptor group will be assessed as having 'demersal' spawning grounds linked to species distribution throughout the inshore waters of the Fish and Shellfish Ecology Study Area. For example, berried (gravid) brown crab females burrow into the sediment and remain sedentary whilst eggs develop, and may be impacted to a greater extent than mobile male or non-gravid female brown crabs (Neal and Wilson, 2008).

11.5.1.1 Magnitude of impact

130. The magnitude of impact associated with temporary habitat loss/physical disturbance is based on the worst-case scenario of direct seabed impact within the Maximum Footprint Area. This represents approximately 6.48km² of seabed, constituting 0.08% of the Fish and Shellfish Ecology Study Area. Therefore, the magnitude of temporary habitat loss/physical disturbance is considered **Low**.

11.5.1.2 Sensitivity of the receptor

131. Elasmobranch species are tolerant and adaptable to natural changes in distributions of prey species, due to their mobility and varied diets. The species identified within the Fish and Shellfish Ecology Study Area are not bound by localised habitats to the same degree as their prey species. Therefore, elasmobranch species are considered to have a **Low** sensitivity to temporary habitat loss/physical disturbance.

132. Demersal and pelagic species are predominantly mobile and are, therefore, considered tolerant and adaptable to temporary habitat loss/physical disturbance. However, it is acknowledged that both sandeel and Atlantic herring have elevated sensitivity to this impact, due to specific life history strategies. Whilst modelling suggests that neither of these species has significant areas of high spawning potential within the Maximum Footprint Area (0.02% for sandeel and no high spawning potential for Atlantic herring, see Table 11.14 and Table 11.15), demersal and pelagic fish are considered to have a **Medium** sensitivity to temporary habitat loss/physical disturbance. As migratory species are likely to transit through the area midwater, no impact pathway exists for these species.

133. Shellfish species are less mobile and have less tolerance and adaptability to temporary habitat loss/physical disturbance, in comparison to the other receptor groups. Some species, such as the brown crab, exhibit variation in sensitivity based on life history, and are considered to have a moderate sensitivity to temporary loss of habitat. Therefore, shellfish are considered to have a **Medium** sensitivity to temporary habitat loss/physical disturbance.

11.5.1.3 Significance of effect

134. The **Low** magnitude of impact, combined with the **Low** to **Medium** sensitivity of all fish and shellfish receptor groups, results in the impact of temporary habitat loss/physical disturbance having a **Minor Adverse** effect, and is therefore **Not Significant** in EIA term.

11.5.1.4 Further Mitigation

135. The assessment of minor adverse and non-significant impact of temporary habitat loss/physical disturbance enables the conclusion that **No Further Mitigation** is required.

11.5.2 Impact 2: Temporary increased suspended sediments and sediment deposition

136. The construction phase of the Offshore Project is predicted to result in an increase in suspended sediment concentration and increased sediment deposition, as a result of installation activities related to foundations, mooring lines, foundations, cable/scour protection, and export and array cables (including pre-cable works such as pre-lay grapnel run (PLGR) or sand wave levelling). Works at the landfall (up to MHWS) site may also increase suspended sediments through potential open-cut trenching. Of these, the activities most likely to cause direct physical disturbance of the seabed are the installation/burial of cables, and installation of anchors. Details of worst-case scenarios are provided in **Chapter 8 Table 8.12** and in **Chapter 9 Table 9.14**.

137. Sediments within the array and ECC are primarily comprised of sand, with gravelly sand and sandy gravel also common, and mud and gravel less common. The mean proportion of sand across all samples was 79.6% (+/-4.9), whilst the mean mud and gravel contents were 6.9% (+/-2.5) and 13.5% (+/-4.4) respectively (**Chapter 8 Section 8.4.1**). Dispersion of fine sediment from these areas is, therefore, predicted to be very low, and increases in suspended sand and mud concentration in the water column will be short in duration. Coarser sediments would likely remain close to the point of disturbance, whilst fine sediments may form a plume and become quickly dispersed by both tidal and wave action. As detailed in **Chapter 8 Section 8.6.3**, the maximum displacement volume of sediment predicted to arise from jetting/ploughing, or trenching/cutting for cable installation (including sand wave removal), is 1,684,800 m^3. The increase in suspended sediments is predicted to be within the range of natural variability within the region (e.g. suspended sediment increases as a result of storms), and the progressive nature of construction of the ECC will result in a localisation of disturbance.

11.5.2.1 Magnitude of impact

138. Although there may be events of highly increased suspended sediments and sediment deposition, the impact in the context of the wider Study Area will be short-term in nature and have the potential for rapid dispersal. Therefore, the magnitude of increased suspended sediments and sediment deposition is considered **Low**.

11.5.2.2 Sensitivity of the receptor

139. Increases in suspended sediments may reduce penetration of light through the water column, leading to a reduction in photosynthetic capabilities of phytoplankton (Cloern, 1987). This can have a cascading effect across trophic levels via food reduction, from zooplankton up to fish (Henley *et al.*, 2000). The effect is exacerbated in fish reliant on sight for predation success, as visibility in turbid waters is obstructed. However, due to the localised and temporary nature of the increase in suspended sediments, the affected area is unlikely to represent a significant portion of the hunting grounds for these fish species. Furthermore, as the majority of predatory fish species are highly mobile, they are likely to avoid areas of increased suspended sediments until they have returned to background levels (ABP Research, 1999; EMU, 2004).

140. The potential for suspended sediments to affect levels of zooplankton and phytoplankton has been shown to impact the presence of basking sharks (Arruda *et al.*, 1983; Hart, 1988). However, as the site is not considered a hot spot for foraging basking sharks, and given the low density of basking sharks detected within the surveyed area, there is not predicted to be any significant impact on this species from increased suspended sediments.

141. For demersal species, where the amount of sediment deposited is relatively small or short-term, effects are likely to be minimal, as adult species are likely to be capable of migrating vertically through deposited sediments (Nichols *et al.*, 1990; Bolam *et al.*, 2003). Therefore, adult fish within demersal, pelagic, elasmobranch, and migratory receptor groups are considered to have a **Negligible** sensitivity to increased suspended sediments and sediment deposition.

142. Larval stages and eggs of these fish assemblages, however, may be more susceptible to the effects of suspended sediment and sediment deposition due to their limited mobility. The sensitivity to these effects varies with species. Atlantic cod eggs are known to lose buoyancy with increasing sediment concentration and exposure time (Westerberg *et al.*, 1996). Conversely, sandeel eggs are likely to be more tolerant of suspended sediments and deposition due to the high natural variability within their breeding grounds (GoBe Consultants Ltd, 2018). Atlantic herring have also been shown to exhibit a high tolerance to increases in suspended sediment concentrations (Mesieh *et al.*, 1981; Kiorboe *et al.*, 1981), with positive effects reported at intermediate turbidity levels (35 JTU) for larvae (Utne-Palm, 2004). Mortality for Atlantic herring is reported with extended periods of smothering (Griffin *et al.*, 2009). However, due to the limited duration of the Offshore Project, and because Atlantic herring spawning grounds tend to be located in gravel or

coarse sand where plume dispersal is minimal, smothering is unlikely to occur (Haegele and Schweigert, 1985). There are no known Atlantic herring spawning grounds within the Fish and Shellfish Ecology Study Area, however regions to the north of Lundy have been identified as having up to medium potential for herring spawning (Figure 11.7). Although some species of these fish assemblages may be tolerant to increased suspended sediment and sediment deposition, they are restricted by their limited mobility. Therefore, the larval and egg stages of demersal, pelagic, elasmobranch, and migratory receptor groups are considered to have a **Medium** sensitivity to increased suspended sediments and sediment deposition.

143. Filter-feeding shellfish may also be affected by increased suspended sediments or sediment deposition, through a reduction in phytoplankton and zooplankton and a concurrent increase in inorganic material, which have the potential to clog feeding structures (Pineda *et al.*, 2017). In king and queen scallops, elevated suspended particulate matter has been shown to not have any short-term effects on survival, with emergence from deposition under coarse and medium grain sizes (such as are primarily found at the Offshore Project area) higher than for fine sediments (Szostek *et al.*, 2013). Mussels may tolerate smothering by several centimetres (Essink, 1999), and appear able to maintain filtration even with increased fine sediments (Lummer *et al.*, 2016). Norway and European lobster are unlikely to be affected by light deposition (<5 cm) of sediment (Sabatini and Hill, 2008; Gibson-Hall *et al.*, 2020), but may increase movement away from affected areas with higher levels, due to reduction in available habitat and prey species (Pottle and Einer, 1982). Brown crab are assessed as having a low intolerance to suspended sediments and sediment deposition, due to their ability to escape from under silt or move away from areas of high suspended sediments (Neal and Wilson, 2008). Light sediment deposition is likely to occur over an extended area during construction and is predicted to have a negligible impact on shellfish within the wider Study Area. However, directly adjacent to construction activities, smothering at an extent where shellfish mortality may be experienced is likely to occur. Therefore, the shellfish receptor group is considered to have a **Medium** sensitivity to increased suspended sediments and sediment deposition.

11.5.2.3 Significance of effect

144. The low impact and negligible sensitivity of adult stages of demersal, pelagic, elasmobranch, and migratory fish receptor groups, results in the impact of increased suspended sediment and sediment deposition having a **Negligible** effect, which is **Not Significant** in EIA terms.

145. The low impact and medium sensitivity of larval/egg stages of demersal, pelagic, elasmobranch, and migratory receptor groups as well as the medium sensitivity of shellfish receptors, results in the impact of suspended sediments and sediment deposition having a **Minor Adverse** effect, which is **Not Significant** in EIA terms.

11.5.2.4 Further Mitigation

146. The assessment of minor adverse and non-significant impact of increased suspended sediments and sediment deposition enables the conclusion that **No Further Mitigation** is required.

11.5.3 Impact 3: Underwater noise and vibration

147. The impacts on fish and shellfish receptors from underwater noise and vibration caused by construction activities are assessed in full detail in **Appendix 13.A: Underwater Noise and Vibration Technical Report**. Noise generation, and its disturbance, injury, and mortality impacts on receptor groups, is divided into three groups based on the type of noise generated:

- Unexploded Ordnance (UXO) clearance
- impact piling (i.e. high-level impulsive subsea noise)
- other noise making activities.

148. Approximate subsea noise levels have been modelled for each group using a proprietary modelling approach based on data from Subacoustech Environmental's underwater noise measurement database. The approach has also integrated site-specific parameters and noise sources, where a proxy has been used due to gaps in the available data.

11.5.3.1.1 UXO clearance

149. There is a possibility that Unexploded Ordnance (UXO) may exist within the boundary of the Offshore Project, within a range of charge weights, and that these will have to be safely cleared before the construction of the Offshore Project may begin.

150. A range of explosive sizes has been considered and, in each case, it has been assumed that the maximum explosive charge in each device is present. It is considered that this charge either detonates with the clearance (high-order) or alternatively via deflagration (low-order). Three UXO clearance scenarios have been considered for this study:

- high-order detonation, unmitigated
- high-order detonation, with bubble curtain

- low-order clearance (e.g. deflagration) .

151. Calculations for UXO clearance estimations are detailed in **Chapter 13 Appendix 13.A** and assume a worst-case scenario where the UXO to be detonated is not buried, degraded, or subject to any other significant attenuation from its "as new" condition. It therefore assumes that a high-order clearance technique is used, where an additional charge ("donor charge") is used to detonate the explosive material, resulting in a blast wave equivalent to full detonation of the device. The range of estimated charge weights that could be present within the Offshore Project Area is determined within the Unexploded Ordnance Threat and Risk Assessment (6 Alpha Associates, 2022), and listed in **Table 11.18**.

Table 11.18 Selection of potential UXO and respective charge weights, NEQ

Description	4.7" Artillery	SC-50 HE Bomb	250 lb MC Bomb	SC-250 HE Bomb	Mark XV Mine	1,000 lb MC Bomb
Predicted charge weight, NEQ	3.1kg	25kg	67.8kg	130kg	227kg	309.4kg

152. Estimation of the source noise level for each charge weight has been carried out in accordance with the methodology of Soloway and Dahl (2014), which follows Arons (1954) and MTD (1996).

153. Deflagration is a controlled method of UXO clearance, which destroys but does not detonate the internal explosive material in a "low order" burn. This technique significantly reduces the environmental effects compared to a high-order clearance. However, noise impacts remain in association with the initial donor charge (typically < 250g). A prediction of this impact is based on a charge weight of 2kg, which represents a high-end scenario for deflagration, but the process could also result in a worst-case complete detonation of the UXO.

154. Bubble curtains may be used to reduce noise impacts from high-order or low-yield clearances, and modelled noise impacts include these scenarios as separate results. A summary of the impact ranges for UXO detonation, and mitigated (bubble curtain) UXO detonation using the unweighted SPL_{peak} explosion noise criteria from Popper *et al.* (2014) for species of fish, are given in Table 11.19 and Table 11.20, below, respectively.

Table 11.19 Summary of the impact ranges (m) for UXO detonation using the unweighted SPL_{peak} explosion noise criteria from Popper et al. (2014) for species of fish

Popper *et al.* (2014) Unweighted SPL_{peak}		Low-yield	Low-order	25kg	67.8kg	130kg	227kg	309.4kg
	234dB	130	80	170	240	300	370	410

Popper *et al.* (2014) Unweighted SPL_{peak}		Low-yield	Low-order	25kg	67.8kg	130kg	227kg	309.4kg
Mortality & potential mortal injury	229dB	210	120	290	410	510	610	680

Table 11.20 Summary of the impact ranges (m) for mitigated (bubble curtain) UXO detonation using the unweighted SPL_{peak} explosion noise criteria from Popper et al. (2014) for species of fish

Popper et al. (2014) Unweighted SPL_{peak}		Low-yield	Low-order	25kg	67.8kg	130kg	227kg	309.4kg
Mortality & potential mortal injury	234dB	<50	<50	65	90	110	130	140
	229dB	80	<50	100	140	180	220	240

11.5.3.1.2 Impact Piling

155. Modelling of high-level impulsive subsea noise, such as that caused through piling activities, has been undertaken using the INSPIRE model (version 5.1). This is a semi-empirical underwater noise propagation model that is based on numerical, geometric, and energy loss methodology. It is based around a combination of numerical modelling, using a combined geometric and energy flow/hysteresis loss methodology, and actual measured data, and has been validated in Thompson *et al.* (2013). It allows estimations of noise metrics from piling, including propagation through shallow mixed waters representative of the region surrounding the Offshore Project Area. Noise metrics are then further processed to assess the potential impacts on fish and shellfish receptors.

156. The INSPIRE model estimates unweighted SPL_{peak}, SEL_{ss} and SEL_{cum} noise levels, with calculations made along 180 equally spaced radial transects. The results presented in this assessment, and in more detail in **Chapter 13 Appendix 13.A**, should be considered conservative as maximum design parameters and worst-case assumptions have been selected for:

- piling hammer blow energies
- soft start, ramp-up profile and strike rate
- total duration of piling
- receptor swim speeds.

157. Modelling was conducted at three locations within the Windfarm Site: the southeast (SE) corner giving a worst-case location for the OSP at the closest point to the Bristol Channel Approaches SAC, and mooring anchor locations covering the extents of the

White Cross site at the northwest (NW) and south-west (SW) corners. Further details of modelling locations are included in **Chapter 13 Appendix 13.A**.

158. For fish with a swim bladder involved in hearing, TTS onset is likely to occur at 186dB SEL_{cum}, while injury and mortality are not expected until an exposure of >203dB SEL_{cum} (Popper *et al.*, 2014). This receptor group is predicted to be the most sensitive, therefore higher levels of sound exposure will be required before these effects are predicted to occur for all other receptor groups. A summary of the predicted impact ranges at the OSP location with the maximum impact is presented below in **Table 11.21.**

Table 11.21 Summary of the impact ranges for impact piling modelling at the SE (OSS) location using the unweighted SEL_{cum} pile driving criteria from Popper et al. (2014) for species of fish assuming both fleeing and stationary animals

Popper *et al.* (2014) Unweighted SEL_{cum}		Area	Maximum range	Minimum range	Mean range
Fleeing	**219dB**	<0.1km²	<100m	<100m	<100m
	216dB	<0.1km²	<100m	<100m	<100m
	210dB	<0.1km²	<100m	<100m	<100m
	207dB	<0.1km²	<100m	<100m	<100m
	203dB	<0.1km²	<100m	<100m	<100m
	186dB	1,400km²	24km	18km	21km
Stationary	**219dB**	8.4km²	1.7km	1.6km	1.6km
	216dB	21km²	2.6km	2.6km	2.6km
	210dB	110km²	6.0km	5.9km	5.9km
	207dB	230km²	8.6km	8.5km	8.5km
	203dB	550km²	14km	13km	13km
	186dB	6,500km²	51km	39km	46km

159. Modelling predicts that the largest impact ranges are predicted for the OSP foundation scenario at the SE location, with maximum recoverable injury (203dB SEL_{cum}) ranges up to 14km for stationary receptors, and less than 100m for a fleeing receptor. TTS ranges (186dB SEL_{cum}) for fish with a swim bladder involved in hearing will be up to 24km for fleeing fish, or 51km for stationary receptors.

160. Elasmobranchs may be less sensitive to underwater sound exposure, compared to bony fishes, due to their absence of a swim bladder. This may reduce their ability to detect the pressure component of sound, with the particle displacement component acting as the primary stimulus for perceiving a sound field (Myrberg, 2001; Casper and Mann, 2006).

161. Audiograms performed on five species of elasmobranchs reveal most sensitivity occurs at low frequencies, between 20-1,000 Hz (Casper and Mann, 2009). Sudden high-intensity noise outputs (10x ambient) within 10m of individual elasmobranchs

may elicit fright or escape responses, but may be negated with habituation (Myrberg, 2001). However, there is a strong lack of data on this topic (Casper *et al.*, 2012; Hawkins *et al.*, 2015). All impacts anticipated from the Offshore Project during construction equate to a maximum worst-case scenario of <1 basking shark experiencing recoverable injury. Mitigation methods (detailed in **Chapter 13: Marine Mammal and Marine Turtle Ecology Appendix 13.X Marine Mammal Mitigation Plan**), such as the use of a marine mammal observer (MMO) to ensure there are no marine mammals or basking sharks in the direct vicinity prior to any piling activity, will also mitigate the risk of mortality of these receptors.

162. Shellfish exposed to substrate vibration from anthropogenic noise (such as piling) may react by closing their valves, reducing water filtration capacity (Roberts *et al.*, 2015). In small-scale pile-driving exposures, mussels *Mytilus edulis* exhibited behavioural and physiological changes including variation in valve gape and oxygen demand (Roberts *et al.*, 2016). Hermit crabs *Pagurus bernhardus* under the same conditions did not show any significant behavioural change but may have been affected by stress during deployment. Of the limited studies that have been performed, results vary greatly, with some showing tissue damage and others no change at all (Carroll *et al.*, 2017).

11.5.3.1.3 Other noise making activities

163. Modelling of low-level, non-impulsive subsea noise was conducted, based on data from Subacoustech Environmental's underwater noise measurement database or other available data, scaled to relevant parameters for the site. Noise modelling requires knowledge of the source level (i.e. noise level at one metre from the noise source). Predicted source levels are presented in **Table 11.22**. This modelling method does not account for bathymetry or other environmental conditions, to allow it to be applied to any location in/around the White Cross site. The duration the noise is present within the environment, has also been considered for SEL_{cum} calculations, assuming a worst-case duration of 12hr in any given 24hr period (aside from 24hr vessel noise).

Table 11.22 Summary of impact ranges for different noise sources using shipping and continuous noise criteria from Popper et al. (2014) for species of fish with a swim bladder involved in hearing.

Popper *et al.* (2014) Unweighted SPL_{RMS}	Source level (dB re 1µPa @ 1m)	Recoverable injury 170dB (48hr)	Temporary Threshold Shift 158dB (12hr)
Vessel movement (large)	168	<10m	<10m
Vessel movement (medium)	161	<10m	<10m

Popper *et al.* (2014) Unweighted SPL_{RMS}	Source level (dB re 1µPa @ 1m)	Recoverable injury 170dB (48hr)	Temporary Threshold Shift 158dB (12hr)
Backhoe dredging	165	<10m	<10m
Suction dredging	186	<10m	30m
Cable laying	171	<10m	10m
Trenching	172	<10m	10m
Rock placement	172	<10m	20m
Drag embedment anchors	171	<10m	<10m
Suction pile installation	192	20m	60m

164. Modelling was based on impacts to fish with a swim bladder involved in hearing, as these species have the highest sensitivity to underwater noise levels. Based on the modelling of noise levels generated by likely construction activities, results indicated that for most low-level, non-impulsive noise, the maximum distance from the source at which a fish with a swim bladder involved with hearing would experience recoverable injury (within 48hr) was 10m. The exception to this was for suction piling installation, which would expose the receptor to injury if within 20 m. For exposure to Temporary Threshold Shift (TTS) (for 12hrs), the range of distances fell between <10-60m.

165. As discussed in the Biological Baseline section above, basking sharks may be present in low quantities within the Fish and Shellfish Ecology Study Area at certain times of year. These large elasmobranchs are not, typically, disturbed or affected by the presence of vessels (Speedie *et al.*, 2009) or Autonomous Underwater Vehicles (AUVs) (Hawkes *et al.*, 2020), although in the latter study sharks exhibited an escape response when contact was made. In some cases, basking sharks have appeared to be disturbed at distances of 1km, while in others, no change in behaviour was observed until the vessel was <10m from individuals (Bloomfield and Solandt, 2008). Disturbance susceptibility may also be affected by size of the individual, as large sharks exhibiting feeding behaviour appear to be less affected by vessels than smaller sharks (Speedie *et al.*, 2009).

166. Behavioural responses in elasmobranchs, in response to underwater noise, have been measured (Chapuis *et al.*, 2019), however they have relatively narrow auditory range and poor sensitivity when compared to many other teleost fishes (Hart and Colin, 2015), and appear to be resistant to noise at a benchmark level (Wilding *et al.*, 2020). A study conducted in southwest England reported that engine noise and angle of approach of vessels causes limited behavioural disturbance (Wilson 2000

unpublished; as cited in Speedie *et al.*, 2009), but there remains a research gap surrounding sound detection in basking sharks.

167. Shellfish receptor groups may also be affected by underwater noise. High frequency (100-200Hz) acoustic exposure has been shown to compromise the immune system in marine invertebrates such as Mediterranean mussels *Mytilus galloprovincialis* (Vazzana *et al.*, 2020a) and sea urchins *Arbacia lixula* (Vazzana *et al.*, 2020b). However, despite higher values of certain biochemical stress parameters, there was no significant change in mussel behaviour (Vazzana *et al.*, 2016). In sea slugs, underwater noise had interactive effects with the host biochemical and immune systems, which were positively correlated with noise frequency (Tu *et al.*, 2022). In hermit crabs, vessel noise may delay the escape response to predatory stimuli (Nousek-McGregor and Mei, 2016), or may cause crabs to modify grouping behaviour (Tidau and Briffa, 2019a) or select suboptimal shells (Walsh *et al.*, 2017; Tidau and Briffa, 2019b). In European green crab, boat noise (but not equally loud ambient noise) reduced camouflage abilities and reduced efficacy of the anti-predator escape response (Carter *et al.*, 2020).

11.5.3.2 Magnitude of impact

11.5.3.2.1 UXO clearance

168. Due to the limited impact range of water within which mortality will occur for mitigated, low-order clearance (an area of <0.01km²), the number of fish and shellfish species likely to be in the range of this UXO clearance event is likely to be a negligible proportion of the population in the wider Fish and Shellfish Ecology Study Area. For the worst-case scenario, of a 309kg unmitigated UXO clearance, the impact range is modelled as 680 m, for an area of 1.45km², however this scenario is extremely unlikely when considered against a low-order clearance. This represents 0.02% of the Fish and Shellfish Ecology Study Area (7,426km²). Therefore, the magnitude of impact from underwater noise and vibration (UXO clearance) for the worst-case scenario is considered medium. Magnitude of impact from underwater noise and vibration (UXO clearance) for a low-order (deflagration) clearance is considered **low**.

11.5.3.2.2 Impact piling

169. For fish with a swim bladder involved in hearing, the most sensitive Fish and Shellfish receptor group, TTS onset is likely to occur at 186dB SEL_{cum}, while injury and mortality are not expected until an exposure of >203dB SEL_{cum} (Popper *et al.*, 2014). Maximum recoverable injury range for fleeing receptors is therefore determined as being <100m. Based on the results of underwater noise modelling,

and the thresholds outlined in Popper *et al.* (2014), the magnitude of impact for underwater noise and vibration (impact piling) is considered **Low**.

11.5.3.2.3 Other noise making activities

170. The volume of water in which fish have the potential to be subjected to injury or TTS effects from low-level, non-impulsive, subsea noise is negligible, when considered in the context of the wider volume of the Fish and Shellfish Ecology Study Area. Most activities that are predicted to emit low-level, non-impulsive, subsea noise, do so in a manner that is limited both spatially (worst-case impact range of 60m for TTS from suction pile installation) and temporally (only the duration of construction). Therefore, the magnitude of underwater noise and vibration (other noise making activities) is considered **Low**.

11.5.3.3 Sensitivity of the receptor

11.5.3.3.1 UXO clearance

171. For a realistic scenario (low-order deflagration with no mitigation), modelling indicates that mortality and potential mortal injury will occur to the most sensitive fish species within a range of 120m. This event would be instantaneous, so receptors would not be able to escape impact. While some species, including basking sharks, have longer population recovery times, basking sharks are not expected to be present within the Fish and Shellfish Ecology Study Area above low densities. It is predicted that any reduction in fish or shellfish population is likely to recover within 1-5 years. Therefore, fish with a swim bladder that is involved in hearing, fish with no swim bladder, fish with a swim bladder that is not involved in hearing, fish eggs, larval fish stages, and shellfish receptor groups are considered to have a **Low** sensitivity to underwater noise and vibration (UXO clearance).

11.5.3.3.2 Impact piling

172. Fish receptors (and some shellfish) in the area are mobile in nature and must be present within a limited range to undergo unrecoverable impact. For shellfish, data are limited, but indicate that for most species there is little to no impact at levels similar to what will be used during the construction stage of the Offshore Project (Carroll *et al.*, 2017). Therefore, fish with a swim bladder that is involved in hearing, fish with no swim bladder, fish with a swim bladder that is not involved in hearing, fish eggs, larval fish stages, and shellfish receptor groups are considered to have a **Negligible** sensitivity to underwater noise and vibration (impact piling).

11.5.3.3.3 Other noise making activities

173. The modelling for low-level, non-impulsive, subsea noise was based on a receptor of fish with a swim bladder involved in hearing, as these were determined to be

most sensitive to underwater noise and vibration. The volumes emitted during these activities is lower than would be expected to have a significant effect within the wider Fish and Shellfish Ecology Study Area. Additionally, this receptor is predicted to exhibit mobile fleeing or avoidance behaviour in response to any detected noise or vibration, thereby reducing their likelihood of mortality or TTS. Therefore, fish with a swim bladder that is involved in hearing receptor group, is considered to have a **Negligible** sensitivity to underwater noise and vibration (other noise making activities).

174. All other receptor groups (fish with no swim bladder, fish with a swim bladder that is not involved in hearing, fish eggs, larval fish stages, and shellfish) have a lower sensitivity to underwater noise. Therefore, fish with no swim bladder, fish with a swim bladder that is not involved in hearing, fish eggs, larval fish stages, and shellfish receptor groups are considered to have a **Negligible** sensitivity to underwater noise and vibration (other noise making activities).

11.5.3.4 Significance of effect

11.5.3.4.1 UXO clearance

175. Due to the low magnitude of impact and low sensitivity of fish and shellfish to disturbance, injury and mortality from UXO clearance, these activities are assessed as having a **Minor Adverse** effect, which is **Not Significant** in EIA terms.

11.5.3.4.2 Impact piling

176. Due to the low magnitude of impact and low sensitivity of fish and shellfish to disturbance, injury and mortality from impact piling, these activities are assessed as having a **Minor Adverse** effect, which is **Not Significant** in EIA terms.

11.5.3.4.3 Other noise making activities

177. Due to the low magnitude of the impact and the negligible sensitivity of the most sensitive receptor group to other noise making activities, these activities are assessed as having a **Negligible** effect, which is **Not Significant** in EIA terms.

11.5.3.5 Further Mitigation

178. The assessment of minor adverse and non-significant impact of underwater noise and vibration enables the conclusion that **No Further Mitigation** is required.

11.5.4 Impact 4: Barrier effects

179. Barrier effects occur from a number of sources, including suspended sediment plumes, noise, electromagnetic fields, and anthropogenic structures within the water column. As such, the barrier effects due to suspended sediment plumes, noise, and electromagnetic fields (EMFs) have been assessed in **Section 11.5.2**,

Section 11.5.3, and as part of the operation and maintenance impact pathway in **Section 11.6.3** respectively.

180. Barrier effects due to anthropogenic structures in the water column have the potential to occur via a number of potential pathways throughout construction of the Offshore Project. Anchor and mooring line installation, cable protection installation, OSP installation, floating turbine platform structure installation, and associated seabed clearance may result in impacts to a range of fish and shellfish receptors.

181. The worst-case area of seabed predicted to be impacted during the construction phase of the Offshore Project, is limited to the immediate volume of water surrounding physical structures, including the volume of water containing the OSP and floating turbine platform structures. Therefore, the worst-case scenario includes the volume of displacement by cable protection (2m in height), suspended array cables (200m for each cable end, and assuming 1m diameter cables), and substructures within the water column. The combined worst-case values are presented in **Table 11.23**.

Table 11.23 Worst-case extent of barrier effects during construction.

Potential Pathway	Worst-case Scenario
Volume of WTG anchors/moorings	8 x 12MW turbines using a catenary mooring system totalling 19,200m³
Volume of suspended inter-array cables	10,054.67m³
Volume of protection material for inter-array cables	54,014m³
Volume of protection material for unburied export cables	74,880m³
Volume of protection material for export cable crossings	14,400m³
Volume of scour protection[2]	123,150m³
Cable ground lay vessel anchoring	3,600m²
Volume of floating substructures	8 x 12MW turbines, each mounted to substructure with dimensions 20m (depth) x 10m (diameter) = 1,570.80m³ Total = 12,566.40 m³
Volume of OSP (draft fixed jacket substructure)	16,000m³
Total	327,865.07m³

[2] This is the total volume of seabed sediment and water column loss as a result of scour protection around all WTGs and the offshore substation.

182. The worst-case scenario has been measured as the volume of water column loss due to physical barriers, that prevents fish and shellfish species from accessing habitats/areas as they would in natural conditions. This equates to a volume of 327,865.07m³ of impact in total.

183. The magnitude of the barrier effect can be quantified as a proportion of water volume lost as a result of additional material on the seabed and within the water column. The volume of the Windfarm Site is equal to 3.48km³ (total area of the array multiplied by the average depth across the array (70.5m), assuming a level seabed). The total volume of the export cable corridor is equal to 0.17km³ (total area of the 25m wide cable route corridors for 2 export cables multiplied by a linear gradient in depth from a maximum depth of 72m (the maximum Windfarm Site depth) to a minimum depth of 0m at landfall (up to MHWS), creating an assumed polyhedron 'wedge' of water above the cable). Combined, the volume of water within the Offshore Development Area is approximately 3.65km³

184. The volume of water lost to fish and shellfish species as a result of barrier effects equates to 0.01% of the water volume within the Offshore Development Area. It should be noted that the worst-case scenario for physical barrier effects will be identical to that of the operation and maintenance phase, during which all physical structures are *in situ*.

185. Barrier effects are most likely to impact large pelagic species with limited agility, and benthic species with limited mobility. It is unlikely to impact small, mobile, species that can avoid both static and slow-moving barriers (such as anchor chains). Following completion of construction, this impact is expected to remain until all structures have been decommissioned. Seabed that is not anticipated to return to previous conditions over an extended/permanent period is covered in Section 11.6.1..

186. The species found across the Fish and Shellfish Ecology Study Area are typical of the species found within the Celtic Sea, and there is no evidence suggesting rare or unique habitat relating to Fish and Shellfish Ecology. A number of fish and shellfish species have been identified as having potentially elevated risks of impact due to barrier effects within the Fish and Shellfish Ecology Study Area, across a number of receptor groups.

187. Large elasmobranch species, including basking shark and tope, are highly mobile but are not as agile as smaller elasmobranch and pelagic fish species. As such, these species are likely to avoid transiting between visible mobile cables and through static structures within the water column. Structures that are not clearly visible may lead

to collisions, assessed in **Chapter 12**. Rays, skates, and other small elasmobranch species may be impacted by barrier effects associated with seabed disturbance, such as anchors/moorings and chains rubbing on the seafloor.

188. Mobile demersal species are likely to experience similar impacts to small elasmobranch species, in that barrier effects are limited to seabed disturbance and structures on, or close to, the seabed.

189. Sandeel species burrow into the seabed and, therefore, structures and seabed disturbance have the potential to prevent burrowing in otherwise suitable habitat. For example, chains moving above the seabed, but not in contact and, therefore, not damaging the seabed directly, may prevent individuals from occupying the seabed below.

190. Pelagic species are highly mobile and agile, and are therefore able to transit around and through physical structures. Structures often have an aggregating effect for pelagic species, essentially the opposite of a barrier effect, and this has been assessed in Section 11.6.6. Atlantic herring is a pelagic species with a demersal spawning strategy and, therefore, interacts directly with the seabed. Barrier effects are, therefore, likely to be present, and similar to those experienced by sandeel species and small elasmobranch and demersal species.

191. Migratory species are highly mobile and agile, and are therefore likely to experience barrier effects similar to small elasmobranch and demersal species. Some shellfish species have limited mobility, and therefore the presence of hard structures within the sediment may prevent individuals from accessing or transiting between microhabitats within the sediments. Larger mobile shellfish such as crabs and lobsters will experience similar barrier effects to demersal fish species.

11.5.4.1 Magnitude of impact

192. The magnitude of impact associated with barrier effects is based on the worst-case scenario of water volume lost within the Offshore Development Area. This represents approximately 327,865.07m^3, constituting 0.01% of the Offshore Development Area. Therefore, the magnitude of barrier effects is considered **Negligible**.

11.5.4.2 Sensitivity of the receptor

193. Elasmobranch species vary in their ability to transit between structures. However most species present in the Fish and Shellfish Ecology Study Area are capable of transiting around structures, with limited additional energy burden. Therefore, elasmobranch species are both tolerant and adaptable to barrier effects. Basking

sharks, the largest elasmobranch (and fish) species present in the Fish and Shellfish Ecology Study Area, are the least able to transit within, and between, close structures and will, therefore, potentially exhibit a barrier effect. However, the barrier effect is limited to a very small volume of water within the Offshore Development Area and, therefore, basking sharks will be able to transit around structures with ease by utilising the Fish and Shellfish Ecology Study Area. Therefore, elasmobranch species are considered to have a **Low** sensitivity to barrier effects.

194. Demersal and pelagic species are highly mobile and agile, and are, therefore, both tolerant of, and adaptable to, the presence of structures on the seabed, with the exception of Atlantic herring and sandeel species. Barrier effects will be limited to small volumes on the seabed surface, specifically surrounding the anchor and anchoring chains directly on or above the seabed. This will impact individual Atlantic herring (during the spawning period) and sandeel species within close proximity to infrastructure. Therefore, demersal and pelagic species are considered to have a **Low** sensitivity to barrier effects.

195. Migratory species are highly mobile and agile, and are, therefore, both tolerant of, and adaptable to, the presence of structures on the seabed. All species are capable of transiting through, and around, structures; along migration paths through the Offshore Development Area. Therefore, migratory fish species are considered to have a **Negligible** sensitivity to barrier effects.

196. Shellfish species have a low mobility, and are naturally restricted to their immediate settlement area. Crustaceans and other mobile shellfish are likely to overcome barrier effects in a similar way to small demersal fish (excluding sandeel) and are consequently assumed to have a low sensitivity. Therefore, shellfish are considered to have a **Low** sensitivity to barrier effects.

11.5.4.3 Significance of effect

197. The negligible magnitude of impact, combined with the negligible to low sensitivity of all fish and shellfish receptor groups, results in the impact of barrier effects having a **Negligible** effect, and is therefore **Not Significant** in EIA terms.

11.5.4.4 Further Mitigation

198. The assessment of minor adverse and non-significant impact of barrier effects enables the conclusion that **No Further Mitigation** is required.

11.6 Potential impacts during operation and maintenance

199. The potential impacts of the operation and maintenance of the Offshore Project have been assessed on Fish and Shellfish Ecology receptor groups. A description of the potential effect on Fish and Shellfish Ecology receptor groups caused by each identified impact is given in this section.

11.6.1 Impact 1: Permanent habitat loss

200. Permanent habitat loss has the potential to occur during the operational phase of the Offshore Project. Whilst it is true that substructures within the water column will prevent species from accessing those volumes, this will not account for a significant loss in water column habitat within the Fish and Shellfish Study Area or the Maximum Impact Area. Therefore, this impact exclusively refers to the area of seabed loss due to the placement of infrastructure (such as buried cable routes, catenary chains on the seabed, and anchors/moorings within the seabed).

201. The worst-case area of seabed predicted to be impacted by permanent habitat loss during the operation and maintenance phase of the Offshore Project is presented within **Table 11.24**.

Table 11.24 Worst-case extent of permanent habitat loss during operation and maintenance.

Potential Pathway	Worst-case Scenario
Area of WTG anchors/moorings	8 x 12MW turbines using a catenary mooring system totalling 19,200m²
Area of protection material for inter-array cables	52,514m²
Area of protection material for unburied export cables	131,040m²
Area of protection material for export cable crossings	14,000m²
Area of sand wave excavation for inter-array cables	59,014m²
Area of sand wave excavation for export cables	468,000m²
Area of scour protection for inter-array cables	60,319m²
Area of scour protection for substation	1,257m²
Area of scour protection for export cables	145,040m²
Total	950,384m²

202. The total worst-case scenario area for permanent habitat loss is 950,384m² (0.95km²). This represents 0.01% of the Fish and Shellfish Ecology Study Area (7,426km²), and 1.76% of the total area available to fish and shellfish within the Maximum Footprint Area (54.08km²).

203. Permanent habitat loss is most likely to impact species with demersal life stages and/or have limited mobility. It may also impact species which do not have a direct relationship with the seabed, but prey on species that will be impacted by this effect.

204. The species found across the Fish and Shellfish Ecology Study Area are typical of the species found within the Celtic Sea, and there is no evidence suggesting rare or unique habitat relating to Fish and Shellfish Ecology. A number of fish and shellfish species have been identified as having spawning and nursery grounds within the Fish and Shellfish Ecology Study Area, across a number of receptor groups.

205. Adult individuals within the Fish and Shellfish Ecology receptor groups have varying degrees of mobility, allowing for the displacement from lost habitat. Populations are, therefore, unlikely to undergo any significant change as a result of permanent habitat loss and disturbance at the scale described within **Table 11.24**. Whilst impacts to existing eggs and larvae are more likely to impact local populations, permanent loss is of limited extent compared to the total volume of habitat available within the Fish and Shellfish Ecology Study Area. The permanent loss of the spawning/nursery grounds themselves are more likely to reduce the fecundity (reproductive capability) of the local population due to the multi-cohort impact that this may result in, resulting in an increased impact magnitude.

206. Elasmobranch species including spotted ray, thornback ray and tope shark are all identified within Ellis *et al.* (2012) as having low intensity spawning grounds within the Fish and Shellfish Ecology Study Area. Each of these species is also identified as having similar spawning grounds within the wider region, but outside of the Fish and Shellfish Ecology Study Area. Basking shark are highly mobile, with the distribution driven primarily by the distribution of prey species within the water column (Sims and Merrett, 1997; Sims and Quayle, 1998). Primary foraging habitat loss, due to the presence of structures within the water column, will likely occur for basking shark due to their restricted agility. If required, minor adjustments to distribution will allow basking shark to continue with established foraging behaviour within the rest of the WTG array. Barrier effects are closely related to permanent habitat loss for elasmobranchs, and have been assessed separately in **Section 11.6.5**.

207. Demersal species including anglerfish, cod, sole, plaice, sandeel and whiting are all indicated within Ellis *et al.* (2012) and/or Coull *et al.* (1998) to have low intensity nursery grounds, and both high and low intensity spawning grounds, within the Fish and Shellfish Ecology Study Area. Each of these species is also identified as having similar spawning grounds within the wider region, but outside of the Fish and Shellfish Ecology Study Area. Permanent habitat loss may impact all demersal

species, particularly sandeel. Sandeel species are dependent on specific substrates (as identified in **Section 11.4.1**) and will likely be impacted by permanent habitat loss to a greater extent than other demersal species.

208. Species within the pelagic receptor group have pelagic spawning strategies independent of local substrate and are, therefore, not impacted by permanent habitat loss at the seabed. Atlantic herring is dependent on specific substrates (as identified in **Section 11.4.1**) and will likely be impacted by permanent seabed habitat loss to a greater extent than other pelagic species.

209. Migratory species including Atlantic salmon, sea trout, European eel, river lamprey, sea lamprey, allis shad, and twaite shad are diadromous and mostly anadromous, therefore no spawning grounds are located within the Fish and Shellfish Ecology Study Area and the Maximum Footprint Area. As such, seabed habitat loss is unlikely to impact migratory species. Water column loss may, however, impact species, as it may decrease the available swimming space along migratory routes. Volumetric loss is not expected to impact migratory species at the scale associated with floating offshore windfarms.

210. Shellfish species have varied spawning strategies, however, due to their limited mobility in comparison to fish species, all species within the receptor group will be assessed as having 'demersal' spawning grounds linked to species distribution throughout the inshore waters of the Fish and Shellfish Ecology Study Area. As such, there is potential for a reduction in fecundity for the local population.

11.6.1.1 Magnitude of impact

211. The magnitude of impact associated with permanent habitat loss is based on the worst-case scenario of direct and permanent seabed and water column loss within the Maximum Footprint Area. This represents approximately 0.95km² of seabed, 1.76% of the Maximum Footprint Area, and 0.01% of the Fish and Shellfish Ecology Study Area. Therefore, the magnitude of permanent habitat loss is considered low.

11.6.1.2 Sensitivity of the receptor

212. Elasmobranch species are tolerant of, and adaptable to, natural changes in distributions of prey species, due to their mobility and varied diets. The species identified within the Fish and Shellfish Ecology Study Area are not bound by localised habitats to the same degree as their prey species. Some smaller demersal elasmobranch species are more likely to experience impacts due to permanent habitat loss, however this remains unlikely at the worst-case scenario scale within

the Maximum Footprint Area. Therefore, elasmobranch species are considered to have a **Low** sensitivity to permanent habitat loss.

213. Demersal and pelagic species are predominantly mobile and are, therefore, considered slightly tolerant of, and therefore adaptable to, permanent habitat loss in the water column. However, it is acknowledged that both sandeel and Atlantic herring have elevated sensitivity to this impact, due to specific life history/spawning strategies. Whilst modelling suggests that neither of these species has significant areas of high habitat/spawning potential within the Maximum Footprint Area (0.02% for sandeel and no high spawning potential for Atlantic herring), demersal and pelagic species are considered to have a **Medium** sensitivity to permanent habitat loss.

214. Migratory species are likely to transit through the area midwater, therefore a volumetric loss of swimming space due to physical substructures has the potential to disrupt migration routes. The worst-case scenario scale associated with floating offshore windfarms is unlikely to impact these species, which are mobile enough to avoid substructures and continue along migration routes. Therefore, migratory species are considered to have a **Low** sensitivity to permanent habitat loss.

215. Shellfish species are less mobile and have less tolerance and adaptability to permanent habitat loss in comparison to the other receptor groups. However, shellfish fecundity is often extremely high and, therefore, the population is unlikely to experience any significant decline. The impact is further reduced by the worst-case scenario scale in the context of the Fish and Shellfish Ecology Study Area (0.01%). Therefore, shellfish are considered to have a **Low** sensitivity to permanent habitat loss.

11.6.1.3 Significance of effect

216. The low magnitude of impact, combined with the low to medium sensitivity of all fish and shellfish receptor groups, results in the impact of permanent habitat loss having a **Minor Adverse** effect, and is therefore **Not Significant** in EIA terms.

11.6.1.4 Further Mitigation

217. The assessment of minor adverse and non-significant impact of temporary habitat loss/physical disturbance enables the conclusion that **No Further Mitigation** is required.

11.6.2 Impact 2: Temporary increased suspended sediments and sediment deposition

218. Seabed sediments have the potential to be temporarily suspended in the water column and re-deposited as a result of activities related to the operation or maintenance (including any possible required repairs) of the Offshore Project. However, the magnitude of effects of increased suspended sediment concentration and sediment deposition are determined to be less than those that are predicted to arise during the construction and installation phase of the Offshore Project.

11.6.2.1 Magnitude of impact

219. As assessed in **Section 11.5.2**, the magnitude of suspended sediment concentration and sediment deposition is determined to be low.

11.6.2.2 Sensitivity of the receptor

220. All adult fish receptor groups (pelagic; demersal; migratory; elasmobranch) are determined to have a **Negligible** sensitivity to suspended sediments and sediment deposition, while larval/egg stages and shellfish receptor groups are classified as having a **Medium** sensitivity.

11.6.2.3 Significance of effect

221. Due to the low magnitude of impact and the negligible to medium sensitivities of fish and shellfish to the effects of suspended sediment and sediment deposition, these activities are assessed as having a **Minor Adverse** effect, which is **Not Significant** in EIA terms.

11.6.2.4 Further Mitigation

222. The assessment of minor adverse impact of temporary increased suspended sediments and sediment redeposition enables the conclusion that **No Further Mitigation** is required.

11.6.3 Impact 3: Underwater noise and vibration

223. During operation, underwater noise is expected to be produced via transit of service and maintenance vessels, through cable snapping, and through mechanically generated vibrations from moving turbines. A full assessment of these underwater noises can be found in **Chapter 12 Appendix 12.A**.

224. The primary source of underwater noise from operational WTGs is considered to be mechanically generated vibration from the rotating machinery in the turbines, transmitted into the water column through the structure of the turbine tower and any foundations (Nedwell *et al.*, 2003; Tougaard *et al.*, 2020). For modelling, it is assumed that turbines are operational for 24hr per day. Noise generated above the surface of the water is not expected to pass from air to the water column.

225. The radiating source for a floating turbine is limited to the weighted and buoyant section beneath the sea surface, which is a significantly smaller area than that of a fixed turbine. The noise output is therefore predicted to be lower, however there is the possibility of additional noise from mooring cables. Although this noise source is speculative, sound generated through cable 'snapping' has also been assessed.

226. Cable 'snapping' has been identified at a rate of up to 23 snaps per day, with <10 snaps exceeding 160dB (SPL_{peak}) on most days (JASCO, 2011). The precise source of this noise is unclear, and is not predicted at the Offshore Project, however modelling predicts that under worst-case scenarios (e.g. all turbines producing the maximum number of snaps in a day) the noise level is below any SPL_{peak} PTS or injury criteria for fish.

11.6.3.1 Magnitude of impact

227. The magnitude of impact associated with underwater noise and vibration during operation and maintenance is based on the primary source of underwater noise, that of mechanical noise from spinning turbines. At White Cross, the worst-case scenario of noise output from an 18MW turbine is predicted to be 132dB (SPLRMS) at 150m from the largest proposed turbine, for a turbine running 24hr per day. This output increases to 136dB (SPLRMS) at 100m, or 160dB (SPLRMS) at 10m.

228. Multiple turbines operating simultaneously throughout the array will compound underwater noise within the windfarm boundary, however it has been shown that any additive noise impact will be minimal. For example, if the noise was 136dB (SPL_{RMS}) at 100m from an operational WTG, and the nearest turbine was separated by 1km (approximate minimum separation, actual separations vary between designs), then the predicted noise level contribution from the adjacent turbine would be 24dB lower, which combined, would contribute less than 0.1dB to the overall noise from the closest turbine. For cable 'snapping', there are no currently recommended noise thresholds for disturbance of receptors to rare, intermittent, impulses of this type. However, as 'snapping' occurs at an average of less than one snap per hour, disturbance from this source is considered minimal. Therefore, the magnitude of underwater noise and vibration during operation is considered **Low**.

11.6.3.2 Sensitivity of the receptor

229. Based on criteria from Popper *et al.* (2014) for continuous noise, the TTS threshold of 158dB (SPL_{RMS}) would require an individual receptor to be present within 20m of the turbine for a period of 12hrs. As the noise source is near the surface, and water depths within the array are in the order of 75 m, this is considered a very low risk. Furthermore, studies have demonstrated that fish populations in the vicinity of

offshore windfarms have actually increased in certain cases (Stenberg *et al.*, 2015). Colonisation of wind turbine foundations by shellfish species is also well documented (Kerckhof *et al.*, 2010; Krone *et al.*, 2013). Therefore, fish and shellfish species are considered to have a **Low** sensitivity to operational and maintenance noise and vibration.

11.6.3.3 Significance of effect

230. Due to the low magnitude of impact, and the low sensitivities of fish and shellfish to the effects of underwater noise and vibration, these activities are assessed as having a **Minor Adverse** effect, which is **Not Significant** in EIA terms.

11.6.3.4 Further Mitigation

231. The assessment of minor adverse impact of underwater noise and vibration enables the conclusion that **No Further Mitigation** is required.

11.6.4 Impact 4: Electromagnetic fields

232. Electromagnetic fields (EMFs) occur as a result of electricity transmission through conductive objects, such as transmission cables, and comprises an electric field (E field) and a magnetic field (B field). The electromagnetic attributes of EMFs have the potential to disrupt organs used for navigation and foraging within a number of species. EMFs can have attractive and repulsive effects, that can cause barrier effects dependent on the species and the spatial scale of EMF. In the context of submarine transmission cables, it is well known that EMF strength dissipates rapidly, from 7.85μT at 0m, to 1.47μT at 4m, from the average windfarm inter-array cable buried 1m below the seabed (Normandeau *et al.*, 2011). For perspective, the earth's magnetic field has an estimated background magnitude of 25-65μT (Hutchinson *et al*, 2020). EMF interaction with solids such as the seabed sediment introduces a localised heating effect which, potentially, introduces both positive and negative barrier and fish aggregation effects. However, this will be of small magnitude (maximum of 5.5°C), dissipated within tens of cm from the cable's outer insulating layer, and is therefore unlikely to present additional impact (Boehlert and Gill, 2010; National Grid and Energinet, 2017; Moray Offshore Windfarm Ltd, 2018). There is no E field present outside the insulating layer of all cables.

233. The worst-case maximum EMF magnitude and spatial extent predicted to potentially impact fish and shellfish is presented within **Table 11.25**. The spatial extent of impact has been determined as the cylindrical volume of water surrounding the cable in which EMF is elevated above baseline conditions. There has been limited research specific to EMF in the water column, however it has been determined that

EMF becomes undetectable at 4m from the cable in seawater, as per Normandeau *et al*. (2011). A semi-cylindrical volume of EMF has been assumed for the export cable laid on the seabed[3]. For inter-array cable, a cylindrical volume has been used for the length of suspended inter-array cable, as the remainder of the cable will not be directly exposed to the water column.

Table 11.25 Worst-case extent of electromagnetic fields during operation.

Potential Pathway	Worst-case Scenario
Radius of inter-array cable	0.15m
Radius of export cable	0.15m
Total length of suspended inter-array cable (suspended in water column)	2,200m
Total length of buried inter-array cable (minimum 0.5m)	22,000m
Total length of buried export cable (minimum 0.5m)	187,200m
Maximum detectable distance of EMF surrounding cables	4m
Maximum volume of water in the water column containing identifiable EMF from suspended inter-array cable	118,878m³
Maximum volume of water containing identifiable EMF from buried inter-array cable (0.5m)	453,679 m³
Maximum volume of water containing identifiable EMF from buried export cable (0.5m)	4,289,333m³
Total volume	4,861,8904m³

234. The worst-case volume for inter-array cables is 572,557m³, representing <0.005% of the volume available to fish within the array boundary, of 3.48km³. This value is the total area of the array multiplied by the average depth across the array (70.5m), assuming a level seabed.

235. The worst-case volume for export cables is 4,289,333m³, representing ~2.6% of the volume available to fish within the export cable route corridor (~168,000,000m³). This value is the total area of the 25m wide cable route corridors for 2 export cables multiplied by a linear gradient in depth from a maximum depth of 72m (the maximum Windfarm Site depth) to a minimum depth of 0m at landfall

[3] This assumes the cable is laying on the seabed with no cable protection. This would not be a realistic scenario, with the majority of cable buried in the seabed or under cable protection systems and, therefore, having a reduced effect in the context of fish and shellfish ecology.

(up to MHWS), creating an assumed polyhedron 'wedge' of water above the cable in which fish and shellfish[4] will be present.

236. The total worst-case scenario volume for EMF effects caused by all transmission cables is 4,861,890m³. This represents 0.25% of volume (again determined by the 'wedge' method) available to fish and shellfish within the Maximum Footprint Area (~1,950,000,000m³).

11.6.4.1 Magnitude of impact

237. The magnitude of impact associated with EMFs is based on the worst-case scenario of a 4m radius zone around all array cables, and a 4m radius semi-circular zone around both export cables within the Maximum Footprint Area. The greatest magnitude of impact will be in direct contact with cables, most likely the suspended array cables, in which the maximum EMF magnitude is <50µT. As each turbine has an input and output array cable, the magnitude is compounded throughout the array, however the area of impact is very low in comparison to the total available space, representing just 0.25% of available space within the water column across the Maximum Footprint Area. The cable interacting with the seabed will be buried to a minimum of 0.5m as assessed here but will likely be buried deeper in some regions further reducing EMF within the water column. The buried cable, either within the seabed or under rock protection, will result in a negligible impact zone for fish and shellfish when considered at a population level. Therefore, the magnitude of EMF is considered **Low**.

11.6.4.2 Sensitivity of the receptor

238. Elasmobranch species are thought to be the most sensitive receptor group to EMFs, due to sensory organs such as the Ampullae of Lorenzini, used to detect EMFs produced by prey movement and for navigation. Basking shark have been shown to utilise electroreception to detect nutrient-rich waters for foraging, however the extent of this is unknown (Sims and Quale, 1998; Kempster and Collin, 2011). Whilst it has not been confirmed, the detection of EMFs will likely cause an attractive effect for basking shark, as opposed to a barrier effect, dependent on the EMF magnitude. EMF detection is also thought to regulate egg case flushing in thornback ray, where tail-beating ceases in the presence of potential predators (Ball *et al.*, 2015). It is

[4] Buried shellfish have assumed to be at the seabed surface, which has been deemed appropriate by the assumption that the depth gradient along the cable route corridor is linear (and therefore the total volume will likely include some seabed), and the assumption that no part of the export cable is buried.

possible that fluctuating EMFs, typical of windfarm cables, may reduce egg case oxygenation and stunt juvenile development, or increase the predation rate through habituation and consequent desensitization. Thornback ray and other ray species regularly spawn in the Bristol Channel and are potentially at risk along the export cable route. Therefore, elasmobranch species are considered to have a **Medium** sensitivity to EMFs.

239. Most demersal, pelagic, and migratory species have a lower susceptibility to EMF, as they lack sensitive electroreceptors seen in elasmobranch species. These species are also small and mobile, and can, therefore, respond to areas of elevated EMF by moving away from the area if required. Some migratory species, such as European eel, are thought to utilise magnetic fields during homing behaviour, and exhibit behavioural responses to EMFs at magnitudes of 10 greater than those expected by the Offshore Export Cable and inter-array cables (Eden Environment Ltd, 2017; Westerberg and Lagenflet, 2008). The likelihood of effect is low, as the majority of EMF effect will occur under the seabed, and the volume of effect within the water column available to migratory fish within the Maximum Footprint Area is negligible. Therefore, demersal, pelagic, and migratory species are considered to have a **Low** sensitivity to EMFs.

240. Shellfish species have been shown to respond to EMFs in numerous ways, including both physiological and behavioural responses that are species specific. Many of the available studies undertaken to investigate EMF effects on marine fauna to date have been undertaken under laboratory conditions, and often utilised magnetic fields of significantly greater magnitude than are anticipated for the Offshore Development Area. Comparisons will therefore be made between EMF magnitude used in each given study, and EMFs from submarine transmission cables from the average windfarm inter-array cable buried 1m below the seabed, 7.85μT (average cable EMF) (Normandeau *et al.*, 2011).

241. Edible crabs have been shown to respond to EMFs of 500-1,000μT, but show limited responses to EMF magnitudes of 250μT (Scott *et al.*, 2021), approximately 31 times higher than average cable EMF .

242. Studies on European lobster indicate differing results between studies. Taormina *et al.* (2019) shows no responses to EMFs of 200μT. However, European lobster have been shown to undergo behavioural change, increasing their proportion of large turns and decreasing their height above the seabed in the presence of EMF up to 65.3 μT, approximately 8 times higher than average cable EMF (Hutchinson *et al.*, 2020). Reduced larval development success for European lobster has been shown following exposure to EMFs of 2.8mT (Harsanyi *et al.*, 2022). This value of 2.8mT is

approximately 350 times greater than average cable EMF. Based on currently available literature physiological impacts on shellfish species are not anticipated until a 350 times increase in EMF magnitude, and behavioural changes are not anticipated until an 8 times increase in EMF magnitude. Therefore, shellfish species are considered to have a **Negligible** sensitivity to EMFs.

11.6.4.3 Significance of effect

243. The low magnitude of impact, combined with the negligible to medium sensitivity of all fish and shellfish receptor groups, results in the impact of EMFs having a **Minor Adverse** effect, and is therefore **Not Significant** in EIA terms.

11.6.4.4 Further Mitigation

244. The assessment of minor adverse and non-significant impact of EMFs enables the conclusion that **No Further Mitigation** is required.

11.6.5 Impact 5: Barrier effects

245. Barrier effects occur from a number of sources, including suspended sediment plumes, noise, electromagnetic fields, and anthropogenic structures within the water column. As such, the barrier effects due to suspended sediment plumes, noise, and electromagnetic fields (EMFs) have been assessed in **Section 11.5.2**, **Section 11.5.3**, and as part of the operation and maintenance impact pathway in **Section 11.6.3** respectively.

246. Physical barrier effects due to operation and maintenance will be similar to those occurring during construction, with the exception of any future plans to lay additional cable protection on the seabed. This activity will decrease the opportunity of some species to move between sites straddling the protection and, therefore, present a slightly elevated risk of barrier effects for demersal fish and shellfish species.

247. The worst-case scenario for barrier effects during the operation and maintenance phase of the Offshore Project is similar to the worst-case scenario for barrier effects during the construction phase, outlined in **Table 11.23** and **Section 11.5.4**.

11.6.5.1 Magnitude of impact

248. As determined within **Section 11.5.4**, the magnitude of impact associated with barrier effects is based on the worst-case scenario of water volume lost within the Offshore Development Area. This represents approximately 327,865.07m^3, constituting 0.01% of the Offshore Development Area. Therefore, the magnitude of barrier effects is considered **Negligible**.

11.6.5.2 Sensitivity of the receptor

249. The sensitivity of elasmobranch, demersal, pelagic, migratory and shellfish species to barrier effects is determined in full within **Section 11.5.4**, with sensitivities determined to range between **Negligible** and **Low**.

11.6.5.3 Significance of effect

250. The negligible magnitude of impact, combined with the negligible to low sensitivity of all fish and shellfish receptor groups, results in the impact of barrier effects having a **Negligible** effect, and is therefore **Not Significant** in EIA terms.

11.6.5.4 Further Mitigation

251. The assessment of minor adverse and non-significant impact of barrier effects enables the conclusion that **No Further Mitigation** is required.

11.6.6 Impact 6: Fish aggregation effects

252. The introduction of physical substructures associated with offshore windfarms will cause fish aggregation effects over time (Wilhelmsson *et al*., 2006). Physical structures provide a foundation for settling invertebrates, which increase the organic matter surrounding the structure, and underpin artificial reef ecosystems through 'bottom-up' control of productivity. Increasing nutrient availability and biomass presents opportunities for all fish and shellfish species, from top predators to detritivores (Raoux *et al*., 2017).

253. In some instances, fish aggregation effects can be detrimental to the health of offshore ecosystems. For example, the additional settlement opportunity provided by anthropogenic structures often leads to an increase in invasive and rare species, increasing nutrient load beyond natural variation, and potentially the 'absorption' of fringe populations that increases short-term 'barrenness' of surrounding habitats. It is not likely that the small spatial scale of fish aggregating device (FADs) effects associated with the WTG floating substructures will have significant 'absorbing' effects.

254. Structures provide an increase in habitat complexity by increasing opportunities for shelter and increasing microhabitat diversity. Fish aggregation effects have been observed in multiple offshore industries, including monopile foundation WTG arrays (Raoux *et al*., 2017; Rouse *et al*., 2017). Floating windfarms, generally, have a reduced extent of physical structures that extend throughout the water column, limited to the OSP, anchoring/mooring chains, and transmission cables. As such, the

scale of fish aggregation effects will be reduced compared to other subsea industries (Linley *et al.*, 2007).

255. The worst-case scenario for fish aggregation (assumed to occur within the same volume of water as barrier effects) during the operation and maintenance phase of the Offshore Project is similar to the worst-case scenario for barrier effects during the construction and operation and maintenance phases, outlined in **Table 11.23**. This equates to 3327,865.07m^3, or 0.01% of the Offshore Development Area. For further information, refer to the barrier effect **Section 11.5.4** and **Section 11.6.5**.

256. Fish aggregation, over time, has the potential to increase the frequency of vessel collision during the maintenance phase of the Offshore Project. Whilst most species will not be affected, larger species such as basking shark may be susceptible to this secondary impact, as a result of spending greater time foraging in surface waters within and surrounding the array.

11.6.6.1 Magnitude of impact

257. The magnitude of impact associated with barrier effects and fish aggregation is based on the worst-case scenario of the volume of water column loss within the Offshore Development Area. This represents approximately 327,865.07m^3, constituting 0.01% of the Offshore Development Area. Due to the small scale of infrastructure that traverses the entire water column, the 'absorption' of individuals from fringe habitats, particularly demersal and bentho-pelagic species, will be of negligible significance compared to the potential effects of other offshore developments. There is greater opportunity for aggregation around the OSP's foundations, due to the lattice-like structure that provides shelter from larger predators. However, the use of only one substation is unlikely to have a significant effect during the lifetime of the Offshore Project. Therefore, the magnitude of barrier effects and fish aggregation is considered **Negligible**.

11.6.6.2 Sensitivity of the receptor

258. Elasmobranch species vary in their ability to interact with structures, with most species present in the Fish and Shellfish Ecology Study Area being capable of transiting within, and around, the substation and substructures with limited additional energy burden. Therefore, elasmobranch species are both tolerant of, and adaptable to, fish aggregation effects. Basking sharks are unlikely to aggregate within the array, as substructures are unlikely to cause elevated primary productivity through nutrient upwelling. Predatory elasmobranch species may benefit from the slight increase in prey availability caused by fish aggregation effects. However, this is likely to be limited, due to the small spatial scale of the Offshore Project.

Therefore, elasmobranch species are considered to have a **Negligible** sensitivity to fish aggregation effects.

259. Most pelagic, demersal, and migratory species are highly mobile and agile, and are therefore both tolerant of, and adaptable to, fish aggregation effects. Demersal fish are likely to increase in abundance in the vicinity of structures on the seabed (Wilhelmsson *et al*., 2006), however a consequent increase in predator density may have a negative effect on the local populations of small prey species (Leitão *et al*., 2008). In this case, the reduction in prey species due to short-term focussed predation may, in-turn, limit the predator aggregation effect, but the increased predation rate is unlikely to occur at a significant level in the context of the Offshore Project's scale and could be considered negligible. However due to a level of uncertainty, as a precautionary measure , pelagic, migratory, and demersal species are considered to have a **Low** sensitivity to fish aggregation effects.

260. Shellfish species have a low mobility and are naturally restricted to their immediate settlement area. However the addition of structures within the water column increases the opportunity for encrusting species (such as blue mussel) to settle (Wilhelmsson *et al*., 2006). In addition, many shellfish species are detritivores or suspension feeders, and will benefit from the accumulation of nutrients associated with fish aggregation effects. However, as stated above, predation densities may increase as a result of the aggregation effect, but is unlikely due to the limited extent of substructures that traverse the entire water column and the scale of the Offshore Project. Therefore, shellfish are considered to have a **Low** sensitivity to fish aggregation effects as a precautionary measure.

11.6.6.3 Significance of effect

261. The negligible magnitude of impact, combined with the negligible to low sensitivity of all fish and shellfish receptor groups, results in the impact of fish aggregation effects having a **Negligible** effect, and is therefore **Not Significant** in EIA terms.

11.6.6.4 Further Mitigation

262. The assessment of minor adverse and non-significant impact of fish aggregation effects enables the conclusion that **No Further Mitigation** is required.

11.6.7 Impact 7: Ghost fishing

263. Ghost fishing refers to the trapping/entanglement of individuals within man-made debris, most commonly abandoned, lost, or discarded fishing gear (ALDFG) (Richardson *et al*., 2019). In the context of the Offshore Project, ALDFG may drift onto mooring lines. Ghost nets are a well-known cause of mortality in all fish and

shellfish receptor groups, however the degree of impact is dependent on the size and location of ALDFG. For example, elasmobranch and pelagic species may be impacted by free-floating netting and hooks within the water column, or caught on infrastructure in mid-water. Demersal and shellfish species are more likely to be impacted by ALDFG on, or near, the seabed (such as pots and traps), and nets caught on structures such as anchors/moorings, surface-laid cables and cable protection, and the base of the OSP. Elasmobranch species are at an elevated risk of entanglement in ALDFG due to their size, with ALDFG causing 74% of entanglement observations in published literature (Parton *et al.*, 2019). It is thought that lost static gear such as pots and traps have a low impact due to the relatively high retrieval rate, and the possibility of escape for most species that may reduce mortality (Brown and Macfadyen, 2007).

264. Ghost fishing, typically, has a reduced impact on fish populations in comparison to targeted fishing, particularly in the case of lost trawling nets, as nets are often tangled and have a reduced area of coverage compared to their normal use within the fishing industry. In addition, ghost fishing has a reduced degree of selectivity, and may impact all receptor groups (including mammals and birds) for an extended period of time, exceeding that of normal industry use. The passive nature of ALDFG such as trawling nets may elevate this risk due to a fish aggregating effect, particularly of predatory species that are attracted to trapped carcasses, and which may themselves be trapped/entangled.

265. A worst-case scenario for this impact is difficult to determine due to the unknown location and likelihood of lost gear entering the array at any point in time. Data can be inferred from multiple sources, including fisheries data (Piet *et al.*, 2021) and charitable citizen science, however this is not likely to be sufficiently representable within the Windfarm Site. Annual monitoring of anchor/moorings will be undertaken during the lifetime of the Offshore Project. Remotely operated vehicles (ROVs) will be used to identify any entanglement hazards such as ALDFG snagged on Project substructures.

11.6.7.1 Magnitude of impact

266. The magnitude of impact associated with ghost fishing is based on the continuous monitoring of Project substructures for the presence of ALDFG and other potential entanglement hazards. If identified, these hazards will be removed as part of the maintenance of the Offshore Project’s infrastructure during the operational phase. Therefore, the magnitude of ghost fishing is considered **Negligible**.

11.6.7.2 Sensitivity of the receptor

267. ALDFG associated with ghost fishing has the potential to cause entanglement and mortality for all receptor groups. As such, elasmobranch, pelagic, demersal, migratory, and shellfish species are all considered intolerant to ghost fishing. Therefore, all species within the fish and shellfish receptor groups are considered to have a **High** sensitivity to ghost fishing.

11.6.7.3 Significance of effect

268. The negligible magnitude of impact, combined with the high sensitivity of all fish and shellfish receptor groups, results in the impact of ghost fishing having a **Minor Adverse** effect, and is therefore **Not Significant** in EIA terms.

11.6.7.4 Further Mitigation

269. The assessment of minor adverse and non-significant impact of ghost fishing enables the conclusion that **No Further Mitigation** is required.

11.7 Potential impacts during decommissioning

270. No decision has been made regarding the final decommissioning policy for the Offshore Project as it is recognised that industry best practice, rules and legislation change over time. The decommissioning methodology would be finalised nearer to the end of the lifetime of the Offshore Project to be in line with current guidance, policy and legalisation at that point. Any such methodology would be agreed with the relevant authorities and statutory consultees. The decommissioning works are likely to be subject to a separate licencing and consenting approach.

271. The anticipated decommissioning activities are outlined in **Section 5.10** of **Chapter 5: Project Description**. The potential impacts of the decommissioning of the Offshore Project have been assessed for fish and shellfish ecology on the assumption that decommissioning methods will be similar or of a lesser scale than those deployed for construction. The types of impact would be comparable to those identified for the construction phase:

- Impact 1: Temporary habitat loss/physical disturbance
- Impact 2: Temporary increased suspended sediments and sediment deposition
- Impact 3: Underwater noise and vibration
- Impact 4: Barrier effects

272. The significance of impacts would be comparable to or less than those identified for the construction phase. Accordingly, given the construction phase assessments concluded "no effect" or "negligible adverse effect" for fish and shellfish ecology

receptors, it is anticipated that the same would be valid for the decommissioning phase regardless of the final decommissioning methodologies. For example, noise impacts will be lower (as piling is unlikely). Should it be determined appropriate for cables to be left *in situ*, there will be reduced seabed disturbance. Where differences are identified at the time of decommissioning, these will be identified and assessed.

273. Therefore, **Minor Adverse** effects are expected as a maximum case, which are **Not Significant** in EIA terms.

274. The assessment of minor adverse and non-significant cumulative effect of fish aggregation enables the conclusion that **No Further Mitigation** is required.

11.8 Potential cumulative effects

275. The approach to cumulative effect assessment (CEA) is set out in **Chapter 6: EIA Methodology**. Only projects which are reasonably well described and sufficiently advanced to provide information on which to base a meaningful and robust assessment have been included in the CIA. Projects which are sufficiently implemented during the site characterisation for the Offshore Project have been considered as part of the baseline for the EIA. Where possible OWL has sought to agree with stakeholders the use of as-built project parameter information (if available) as opposed to consented parameters to reduce over-precaution in the cumulative assessment. The scope of the CIA was therefore be established on a topic-by-topic basis with the relevant consultees.

276. The cumulative effect assessment for Fish and Shellfish Ecology was undertaken in two stages. The first stage was to consider the potential for the impacts assessed as part of the project to lead to cumulative effects in conjunction with other projects. The first stage of the assessment is detailed in **Table 11.26**.

Table 11.26 Potential cumulative effect s considered for Fish and Shellfish Ecology

Impact	Potential for cumulative effect	Rationale
Temporary and permanent habitat loss/physical displacement	Yes	Limited to the direct footprint of the Development Area, however potential for a change in significance in combination with concurrent works.
Increased suspended sediments and	Yes	Potential for concurrent works resulting in suspended sediments to occur during the construction and/or operations and maintenance phases of the Offshore Project.

Impact	Potential for cumulative effect	Rationale
sediment deposition		
Underwater noise and vibration	Yes	Works associated with the Offshore Project may overlap with the works on other developments within the region that also have the potential for underwater noise and vibration impacts.
Barrier Effects	No	Barrier effects on Fish and Shellfish receptors are of highly limited spatial extent and have been assessed as Negligible in Section 11.5.4 and Section 11.6.5.
Permanent habitat loss	Yes	Permanent habitat loss has the potential to reduce habitat availability, and in combination with other developments the significant of this impact has the potential to change.
Electromagnetic fields	Yes	EMF has the potential to result in changes to the behaviour and physiology in fish and shellfish receptors in high levels of exposure. Whilst exposure resulting from the Offshore Project is considered of Minor Adverse significance, this may change in combination with other developments.
Fish Aggregation	No	The assessment in concluded that the effect of fish aggregation as a result of the Offshore Project was Negligible in Section 11.6.6. This is consistent with the lack of substructures associated with floating OWFs, compared to other marine developments.
Ghost fishing	Yes	Whilst the magnitude of this impact is assessed as Negligible for the Offshore Project, the High sensitivity of all fish and shellfish receptor groups indicates a need to consider cumulative effects.

277. The second stage of the CIA is to evaluate the projects considered for the CIA to determine whether a cumulative effect is likely to arise. The list of considered projects (identified in **Chapter 6: EIA Methodology Section 6.6.11**) and their anticipated potential for cumulative effects are summarised in **Table 11.27**.

Table 11.27 Projects considered in the cumulative effect assessment on Fish and Shellfish Ecology

Project	Status	Distance from windfarm site (km)	Included in the CIA?	Rationale
WACS Subsea Cable	Active	0	Yes	Project within windfarm site
TGN Atlantic Subsea Cable	Active	0	Yes	Project within windfarm site
TAT-11 Subsea Cable	Decommissioned	0.26	Yes	Project within 50km of windfarm site
Milford Haven Industrial Disposal Site	Closed	1.62	Yes	Project within 50km of windfarm site
Apollo Subsea Cable	Active	7.61	Yes	Project within 50km of windfarm site
TGN Western Europe Subsea Cable	Active	11.19	Yes	Project within 50km of windfarm site
Arctic Fibre Subsea Cable	Proposed	12.71	Yes	Project within 50km of windfarm site
French Telecommunications Cable 328 Subsea Cable	Active	13.62	Yes	Project within 50km of windfarm site
Llŷr 2Proposed FLOW Lease Area 1 Offshore Wind	Proposed	16.05	Yes	Project within 50km of windfarm site
Llŷr 1	Proposed	16.86	Yes	Project within 50km of windfarm site
Valorous Offshore Wind	Proposed	19.12	Yes	Project within 50km of windfarm site
AC-2 Subsea Cable	Active	23.76	Yes	Project within 50km of windfarm site

Project	Status	Distance from windfarm site (km)	Included in the CIA?	Rationale
TAT-14 Subsea Cable	Decommissioned	28.03	Yes	Project within 50km of windfarm site
Proposed FLOW Lease Area 17 Offshore Wind	Proposed	31.62	Yes	Project within 50km of windfarm site
SOLAS Subsea Cable	Active	31.62	Yes	Project within 50km of windfarm site
Erebus Offshore Wind	Planning	33.23	Yes	Project within 50km of windfarm site
GLO1 Subsea Cable	Active	35.99	Yes	Project within 50km of windfarm site
EIG Subsea Cable	Active	36.62	Yes	Project within 50km of windfarm site
Hartland Point Disposal Site	Closed	48.98	Yes	Project within 50km of windfarm site

278. It is noted that the first project listed is the Town and Country Planning Application for the onshore elements of the White Cross OWF which are a separate element to the offshore Section 36 consent application for which this ES is prepared. The specific combined project elements are assessed cumulatively first and then cumulatively with all other projects.

11.8.1 Cumulative Impact 1: Temporary and permanent habitat loss/physical displacement

279. Temporary and permanent habitat loss/physical displacement is limited to the direct footprint of the Development Area, and is therefore relevant for overlapping projects or those in close proximity to the Development Area. As such, the projects within 10km have been screened in for the assessment of this impact, including WACS, TGN Atlantic, TAT-11, Milford Haven Industrial, and Apollo. Cumulative temporary and permanent habitat loss/physical disturbance are only likely to occur during

infrequent maintenance of the subsea cables, as the Milford Haven Industrial disposal site is closed.

11.8.1.1 Significance of effect

280. The cumulative effect of temporary and permanent habitat loss/physical disturbance is considered **Minor Adverse** and is therefore **Not Significant** in EIA terms.

11.8.1.2 Further Mitigation

281. The assessment of minor adverse and non-significant cumulative effect of temporary and permanent habitat loss/physical disturbance enables the conclusion that **No Further Mitigation** is required.

11.8.2 Cumulative Impact 2: Increased suspended sediments and sediment deposition

282. Increased magnitude of impact of suspended sediments and sediment deposition as a result of cumulative effects during the construction phase is a possibility. However, suspended sediment and sediment deposition effects as a result of these activities are not predicted to expand significantly beyond the extents of the Offshore Project boundaries. Furthermore, the majority of suspended sediment is likely to clear within several tidal cycles, therefore any cumulative works would need to occur within this same period. Similarly, suspended sediments during operation are predicted to arise only during repair and remediation works, and will dissipate within several tidal cycles, it is unlikely there will be any cumulative effect.

11.8.2.1 Significance of effect

283. The cumulative effect of suspended sediments and sediment deposition is considered **Minor Adverse** and is therefore **Not Significant** in EIA terms.

11.8.2.2 Further Mitigation

284. The assessment of minor adverse and non-significant cumulative effect of increased suspended sediments and sediment deposition enables the conclusion that **No Further Mitigation** is required.

11.8.3 Cumulative Impact 3: Underwater noise and vibration

285. The construction of the Offshore Project is unlikely to coincide with the construction of subsea telecommunications cable laying, but may overlap with the construction of the Valorous project. No overlap with the Milford Haven Industrial aggregate disposal site is expected, as this site has been closed. No overlap with other OWFs

is expected during the construction phase, as the Offshore Project is likely to be in operation by this time.

286. The operation and maintenance of the Offshore Project is likely to coincide with the operation and maintenance of subsea telecommunications cable laying, and multiple floating OWFs such as the Valorous and Erebus projects and, potentially, the construction of other projects assigned to the 3 proposed lease areas north of the Offshore Project. The assessment of underwater noise and vibration in **Section 11.5.3** concluded that the magnitude of effect for the Offshore Project is low, which has been assumed as the magnitude of impact during the construction of future floating OWFs. Operational noise is considered negligible, and noise during maintenance of the Offshore Project will be of lower magnitude than the construction of the Offshore Project.

287. It is expected that the magnitude of operational and maintenance-associated noise will not increase due to the cumulative operation and maintenance of multiple floating OWFs. In addition, the operational noise of the Offshore Project will likely be exceeded by noise associated with the construction of future floating OWFs, which does not constitute a cumulative increase in the magnitude of noise as a direct result of the Offshore Project. Cumulative impact of the Offshore Project will only occur when any maintenance work of the Offshore Project is conducted simultaneously with any construction/maintenance work of other projects.

11.8.3.1 Significance of effect

288. As such, the cumulative effect of underwater noise and vibration is considered **Minor Adverse** and is therefore **Not Significant** in EIA terms.

11.8.3.2 Further Mitigation

289. The assessment of minor adverse and non-significant cumulative effect of underwater noise and vibration enables the conclusion that **No Further Mitigation** is required.

11.8.4 Cumulative Impact 4: Permanent habitat loss

290. At the end of the construction phase, the worst-case scenario of permanent habitat loss/physical disturbance is approximately 982,273m² (0.98km²), assuming that temporary habitat loss/physical disturbance due to the construction of the Offshore Project has recovered to baseline conditions prior to the operation and maintenance phase of the Offshore Project. This equates to 0.01% of the Fish and Shellfish Study Area, and is assessed as being No Significant within Section 11.6.1. In combination with developments provided in Table 11.27, the extent of total permanent habitat

loss is anticipated to remain at levels below those likely to result in an impact to the local fish and shellfish population. These effects are highly localised and represent only a small proportion of total available habitat for species within the region. Further, the high mobility and/or fecundity of many fish and shellfish species will allow for rapid recovery at a population level should impact result.

11.8.4.1 Significance of effect

291. Therefore, the cumulative effect of permanent habitat loss is considered **Minor Adverse** and is therefore **Not Significant** in EIA terms.

11.8.4.2 Further Mitigation

292. The assessment of minor adverse and non-significant cumulative effect of permanent habitat loss enables the conclusion that **No Further Mitigation** is required.

11.8.5 Cumulative Impact 5: Electromagnetic fields

293. Cumulative EMF effects are likely to occur if subsea cable is situated in close proximity to (<2km), or transects the Maximum Footprint Area. Two telecommunications cables fall into this category, namely WACS and TGN Atlantic, however both of these cables are fibre optic and therefore do not emit EMF. Other proposed OWF projects that utilise EMF-emitting power cables, are sufficiently distant from the Maximum Footprint Area for no compounding EMF impacts to occur. However, the presence of additional cables within the Celtic Sea may alter the behaviour of some wide-ranging receptors, such as demersal shark and ray species, and the cumulative effect of additional renewable projects may increase the spatial scale of impact. There is a lack of data as to both the cumulative effect of EMF between distant renewable developments, and the location/extent of power cable used within future floating OWF projects. It is therefore assumed that the low magnitude of impact assessed for the Offshore Project in **Section 11.6.3** and in other OWF projects will reflect that of Round 4 leasing sites in the future.

11.8.5.1 Significance of effect

294. As such, the cumulative effect of EMFs is considered **Minor Adverse**, and is therefore **Not Significant** in EIA terms.

11.8.5.2 Further Mitigation

295. The assessment of minor adverse and non-significant cumulative effect of EMFs enables the conclusion that **No Further Mitigation** is required.

11.8.6 Cumulative Impact 6: Ghost fishing

296. Annual monitoring of anchor/moorings will be undertaken during the lifetime of the Offshore Project. Remotely operated vehicles (ROVs) will be used to identify any entanglement hazards, such as ALDFG, snagged on Project substructures. As a result, the magnitude of this effect is considered negligible. Ghost fishing resulting from other infrastructure is likely negligible when considering the wider spatial scale of the Fish and Shellfish Ecology Study Area.

11.8.6.1 Significance of effect

297. Therefore, the cumulative effect of ghost fishing is considered **Minor Adverse** and is therefore **Not Significant** in EIA terms.

11.8.6.2 Further Mitigation

298. The assessment of minor adverse and non-significant cumulative effect of ghost fishing effects enables the conclusion that **No Further Mitigation** is required.

11.9 Potential transboundary impacts

299. The Scoping Report (Reference Number: EIA/2022/00002) identified that there was no potential for significant transboundary effects regarding fish and shellfish impacts from the Offshore Project upon the interests of other EEA States, and is therefore scoped out.

11.10 Inter-relationships

300. Inter-relationship impacts are covered as part of the assessment and consider impacts from the construction, operation or decommissioning of the Offshore Project on the same receptor (or group). A description of the process to identify and assess these effects is presented in **Chapter 6: EIA Methodology**. The potential inter-relationship effects that could arise in relation to Fish and Shellfish Ecology include both:

- **Project lifetime effects:** Effects arising throughout more than one phase of the Offshore Project (construction, operation, and decommissioning) to interact to potentially create a more significant effect on a receptor than if just one phase were assessed in isolation
- **Receptor led effects:** Assessment of the scope for all relevant effects to interact, spatially and temporally, to create inter-related effects on a receptor (or group). Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

301. Table 11.28 serves as a sign-posting for inter-relationships.

Table 11.28 Fish and Shellfish Ecology Inter-relationships

Topic and description	Related chapter	Where addressed in this Chapter	Rationale
Temporary habitat loss/physical disturbance	**Chapter 8: Marine and Coastal Processes** **Chapter 11: Benthic and Intertidal Ecology** **Chapter 12: Marine Mammal and Marine Turtle Ecology** **Chapter 14: Commercial Fisheries**	**Section 11.5.1**	Habitat loss through temporary or permanent alteration of the seabed could potentially disturb the form and function of the seabed (e.g. sand waves). Loss of habitat may also have knock-on effects on predator species, which may affect marine mammal populations, or populations of commercially important fishes.
Permanent habitat loss		**Section 11.6.1**	
Increased suspended sediments and sediment deposition	**Chapter 12: Marine Mammal and Marine Turtle Ecology** **Chapter 14: Commercial Fisheries**	**Section 11.5.2**	An increase in suspended sediment concentration could affect foraging success of predatory mammals and fishes. Similarly, sediment deposition has the potential to smother larval/egg stages or benthic species, with negative implications for commercial fishing that targets these species.
Underwater noise and vibration	**Chapter 12: Marine Mammal and Marine Turtle Ecology** **Chapter 14: Commercial Fisheries**	**Section 11.5.3**and **11.6.3**	Underwater noise from UXO clearance or construction/operation activities has the potential to cause TTS, PTS, or mortality in some species of marine mammals or commercial fish

Topic and description	Related chapter	Where addressed in this Chapter	Rationale
			species in worst-case scenarios.
Barrier effects	**Chapter 12: Marine Mammal and Marine Turtle Ecology**	**Section 11.6.5**	The presence of the windfarm infrastructure (e.g. turbines and substructures) during the operational phase has the potential for barrier effects for marine mammals accessing or transiting through the area.
Ghost fishing	**Chapter 12: Marine Mammal and Marine Turtle Ecology**	**Section 11.6.7**	There is a potential risk of indirect entanglement with marine mammal species if ghost fishing gear becomes attached to structures within the windfarm.

11.11 Interactions

302. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The areas of interaction between impacts are presented in **Table 11.29**, **Table 11.30** and **Table 11.31**, along with an indication as to whether the interaction may give rise to synergistic impacts. This provides a screening tool for which impacts have the potential to interact.

303. **Table 11.32** then provides an assessment for each receptor (or receptor group) related to these impacts in two ways. Firstly, the impacts are considered within a development phase (i.e. construction, operation, maintenance or decommissioning) to see if, for example, multiple construction impacts could combine. Secondly, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across development phases. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of effect; the sensitivity is constant whereas the magnitude may differ. Therefore, when considering the potential for impacts to be additive it is the magnitude of effect which is important – the magnitudes of the different effects are combined upon the same sensitivity receptor. If minor impact and minor impact were added this would effectively double count the sensitivity.

304. The impact assessment set out in Sections 11.5, 11.6, and 11.7concluded that the significance of potential effects on fish and shellfish ecology arising from all impacts identified during the construction, operation and decommissioning of the Offshore Project were Not Significant in EIA terms. As such, interactions between these effects within and between the development phases would not occur.

Table 11.29 Interaction between impacts during construction

Construction	Impact 1: Temporary habitat loss/physical disturbance	Impact 2: Temporary increased suspended sediment and sediment deposition	Impact 3: Underwater noise and vibration	Impact 4: Barrier effects
Impact 1: Temporary habitat loss/physical disturbance				
Impact 2: Temporary increased suspended sediment and sediment deposition	Yes			
Impact 3: Underwater noise and vibration	Yes	Yes		
Impact 4: Barrier effects	Yes	Yes	Yes	

Table 11.30 Interaction between impacts during operation and maintenance

Potential impact							
Operation and Maintenance	**Impact 1: Permanent habitat loss**	**Impact 2: Temporary increased suspended sediment and sediment deposition**	**Impact 3: Underwater noise and vibration**	**Impact 4: Electro-magnetic fields**	**Impact 5: Barrier effects**	**Impact 6: Fish aggregation effects**	**Impact 7: Ghost fishing**
Impact 1: Permanent habitat loss							
Impact 2: Temporary increased suspended sediment and sediment deposition	Yes						
Impact 3: Underwater noise and vibration	Yes	Yes					
Impact 4: Electro-magnetic fields	Yes	Yes	Yes				
Impact 5: Barrier effects	Yes	Yes	Yes	Yes			
Impact 6: Fish aggregation effects	Yes	Yes	Yes	No	No		
Impact 7: Ghost fishing	Yes	Yes	No	No	No	Yes	

Table 11.31 Interaction between impacts during decommissioning

Potential impact				
Decommissioning	**Impact 1: Temporary habitat loss/physical disturbance**	**Impact 2: Temporary increased suspended sediment and sediment deposition**	**Impact 3: Underwater noise and vibration**	**Impact 4: Barrier effects**
Impact 1: Temporary habitat loss/physical disturbance				
Impact 2: Temporary increased suspended sediment and sediment deposition	Yes			
Impact 3: Underwater noise and vibration	Yes	Yes		
Impact 4: Barrier effects	Yes	Yes	Yes	

Table 11.32 Potential interactions between impacts on Fish and Shellfish Ecology

Highest level significance					
Receptor	Construction	Operation and Maintenance	Decommissioning	Phase Assessment	Lifetime Assessment
Fish and Shellfish	Minor adverse	Minor adverse	Minor adverse	Impact no greater than as assessed alone *Construction* Impacts of fish and shellfish receptors relating to both suspended sediments and underwater noise will occur over only short periods throughout the construction phase. There is the potential for interactions between these impacts and temporary habitat loss as a result of disturbance to the seabed via installation of infrastructure. This temporary habitat disturbance is likely to be of limited spatial scale comprising only a small portion of available habitat within the wider Fish and Shellfish Ecology Study Area. Therefore, there is limited potential for increased significance as a result of the interactions between construction phase impacts.	Impact no greater than as assessed alone The spatial footprint of underwater noise impacts, and the habitat disturbance and associated suspended sediment, during the construction phase are likely to have the greatest magnitude of effect across the Offshore Project lifetime. Impacts during later phases of the Offshore Project are likely to be of similar or reduced magnitude. Current literature does not indicate long term impacts on fish and shellfish as a result of operational offshore wind farm arrays. Therefore, it is determined that interaction across the lifetime of the Offshore Project will not result in a change in determined significance levels of assessed impacts.

Highest level significance					
				Operation and Maintenance Permanent habitat loss as a result of the Offshore Project will be confined to the infrastructure footprint throughout its lifetime. Similarly, EMF effects will be confined to the volume of water immediately surrounding energy transmitting infrastructure, with a low determined magnitude. Suspended sediment will only occur during required maintenance activities and is likely to dissipate rapidly via tidal and wave action. Underwater noise will also occur only during maintenance activities, and only for short periods of time during these activities. Therefore, there is limited potential for increased significance as a result of the interactions between operation and maintenance phase impacts. *Decommissioning* It is anticipated that the decommissioning impacts	

Highest level significance					
				would be similar in nature to those of construction	

11.12 Summary

305. This chapter has investigated the potential effects on fish and shellfish receptors arising from the Offshore Project. The range of potential impacts and associated effects considered has been informed by the Scoping Opinion, consultation, and agreed through ETG Meetings, as well as reference to existing policy and guidance. The impacts considered include those brought about directly, as well as indirectly.

306. The Fish and Shellfish Ecology Study Area (which encompasses the Windfarm Site) is located in the southern section of the outer Bristol Channel. The area extends seaward (west) from the Devon coastline, at the mouth of the rivers Taw and Torridge, and encompasses Bideford Bay and Lundy Island.

307. A variety of commercially and ecologically important fish and shellfish species are present across the area, which have been classified into elasmobranchs, demersal fish, pelagic fish, shellfish, and migratory species receptor groups. Some regions of the Windfarm Site and ECC have the potential to act as spawning and nursery grounds for a range of species across receptor groups.

308. For the assessment of impacts related to underwater noise and vibrations, receptors were classified into the following categories: fish with a swim bladder used in hearing, fish with a swim bladder not used in hearing, fish with no swim bladder, fish eggs and larvae, and shellfish.

309. **Table 11.33** presents a summary of the impacts assessed within this ES chapter, any commitments made and mitigation required, and the residual effects. No significant effects on fish and shellfish ecology were identified, with all effects assessed as of negligible residual effect.

310. The assessment of cumulative effects from the Offshore Project and other developments and activities concluded that as predicted residual effects arising from the Offshore Project are negligible, cumulative effects with other developments would be negligible.

311. The screening of transboundary impacts identified that there was no potential for significant transboundary effects regarding fish and shellfish impacts from the Offshore Project upon the interests of other EEA States.

Table 11.33 Summary of potential impacts for fish and shellfish ecology during construction, operation, maintenance and decommission of the Offshore Project

Potential impact	Receptor	Sensitivity	Magnitude	Significance	Potential mitigation measure	Residual impact
Construction						
Impact 1: Temporary habitat loss/physical disturbance	Elasmobranchs	Low	Low	Minor Adverse	n/a	n/a
	Pelagic and demersal fish	Medium				
	Migratory fish	Negligible				
	Shellfish	Medium				
Impact 2: Temporary increased suspended sediment and sediment deposition	Elasmobranch, pelagic, demersal, and migratory fish (adult stages)	Negligible	Low	Minor Adverse	n/a	n/a
	Elasmobranch, pelagic, demersal, and migratory fish (larval/egg stages)	Medium		Minor Adverse		
	Shellfish	Medium		Minor Adverse		
Impact 3: Underwater noise and vibration	All fish and shellfish	UXO clearance: low	UXO clearance: low	UXO clearance: Minor Adverse	n/a	n/a
		Impact piling: low	Impact piling: low	Impact piling: Minor Adverse		
		Other noise making activities: low	Other noise making activities: negligible	Other noise making activities: Negligible		
	Elasmobranchs	Low	Low	Negliglbe	n/a	n/a

Potential impact	Receptor	Sensitivity	Magnitude	Significance	Potential mitigation measure	Residual impact
Impact 4: Barrier effects	Demersal and pelagic fishes	Low				
	Migratory fishes	Low				
	Shellfish	Low				
Operation and Maintenance						
Impact 1: Permanent habitat loss	Elasmobranchs	Low	Low	Minor Adverse	n/a	n/a
	Demersal and pelagic fishes	Medium				
	Migratory fishes	Low				
	Shellfish	Low				
Impact 2: Temporary increased suspended sediment and sediment deposition	Elasmobranch, pelagic, demersal, and migratory fish (adult stages)	Negligible	Low	Negligible	n/a	n/a
	Elasmobranch, pelagic, demersal, and migratory fish (larval/egg stages)	Medium		Minor Adverse		
	Shellfish	Medium		Minor Adverse		
Impact 3: Underwater noise and vibration	All fish and shellfish	Low	Low	Minor Adverse	n/a	n/a
	Elasmobranchs	Medium	Low	Minor Adverse	n/a	n/a

Potential impact	Receptor	Sensitivity	Magnitude	Significance	Potential mitigation measure	Residual impact
Impact 4: Electro-magnetic fields	Pelagic, demersal, and migratory fish	Low				
	Shellfish	Negligible				
Impact 5: Barrier effects	Elasmobranchs	Low	Negligible	Negligible	n/a	n/a
	Pelagic and demersal fish	Low				
	Migratory fish	Low				
	Shellfish	Low				
Impact 6: Fish aggregation effects	Elasmobranchs	Negligible	Negligible	Negligible	n/a	n/a
	Pelagic, demersal, and migratory fish	Low				
	Shellfish	Low				
Impact 7: Ghost fishing	All fish and shellfish	High	Negligible	Minor Adverse	n/a	n/a
Decommissioning						
Impact 1: Temporary habitat loss/physical disturbance	Elasmobranchs	Low	Low	Minor Adverse	n/a	n/a
	Pelagic and demersal fish	Medium				
	Migratory fish	Negligible				
	Shellfish	Medium				
Impact 2: Temporary increased suspended sediment and sediment deposition	Elasmobranch, pelagic, demersal, and migratory fish (adult stages)	Negligible	Low	Minor Adverse	n/a	n/a
	Elasmobranch, pelagic, demersal, and migratory fish	Medium		Minor Adverse		

Potential impact	Receptor	Sensitivity	Magnitude	Significance	Potential mitigation measure	Residual impact
	(larval/egg stages)					
	Shellfish	Medium		Minor Adverse		
Impact 3: Underwater noise and vibration	All fish and shellfish	UXO clearance: low	UXO clearance: low	UXO clearance: Minor Adverse	n/a	n/a
		Other noise making activities: low	Other noise making activities: negligible	Other noise making activities: Negligible		
Impact 4: Barrier effects	Elasmobranchs	Low	Low	Minor Adverse	n/a	n/a
	Demersal and pelagic fishes	Medium				
	Migratory fishes	Negligible				
	Shellfish	Low				

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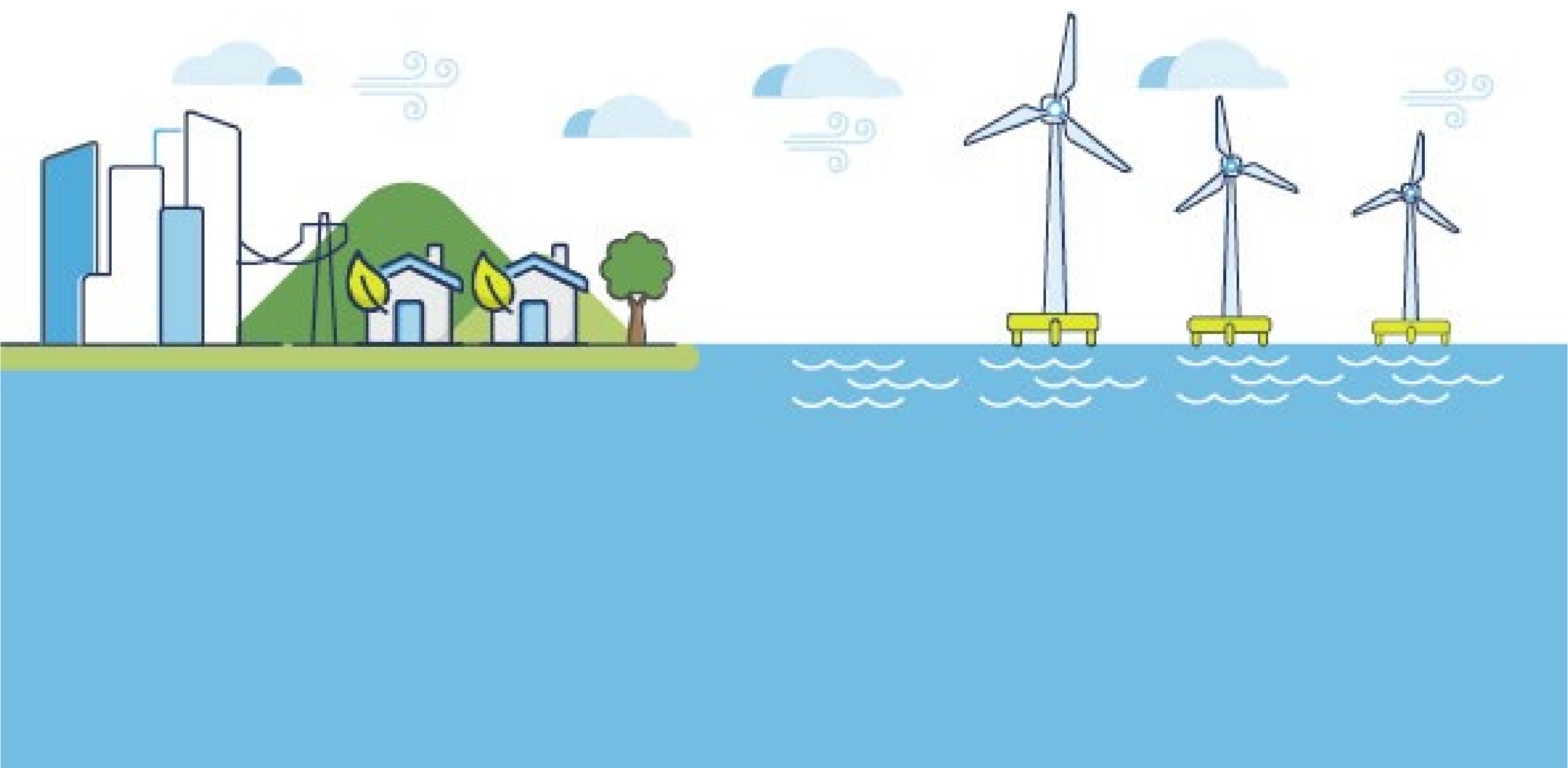
WHITE CROSS

White Cross Offshore Windfarm Environmental Statement

Appendix 11.A: Fish and Shellfish Technical Report



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1. Appendix Purpose

The Fish and Shellfish Ecology Appendix provides background information pertaining to both the ecology and conservation status of species identified as having presence or potential presence within the Fish and Shellfish Ecology Study Area (ICES Rectangles 30E5, 31E4 and 31E5). Where species are listed as Least Concern by the IUCN and have not been included in any of the other conservation lists, they have been excluded from the conservation status tables. This Appendix should be read alongside **Chapter 11: Fish and Shellfish Ecology**. Data through this Appendix are organised by receptor group as defined within **Chapter 11: Fish and Shellfish Ecology**:

- Elasmobranchs
- Demersal Fish
- Pelagic Fish
- Shellfish
- Migratory Fish.

2. Elasmobranchs

Table 2.1 Ecology of elasmobranch species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Basking shark *Cetorhinus maximus*	Present in the summer months, usually between May and September	Occurs mostly offshore but does venture into shallows near shore	Unknown	Passive filter feeder, feeding solely on plankton
Blonde ray *Raja brachyura*	Spawning occurs between February and August	Varied depth range depending on location, up to 150 m in NE Atlantic, 10-300 m in Mediterranean, and globally up to 900 m. Typically occurs on soft substrate such as sandy and muddy ground	Shallow, coastal waters are used as nursery areas, leading to an increased presence of juveniles	Both adults and juveniles feed on crustaceans, with larger adults also taking cephalopods and small teleosts
Blue shark *Prionace glauca*	Young are born in spring early summer. Nursery grounds not located in this area.	Oceanic and pelagic, from surface up to 1,160 m. More commonly found over deep waters, occasional over continental shelf	Highly migratory, undertaking annual clockwise transatlantic migrations	Feed on relatively small prey, especially squid and bony fishes, and to a lesser extent other invertebrates, small sharks and mammalian carrion
Common smoothhound *Mustelus mustelus*	Limited information on the reproductive biology of this species	Most common over sandy and muddy substrates at <50 m over continental shelf, recorded up to 350 m. Mostly demersal in nature, occasionally midwater	Not described as migratory	Primarily feeds on crustaceans, also cephalopods and teleosts

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Cuckoo ray *Leucoraja naevus*	Egg cases produced throughout the year	Demersal from 30-500 m, though most common <200 m. Found on continental shelf and upper slopes over sandy and coarse sediment	Not described as migratory	Feeds on crustaceans, polychaete worms and teleosts
Lesser spotted dogfish *Scyliorhinus canicula*	Egg-laying occurs during spring and early summer	Found from shallow sublittoral waters up to 400 m, mostly on sand and mud, but also on algae, rocky and gravelly bottoms	Females come inshore during the warmer months to lay eggs	It feeds opportunistically on a range of benthic fauna, mostly crustaceans and molluscs. Feeding intensity is highest during the summer
Nursehound *Scyliorhinus stellaris*	Spring and summer are when egg-laying occurs	Found at depths of up to 125 m but most common between 20-63 m. Prefers rough, rocky or coralline grounds with algal cover	Shallow waters are used for egg-laying.	Take a variety of prey, mostly crustaceans, but also molluscs, small teleosts and S. canicula
Shagreen ray *Leucoraja fullonica*	Limited information on the reproductive biology of this species	Demersal from 30-550 m, found primarily on outer continental shelf. No preference for substrate	Not described as migratory	Predominant prey comprise benthic invertebrates and teleosts, though large individuals take teleosts and cartilaginous fish
Small-eyed ray *Raja microocellata*	Eggcases frequently laid June September	Found at depths of up to 100 m. Favours soft sandy substrates on the continental shelf	Not described as migratory	Adults feed on teleosts, whereas juveniles feed on benthic crustaceans
Spotted ray *Raja montagui*	Limited information on the reproductive biology of this species	Majority of population found in waters 100-500 m deep. Prefers soft, sandy substrates in coastal seas and on continental shelves	Mostly non-migratory, though females migrate to shallow waters	Adults feed on large crustaceans, teleost fish, polychaetes and molluscs, juveniles on small crustaceans

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
			from April-July to spawn	
Spurdog *Squalus acanthias*	Timing of reproduction varies by location, though it broadly occurs between January August	Found in inshore waters to continental shelf, most commonly 10-200 m but recorded up to 900 m. Is epibenthic but also occurs in water column, with no preference for habitat	Highly migratory, dependent on age and sex. Young females migrate to shallow waters to give birth	In this region their diet is mostly teleost fish (herring, whiting, Norway pout, cod, and Atlantic mackerel), with crustaceans often taken by smaller individuals
Starry smoothhound *Mustelus asterias*	Gives birth to pups in the summer. Adults may migrate inshore in summer	Predominantly found on sandy and gravelly bottoms, at depths of 1-100 m on continental shelves	Young are born inshore, adults may migrate inshore in the summer	Feeds almost exclusively on crustaceans
Thornback ray *Raja clavata*	Overwinters in deeper water, migrating into shallower areas in the late spring and summer (February-September) to spawn	Inhabits continental shelf and upper slope waters from 10-300 m, though it is most abundant in waters 10-60 m. Frequents a range of sediments, though not typically coarser sediments	Mostly non-migratory, though fish often moves close inshore during the spring	Adults feed on large crustaceans and small teleost fish such as sandeels, small gadoids and dragonets, whereas juveniles prefer small crustaceans
Tope shark *Galeorhinus galeus*	Mating and parturition occurs during the spring	Found inshore through to 550 m depth, mostly near the seabed	Highly migratory in this region, moving north in the summer, and south in the winter. Females give birth in shallow waters	Feeds mostly on a wide variety of teleost fish, in addition to some invertebrates
Starry Ray *Amblyraja radiata*	Eggcases laid on sandy or muddy flats year-round	Demersal from 18-1,400 m depth. Most commonly found between 25-440 m	Not described as migratory (max 180 km)	Scavenger and predator of fish, crustaseans, polychaetes, hydroids,

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
		on continental and insular shelves and slopes on various substrates		molluscs, cephalopods and echinoderms.
Thresher Shark *Alopias vulpinus*	Migrates to the UK in summer	Oceanic and pelagic, from surface up to 650 m. More commonly found in nearshore temperate waters, often over continental shelf	Migrates to the UK in summer following warm water	Primarily feeds on schooling fishes, also takes cephalopods, pelagic crustaceans, and occasionally seabirds

Table 2.2 Conservation status of elasmobranch species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	IUCN Red List	OSPAR Annex V species	UK Post-2010 Biodiversity Framework	UK Wildlife and Countryside Act 1981, Schedule 5	Habitats Directive, Annex II	Species of Conservation Interest (under Marine Conservation Zone process)
Basking shark *Cetorhinus maximus*	Endangered (Global and Europe)	Yes	Yes	Yes	No	No
Blonde ray *Raja brachyura*	Near Threatened (Global and Europe)	No	No	No	No	No
Blue shark *Prionace glauca*	Near Threatened (Global and Europe)	No	Yes	No	No	No
Common smoothhound *Mustelus mustelus*	Vulnerable (Global and Europe)	No	No	No	No	No
Nursehound *Scyliorhinus stellaris*	Near Threatened (Global and Europe)	No	No	No	No	No
Shagreen ray *Leucoraja fullonica*	Vulnerable (Global and Europe)	No	No	No	No	No
Small-eyed ray *Raja microocellata*	Near Threatened (Global and Europe)	No	No	No	No	No

Species	IUCN Red List	OSPAR Annex V species	UK Post-2010 Biodiversity Framework	UK Wildlife and Countryside Act 1981, Schedule 5	Habitats Directive, Annex II	Species of Conservation Interest (under Marine Conservation Zone process)
Spotted ray *Raja montagui*	Least Concern	Yes	No	No	No	No
Spurdog *Squalus acanthias*	Vulnerable (Global), Endangered (Europe)	Yes	Yes	No	No	No
Starry smoothhound *Mustelus asterias*	Least Concern (Global), Near Threatened (Europe)	No	No	No	No	No
Thornback ray *Raja clavata*	Near Threatened (Global and Europe)	Yes	No	No	No	No
Tope shark *Galeorhinus galeus*	Vulnerable (Global and Europe)	No	Yes	No	No	No
Starry Ray *Amblyraja radiata*	Vulnerable (Global) Least Concern (Europe)	No	No	No	No	No
Thresher Shark *Alopias vulpinus*	Vulnerable (Global) Endangered (Europe)	No	No	No	No	No

3. Demersal Fish

Table 3.1 Ecology of demersal fish species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Anglerfish *Lophius piscatorius*	Spawning occurs between January-June	Occur at depths from coast up to 1,000 m, on sandy and muddy bottoms. May also be found on rocky bottoms	Migrate between inshore and offshore spawning grounds	Feeds mostly on fish that it lures
Atlantic cod *Gadus morhua*	Spawning occurs in winter and beginning of spring	Juveniles prefer shallower waters (10-30 m) with complex habitats than adults (up to 600 m)	Migrate between spawning, feeding and overwintering areas, journeys of <200 km	Omnivorous, feeding on mostly fish and invertebrates
Bass *Dicentrarchus labrax*	Spawning occurs in spring	Inhabit coastal waters up to 100 m on range of bottom types	Migrate from coastal to offshore waters in winter	Feeds mostly on shrimp and molluscs, as well as fish
Black sea bream *Spondyliosoma cantharus*	Spawning occurs in April and May	Found over seagrass beds, rocky and sand bottoms, at depths of up to 300 m	None reported	Omnivorous, feeding on seaweeds and small invertebrates, especially crustaceans
Brill *Scophthalmus rhombus*	Spawning occurs in first half of year, varies by location	Live on sandy or mixed bottoms up to 50 m	Adults found more offshore than juveniles	Feed on benthic fish and crustaceans
Wrasse (*Labrus* **spp.)**	Unknown	Mainly found between 10-80 m,	None reported	Feeds mainly on crustaceans but also

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
		over rocks, hard ground or algae		on fish, molluscs and worms
Dab *Limanda limanda*	Spawning occurs in spring and early summer in British waters	Mostly found over sandy ground at depths of 20-40 m, sometimes up to 150 m. Young live inshore	Adults migrate inshore from deeper water in the warmer summer months	Opportunistic feeder, though mainly on crustaceans and small fish
European hake *Merluccius merluccius*	Spawning occurs April-December, with a peak in February-March	Found usually between 30-1075 m, normally 70-400 m	Diurnal; off bottom during day, on bottom at night	Feed mainly on fish, with young feeding on small crustaceans
Gilthead seabream *Sparus aurata*	Spawning occurs October-December	Found on seagrass bed and sandy bottoms, up to 150 m depth though more frequently 1-30 m	None reported	Mainly carnivorous, though occasionally eats seagrass. Feeds on shellfish, including mussels and oysters
Grey gurnard *Eutrigla gurnardus*	Spawns April to August	Common on sand, rocky and muddy bottoms between coastal and 140 m depth	None reported	Feeds on crustaceans and fish
Grey triggerfish *Balistes capriscus*	Spawning uncommon in UK waters	Found from intertidal to 100 m. Inhabits rocky areas and wrecks	Poor swimmers, likely in UK waters by travelling along currents	Feeds on benthic invertebrates, such as molluscs and crustaceans
Haddock *Melanogrammus aeglefinus*	Spawning takes place from March to May	Found over rock, sand gravel or shells, at depths of 40-300 m	None reported for UK waters	Feeds on variety of benthic organisms, including crustaceans,

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
				molluscs and teleosts
John Dory *Zeus faber*	Spawning occurs at the end of winter/early spring	Remains near seabed	None reported	Feeds mostly on teleosts, also cephalopods and crustaceans
Lemon sole *Microstomus kitt*	The timing of spawning is related to a temperature threshold	Found on stony bottoms at depths 20-200 m	None reported	Feeds on invertebrates, primarily polychaetes
Ling *Molva molva*	Spawn in spring	Occurs mostly in deep water (100-400 m) over rocky bottoms	Unknown	Feeds on large fish and invertebrates
Megrim *Lepidorhombus whiffiagonis*	Unknown, though spawning occurs in deep waters off west of British Isles	Occurs at depths 100-700 m, over soft bottoms	Not reported	Feeds on small bottom-living fishes, cephalopods and crustaceans
Plaice *Pleuronectes platessa*	Spawn mostly between January-March in well-defined spawning grounds	Occurs on mud and sandy bottoms, from intertidal to about 100 m depth (increase in water depth with age)	Migrate for spawning activity	Feed mainly on thin-shelled molluscs and polychaetes. Active at night
Pollock *Pollachius pollachius*	Spawn in the late winter to spring	Found from nearshore to 200 m, over hard bottoms	Larger individuals move to more open sea. May take spawning migrations	Major predator of young cod
Pouting (Bib) *Trisopterus luscus*	Unknown	Found inshore down to 300 m, over mixed rock	Moves inshore to waters <50 m for spawning	Feeds mostly on crustaceans, but also on small fish,

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
		and sand, also around wrecks		molluscs and polychaetes
Striped red mullet *Mullus surmuletus*	Spawning occurs in May-July	Occurs mostly at depths up to 100 m over hard broken grounds	Adults migrate to shallows in spring/summer; juveniles move summer/autumn	Feeds mostly on benthic invertebrates
Saithe *Pollachius virens*	Unknown	Occurs up to 350 m	Enters coastal waters in spring and returns to deeper waters in winter	Adults feed on other fish, whereas small fish feed primarily on crustaceans
Sand eel Ammodytidae	Spawning recorded in December and January	Occurs up to 150 m over sandy bottoms, both inshore and offshore	Bury in bottom during night and winter, migrate in water column during strong tidal currents	Feed on plankton
Sand sole *Pegusa lascaris*	Unknown	Occurs at depths usually 20-50 m. Found on gravel, sand or mud	None reported	Feeds on a wide range of crustaceans, mostly bivalves
Turbot *Scophthalmus maximus*	Spawning season is April-August	Most common on sandy, rocky or mixed bottoms. Depth range 20-70 m	None reported	Feeds mostly on benthic fish and less on crustaceans and bivalves
Whiting *Merlangius merlangus*	Spawning occurs January-September	Depth range 10-200 m, most commonly 30-100 m, over mud and gravel bottoms mostly, but also on sand and rock	Individuals migrate to open sea after first year	Feed on a range of benthic prey

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Witch flounder *Glyptocephalus cynoglossus*	In Irish Sea, spawns March-May	Inhabits soft mud bottoms at depths of 45-366 m	None reported	Feeds on crustaceans, polychaetes, brittle stars and fish
Mullet - Other	Catadromous, migrating to sea to spawn in February - April	Inshore areas up to 10 m depth. Common in brackish water in estuaries and harbours	Migrate into saltwater to spawn	Scavenger that feeds on vegetation and organic matter on the seabed or in the water column.
Monkfish or Anglerfish *Lophius piscatorius*	Spawn in deep water during spring/early summer	Deep offshore areas >50 m. Often severla hundred m deep.	None reported	Feeds on almost any organism within size and range of jaws
Conger Eel *Conger conger*	Reach maturity at 5-15 years, migrates to deeper water to spawn only once and consequently die.	Utilise crevices and holes in rocky reefs, wrecks, and artificial environments	Diurnal; migrate to deeper waters (up to 4000 m) in the mid-Atlantic to spawn	Feeds primarily on fish, but will readily take cephalopods and crustaeans
European flounder *Platichthys flesus*	Spawns in spring in deeper, warmer waters	Found on muddy or sandy substrates in shallow water. Tolerant of marine, brackish and freshwater environments	Migrates to saltwater to spawn	Feeds on benthic fauna, including small fishes and invertebrates
Red gurnard *Chelidonichthys cuculus*	Spawns in the summer in inshore waters	Found over sand, gravel, and rocky substrates	Migrates from deep to shallow waters to spawn in the summer	Feeds on crustaceans, other invertebrates, and fish
Four-Spotted Megrim *Lepidorhombus boscii*	Spawns between February and May	Found on soft substrates	Unknown	Feeds mainly on crustaceans and fish

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Red Scorpionfish *Scorpaena scrofa*	Unknown	Found on various substrates	Unknown	Feeds on fish, crustaceans, and molluscs
Greater Weever *Trachinus draco*	Spawns in June - August	Found on various substrates near the coastline	Unknown	Feeds on small invertebrates and fish
Tub gurnard *Chelidonichthys lucerna*	Spawns in the summer in inshore waters	Found on muddy sand and gravel up to 318 m depth	Migrates from deep to shallow waters to spawn in the summer	Feeds on fish, crustaceans, and molluscs
Blue Whiting *Micromesistius poutassou*	Spawns late winter - early spring	Pelagic, found commonly at depths of 300-400 m but can reach 1000 m	Daily vertical migrations	Feeds primarily on small crustaceans, but large individuals will take small fish and cephalopods
Long Rough Dabs *Hippoglossoides platessoides*	Spawns in spring	Found on soft substrates	Unknown	Feeds on invertebrates and small fish
Red (Blackspot) *Seabream Pagellus bogaraveo*	Protandric hermaphrodite (male during first maturity, female after 2-7 years). Spawns from January to June	Found on various seabed substrates in inshore waters	Migrate to the continental shelf edge to spawn	Omnivorous but mainly predatory (crustaceans, molluscs, worms, and small fish
Rockling spp.	Spawn from January to September (dependent of species)	Found on muddy sand	Unknown	Feeds on flatfishes and small benthic invertebrates
Wreckfish *Polyprion americanus*	Spawn in the summer	Found on rocky and sandy substrates	Unknown	Feeds on large crustaceans, cephalopods and benthic fishes

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Spiny Scorpionfish *Trachyscorpia echinata*	Unknown	Found on muddy sand substrates	Unknown	Feeds on deep-sea benthic crustaceans, cephalopods, and fishes

Table 3.2 Conservation status of demersal fish species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	IUCN Red List	OSPAR Annex V species	UK Post-2010 Biodiversity Framework	UK Wildlife and Countryside Act 1981, Schedule 5	Habitats Directive, Annex II	Species of Conservation Interest (under Marine Conservation Zone process)
Anglerfish *Lophius piscatorius*	Least Concern	No	Yes	No	No	Yes
Atlantic cod *Gadus morhua*	Vulnerable (Global), Least Concern (Europe)	Yes	Yes	No	No	Yes
European hake *Merluccius merluccius*	Least Concern	No	Yes	No	No	Yes
Gilthead seabream *Sparus aurata*	Least Concern	No	Yes	No	No	Yes
John Dory *Zeus faber*	Vulnerable (Global), Least Concern (Europe)	No	No	No	No	No
Lemon sole *Microstomus kitt*	Data deficient	No	No	No	No	No
Megrim *Lepidorhombus whiffiagonis*	Data deficient (Global and Europe)	Yes	Yes	Yes	No	Yes
Pollock *Pollachius pollachius*	Least Concern	No	Yes	No	No	Yes
Sand sole *Pegusa lascaris*	n/a	No	Yes	No	No	Yes

Species	IUCN Red List	OSPAR Annex V species	UK Post-2010 Biodiversity Framework	UK Wildlife and Countryside Act 1981, Schedule 5	Habitats Directive, Annex II	Species of Conservation Interest (under Marine Conservation Zone process)
Whiting *Merlangius merlangus*	Near Threatened (Global), Vulnerable (Europe)	No	No	No	No	No
Witch flounder *Glyptocephalus cynoglossus*	Least Concern	No	Yes	No	No	Yes
Blue Whiting *Micromesistius poutassou*	Least Concern	No	Yes	No	No	No
Red (Blackspot) *Seabream Pagellus bogaraveo*	Near Threatened	No	No	No	No	No
Wreckfish *Polyprion americanus*	Data Deficient	No	No	No	No	No
Spiny Scorpionfish *Trachyscorpia echinata*	Data Deficient	No	No	No	No	No

4. Pelagic Fish

Table 4.1 Ecology of pelagic fish species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Atlantic herring *Clupea harengus*	Comes to coastal areas to spawn. Both autumn and winter-spawning stock present	Occupy the water column from surface to 200m depth	Comes to coastal areas to spawn	Feed mostly on small shrimps and copepods, with occasional filter-feeding
Atlantic horse mackerel *Trachurus trachurus*	Spawning occurs in early spring for the "West stock"	Found on continental shelves (frequently over sandy bottoms) up to 500 m depth	Following spawning the stock migrates north to southern Norway/northern North Sea	Feeds on crustaceans, cephalopods and fish
Atlantic mackerel *Scomber scombrus*	Spawning occurs during summer	Widely distributed on coastal shelves up to 200 m depth	Migrate in winter and early spring to spawning areas (inshore); spawn in summer; migration to post-spawning feeding grounds and overwinter areas	Filter-feeders on zooplankton, such as small fish and prawns
European sprat *Sprattus sprattus*	Spawn throughout the year, though primarily in spring and summer	Occurs in the water column at depths of 10-150 m	Shows strong migrations between winter feeding and summer spawning grounds. Diurnal migrations through the water column	Feeds on planktonic crustaceans
Atlantic bluefin tuna *Thunnus thynnus*	Arrive in late spring and may remain until winter	Up to depths of 1000 m	Wide ranging migration moving between UK waters, central and western Atlantic and Mediterranean	Feed on a wide range of fish species
Atlantic Bonito *Sarda sarda*	Spawn in June	Pelagic above the continental shelf	Unknown	Feed on schooling fish and invertebrates

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
European Pilchard *Sardina pilchardus*	Spawn in summer	Littoral, commonly found at 25-55 m depth	Dirnal vertical migration, spawn in the North Sea and English Channel	Feed primarily on planktonic crustaceans

Table 4.2: Conservation status of pelagic fish species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	IUCN Red List	OSPAR Annex V species	UK Post-2010 Biodiversity Framework	UK Wildlife and Countryside Act 1981, Schedule 5	Habitats Directive, Annex II	Species of Conservation Interest (under Marine Conservation Zone process)
Atlantic herring *Clupea harengus*	Least Concern	No	Yes	No	No	Yes
Atlantic horse mackerel *Trachurus trachurus*	Vulnerable (Global), Least Concern (Europe)	No	Yes	No	No	Yes
Atlantic mackerel *Scomber scombrus*	Least Concern	No	Yes	No	No	Yes
Atlantic bluefin tuna *Thunnus thynnus*	Near Threatened	Yes	Yes	No	No	Yes
European Pilchard *Sardina pilchardus*	Least Concern (Global) Near Threatened (Europe)	No	No	No	No	No

5. Shellfish

Table 5.1 Ecology of shellfish species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Brown crab *Cancer pagurus*	Mating takes place in spring and summer. Females are berried for 6-9 months, during which they remain in pits dug into the sediment or under rocks, not feeding. Larvae are released in late spring/early summer juveniles settle in the intertidal zone in late summer/early autumn	Usually at depths between 6 m-40 m, but can be found offshore at depths of up to 100 m. Found on a range of substrates such as sand, gravel and rocky seabed	Juveniles may remain in intertidal areas for approximately 3 years before moving to subtidal areas	Crustaceans including smaller brown crabs as well as bivalve molluscs
Common cockle *Cerastoma edule*	Main reproductive season is May-June	Burrows in sand, mud, and gravel substrate in intertidal zone	N/A	Filter feeder
Common cuttlefish *Sepia officinalis*	Spawns in shallow waters in spring and summer	Found on sandy and muddy substrate, up to 200 m though more common up to 100 m	Undergoes seasonal migrations between inshore waters in spring and summer and shelf grounds in autumn and winter	Feeds on small molluscs, crustaceans, cephalopods and teleosts
Common octopus *Octopus vulgaris*	Spawning peaks in spring and early summer	Prefers rocky, sandy muddy bottom, in water depths from the intertidal to 150 m	Undertakes limited seasonal migrations	Feeds mostly on fish, crustaceans and molluscs

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Common prawn *Palaemon serratus*	Mating directly after first moult; females carry eggs for 9-11 months	Rocky and muddy bottoms in the shallows (up to 40 m)	Occur in shallows (feeding and nursery habitat) during summer months and in deeper water during winter. Also tidal and diurnal migrations	Omnivorous, feeding on seaweed and small crustaceans
Common whelk *Buccinium undatum*	Whelk have a low fecundity and entirely benthic reproductive strategy. Whelk spawn between November and January, laying distinctive egg masses which are then attached to suitable substrate	Muddy sand, gravel and rock	Common whelk has low growth rates and restricted adult movements	Carnivorous predator and active scavenger
European lobster *Homarus gammarus*	Mating takes place in the summer and is annual or bi-annual. Eggs carried for 10-11 months	Rocky and stony substrata, usually not deeper than 50 m	Do not undertake migrations; will only move a few miles along the shore	Preys on crabs, molluscs, sea urchins, polychaete worms and starfish
European spider crab *Maja squinado*	This species is thought to move offshore during the autumn and inshore during the spring	Adults occur in sublittoral to depths of 90 m, on rocky bottoms with algae. Juveniles prefer shallows on mixed soft/hard bottoms	Only use slow, small-scale, non-directional movements	Feed upon algae and molluscs during the winter and echinoderms during the summer; general omnivorous diet
European spiny lobster *Palinurus elephas*	Spawning occurs between June-October	Lives subtidally on rocky substrates, over depths of 5-200 m	None reported	Omnivorous, feeds on hard-shelled organisms such as molluscs,

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
				echinoderms and crustaceans
European squid *Loligo vulgaris*	Spawning occurs intermittently over several months (season varies; in English Channel peak is late autumn/early winter)	Usually in the water column over sandy and hard bottoms. Occurs down to 200 m	Abundance varies	Squid feed upon fish, as well as crustaceans, polychaetes and other cephalopods
King scallop *Pecten maximus*	Scallops spawn in spring or summer and probably require dense concentrations to achieve the successful production of larvae	Coarse gravel with some erect epifauna and shell is known to be suitable for successful settlement and recruitment of larvae to the stock	N/A	Filter feeder
Norway lobster *Nephrops norvegicus*	Spawn in summer and autumn	Inhabits muddy bottoms, in waters 20-800 m deep, though usually 200-600 m	None reported	Nocturnally feeds on detritus, crustaceans and worms
Periwinkle *Littorina littorea*	Spawns in February-June	Found at depths of 0-60 m, on both hard and soft bottoms	None reported	Grazes on marine plants such as seaweed and seagrass
Queen scallop *Aequipecten opercularis*	Scallops spawn in spring or summer and probably require dense concentrations to achieve the successful production of larvae	Coarse gravel with some erect epifauna and shell is known to be suitable for successful settlement and recruitment of larvae to the stock	N/A	Filter feeder

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Velvet swimming crab *Necora puber*	Mating occurs after the moult. Females bear eggs mostly in spring, eggs hatch in late spring	Shallow and intertidal to 80 m	Females migrate to soft substrates for egg laying	Opportunistic feeder, mostly on molluscs and crustaceans but also detritus and algae
Northern Stone Crab *Lithodes maja*	Unknown but fecundity is thought to be low	Demersal from 10-1000 m depth, various substrates	Unknown	Scavenger

Table 5.2 Conservation status of elasmobranch species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	IUCN Red List	OSPAR Annex V species	UK Post-2010 Biodiversity Framework	UK Wildlife and Countryside Act 1981, Schedule 5	Habitats Directive, Annex II	Species of Conservation Interest (under Marine Conservation Zone process)
Brown crab *Cancer pagurus*	Not assessed	No	No	No	No	No
Common cockle *Cerastoma edule*	Not assessed	No	No	No	No	No
Common prawn *Palaemon serratus*	Not assessed	No	No	No	No	No
Common whelk *Buccinium undatum*	Not assessed	No	No	No	No	No
European spider crab *Maja squinado*	Not assessed	No	No	No	No	No
European spiny lobster *Palinurus elephas*	Vulnerable	No	Yes	No	No	Yes
European squid *Loligo vulgaris*	Data deficient	No	No	No	No	No
King scallop *Pecten maximus*	Not assessed	No	No	No	No	No
Periwinkle *Littorina littorea*	Not assessed	No	No	No	No	No
Queen scallop *Aequipecten opercularis*	Not assessed	No	No	No	No	No
Velvet swimming crab *Necora puber*	Not assessed	No	No	No	No	No
Northern Stone Crab *Lithodes maja*	Not assessed	No	No	No	No	No

6. Migratory Fish

Table 6.1 Ecology of migratory fish species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
Atlantic salmon *Salmo salar*	The seasonality of salmon species can vary by population. Spawning usually takes place between November and February. Eggs hatch in spring and with juveniles remaining in a freshwater environment for 1-4 years before entering the marine environment between April and May as smolts. They then remaining at sea for 2-4 years.	Atlantic salmon spawn in rivers, before migrating to the marine environment as smolt. UK populations are known to migrate north to feed. Post-smolts are thought to remain close to the surface, but they may migrate to deep-sea feeding areas, within the Norwegian Sea and Greenland. There are no SACs, SCIs or cSACs within the Fish and Shellfish Ecology Study Area designated for Atlantic Salmon.	Adults return to the freshwater environment after 2-4 years in the marine environment. During migration adults tend to remain at water depths of between 13m and 118m, averaging 64m. Natal river migration peaks in late summer early autumn.	It has been hypothesised that deep dives to up to 280m are related to feeding or predator avoidance. Based on work done by Marine Scotland Science, gut content analysis suggest that adult fish are often still feeding, particularly early in the year.
European eel *Anguilla anguilla*	European eels spend most of their life cycle in the freshwater environment. Downstream migration is from August to December (as silver eels)	Both juvenile and adult eels are found throughout the water column. Depth selected can vary with time of day; tagged adult eels swim in shallow warm waters at night and then make a deep dive to 1,000 m where they	European eel spawn in the Sargasso Sea with larvae drifting to Europe on the Gulf Stream. Following this they morph into glass eels and enter rivers from January-June. After between an average of 5-20 years	European eel diet comprises primarily fish, mollusc and crustaceans whilst in the marine environment. Adults do not feed on migration.

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
		remain for the day before ascending again. The purpose of the dive may be for predator avoidance.	of freshwater living, they travel back to the Sargasso Sea to spawn and die.	
River lamprey *Lampetra fluviatilis*	River lamprey remain in freshwater for 5 years or more, where they remain in burrows in river silt beds until adults. They transit to feed in estuaries and coastal waters in July-September.	After metamorphosis (July–September) at three to five years of age, the young adults migrate downstream during darkness to estuaries and coastal waters.	River lamprey spend up to 2 years in the marine environment whilst they reach maturity. In the autumn they stop feeding in preparation for their migration into freshwater, which occurs between October and December. Their upstream migration to spawning grounds occurs in winter and spring, when temperature is low. They undertake these movements at night.	The distribution of river lamprey whilst in the marine environment is dependent on the distribution of the prey species to which they are attached.
Sea lamprey *Petromyzon marinus*	Sea lamprey spend 3-4 years in freshwater environment. Following this, they transit to the open sea, primarily in July-September.	Metamorphosis to the adult form takes place between July and September. The time of the main migration downstream seems to vary from river to river.	Sea lamprey spend 18-24 months in marine waters. Following this, they migrate into freshwater in April-May spawning in May-June.	After metamorphosis and the downstream migration to the sea, the adults feed on fish there. They seem to feed on a wide variety of marine and anadromous fishes, including herring,

Species	Seasonality	Habitat Association	Migration	Predator-prey relationships
				salmon, cod and haddock.
Brown/sea trout ***Salmo trutta***	Nest (redds) building begins at the earliest in September on gravel in freshwater, spawning occurs between January and March. This is done by brown and sea trout, as they mostly return to their natal river. Sea trout migrate coastally during spring, returning for spawning events.	Brown trout spend all their lives in freshwater environments living up to 20 years, and on average 1-3 years. Sea trout migrate to the marine environment on average after 1-3 years, but can remain for up to 9 years in freshwater.	Brown trout are known to migrate from streams to lakes and larger rivers for feeding in spring/early summer (both as post-smolts and as adults). Sea trout usually spend 1 or 2 years at sea, in coastal areas before migrating to freshwater environments in April-June. Sea trout may move between fresh and marine environments multiples times across their lives.	Sea trout diet comprises of small fish and crustaceans in the marine environment.
Shad species (allis *Alosa alosa* and twaite *Alosa fallax*)	Shad remain in the freshwater environment for a short period, usually a few months. Juveniles migrate downstream in April-May.	A suitable estuarine habitat is likely to be very important for shad, both for passage of adults and as a nursery ground for juveniles.	Shad spend 3-4 years in marine environments, specifically in estuarine areas. They return to freshwater in April-May to spawn.	Shad species feed primarily on plankton as juveniles, and small crustaceans and fish in later life stages.

Table 6.2 Conservation status of migratory fish species identified as having potential for presence within the Fish and Shellfish Ecology Study Area.

Species	IUCN Red List	OSPAR Annex V species	UK Post-2010 Biodiversity Framework	UK Wildlife and Countryside Act 1981, Schedule 5	Habitats Directive, Annex II	Species of Conservation Interest (under Marine Conservation Zone process)
Atlantic salmon *Salmo salar*	Least Concern	Yes	No	No	Yes	Yes
European eel *Anguilla anguilla*	Critically Endangered (Global and Europe)	No	No	No	No	Yes
River lamprey *Lampetra fluviatilis*	Least Concern	No	No	No	Yes	No
Sea lamprey *Petromyzon marinus*	Least Concern	Yes	No	No	Yes	No
Brown/sea trout *Salmo trutta*	Least Concern	Yes	Yes	No	No	No
Allis shad *Alosa alosa*	Least Concern	Yes	No	Yes	Yes	Yes
Twaite shad *Alosa fallax*	Least Concern	No	No	Yes	Yes	No

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