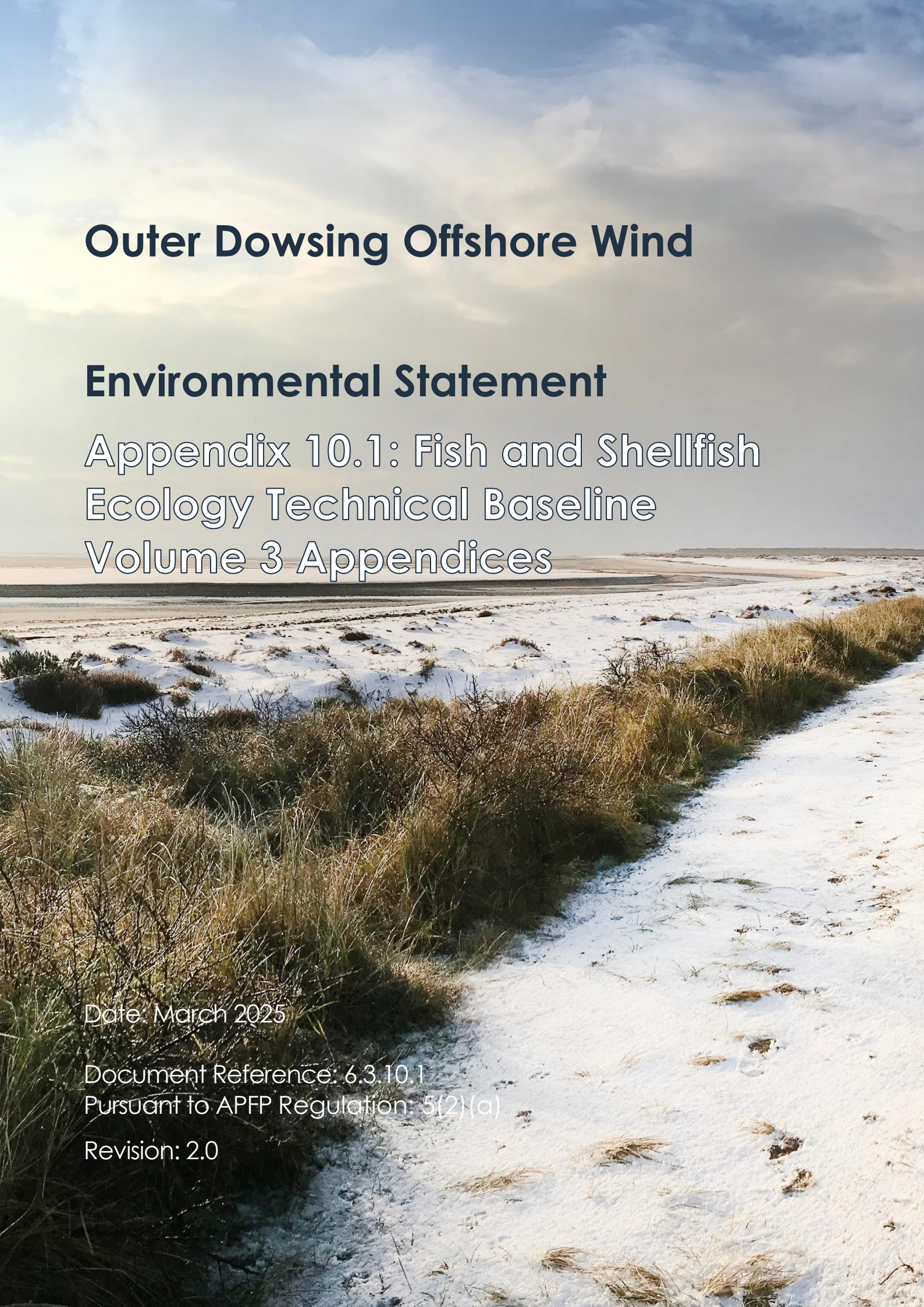

Outer Dowsing Offshore Wind

Environmental Statement

Appendix 10.1: Fish and Shellfish Ecology Technical Baseline

Volume 3 Appendices

Date: March 2025

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1.0	March 2024	DCO Application	GoBe	GoBe	Shepherd and Wedderburn	ODOW
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Acronyms & Definitions

Abbreviations / Acronyms

Abbreviation / Acronym	Description
ANS	Artificial Nesting Structures
BAP	Biodiversity Action Plan
BGS	British Geological Survey
Cefas	Centre for Environment, Fisheries and Aquaculture
CIEEM	Chartered Institute of Ecology and Environmental Management
DCO	Development Consent Order
DDV	Drop Down Video
Defra	Department for Environment, Food & Rural Affairs
DESNZ	Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC).
ECC	Export Cable Corridor
eDNA	Environmental DNA
EIA	Environmental Impact Assessment
EIFCA	Eastern Inshore Fisheries & Conservation Authority
EMF	Electromagnetic Fields
ES	Environmental Statement
HMPA	Highly Protected Marine Area
IBTS	International Bottom Trawl Survey
ICES	The International Council for the Exploration of the Sea
IFCA	Inshore Fisheries & Conservation Authority
IHLS	International Herring Larval Survey
IUCN	International Union for Conservation of Nature
LPUE	Landings Per Unit Effort
MBES	Multi-Beam Echo Sounder
MCZ	Marine Conservation Zone
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MPA	Marine Protected Area
NERC	Natural Environment and Rural Communities
NIMF	Nationally Important Marine Features
NSIBTS	North Sea International Bottom Trawl Survey
NSIP	Nationally Significant Infrastructure Project
NSSS	North Sea Sandeel Survey
ORCP	Offshore Reactive Compensation Platform
ORJIP	Offshore Renewable Joint Industry Project
OSPAR	Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic)
OWF	Offshore Windfarm
PSA	Particle Size Analysis

Abbreviation / Acronym	Description
rMCZ	Recommended MCZ
SAC	Special Area of Conservation
SBP	Sub-Bottom Profiler
SSC	Suspended Sediment Concentration
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
TAC	Total Allowable Catch
UHRS	Ultra-High Resolution Seismic
UK	United Kingdom
VER	Valued Ecological Receptor
WFO	The Wash Fishery Order
ZoI	Zone of Influence

Definitions

Term	Definition
The Applicant	GTR4 Limited (a joint venture between Corio Generation (and its affiliates), TotalEnergies and Gulf Energy Development), trading as Outer Dowsing Offshore Wind.
AfL array area	The area of the seabed awarded to GT R4 Ltd. through an Agreement for Lease (AfL) for the development of an offshore wind farm, as part of The Crown Estate's Offshore Wind Leasing Round 4.
Array area	The area offshore within which the generating station (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling will be positioned, including the ORBA.
Baseline	The status of the environment at the time of assessment without the development in place.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the sensitivity of the receptor, in accordance with defined significance criteria
EIA Directive	European Union 2011/92/EU (as amended by Directive 2014/52/EU).
EIA Regulations	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Regulations, including the publication of an Environmental Statement (ES).
Environmental Statement (ES)	The suite of documents that detail the processes and results of the EIA.

Term	Definition
Evidence Plan	A voluntary process of stakeholder consultation with appropriate Expert Topic Groups (ETGs) that discusses and, where possible, agrees the detailed approach to the Environmental Impact Assessment (EIA) and information to support Habitats Regulations Assessment (HRA) for those relevant topics included in the process, undertaken during the pre-application period.
Export cables	High voltage cables which transmit power from the Offshore Substations (OSS) to the Onshore Substation (OnSS) via the Offshore Reactive Compensation Platform (ORCP).
Habitats Regulations Assessment (HRA)	A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI) and compensatory measures.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Inter-array cables	Cable which connects the wind turbines to each other and to the offshore substation(s).
Landfall	The location at the land-sea interface where the offshore export cables and fibre optic cables will come ashore.
Mitigation	Mitigation measures are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Order Limits within which the export cables running from the array to landfall will be situated.
Offshore Restricted Build Area (ORBA)	The area within the array area, where no wind turbine generator, offshore transformer substation or offshore accommodation platform shall be erected.
Offshore Reactive Compensation Platform (ORCP)	A structure attached to the seabed by means of a foundation, with one or more decks (including bird deterrents) housing electrical reactors and switchgear for the purpose of the efficient transfer of power in the course of HVAC transmission by providing reactive compensation.
Offshore Substation (OSS)	A structure attached to the seabed by means of a foundation, with one or more decks and a helicopter platform (including bird deterrents), containing — (a) electrical equipment required to switch, transform, convert electricity generated at the wind turbine generators to a higher voltage and provide reactive power compensation; and (b) housing accommodation, storage, workshop

Term	Definition
	auxiliary equipment, radar and facilities for operating, maintaining and controlling the substation or wind turbine generators
Outer Dowsing Offshore Wind (ODOW)	The Project.
Order Limits	The area subject to the application for development consent. The limits shown on the works plans within which the Project may be carried out.
Pre-construction and post-construction	The phases of the Project before and after construction takes place.
Project Design Envelope	A description of the range of possible elements that make up the Project's design options under consideration, as set out in detail in the project description. This envelope is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
Study Area	Area(s) within which environmental impact may occur – to be defined on a receptor-by-receptor basis by the relevant technical specialist.
Subsea	Subsea comprises everything existing or occurring below the surface of the sea.
The Applicant	GT R4 Ltd. The Applicant making the application for a DCO. The Applicant is GT R4 Limited (a joint venture between Corio Generation, TotalEnergies and Gulf Energy Development (GULF)), trading as Outer Dowsing Offshore Wind. The project is being developed by Corio Generation (a wholly owned Green Investment Group portfolio company), TotalEnergies and GULF.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
The Project	Outer Dowsing Offshore Wind, an offshore wind generating station together with associated onshore and offshore infrastructure.
Wind turbine generator (WTG)	A structure comprising a tower, rotor with three blades connected at the hub, nacelle and ancillary electrical and other equipment which may include J-tube(s), transition piece, access and rest platforms, access ladders, boat access systems, corrosion protection systems, fenders and maintenance equipment, helicopter landing facilities and other associated equipment, fixed to a foundation.

Reference Documentation

Document Number	Title	Most Recent Examination Reference
6.1.3	Project Description	V2 Submitted at Deadline 5
6.1.7	Marine Physical Processes	V2 Submitted at Deadline 5
6.1.9	Benthic Subtidal and Intertidal Ecology	V2 Submitted at Deadline 5
6.1.10	Fish and Shellfish Ecology	V2 Submitted at Deadline 5
6.1.14	Commercial Fisheries	V2 Submitted at Deadline 5
6.3.7.1	Physical Processes Technical Baseline	AS-003
6.3.7.2	Physical Processes Numerical Modelling Report	APP-151
6.3.9.1	Benthic Ecology Technical Report (Array)	APP-154
6.3.9.2	Benthic Ecology Technical Report (ECC)	REP3-018
6.3.11.2	Underwater Noise Assessment	V2 Submitted at Deadline 5

10 Fish and Shellfish Ecology Technical Baseline

10.1 Introduction

10.1.1 Project Background

1. This technical report has been prepared as an Appendix of the Outer Dowsing Offshore Wind ('the Project') Environmental Statement (ES) which presents the results of the Environmental Impact Assessment (EIA) fish and shellfish ecology baseline characterisation. Specifically, this technical report details the technical baseline for fish (both pelagic and demersal, including elasmobranch species) and shellfish (molluscs and crustaceans) ecology of the Project seaward of Mean High Water Springs (MHWS) as well as the wider surrounding area.
2. GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as 'The Applicant', is proposing to develop the Project. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, Offshore Reactive Compensation Platforms (ORCP), onshore cables, connection to the electricity transmission network, ancillary and associated development and areas for the delivery of up to two Artificial Nesting Structures (ANS) and the creation and recreation of a biogenic reef (if these compensation measures are deemed to be required by the Secretary of State) (see Volume 1, Chapter 3: Project Description (document reference 6.1.3) for full details).

10.1.2 Purpose and Structure of this Document

3. The purpose of this report is to provide a contemporary and comprehensive analysis of site-specific and regional fish and shellfish ecology data within the study area and potential Zones of Influence (ZoI) defined for the Project.
4. The remainder of this document is structured in the following way:
   - Definition of the proposed study area;
   - Outline of data sources used to inform the characterisation;
   - A review of the baseline (existing) conditions of the array area, the Artificial Nesting Structures (ANS) the offshore Export Cable Corridor (ECC), and the Biogenic Reef Restoration Search Area;
   - Identification of fish and shellfish Valued Ecological Receptors (VERs) for the Project; and
   - Conclusion.
5. It is important to note that this document accompanies Volume 1 Chapter 10: Fish and Shellfish Ecology (document reference 6.1.10) and should be read in conjunction with
   - Volume 1, Chapter 9: Benthic and Intertidal Ecology (document reference 6.1.9);
   - the Benthic Ecology Technical Reports

- Volume 3, Appendix 9.1: Benthic Ecology OWF Area Results Report (document reference 6.3.9.1; and
- Volume 3, Appendix 9.2: Benthic Ecology Technical Report (ECC) (document reference 6.3.9.2), with regards to the Particle Size Analysis (PSA); and

- Volume 1, Chapter 7: Marine Physical Processes (document reference 6.1.7);
- The Marine Physical Processes appendices
  - Volume 3, Appendix 7.1: Physical Processes Technical Baseline (document reference 6.3.7.1); and
  - Volume 3, Appendix 7.2: Physical Processes Modelling Report (document reference 6.3.7.2).

10.2 Scope and Methodology

10.2.1 Overview

6. This report provides a baseline characterisation of the existing environment for fish and shellfish ecology. It includes the findings of a desktop study collating site-specific data collected within the Project AfL array area and across the offshore ECC, regional datasets and industry specific monitoring undertaken for a number of regional offshore windfarms. This report accompanies Chapter 10: Fish and Shellfish Ecology (document reference 6.1.10).
7. The following aspects are also considered, where appropriate, for fish and shellfish resource in the area:
   - Spawning grounds;
   - Nursery grounds;
   - Feeding grounds;
   - Overwintering areas for crustaceans; and
   - Migration routes.

10.2.2 Fish and Shellfish Study Area

8. For the purposes of this report, the fish and shellfish study area is presented in Figure 10.1.1 and has been defined at the following spatial scales:
   - For direct (primary) impacts on fish and shellfish receptors, the study area includes the Project windfarm array area and the offshore ECC, beyond the array boundary, up to and including the intertidal zone, up to MHWS;

- For secondary impacts with a larger ZoI (the Sedimentary ZoI) that can extend to receptors beyond the direct footprint of the Project, for example increased Suspended Sediment Concentrations (SSCs), a wider study area has been defined based on the project specific numerical modelling (Volume 3, Appendix 7.2; document reference 6.3.7.2) and has been scaled to conservatively represent the equivalent distance of tidal excursion on a mean spring tide and comprises a distance of between, approximately, 10km (at landfall), 15km (within the ECC) and 12km from the array area. This ZoI encapsulates the maximum extent of measurable plumes predicted by the modelling, although the majority of suspended sediment is expected to be deposited much closer to the disturbance activity; and
- A precautionary 50km study area has been defined for underwater noise impacts on fish and shellfish receptors, which fully encompasses subsea noise impact ranges predicted for recent United Kingdom (UK) offshore windfarm applications in the southern North Sea region.

9. The exact extents over which noise effect thresholds will be reached has been determined through detailed underwater noise modelling, based on the maximum design scenario (MDS) and relates to the greatest spatial, and greatest temporal effects. The maximum impact ranges from underwater noise will be up to 24km from the array area, up to 28km from the ANS, and 16km from the ORCP (Volume 3, Appendix 11.2: Underwater Noise Assessment (document reference 6.3.11.2)). The variations in these impact ranges arise from differences in bathymetry around the different parts of the Order Limits and the specific piling parameters. To ensure a precautionary approach and due to the highly mobile nature of many fish species, the ZoI study area for underwater noise has been informed by impact ranges for recent UK offshore windfarm applications. Until recently, modelling of impact ranges for fish assumed a fleeing response; however, recent projects (e.g. RWE, 2022; Equinor, 2022; Ørsted, 2021; Vattenfall, 2019) have been advised by statutory advisers to also consider stationary receptor modelling for some species groups, in part due to specific behaviours at certain life stages and also the limited data on fish reactions to noise stimulus over large distances. The maximum impact ranges for both stationary (e.g., spawning Atlantic herring *Clupea harengus*) and fleeing receptors from recent Offshore Windfarm (OWF) applications have been presented in Table 10.1 below. Taking the maximum impact ranges as informed by underwater noise modelling for recent offshore windfarm projects, a 50km ZoI for underwater noise impacts is deemed suitably precautionary.

Table 10.1: Maximum impact ranges for fleeing and stationary receptors from recent OWF applications.

Project	Maximum impact range for a fleeing receptor	Maximum impact range for a stationary receptor
Awel y Môr OWF (RWE, 2022)	17km	36km
Sheringham Shoal and Dudgeon OWF Extension Projects (Equinor, 2022)	10km	19km
Hornsea Four OWF (Ørsted, 2021)	26km	38km
Norfolk Boreas OWF (Vattenfall, 2019)	6.5km	18km

10.2.3 Data Sources

10. A detailed desktop review was carried out to establish the baseline of information available on fish and shellfish populations in the study area for the Project. Information was sought on fish and shellfish ecology in general and on spawning and nursery behaviour and habitats for key species. Species of commercial importance were identified through reference to Volume 1, Chapter 14: Commercial Fisheries (document reference 6.1.14), and the individual species accounts presented herein detail whether or not the species assessed are considered to be of commercial importance.
11. Data to support the baseline characterisation of the Project study area were extracted from the sources listed in Table 10.2 below.

Table 10.2: Data sources used to inform the Project baseline characterisation.

Data source	Data utilisation
Existing data sources	
Environmental Statements (ES), and pre- and post-construction monitoring reports from other OWF developments within the defined study area: ▪ Triton Knoll OWF herring larvae survey (Linnane and Simpson, 2011), seasonal trawl surveys (Linnane *et al*., 2011) and ES (RWE, 2012); ▪ Sheringham Shoal OWF herring spawning survey, and pre- and post-construction elasmobranch surveys (Brown & May Marine Ltd, 2009, 2010, 2015) and ES (Scira, 2006); ▪ Dudgeon OWF pre-construction adult fish surveys (Brown & May Marine Ltd, 2008a,b), baseline ecology study (Fugro, 2015) and ES (Royal Haskoning, 2009); and ▪ Hornsea Project One, Hornsea Project Two and Hornsea Project Three (as cited in Ørsted, 2018) and Hornsea Project Four ES (Ørsted, 2021).	Site-specific fish and shellfish surveys for OWF projects in the area and existing regional accounts of fish and shellfish ecology. Used to provide information to support the fish and shellfish ecology characterisation for the Project study area and broader region.
British Geological Survey (BGS) Seabed Sediment datasets (BGS, 2015).	PSA data presented to provide an indication of the location of suitable habitat and spawning grounds for sandeel and herring across the region.
EUSea Map broadscale marine habitat data (2021).	Broadscale marine habitat data presented to provide an indication of the location of suitable habitat and spawning grounds for sandeel and herring.
Fisheries Sensitivity Maps in British Waters (Coull *et al*., 1998).	Used to provide information on likely spawning or nursery areas for commercial species.
Ellis et al. (2010) Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (MPAs).	Used to provide information on fish spawning and nursery grounds.
Ellis *et al*. (2012) Spawning and nursery grounds of selected fish species in UK waters	
The International Herring Larval Survey (IHLS) data (International Council for the Exploration of the Sea (ICES), (1967-2015).	Time-series trawl data on herring larvae distribution used to characterise areas of actively spawning herring in relation to the Project.

Data source	Data utilisation
Marine Management Organisation (MMO) UK Sea Fisheries Monthly Reports and Annual Statistics Reports.	Commercial fisheries specific data (national and regional coverage). Used to provide data related to fisheries landings within the area.
Screening spatial interactions between marine aggregate application areas and sandeel habitat (Latto *et al*., 2013).	Methodologies used to identify spawning habitats of herring and sandeel within the study area.
Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas (Reach *et al*., 2013).	
The International Bottom Trawl Surveys (IBTS) (ICES, 1965-2022).	Time-series groundfish survey data collected throughout European seas used to characterise the fish assemblages across the study area.
ICES beam trawl surveys (ICES, 1995-2022).	
ICES North Sea International Bottom Trawl Survey (NSIBTS) data (ICES, 1965-2022).	
ICES North Sea Sandeel Survey (NSSS)	Annual sandeel dredge survey data, used to provide an indication of the presence, abundance and distribution of sandeel across the North Sea.
Boyle and New (2018) Offshore Renewable Joint Industry Project (ORJIP) Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options.	The study report presents a spatial analysis of the International Herring Larval Survey (IHLS) herring larval data collected over a ten-year period. The methodology defined within this study was used to undertake a spatial analysis of the IHLS data in relation to the Project to identify areas of active spawning herring grounds with overlap with the array area and offshore ECC.
Site-specific survey data	
Site-specific Benthic Ecology Baseline Characterisation Surveys.	Site-specific survey data from the AfL array area and the offshore ECC inclusive of benthic grabs; Drop Down Video (DDV); epibenthic trawls; PSA; sediment total carbon content; sediment contaminant analysis; and lab work, data analysis and reporting.
Site-specific Geophysical Survey.	Includes shallow geophysical, ultra-high resolution seismic (UHRS), side scan sonar (SSS), multi-Beam Echo Sounder (MBES), magnetometer, high frequency sub-bottom profiler (SBP) and vibrocore collection.
Site-specific Environmental DNA (eDNA) Survey.	Water column and sediment eDNA samples collected alongside the geophysical surveys, used to provide a snapshot of fish and shellfish species presence (from approximately the past 24 hours) at each sample location.

10.2.4 Data Limitations

12. Mobile species such as fish exhibit varying spatial and temporal patterns. All surveys from across the Project study area were undertaken to provide a semi-seasonal description of the fish and shellfish assemblages within the fish and shellfish study area. Notably, the data collected during these surveys represent snapshots of the fish and shellfish assemblage within the study area at the time of sampling and the fish and shellfish assemblages may vary considerably, both seasonally and annually. Should species be absent from the regional surveys, they should still be included in baseline characterisation. The baseline description draws upon (or defaults to) wider scientific literature and available information, as this provides a more thorough, robust, and longer time-series evidence base. This ensures a more comprehensive and precautionary baseline, identifying all species that are likely to be present within the study area.
13. The efficiency of the surveys varies depending on the nature of the survey methods used and the species recorded. For example, a semi-pelagic otter trawl would not collect pelagic species (e.g., herring and sprat *Sprattus sprattus*) as efficiently as a pelagic trawl, and a 2m scientific beam trawl would not be as efficient at collecting sandeel and shellfish species as other methods used commercially in the study area (e.g., sandeel or shrimp trawls and shellfish potting). This limits the data utility in capturing relative abundances of species within the area. To minimise this limitation caused by survey methodology, sensitive receptors have been chosen based on their presence or absence in surveys, rather than whether that species contributes more significantly to the fish assemblage in the survey data.
14. Coull *et al*. (1998) and Ellis *et al*. (2012) are considered key references for providing broadscale overviews of the potential spatial extent of spawning grounds and the relative intensity and duration of spawning. Both Coull *et al*. (1998) and Ellis *et al*. (2012) are based on a collection of various data sources. Many of the conclusions drawn by Coull *et al*. (1998) are based on historic research and data do not necessarily account for more recent changes in fish distributions and spawning behaviour. Ellis *et al*. (2012) is also limited by the wide scale distribution of sampling sites used for the annual international larval survey data used, consequently resulting in broadscale grids of spawning and nursery grounds. The spatial extent of the spawning grounds and the duration of spawning periods indicated in these studies are therefore considered likely to represent the maximum theoretical extent of the areas and periods within which spawning will occur. Spawning grounds may therefore be smaller in extent and display shorter spawning periods and, in some cases, spawning grounds indicated by these sources may no longer be active. Where available, additional research publications and data have been reviewed to provide the best, most contemporary and site-specific information. When considering demersal spawners which display substrate dependency (e.g., herring and sandeel), site-specific PSA and geophysical data (collected along the Project ECC and in the AfL array area) have been used to ground truth the Coull *et al*. (1998) and Ellis *et al*. (2012) datasets.

15. The EUSeaMap (2021) broadscale marine habitat data have also been used to identify preferred sandeel and herring spawning habitats. It should be acknowledged that this dataset is somewhat limited by the broadscale nature of the data, as it does not account for small-scale, localised differences in seabed sediments, unlike the data obtained from site-specific grab sampling. In this case it is important to review all the datasets presented to develop a clear overview of preferred sandeel and herring habitat.
16. Site-specific PSA data have been collected along the ECC and across the AfL array area to confirm and validate the broadscale data (Coull *et al*., 1998; Ellis *et al*., 2012; EUSeaMap, 2021). These data have been classified in accordance with the Latto *et al*. (2013) and Reach *et al*. (2013) classifications to identify areas of preferred spawning habitat for sandeel and herring, respectively. The use of PSA data and broadscale habitat mapping is intended to provide a proxy for the presence of sandeel and herring spawning habitat in these locations (based on suitability of habitats, i.e., the potential for spawning rather than actual contemporary spawning activity). Whilst grab samples provide detailed information on the sediment types, they cannot cover wide swaths of the seabed and consequently only represent point samples. The PSA data are therefore interpreted in combination with additional PSA data across the site, sourced from the BGS (BGS, 2015), to provide the most comprehensive cover of the fish and shellfish study area. It is important to note that although the data used in the characterisation of the fish and shellfish baseline conditions (as detailed in Table 10.2) span a long time period, with some sources published over a decade ago, the information presented represents a long-term dataset. This allows for a detailed overview of the characteristic fish and shellfish species in the study area. The diversity and abundance of many species, particularly demersal fish species, is linked to habitat types, which have remained relatively constant in the study area, indicating no major shift in the fish and shellfish communities over the time period of the data used in this report.

17. eDNA data have also been collected alongside the geophysical surveys to provide a snapshot of fish and shellfish species presence (from approximately the preceding 24-hours) at each sample location. As eDNA is a relatively new way of supplementing baseline characterisation in offshore wind projects, there is not a wealth of literature or protocols available to understand the implications of these data. Although eDNA shows great promise in identifying receptors and aiding EIA monitoring, there are potentially some challenges when applying such data within the context of a more generic EIA framework within marine environments. As a result of these challenges, the use of eDNA is recommended as a proxy for the presence of a receptor and not a direct measure of presence (Hinz *et al*., 2022). For example, one of the challenges is defining a sampling unit and sampling strategy with respect to the survey area which can create further challenges in drawing comparisons between different areas, across spatial and temporal scales (Hinz *et al*., 2022). In addition, statistical modelling presents itself as a challenge when using eDNA in marine EIA assessments due to the possibility of collecting both false positives and negatives in samples. As such, it is considered vital that the uncertainty in presence/absence estimates is provided during data processing (Hinz *et al*., 2022). The transport of eDNA fragments in marine environments is also generally unknown and influencing factors such as shedding dynamics, biogeochemical and physical processes need to be well understood in order to link a fragment of eDNA with a potential receptor's presence (Hinz *et al*., 2022).
18. Despite the data limitations detailed within this section of the report, the data as included in Table 10.2 is considered a robust and sufficient evidence base to inform the fish and shellfish baseline characterisation and underpin the assessment process, as agreed with the MMO through the EPP within the ETG meeting held on the 26 August, 2022.

10.3 Baseline Conditions

19. This section characterises the fish and shellfish ecology baseline in the following sub-sections:
    - Fish and Shellfish Assemblage;
    - Spawning and Nursery Grounds;
    - Species of Commercial Importance;
    - Diadromous species;
    - Elasmobranchs; and
    - Species of Conservation Importance and Designated Sites.
20. Due to the demersal spawning nature of herring and sandeel resulting in their increased sensitivity to potential impacts from the development, herring and sandeel have been addressed in separate sub-sections.

10.3.1 Fish and Shellfish Assemblage

21. The following section describes the fish and shellfish communities present within the study area (Figure 10.1.1). The baseline description of the study area draws on site-specific data collected within the AfL array area and offshore ECC, regional datasets and industry specific accounts and monitoring studies undertaken for a number of the existing or proposed OWFs in the southern North Sea region.
22. The datasets include both a snapshot of the current species composition across the southern North Sea and within the study area, alongside long-term time series data (e.g., bottom trawl surveys), which show the species composition to have remained consistent, subject to natural variation, overtime. Therefore, the data presented are considered both spatially, and temporally appropriate for the purposes of undertaking an EIA.

10.3.2 Site-Specific Surveys

Grab Sampling and Camera Transects

23. In the grab samples within the AfL array area (Figure 10.1.2) Raitt's sandeel *Ammodytes marinus* were identified at station OWF_42, smooth sandeel *Gymnammodytes semisquamatus* were present at stations 47 and 55, and lesser weaver *Echiichthys vipera* were present at station 63. Of the shellfish, brown crab *Cancer pagurus*, harbour crab *Liocarcinus* spp. and spider crab *Inachus* spp. were all identified at station 04. Harbour crab and brown crab were also present at station 24, and stations 43 and 76, respectively (GEOxyz, 2022a). Within the offshore ECC (Figure 10.1.3), Raitt's sandeel were present at one station (52), harbour crab were present at five stations (21, 23, 44, 48 and 59), pink shrimp *Pandalus montagui* were present at two stations (42 and 50) and brown shrimp *Crangon crangon* were present at one station (48) (GEOxyz, 2022b). Raitt's sandeel is included within the UK Biodiversity Action Plan (BAP) Priority Species List as it has shown a marked decline in the UK and is considered an important food source for many commercial fish, seals and seabirds.
24. Camera transects showed homogenous sand with negligible hard substrate. Within the offshore ECC, fauna observed on the seabed stills and videos were limited to sporadic sightings of plaice *Pleuronectes platessa*, common dragonet *Callionymus lyra*, lesser weaver and goby species *Gobiidae* spp., along with brown crab, harbour crab, spider crab species (toad crab *Hyas coarctatus,* and great spider crab *Hyas areneus*) and velvet swimming crab *Necora puber* (GEOxyz, 2022b). These species were also observed within the AfL array area, as well as pogge *Agonus cataphractus*, longspined bullhead *Taurulus bubalis* and sandeel species *Ammodytidae* spp. (GEOxyz, 2022a).

Epibenthic Trawls

25. Site-specific epibenthic trawls conducted within the AfL array area revealed a fish community characterised by demersal species including dab *Limanda limanda*, plaice, goby species, bull rout *Myoxocephalus scorpius*, grey gurnard *Eutrigla gurnardus*, Mediterranean scaldfish *Arnoglossa laterna*, solenette *Buglossidium luteum*, pogge and common dragonet as well as the inshore species lesser weever and longspined bullhead (GEOxyz, 2022a). Several commercially important species such as whiting *Merlangius merlangus*, ling *Molva molva* and common sole *Solea solea* were recorded at low abundances. The greater sandeel *Hyperoplus lanceolatus*, lesser sandeel *Ammodytes tobianus*, smooth sandeel and Raitt's sandeel were all recorded in the epibenthic trawls. The shellfish community included brown crab, spider crab species (toad crab and great spider crab), harbour crab, velvet swimming crab, hermit crab *Pagurus bernhardus*, brown shrimp, pink shrimp, queen scallop *Aequipecten opercularis* and blue mussel *Mytilus edulis*.
26. Four fish species recovered in trawl analysis are UK BAP Priority Species and Species of Principal Importance in England and are species of commercial value: Raitt's sandeel, whiting, plaice, and common sole. No specimens of ocean quahog *Arctica islandica* were observed on underwater video footage or recorded in grab/epibenthic trawl macrofauna datasets.
27. Site-specific epibenthic trawls conducted within the offshore ECC revealed a similar fish community to that within the AfL array area. In addition to much of the fish species found in the array area, thornback ray *Raja clavata* and common seasnail *Liparis liparis* were recorded within the offshore ECC (GEOxyz, 2022b). The shellfish community was also similar between the array area and the offshore ECC, with the addition of king scallop *Pecten maximus* and common whelk *Buccinum undatum* within the offshore ECC.

eDNA

28. A total of 28 fish species were identified within the AfL array area and ECC (Figure 10.1.2 and Figure 10.1.3), 24 bony and four elasmobranch species (GEOxyz, 2022c). Species assignment was undertaken to a minimum 50% confidence level, based on the similarity of a genetic sequence to library references for a particular species. Species of note that were not recorded in the other site-specific surveys along with their species identification confidence level are shown in Table 10.3.

Table 10.3: Fish species of note identified in the eDNA dataset.

Species recorded	AfL Array area	Offshore ECC	Species Identification Confidence (%)
Northern rockling *Ciliata septentrionalis*	✓	X	78.1
European bass *Dicentrarchus labrax*	X	✓	73.5 – 78.2
European anchovy *Engraulis encrasicolus*	X	✓	79.9
Tope shark *Galeorhinus galeus*	✓	✓	77.1
Starry smooth-hound *Mustelus asterias*	✓	✓	65.3 – 78.6
European perch *Perca fluviatilis*	X	✓	71.1
Spotted ray Raja montagui	✓	✓	51.9 – 52.5
Atlantic salmon *Salmo salar*	X	✓	66.7
Brown trout *Salmo trutta*	✓	X	79.9
European sardine *Sardina pilchardus*	✓	✓	76.5 – 77.7
Atlantic mackerel *Scomber scombrus*	✓	✓	67.9 – 78.5
Small-spotted catshark *Scyliorhinus canicula*	✓	✓	85.1
Sprat *Sprattus sprattus*	✓	✓	50.1 – 65.2
Whiting pout *Trisopterus luscus*	X	✓	74.5

29. The UK BAP Priority species and the International Union for Conservation of Nature (IUCN) 'Critically Endangered' tope shark was identified in both the AfL array area and the offshore ECC. The starry smoothhound, a species classed as 'Near Threatened' on the IUCN Red List due to its declining population status was also identified, along with the spotted skate, which is protected as an Oslo/Paris Convention (OSPAR) Threatened and Declining Species. An additional UK BAP Priority species due to its 'National Scarcity' was also identified: the Atlantic herring.

10.3.3 Regional Surveys

30. Long-term time series data that cover the greater North Sea and the study area include ICES NSIBTS. These data have a significant spatio-temporal coverage and have been carried out in quarters 1 and 3 of each year for the last 40 years. Surveys have been conducted using beam trawls across the wider North Sea. For the purpose of this study, the ICES squares closest to the project have been focused on (35F0, 35F1, 36F0 and 36F1). NSIBTS data collected from 2020 to 2022 were dominated by plaice, whiting, Atlantic mackerel *Scomber scombrus*, Atlantic herring and dab (ICES, 2020-2022).
31. Annual beam trawl surveys have been undertaken since 1995 across the southern North Sea by the Department for Environment, Food & Rural Affairs (Defra) in order to assess the relative abundances of plaice and common sole. As stated above, for the purpose of this study ICES squares 35F0, 35F1, 36F0 and 36F1 have been focussed on. Beam trawl survey data collected from 2020 to 2022 were dominated by dab, lemon sole *Microstomus kitt*, plaice and common sole (ICES, 1995-2022).
32. Annual herring larvae surveys have been undertaken across the North Sea since 1967 to provide quantitative estimates of herring larval abundance, which are used as a relative index of changes of herring spawning-stock biomass (ICES, 2012-2024). These IHLS data have been used to determine areas of active herring spawning relative to the Project.
33. Centre for Environment, Fisheries and Aquaculture (Cefas) Young Fish Surveys were undertaken between 1981 and 2010, surveying juvenile fish around the British Isles, predominantly along the south and east coasts. Annual beam trawls were undertaken across the nearshore ECC and recorded consistent high abundances of goby species *Pomatoschistus* spp., plaice, lesser pipefish *Syngnathus rostellatus*, dab, common sole and greater pipefish *Syngnathus acus* from 2000 to 2010 (Burt *et al*., 2019).

10.3.4 Offshore Wind Development Surveys

34. A number of surveys have been conducted as part of other OWF developments that sampled stations within the Project study area (Figure 10.1.4) and were designed to obtain baseline information regarding diversity and abundance of fish and shellfish.
35. A pre-construction site-specific herring larvae survey carried out within and around the Triton Knoll OWF (Linnane and Simpson, 2011) showed that, although herring larvae were recorded within the survey area, the abundances were too low to indicate the presence of herring spawning grounds in the survey area. Herring larvae abundances were highest to the northwest of the development site, approximately 20km from the Triton Knoll OWF. Closer to the development area, herring larval abundances decreased significantly and were absent from much of the area to the east of the development site. None of the herring larvae recorded possessed yolk sacks and so had not recently hatched. This indicated that these larvae were at least ten days old and may therefore have hatched further north and drifted south on currents. This led to the conclusion that consistent herring spawning grounds were not present either within or in the vicinity of the Order Limits.

36. Otter trawl and beam trawl surveys undertaken in Autumn 2008, Winter 2009 and Spring 2009 within the Triton Knoll development site and in the surrounding area (Linnane *et al*., 2011) found that the demersal fish communities in the vicinity of the windfarm site were typical of the southern North Sea. Dominant species included dab, bull-rout, pogge, dragonet, and goby species. Less abundant species included grey gurnard, lemon sole, sandeel and lesser weaver.
37. The findings of a post-construction herring larvae survey carried out over an area relevant to the Sheringham Shoal OWF indicate that within the survey dates (21st September – 8th December 2009) herring spawning did not occur within the area surveyed (Brown & May Marine Ltd, 2009a). Where spawning was considered to have occurred in the area in the past, it is possible, as postulated by Schmidt *et al*. (2009), that the stock collapse in the 1970's has resulted in a change in the herring spawning patterns within the North Sea with some former spawning grounds no longer existing. It should therefore be noted that spawning grounds should not be seen as rigid, unchanging descriptions of presence or absence as they can change from year to year (Ellis *et al*., 2012). Specifically, discrete pockets of spawning beds that herring use are not so easily identified due to the specific habitat and environmental conditions that herring require to enable successful spawning to take place (Boyle and New, 2018). A total of 26 bycatch species were caught during the survey. In the majority of trawls, the catch was predominantly sprats. Other species recorded were Atlantic cod *Gadus morhua*, dab, sandeel, common sole, whiting, thornback ray and Atlantic mackerel.
38. A pre-cable installation elasmobranch survey undertaken along the Sheringham Shoal OWF ECC (Brown & May Marine Ltd, 2010) recorded five species of elasmobranchs: starry smooth-hound, small-spotted catshark, thornback ray, common smooth-hound *Mustelus mustelus* and spotted ray *Raja montagui*. Bycatch species caught were European bass, dab and tub gurnard *Chelidonichthys lucerna*. A post-cable installation survey, which repeated the methodology of Brown & May Marine Ltd (2010), recorded a further elasmobranch species: tope shark (Brown & May Marine Ltd, 2015). Overall, higher abundances of small-spotted catshark and starry smooth-hound were recorded in the survey. European bass, whiting, dab, grey gurnard, red gurnard *Chelidonichthys cuculus*, longspined bullhead and tub gurnard were recorded as bycatch species.
39. At Dudgeon OWF, pre-construction surveys were carried out in the autumn and spring periods across the array area and offshore ECC (Brown & May Marine Ltd, 2008a,b). The principal shellfish species recorded in these surveys include velvet swimming crab, brown crab, European lobster *Homarus gammarus*, pink shrimp and brown shrimp. The principal fish species recorded include whiting, Atlantic herring, Atlantic cod, plaice, red mullet *Mullus smurletus* and lemon sole. A post-construction baseline ecology study, consisting of grab sample and beam trawl surveys, (Fugro, 2014) found that pink shrimp were one of the most dominant species from trawl samples, along with brown shrimp and harbour crabs.

40. Otter trawl and epibenthic beam trawl surveys conducted between 2010 and 2012 across the former Hornsea Zone (Hornsea Project One, Hornsea Project Two and Hornsea Three) (Ørsted, 2018) revealed a species assemblage typical of this area of the North Sea. The fish community was largely characterised by demersal species recorded in abundance during surveys, including whiting, dab, plaice, solenette and grey gurnard. Less abundant species included lemon sole, common sole and Atlantic cod. Surveys also recorded smaller demersal species such as bull rout, lesser weaver, common dragonet and Mediterranean scaldfish. Pelagic species were also recorded during surveys, including Atlantic herring, sprat, European common squid *Alloteuthis subulata* and European squid *Loligo vulgaris*. A total of 84 species were recorded in the otter and epibenthic beam trawls undertaken withing the Hornsea Four study area. Solenette dominated the trawls along with scaldfish, dab, plaice and lemon sole. Atlantic salmon, Atlantic cod, whiting and sandeels were also recorded in the area (Ørsted, 2021).

10.4 Spawning and Nursery Grounds

41. This section describes fish species which have spawning and nursery areas that are within or overlap the study area (Figure 10.1.1).
42. Spawning and nursery areas are categorised by Ellis *et al*. (2012) as either 'high' or 'low' intensity dependent on the level of spawning activity or abundance of juveniles recorded in these habitats. Coull *et al*. (1998) does not always provide this level of detail. The spatial extent of the spawning grounds and the duration of spawning periods indicated in these studies are therefore considered likely to represent the maximum theoretical extent of the areas and periods within which spawning will occur.
43. Due to the demersal spawning nature of herring and sandeel, and therefore their increased sensitivity to potential impacts from the development, herring and sandeel have been addressed separately to provide more detail, in paragraph 54 *et seq*.

10.4.1 Spawning Grounds

44. Species of fish and shellfish that are known to spawn in relatively close proximity to, or potentially overlapping with the study area (Coull *et al*., 1998; Ellis *et al*., 2012) are presented in Figure 10.1.5, Figure 10.1.6 and Figure 10.1.7.
45. A 'high intensity' plaice spawning ground overlaps the study area (Ellis *et al*., 2012). 'Low intensity' spawning grounds are present across the study area for sandeel and common sole (Ellis *et al*., 2012). There are also spawning grounds present across the study area for lemon sole, mackerel, and sprat (see Figure 10.1.5 and Figure 10.1.7) (Coull *et al*., 1998). These spawning grounds are extensive across the North Sea (Ellis *et al*., 2012) and the interaction between the sites and the study area is small.
46. An Atlantic cod spawning ground overlaps the study area (Ellis *et al*., 2012). The relative frequency of the presence of aggregations of cod in IBTS (ICES DATRAS, 2023b) from 2010 to 2020, shows aggregations of 'running' adults throughout the eastern channel, Southern Bight, and North Sea.
47. A 'low intensity' whiting spawning ground overlaps the study area (Ellis *et al*., 2012). The relative frequency of the presence of aggregations of whiting IBTS (ICES DATRAS, 2023b) from 2010 to 2020 (Q1), shows aggregations of 'running' adults throughout the eastern channel, Southern Bight, and North Sea.
48. A Banks (Central North Sea) herring spawning grounds intersects the Project array area and offshore ECC (Coull *et al*., 1998) (Figure 10.1.5). Furthermore, there is an inshore herring spawning ground located to the south of the offshore ECC (Coull *et al*., 1998). These are detailed further in paragraph 54 *et seq*.

49. A Norway lobster *Nephrops norvegicus* (herein referred to as Nephrops) spawning ground lies to the east of the array area (Figure 10.1.6) (Coull *et al*., 1998). These spawning grounds are significant in size, spanning large areas across the southern North Sea and the Channel. This is evidenced in the ICES IBTS from 2010 – 2020 (Q3+Q4+Q1 catches), which show aggregations (relative frequency) of Norway lobster across the North Sea. As Nephrops spawning sites are significant in size, the interaction between the sites and the study area is small.
50. The ORCPs, situated within the inshore ECC, lies within low intensity spawning grounds for sandeel and sole (Ellis *et al*., 2012; Coull *et al.*, 1998), and also lies within spawning grounds for lemon sole and herring (Coull *et al.*, 1998).

Compensation areas

51. The north ANS area lies within low intensity spawning grounds for sandeel, cod and whiting (Ellis *et al*., 2012; Coull *et al.*, 1998), and a high intensity plaice spawning ground. The north ANS area also lies within herring, lemon sole and sprat spawning grounds (Coull *et al.*, 1998).
52. The south ANS area lies within low intensity spawning grounds for cod, lemon sole, mackerel, sandeel, sole and whiting (Ellis *et al*., 2012; Coull *et al.*, 1998).
53. The Biogenic Reef Restoration area is located within low intensity spawning grounds for sandeel and sole (Ellis *et al*., 2012; Coull *et al.*, 1998) and spawning grounds for herring and lemon sole (Coull *et al.*, 1998).

Table 10.4: Summary of spawning timings (Coull *et al*., 1998) in the southern North Sea for fish species known to have spawning habitats in the study area (Light blue indicates spawning period, dark blue indicates peak spawning period).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plaice												
Whiting												
Atlantic cod												
Sandeel												
Common sole												
Atlantic herring												
Lemon sole												
Mackerel												
Sprat												
Nephrops												

Herring and Sandeel Spawning Grounds and Habitats

54. Herring and sandeel are of particular relevance when considering impacts to spawning areas as they are demersal spawners. As such, they have specific requirements in terms of spawning grounds, with seabed sediment being the primary determinant (Maravelias *et al*., 2000). Due to their reliance on specific substrates, sandeel and herring are more susceptible to seabed disturbance impacts, inclusive of impacts from increased SSC and sediment deposition.

55. Sandeel, as their name suggests, spawn in coarse sands to gravelly sands, whilst herring prefer to spawn in coarser sediments comprising sandy gravels to gravel. Data from Coull *et al*. (1998) and Ellis *et al*. (2012) suggest that the fish and shellfish study area lies within both sandeel and herring spawning grounds. Spawning grounds for sandeel are significant in size, identified across much of the southern North Sea (Ellis *et al*., 2012). Herring spawning grounds are patchier, with a significant area located in the northern area of the fish and shellfish study area (Coull *et al*., 1998).

Herring

56. The preferred sediment habitat for herring spawning is gravel, with some tolerance of more sandy sediments, although these are primarily on the edge of any spawning grounds (Stratoudakis *et al*., 1998). Herring spawning beds are typically small, localised features. Actual spawning habitat, or habitat that could be used for spawning activity, likely comprises relatively small seabed features, with discrete spatial extents, although these may be spread across wide areas of suitable seabed spawning habitat at a regional scale (e.g., spawning grounds). Eggs are laid on the seabed, usually in water 10-80m deep, in areas of gravel, or similar coarse habitats (e.g., coarse sand, shell and maerl), with well oxygenated waters (Ellis *et al*., 2012; Bowers, 1980; De Groot, 1980; Aneer, 1989; Stratoudakis *et al*., 1998).
57. Areas of potential herring spawning habitat have been identified using site-specific PSA data (GEOxyz, 2022a,b) and geophysical survey data (Enviros, 2022), BGS sediment data (BGS, 2015) and broadscale habitat mapping (EUSeaMap, 2021). These data have been classified in accordance with the Reach *et al*. (2013) classifications to further refine the understanding of areas of potential herring spawning habitat within the proposed development site. Areas of potential herring spawning habitat are shown in Figure 10.1.13 to Figure 10.1.19.
58. Site-specific PSA data (GEOxyz, 2022a,b) collected within the AfL array area were primarily characterised by sandy gravel and gravelly sand, which are classified as ‘prime, preferred’, ‘sub-prime, preferred’ and ‘suitable, marginal’ herring spawning habitats. ‘Prime, preferred’ herring spawning habitat was found at 22.2% of the sample points, which were mainly clustered towards the south of the AfL array area. 41.9% of the AfL array area was deemed as ‘unsuitable’ herring spawning habitat (GEOxyz, 2022a). EUSeaMap (2021) data, as presented in in Figure 10.1.13 and Figure 10.1.14, show significant areas of fine sand and muddy sand sediments across the AfL array area. This is supported by the site-specific geophysical data, which identified areas of coarse sediment consisting of Gravel and gravelly Sand, and finer sediments consisting of Sand and sandy Clay across the AfL array area (Enviros, 2022).

59. Site-specific PSA data (GEOxyz, 2022b) show the offshore ECC is largely dominated by 'unsuitable' herring spawning habitats (Figure 10.1.14 to Figure 10.1.16). There are areas of 'sub-prime, preferred' and 'suitable, marginal' habitats located in the mid-section of the ECC (Geoxyz, 2020b). On a broader scale, EUSeaMap (2021) data show that the inshore section of the offshore ECC is located within significant areas of mixed sediments and coarse sediment. The further offshore area of the ECC is dominated by areas of coarse sediment, interspersed with fine sand and muddy sand sediments. Across the region, to the northwest of the study area there are large areas of 'prime, preferred' herring spawning habitat, with significant areas of 'unsuitable' habitat to the north of the AfL array area. The south of the study area has more of a range of herring spawning habitat suitability, with a significant patch of 'prime, preferred' and 'sub-prime preferred' habitat (BGS, 2015).
60. The ORCPs, situated within the offshore ECC, lie within a herring spawning ground (Coull *et al*. 1998; Ellis *et al*., 2012). The substrate within the ORCP is classified as circalittoral coarse sediment, with areas of 'prime, preferred' and 'sub-prime preferred' habitat (Reach *et al*., 2013).
61. The sediment distribution envelope within the study area and across the broader region is considered to have remained consistent over the last 20 years, as evidenced through reference to the named sources above. Therefore, the data are considered to remain robust and appropriate for the purposes of undertaking an EIA.
62. Whilst these data indicate the potential for herring spawning habitats within the AfL array area and the nearshore and mid-section of the offshore ECC, IHLS data (ICES, 2012-2024) (as shown in Figure 10.1.18 and Figure 10.1.19) indicate that areas of high intensity spawning activity are located to the north of the Project. For the purposes of the assessment, it is assumed that the Coull *et al*. (1998) data represent historical spawning grounds, which may be recolonised in the future, whereas the IHLS data (ICES, 2012-2024) provide an indication of the areas of seabed in active use for spawning.

Herring migration

63. Herring spend their first few years in coastal nurseries, before moving offshore to deeper waters, where they join the adult populations (MacKenzie, 1985). These populations undertake feeding and spawning migrations to the western areas of the North Sea, with migrations following a clockwise circuit (Cushing, 2001) (Plate 1). The North Sea migration patterns, despite environmental variation, are considered to remain relatively constant over periods of several years (Corten, 2001). The Banks (Dogger) herring stock migrate in a clockwise circuit, from the northeast to the Banks spawning ground and then continuing in a northerly direction (Cushing, 2001).

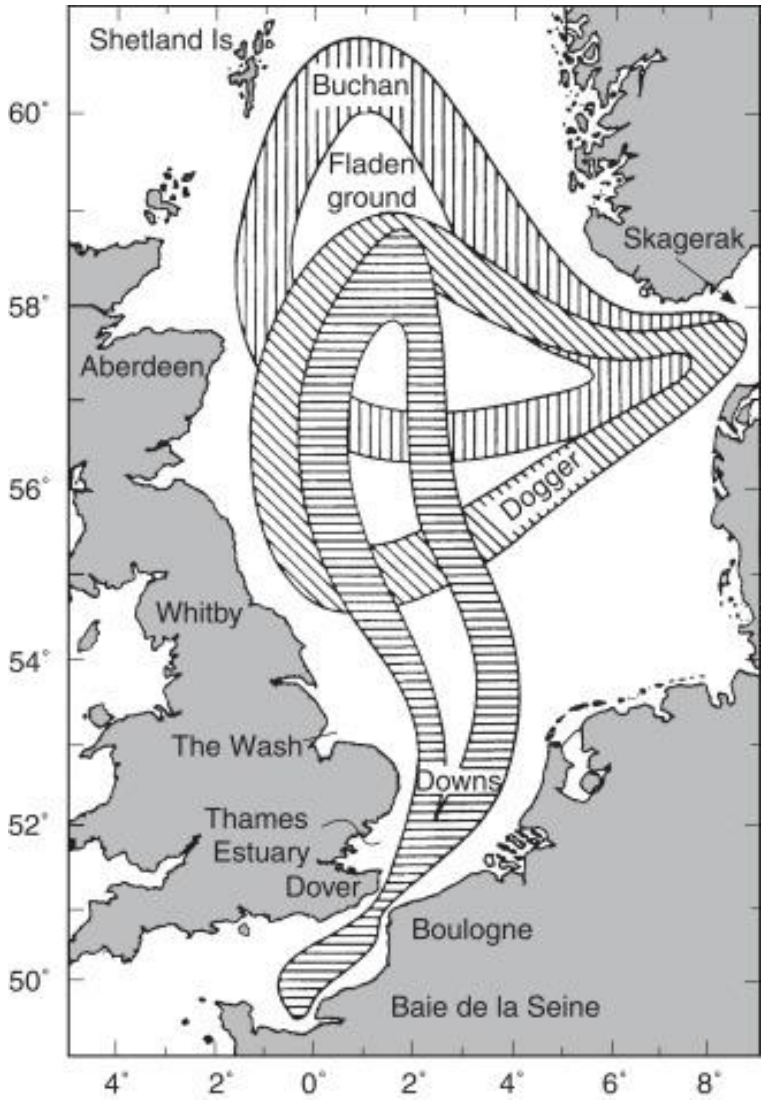

Plate 1: The migration circuits of the three groups of spawners in the North Sea: Buchan, Dogger and Downs (taken from Cushing, 2001)

Sandeel

64. Sandeel also spawn in coarse sediments, although their preferred spawning habitats are sandier than those of herring. Sandeel prefer habitats composed of sand to gravelly sand but will tolerate sandy gravels as a marginal spawning habitat.
65. Sandeel are highly substrate specific (Wright *et al*., 2000); after an initial larval dispersal period, sandeel display a degree of site fidelity (Jensen *et al*., 2011), so their settled distribution reflects the distribution of preferred habitat. Sandeel rarely occur in sediments where the silt content (particle size <0.63µm) is greater than 4%, and they are absent in substrates with a silt content greater than 10% (Holland *et al*., 2005; Wright *et al*., 2000).
66. Areas of potential sandeel spawning habitat have been identified using site-specific PSA data (GEOxyz, 2022a,b) and broadscale habitat mapping (EUSeaMap, 2021). These data have been classified in accordance with the Latto *et al*. (2013) classifications to further refine the understanding of areas of potential sandeel spawning habitat within the Project site. Areas of potential sandeel spawning habitat are shown in Figure 10.1.20 to Figure 10.1.23. Additionally, Figure 10.1.6 highlights the extent of low intensity sandeel spawning ground across the array area, with an area of high intensity spawning to the northeast (Ellis *et al*., 2012). Furthermore, both the north and south ANS areas and the Biogenic Reef Restoration Areas are located within low intensity spawning grounds for sandeel (Ellis *et al*., 2012; Coull *et al.,* 1998).
67. Site-specific PSA data (GEOxyz, 2022a) collected across the AfL array area were primarily characterised by sandy gravel and gravelly sand, largely characterised as ‘prime, preferred’, ‘sub-prime, preferred’ and ‘suitable, marginal’ sandeel habitat (37%, 16% and 36% of the AfL array area respectively). EUSeaMap (2021) data, as presented in Figure 10.1.20 and Figure 10.1.21, show significant areas of fine sand and muddy sand sediments across the array area. This is supported by the site-specific geophysical data, which identified the presence of finer sediments consisting of Sand and sandy Clay across the AfL array area (Enviros, 2022).
68. Site-specific PSA data (GEOxyz, 2022b) collected along the ECC show areas of ‘prime, preferred’, ‘sub-prime, preferred’ and ‘suitable, marginal’ sandeel habitat in the offshore section and mid-section of the ECC, with the nearshore section of the ECC dominated by ‘unsuitable’ sandeel habitat (see Figure 10.1.22 and Figure 10.1.23).
69. On a broader scale, as the area to the northwest of the study area has significant areas of coarse sediment (EUSeaMap, 2021), this area is largely considered ‘unsuitable’ for sandeel spawning (BGS, 2015). To the north of the AfL array area, where there are large areas of fine sand and sand (EUSeaMap, 2021), there are significant areas that are ‘prime, preferred’ sandeel spawning habitat. There are also areas of ‘prime, preferred’ sandeel spawning habitat in fine sand and muddy sand habitat to the south of the ECC and AfL array area. Between these areas, there is a significant region of ‘suitable, marginal’ and ‘unsuitable’ habitat in coarse sediments.

70. The ORCPs lie within the ECC and are situated in an area classified as a low intensity sandeel spawning ground (Ellis *et al*., 2012). The ORCPs comprise of circalittoral coarse sediment, providing 'suitable, marginal' and 'unsuitable' habitat for sandeel (Reach *et al*., 2013).
71. Annual sandeel surveys conducted as part of the NSSS from 2017 to 2023 , revealed a high abundance (893-1500) of Raitts sandeel across both the array area and the wider fish and shellfish study area (Figure 10.1.20). Higher sandeel abundances are also consistent with areas of "prime, preferred" habitats as identified in BGS sediment data (BGS, 2015) and site-specific PSA data (GEOxyz, 2022a,b) (classified in accordance with the Latto *et al*. (2013) classifications) (Figure 10.1.21).
72. Site-specific epibenthic trawls (GEOxyz, 2022a) within the array area indicated varying abundances of smooth sandeel and greater sandeel, ranging from low (1) to medium (4-5) abundance across the array area and higher abundances (14-49) of Raitts sandeel. Site specific grab samples (GEOxyz, 2022a) within the array area also found medium abundances (4-5) of Raitts sandeel present (Figure 10.1.20). Site-specific epibenthic trawls through the offshore ECC identified low abundances (2-3) of greater sandeel. Areas of higher sandeel abundance overlap with "prime, preferred" habitat, whereas areas of lower sandeel abundance appear to coincide with either "sub-prime" or "suitable, marginal" habitat suitability (as shown by the BGS data (BGS, 2015) and site-specific PSA data (GEOxyz, 2022a) presented in Figure 10.1.21).

Compensation areas

73. The north ANS area is located within a herring spawning ground (Coull *et al.*, 1998) and a low intensity sandeel spawning ground (Ellis *et al*., 2012; Coull *et al.*, 1998). The substrate within the ANS area is classified as circalittoral coarse sediment, with areas of 'prime, preferred' and 'sub-prime, preferred' herring spawning substrates (Reach *et al*., 2013), and 'unsuitable' and 'suitable, marginal' sandeel spawning substrates (Latto *et al*., 2013).
74. The South ANS area is located within a sandeel spawning ground (Ellis *et al*., 2012; Coull *et al.*, 1998). The substrate within the ANS area is classified as circalittoral coarse sediment and circalittoral fine or muddy sand, with areas of 'prime, preferred' sandeel spawning substrates (Latto *et al*., 2013).
75. The Biogenic Reef Restoration Area is located within a sandeel spawning ground and a herring spawning ground (Ellis *et al*., 2012; and Coull *et al.*, 1998). The substrate within the Biogenic Reef Restoration Search Area is classified as circalittoral mixed sediment and fine sands, with areas of reef habitat. The area is classified as 'unsuitable' and 'suitable, marginal' herring spawning habitat (Reach *et al*., 2013), and a combination of ''unsuitable', 'suitable, marginal', and 'prime, preferred' sandeel spawning substrates (Latto *et al*., 2013).

10.4.2 Nursery Grounds

76. The North Sea provides important nursery ground habitat for a variety of fish species. The fish and shellfish ecology study area coincides with 'high intensity' nursery grounds for cod and herring (Coull *et al*., 1998; Ellis *et al*., 2012) (Figure 10.1.8 and Figure 10.1.9).
77. A high intensity nursery ground for whiting also interacts with the study area (Coull *et al*., 1998; Ellis *et al*., 2012) (Figure 10.1.12). However, relative frequencies of the presence of aggregations of juvenile whiting (0 group), recorded in IBTS (ICES DATRAS, 2023b) from 2010 to 2020 (Q3 and Q4), showed aggregations of juveniles in the southern North Sea and northern North Sea, with comparatively lower aggregations of juveniles in the fish and shellfish study area.
78. 'Low intensity' nursery grounds are present across the study area for anglerfish *Lophius piscatorius*, ling, sandeel, spurdog *Squalus acanthias*, thornback ray and tope shark (Ellis *et al*., 2012) (Figure 10.1.8, Figure 10.1.9, Figure 10.1.10, and Figure 10.1.11).
79. A low intensity European hake *Merluccius merluccius* nursery ground also interacts with the study area (Figure 10.1.8). However, records from the ICES IBTS (ICES DATRAS, 2023b) in the North Sea, showing relative frequencies of the presence of aggregations of juvenile European hake (0 group), from 2010 to 2020 (Q3 and Q4), showed no aggregations of juveniles in the southern North Sea. With aggregations only evident across the Celtic Sea, off the west coast of Ireland, and in the northern North Sea.

80. A low intensity blue whiting *Micromesistius poutassou* nursery ground also interacts with the study area (Figure 10.1.8). However, records from the ICES IBTS (ICES DATRAS, 2023b) in the North Sea, showing relative frequencies of the presence of aggregations of juvenile blue whiting (0 group), from 2010 to 2020 (Q3 and Q4), showed no aggregations of juveniles in the North Sea. With aggregations only evident of the west coast of Ireland, and off the Orkney Islands.
81. A low intensity mackerel nursery ground also interacts with the study area (Figure 10.1.9). This is evidenced in ICES IBTS (ICES DATRAS, 2023b) in the North Sea. Relative frequencies of the presence of aggregations of juvenile mackerel (0 group), from 2010 to 2020 (Q4 and Q1), showed aggregation of juveniles in the northern North Sea and eastern channel, with comparatively lower aggregations of juveniles in the fish and shellfish study area.
82. A low intensity plaice nursery ground also interacts with the study area (Figure 10.1.10). This is evidenced in ICES Beam Trawl Surveys (ICES Database on Trawl Surveys (ICES DATRAS), 2023a) in the North Sea. Relative frequencies of the presence of aggregations from 2010 – 2020 (Q3 catches), showed aggregations of juvenile plaice (0 group) to the eastern extent of the Southern Bight, off the coasts of Belgium and the Netherlands, with smaller aggregates in the outer Wash, and the wider Thames Estuary.
83. A low intensity common sole nursery ground also interacts with the study area (Figure 10.1.10). This is evidenced in ICES IBTS (ICES DATRAS, 2023b) in the North Sea. Relative frequencies of the presence of aggregations of juvenile common sole (0 group) from 2010 – 2020 (Q3 catches), show aggregations within the fish and shellfish study area and across the Southern Bight, southern North Sea and the eastern channel. Comparatively lower aggregations of juvenile sole were observed in the northern North Sea.
84. A lemon sole nursery ground also interacts with the study area (Figure 10.1.9). This is evidenced in ICES ICES Beam Trawl Surveys (ICES Database on Trawl Surveys (ICES DATRAS), 2023a) in the North Sea. Relative frequencies of the presence of aggregations of juvenile lemon sole (0 group) from 2010 – 2020 (Q3 catches), show aggregations within the fish and shellfish study area, across the wider Thames Estuary, and northern North Sea. Comparatively lower aggregations of juvenile lemon sole were observed in the southern North Sea.
85. A sprat nursery ground also interacts with the study area (Figure 10.1.11). This is evidenced in ICES IBTS (ICES DATRAS, 2023b) in the North Sea. Relative frequencies of the presence of aggregations of juvenile sprat (0 group), recorded in IBTS (ICES DATRAS, 2023b) from 2010 to 2020 (Q3 and Q4), showed aggregations of juveniles in the southern North Sea with a small aggregation identified in the wider Thames Estuary, and comparatively lower aggregations of juveniles in the fish and shellfish study area.
86. There is also a nursery ground present across the study area for *Nephrops* (Figure 10.1.10) (Coull *et al*., 1998). These nursery grounds are significant in size, spanning large areas across the southern North Sea and the Channel. As Nephrops nursery grounds are significant in size, the interaction between the sites and the study area is small.

87. In a wider context, the study area for fish and shellfish ecology has a spatially limited interaction with a small portion of the overall nursery sites for these species across the wider North Sea.
88. The ORCPs lie within low intensity nursery grounds for plaice, sole, lemon sole, cod, whiting and thornback ray and a high intensity herring nursery ground (Ellis *et al.*, 2012; Coull *et al.*, 1998). The ORCP is also located within a nursery ground for lemon sole (Coull *et al.*, 1998).

Compensation areas

89. The north ANS Search Area lies within low intensity nursery grounds for sandeel, anglerfish, spurdog, herring and mackerel and high intensity cod and whiting nursery grounds (Ellis *et al.*, 2012). The ANS Search area also overlaps with sprat and lemon sole nursery grounds (Coull *et al.*, 1998).
90. The south ANS Search Area lies within low nursery grounds for anglerfish, cod, herring, mackerel, plaice, sandeel, whiting and spurdog (Ellis *et al.*, 2012; Coull *et al.*, 1998). The ANS Search Area also lies within a lemon sole nursery ground (Coull *et al.*, 1998).
91. The Biogenic Reef Restoration Search Area is located within low intensity spawning grounds for cod, plaice, sandeel, sole, whiting and thornback ray (Ellis *et al.*, 2012; Coull *et al.*, 1998) and a high intensity herring nursery ground (Ellis *et al.*, 2012; Coull *et al.*, 1998). The Biogenic Reef Restoration Search Area also overlaps with lemon sole nursery grounds (Coull *et al.*, 1998).
92. The compensation areas will be assessed within the ES following refinement of the proposed areas and once details of the works to be undertaken have been finalised.

10.5 Species of Commercial Importance

93. Detailed information on species of commercial importance is provided in Volume 3, Appendix 14.1: Commercial Fisheries Technical Baseline (Document Reference: 6.3.14.1), which identifies brown crab, European lobster, common whelk, king scallop, brown shrimp, blue mussel and common cockle *Cerastoderma edule* as the key commercially important shellfish species. Fish species of commercial importance were identified as sole, plaice, whiting, herring, mackerel, sprat, sandeel and European bass.
94. Fisheries landings from ICES rectangles 36F0, 36F1, 35F0,35F1 35F2 (which encompass the array area, offshore ECC and compensation areas) from 2018 to 2021 were dominated by brown crab, common whelk, common cockle, scallop, European lobster and brown shrimp by both weight (landed weight, tonnes) and value (MMO, 2022).
95. Landings in 2022 into Grimsby port (located south of the Humber estuary) were dominated in shellfish in quantity. Landings from ICES rectangles 36F0, 36F1, 35F0,35F1 35F2 in 2022 showed similarities to the 2018-2021 landings, with landings dominated by brown crab, common whelk, European lobster, common cockle, scallops and brown shrimp by both weight (landed weight, tonnes) and value (MMO, 2023).

10.5.1 Brown Crab

96. Brown crab (also known as edible crab) inhabit a range of intertidal and subtidal habitats, including bedrock, under boulders, mixed coarse grounds and offshore muddy sands, up to depths of approximately 100m (Neal and Wilson, 2008). A study by Natural England observed adult brown crab populations in North Norfolk coastal waters inhabiting areas of higher complexity chalk bed, with juveniles observed in all areas including areas of chalk and flint, and chalk cobbles and sand and gravel where chalk bed is not exposed (Tibbitt *et al*., 2020).
97. Brown crab have a tendency to exhibit higher activity at night when foraging occurs, although smaller crabs are known to be equally active during both day and night (Scott *et al*., 2018).
98. Brown crab populations have a wide range, extending from Scandinavia to Portugal (Bridges, 2018), with adult crabs known to undertake extensive migrations to offshore overwintering grounds, where eggs are hatched, moving back to coastal areas around May (Tonk and Rozemeijer, 2019). However, studies have indicated that there were no migratory exchanges between the North Sea and English Channel. Adult females have shown a migratory movement northward along the east coast from Norfolk to Yorkshire and Humberside (Bannister, 2009).

99. Brown crab is one of the most economically important crab species in UK waters. Traditionally this fishery is mixed, with crab and lobster caught together. A stock assessment of crab undertaken by the Eastern Inshore Fisheries & Conservation Authority (EIFCA) in 2019 identified that local brown crab stocks across the EIFCA district as a whole are stable, and recruitment is sufficient to replace annual depletion from fishing (EIFCA, 2021). A brown crab stock status assessment undertaken in 2019 by Cefas reported a high exploitation rate of brown crab in the southern North Sea, with anecdotal information suggesting a recent expansion of fishing activity in both pot numbers and distribution (Cefas, 2020a).

10.5.2 European Lobster

100. European lobster inhabit solitary shelters in rocky substrates to depths of 150m and have an extensive range, from Scandinavia to North Africa. The availability of suitable habitat is considered to influence the carrying capacity and size structure of lobster populations (Seitz *et al*., 2014; Welby, 2015). They are largely sedentary, although some interaction between inshore to offshore and longshore migration has been recorded at certain locations (Cefas, 2014), although this is thought be led by food availability (Pawson, 1995). European lobsters are largely sedentary, although will forage at night for crabs, gastropods and polychaetes but they are also opportunistic feeders and will scavenge for carrion (Naylor, 2011). Lobster breed once per year in the summer and newly berried females begin to appear from September to December. Juveniles or adult lobsters do not undertake any significant migrations, and juveniles in the first three to four years of life may be particularly sedentary. There is limited information on lobster spawning and nursery habitats in the southern North Sea. It has however been suggested that nearshore waters close to the Humber Estuary may represent overwintering grounds and/or nursery habitats for this species. This is supported by Bennet *et al*. (2006), who suggest that lobster nursery grounds are typically located on rocky coastal areas, although it is difficult to make firm conclusions due to the low abundances recorded (Smart Wind, 2015). A recent lobster stock assessment reports that exploitation of the European lobster stock in the East Anglia region is very high but has been declining since 2017 (Cefas, 2020b). Monitoring of lobster stocks across the region (ICES rectangles 34F0, 34F1 and 35F1) concluded that stocks are stable and currently recover from annual depletion, with recruitment maintaining the LPUE (EIFCA, 2021) (LPUE is used conservatively as a proxy for stock abundance, potentially highlighting areas with higher LPUE as having higher population densities (Welby 2016, cited in EIFCA, 2021)).

10.5.3 Common Whelk

101. Common whelk is a commercially important marine gastropod species fished in coastal waters of the UK and Northern Europe (Hollyman *et al*., 2018). The species is common along all British coasts and has an extensive distribution from Iceland and Norway to Bay of Biscay and throughout the North Atlantic. Common whelk typically inhabit muddy sand, gravel and rock (Haig *et al*., 2015) in the subtidal down to 1,200m, although are occasionally observed in the intertidal (Ager, 2008).

102. The timings of the reproductive cycle of common whelk varies across its distribution as copulation and egg laying are temperature dependent. In UK waters mating is triggered when temperatures fall below at least 12°C, in some cases 9°C as has been evidenced for populations found in the Solent (Kideys *et al*., 1993; Smith *et al*., 2013; Hollyman, 2017). Females deposit egg masses containing up to 2,700 eggs onto hard substrates (Martel *et al*., 1986). However, despite the large number of eggs within the egg masses, successful recruitment is low. Studies on a population within the Solent found approximately 1% of eggs developed to juveniles and the remaining eggs are used as nurse eggs for the developed embryos (Smith, 2013). The sedentary lifestyle of the whelk and lack of planktonic larval stage limits the dispersal of individuals and consequently reduces the genetic variation in a population, leading to distinct, localised populations (Ashfaq *et al*., 2019; Weetman *et al*., 2006; Martel *et al*., 1986).

103. Whelk fisheries are located along the east coast of the UK, with the highest fishing effort recorded in The Wash and North Norfolk. Recent reports from the EIFCA (EIFCA, 2020a) have highlighted an increase in annual landings of common whelk in the past ten years along the east coast of England, with the most significant increase recorded from 2008 to 2016, with recorded landings increasing from 8 tonnes to 2,274 tonnes. Landings per unit effort (LPUE) (used as an indication of the health of stocks) show an increase in common whelk stock levels between 2015 and 2019 (2.2 – 2.8 LPUE (total landings/pots hauled) respectively) (EIFCA, 2020a).

104. Byelaws have been implemented by the EIFCA across the district to ensure the sustainable management of the common whelk fisheries in the region for the benefit of fishermen, the local economy, and marine ecosystems alike. These include the Whelk Permit Byelaw, implemented in 2016, which requires fishers to obtain a whelk permit and fish within certain conditions. A commercial and recreational pot limitation was also implemented to prevent further increases in fishing effort within the district (EIFCA, 2020a).

10.5.4 King Scallop

105. King scallop fisheries around the UK coast represent the most valuable commercial species in the region. Regionally, key king scallop grounds are located to the north of the Project and study area, in the central North Sea. King scallop typically inhabit shallow depressions in the seabed, preferring areas of clean firm sand, fine or sandy gravel, and are occasionally observed on muddy sands (Marshall and Wilson, 2008).

106. In their most recent scallop stock assessment, Cefas (Lawler and Nawri, 2021) identify two main scallop beds, one of which is located within the study area. This bed, however, is located towards the north of the offshore ECC and does not overlap with Project boundaries. Stock surveys have been undertaken since 2017, noting that some stocks in the local king scallop bed, have been hindered due to the presence of static fishing gear. Scallop undertake limited swimming, with swimming behaviours likely to be at a high energy cost, and generally associated with escape scenarios. Consequently, this species is not expected to travel large distances (Marshall and Wilson, 2008).

10.5.5 Brown Shrimp

107. A brown shrimp beam trawl fishery lies within The Wash, to the south of the Project offshore ECC. Brown shrimp are the most commonly encountered shrimp of sandy bays and estuaries typically found on sandy and muddy grounds, often buried with only the eyes and antennae above the sediment surface. Brown shrimp have a high productivity and are an important prey species for many birds, fish and crustaceans. Additionally, the species is also commercially exploited for human consumption (Neal, 2008), being targeted by commercial fishing vessels within the wider region. Brown shrimp is common across all British and Irish coasts, and are widely distributed across the North Sea, with distinct populations located from Spurn Head northwards, and from Spurn Head to Dungeness, kept distinct by fronts of water masses preventing larval mixing (Henderson *et al*., 1990, as cited in Neal, 2008). Seasonal migrations of the brown shrimp typically occur in autumn-winter, and spring, with the transport of larvae to shallow inshore waters occurring in spring, where a mass grow-up of juveniles takes place in the summer (Boddeke, 1976).

10.5.6 Common Cockle

108. Cockle beds are located within The Wash, to the south of the ECC, which provide an important resource for the local fishing industry, particularly to the ports of Boston and King's Lynn. These stocks also provide an essential food resource for the internationally important communities of birds that reside or over-winter in The Wash.

109. Annual intertidal cockle stock assessments undertaken within The Wash, have observed declines in cockle stocks since 2016, although monitoring of stocks since 2000 reveal a cyclical pattern of recovery and decline driven by successful spatfalls, fisheries and natural mortality (EIFCA, 2019). Monitoring of cockle stocks within a small cockle bed at Horseshoe point, in the Humber Estuary, reported similar findings of fluctuating stocks (EIFCA, 2023a). Monitoring undertaken by Cefas on the mortalities of cockles in The Wash since 2021, have attributed those die-offs to a novel *Marteilia* parasite, although results from these studies are yet to be published (EIFCA, 2023a).

110. Various management measures are in place in relation the cockle fishery. The Eastern IFCA manages the cockle fisheries in The Wash under the Wash Fishery Order 1992, which expired in January 2023 and has been replaced by new management measures referred to as the Wash Interim Measures Cockle Fishery 2023. Current fishery management measures include restrictions on fishing methods, temporary closures, closed areas, limits on vessel lengths and daily catches, minimum landings sizes and TACs (EIFCA, 2023b).

10.5.7 Blue Mussel

111. Blue mussels are bivalve molluscs and are very common all around the coast of the British Isles, with large commercial beds in the Wash, Morecambe Bay, Conway Bay and the estuaries of south-west England, north Wales, and west Scotland.

112. The intertidal mussel stocks in The Wash have traditionally provided a valuable resource for the local fishing industry. These stocks also provide an important habitat for invertebrate communities and an essential food resource for the internationally important communities of birds that reside or over-winter in The Wash.

113. Annual intertidal mussel stock surveys have observed declines (die-offs) since 2010, with the cause currently not identified. 2021 surveys of 18 intertidal mussel beds in The Wash, inclusive of the Welland Bank recorded an increase in stock levels in the beds, although the beds themselves revealed they remained in were reportedly in poor condition, with sparse coverage, lots of dead shell and poor-quality mussels (EIFCA, 2022a).

10.6 Diadromous Species

114. Diadromous fish are fish that spend part of their life cycle in freshwater and part in seawater; such species are termed catadromous (born in marine habitats then migrate to freshwater areas) and anadromous (born in freshwater then migrate to, and mature in, the ocean). A number of diadromous fish species have the potential to occur in the fish and shellfish study area, migrating to and from rivers and other freshwater bodies in the area which these species use either for spawning habitat.

115. The Humber Estuary, to the north of the study area, is known to host several key diadromous species, which are known to spawn in the freshwater environments of tributaries flowing into the estuary, including the River Derwent Special Area of Conservation (SAC). These include sea lamprey *Petromyzon marinus* and river lamprey *Lampetra fluviatilis* (both qualifying species of the Humber Estuary SAC and Site of Special Scientific Interest (SSSI)), Atlantic salmon, brown trout, European eel *Anguilla anguilla* , twaite shad *Alosa fallax* and allis shad *Alosa alosa* (Perez-Dominguez, 2008; Allen *et al*., 2003; Proctor *et al*., 2000; Proctor and Musk, 2001).

10.6.1 Atlantic Salmon

116. Atlantic salmon are designated under Annex III of the Bern Convention and freshwater populations on The Conservation of Habitats and Species Regulations (2017). Atlantic salmon are also a UK BAP priority fish species.

117. Atlantic salmon are anadromous fish, spawning in freshwater and feeding at sea. Salmon spawn in upper reaches of rivers, where they live for one to three years before migrating to sea as smolts. At sea, salmon grow rapidly and after one to four years return to their natal river to spawn (Vladić and Petersson (2015).

118. A study by Marine Scotland (2017) investigated the movements of Atlantic salmon smolt in the Cromarty and Moray Firths; the study observed relatively rapid downstream migration, with the fish taking an average of eight days to travel approximately 62km. An eastern movement of smolt was observed from the Cromarty Firth, with observations made up to 30km from shore in the marine environment, and >60 km from the river mouth. This is supported by Thorstad *et al*. (2004) and Finstad *et al*. (2005), who noted that smolts undergo rapid migrations towards open marine areas, away from their river of origin, and in general do not follow nearby shores. However, contradictory evidence from Malcolm *et al*. (2010) suggests that smolt utilise nearshore areas at the commencement of their marine migration.

119. A study investigating the migratory routes of adult Atlantic salmon in Scotland observed a general migratory pattern, whereby salmon migrate through the North Sea, and then travel along the coast back to their home river (Malcom *et al*., 2010), suggesting the potential for integration between adult Atlantic salmon and the nearshore section of the offshore ECC, although this is expected to be of short duration. As detailed in Section 10.3.2, Atlantic salmon were recorded in water column eDNA samples from the offshore ECC.

10.6.2 Brown Trout

120. The Humber estuary is known to host brown trout, with the species known to also occur in The Wash and along the North Norfolk coast. A proportion of brown trout spend a number of years in fresh water before migrating to sea (individual with a marine phase are often referred to as sea trout); However, in contrast to Atlantic salmon, sea trout often return to fresh water to over-winter. Netting and tracking data for post-smolt brown trout suggest that the species typically remain close to the coast for the first couple of months before moving further offshore (Finstad *et al*., 2005 as cited in Malcolm *et al*., 2010). There is little consistency in observed migratory patterns of adult brown trout, with studies on the west coast of Scotland suggesting locally constrained areas, and contrasting studies suggesting wide range migrations, supported by offshore fishing vessel catches of the species suggesting offshore movement and migrations (Malcolm *et al*., 2010). As detailed in Section 10.3.2, brown trout were recorded in water column eDNA samples from the AfL array area.

10.6.3 European Eel

121. European eel are listed as critically endangered on the IUCN Red List and are UK BAP priority fish species. In addition, The Eels (England and Wales) Regulations 2009 (hereafter the Eels Regulations), and Eel Recovery Plan (Council Regulation No 1100/2007) as implemented in accordance with the Eels Regulations, have been established with an aim to protect migrating eels.

122. European eel are catadromous, feeding in freshwater and spawning at sea. The migration routes of adult eels do not appear to hug the UK coastline. The Humber estuary is known to host European eel, with the species known to occur in the Wash and along the North Norfolk coast. The movements of juveniles migrating from the spawning grounds in the Sargasso Sea are thought to primarily dictated by the course of prevailing currents, and there is a general assumption that proximity to Atlantic currents is associated with high eel numbers (Malcolm *et al*. 2010).Given the location and direction of the North Atlantic Drift current, the migratory movements of juvenile European eel are assumed to follow a southern movement along the coast. In contrast to this, the migration routes of adult eels do not appear to hug the UK coastline; however, data on the understanding of European eel movements are scarce (Malcolm *et al*., 2010).

10.6.4 River Lamprey and Sea Lamprey

123. River lamprey and sea lamprey are designated under Appendix III of the Bern Convention, The Conservation of Habitats and Species Regulations (2017), Schedule 5 of the Wildlife and Countryside Act and are UK BAP priority fish species.

124. River lamprey are widespread in the UK, typically occurring close to the coast (Barnes, 2008a). River lamprey are an anadromous species, which grow to maturity in estuaries around Britain and then move into fresh water to spawn in clean rivers and streams. The larvae spend several years in silt beds before metamorphosing and migrating downstream to estuaries (Maitland, 2003).

125. Sea lamprey occur offshore throughout the UK, migrating upstream of rivers to spawn (Barnes, 2008b). Spawning in British rivers usually occurs in later May or June. After hatching, the larvae drift downstream, distributing themselves among suitable silt beds. The larvae spend several years in silt beds before metamorphosing and migrating downstream. Relatively little is known about them after they reach the sea, where they have been found in both shallow coastal and deep offshore waters (Maitland, 2003).

10.6.5 Allis and Twaite Shad

126. Allis shad and twaite shad are designated under Appendix III and Appendix II of the Bern Convention, respectively, The Conservation of Habitats and Species Regulations (2017), Schedule 5 of the Wildlife and Countryside Act 1981 and are UK BAP priority fish species.

127. Allis shad and twaite shad are members of the herring family that spend most of their late juvenile and adult life in coastal waters. In spring, the mature adults enter estuaries and move upstream to the lower reaches of freshwater where they lay their eggs before returning (May-June) to the sea. The post-larval fish drift downstream in late summer and young-of-the-year reach the estuaries in autumn where they probably remain over winter (Potts and Swaby, 1993). It should be noted however that allis shad populations have declined considerably from pollution, over-fishing and river constructions, and there are now no known spawning sites for this species in Britain.

10.7 Elasmobranchs

128. As detailed in Section 10.4, and shown in Figure 10.1.11, nursery grounds for thornback ray, spurdog and tope shark overlap with the study area. Furthermore, as detailed in Section 10.3.4, various elasmobranch species were caught in OWF development surveys; these include thornback ray, tope shark, small-spotted catshark, starry smooth-hound and spotted ray.

129. Elasmobranchs are the group of electrosensitive fish that includes sharks, rays and skates. Elasmobranchs can detect the electrical fields emitted by themselves and other organisms. The most widely known use of electric fields is for prey detection, where the prey item generates an electric field that the predator senses. Electrosensitivity can also be used for orientation. Elasmobranchs are therefore considered a sensitive receptor to electromagnetic fields (EMF) emitted from operational cables.

10.8 Species of Conservation Importance and Designated Sites

10.8.1 Species of Conservation Importance

130. Within the study area there are number of marine and estuarine species protected under national and international legislation that have the potential to be present within the Project study area. These are summarised alongside their corresponding legislation in Table 10.5 below.

Table 10.5: Species of conservation importance with the potential to occur within the study area.

Species	UK BAP Species	The Conservation of Habitats and Species Regulations (2017)	Annex III (Bern Convention)	Section 41 Priority species	OSPAR threatened or declining	Marine Conservation Zone (MCZ) features	IUCN red list	Natural Environment and Rural Communities (NERC) Species of Principle Importance
Atlantic cod	✓	X	X	✓	✓	X	Vulnerable	✓
Plaice	✓	X	X	✓	X	X	Least concern	✓
Common sole	✓	X	X	✓	X	X	Least concern	✓
Whiting	✓	X	X	✓	X	X	Least concern	✓
European bass	X	X	X	X	X	X	Least concern	X
Mackerel	✓	X	X	✓	X	X	Least concern	✓
Brown trout	X	X	X	✓	X	X	Least concern	✓
European eel	✓	X	X	✓	✓	X	Critically endangered	✓
Atlantic salmon	✓	II, V	✓	✓	✓	X	Near threatened	✓
Sea lamprey	✓	II	X	✓	✓	X	Least concern	✓
River lamprey	✓	II, V	X	✓	X	X	Least concern	✓
Twaite shad	✓	II, V	✓	✓	X	X	Least concern	✓
Allis shad	✓	II, V	✓	✓	✓	X	Least concern	✓
Atlantic herring	✓	X	X	✓	X	X	Least concern	✓
Sandeel	✓	X	X	X	X	X	Least concern	✓
Ocean quahog	X	X	X	X	X	✓	X	X

Species	UK BAP Species	The Conservation of Habitats and Species Regulations (2017)	Annex III (Bern Convention)	Section 41 Priority species	OSPAR threatened or declining	Marine Conservation Zone (MCZ) features	IUCN red list	Natural Environment and Rural Communities (NERC) Species of Principle Importance
Thornback ray	X	X	X	X	✓	X	Near threatened	X
Tope shark	✓	X	X	X	X	X	Critically endangered	X
Spurdog	✓	X	X	X	✓	X	Vulnerable	✓
Small-spotted catshark	X	X	X	✓	X	X	Least concern	X
Starry smooth-hound	X	X	X	X	X	X	Near threatened	X
Spotted ray	X	X	X	X	✓	X	Least concern	X

10.8.2 Designated Sites

131. All designated and protected sites within the study area (Figure 10.1.24), where impacts to fish and shellfish receptors could impact the conservation objectives or features of the site by the Project, are described below.

132. The Humber Estuary SAC, the Humber Estuary Ramsar and the Humber Estuary SSSI all have the sea lamprey and river lamprey listed as qualifying features. These species are known to migrate through the Humber estuary to freshwater spawning habitats.

133. The Southern North Sea SAC is designated for the Annex II species harbour porpoise *Phocoena phocoena*. The SAC has a Conservation Objective to maintain Favourable Conservation for the harbour porpoise, which includes the maintenance of the availability of prey habitats (which typically consists of non-spiny fish such as herring, whiting and Atlantic cod, squid and sprat).

134. The only MCZ of relevance to fish and shellfish receptors within the study area (and not overlapping with the Order Limits) is the Holderness Offshore MCZ, which is designated for the ocean quahog, a bivalve mollusc found in sandy seabed throughout the North Sea.

135. The Project is aware that a number of proposed Highly Protected Marine Areas (HPMAs) were consulted on from October to September 2022, which included the Inner Silver Pit South (EIFCA, 2022b). A summary of the consultation responses has been published by Defra (Defra, 2023). Fifty-nine per cent of survey respondents supported the proposal to designate a pilot HPMA at Inner Silver Pit South, with 45% of these strongly supporting the plans. The majority of survey respondents agreed that designation would further the protection of the marine ecosystem (59%). However, after reviewing the evidence, the SoS has decided not to designate Inner Silver Pit South as a HPMA due to the relatively high costs to fishermen incurred by designation. The commercial fishing in this site is comparatively productive compared to the surrounding area and as a result they consider that the benefits of designation would not sufficiently outweigh the impacts on fishers.

10.8.3 Valued Ecological Receptors

136. The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (Chartered Institute of Ecology and Environmental Management (CIEEM) 2018). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g., species listed on The Conservation of Habitats and Species Regulations (2017), UK BAP species or species of principal importance listed under the NERC Act 2006, and species listed as features of existing or recommended MCZs (rMCZs)). Evaluation has also assessed the receptor value in accordance with the functional role of the habitat or species. The criteria used to inform this assessment are listed in Table 10.6 below.

Table 10.6: Criteria used to inform the valuation of ecological receptors in the Project fish and shellfish study area (derived from guidance published by CIEEM (2018)).

VER value	VER criteria used to define value
International	Internationally designated sites, or species designated under international law (i.e. species designated under the OSPAR List of Threatened and/or Declining Species, or species listed as Critically Endangered, Endangered or Vulnerable on the IUCN Red List.)
National	Species protected under national law (i.e., Annex II species listed as features of SACs) within the National Site Network. Annex II species which are not listed as features of SACs in the Project fish and shellfish study area. UK BAP priority species (including grouped action plans) that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, MCZ/rMCZ features (species classified as features of conservation importance and broad scale habitats), species of principal importance and Nationally Important Marine Features (NIMF) that have nationally important populations within the Project fish and shellfish study area, particularly in the context of species/habitat that may be rare or threatened in the UK. Species that have spawning or nursery areas within the Project fish and shellfish study area that are important nationally (e.g., may be primary spawning/nursery area for that species).
Regional	UK BAP priority species (these include grouped action plans) that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, MCZ/rMCZ features (species classified as features of conservation importance, and broadscale habitats), species of principal importance and NIMF that have regionally important populations within the Project fish and shellfish study area (are locally widespread and/or abundant). Species of commercial importance, to fisheries in the area. Species of ecological importance (i.e., are an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages in the Project fish and shellfish study area. Species that have spawning or nursery areas within the study area that are important regionally.
Local	Species of commercial importance but do not form a key component of the fish assemblages within the Project fish and shellfish study area. The spawning/nursery area for the species is located outside of the study area. The species is common throughout the UK but forms a component of the fish assemblages in the study area.

137. With consideration of each receptor's distribution and abundance, spawning and nursery activity, as well as their commercial, conservation and ecological importance, an assessment of the value of each of these receptors within the defined fish and shellfish study area has been provided in Table 10.7.

Table 10.7: Summary of Fish and Shellfish VERs and their value/importance within the Project fish and shellfish study area.

VER	Valuation	Justification
Demersal VERs		
Atlantic cod	International	Study area overlaps low intensity spawning and low intensity nursery grounds. Cod were also recorded in OWF development surveys. Cod are listed as a Section 41 priority species, listed on the OSPAR List of Threatened and/or Declining Species and Habitats, and are listed as vulnerable on the IUCN Red List.
Dab	Local	Recorded throughout the Project fish and shellfish study area in site-specific epibenthic trawls, regional trawls and offshore wind development surveys.
Plaice	Regional	Study area overlaps high intensity spawning grounds and low intensity nursery grounds. UK BAP species (commercial marine fish grouped action plan) and NERC species of principal importance. Recorded throughout the Project fish and shellfish study area in site-specific trawls, regional trawls and offshore wind development surveys. Of commercial importance to the region.
Lemon sole	Local	Study area overlaps spawning grounds and low intensity nursery grounds. Recorded in regional trawls and offshore wind development surveys.
Common sole	Regional	Study area overlaps low intensity spawning ground. Of commercial importance to the region. Recorded in site-specific epibenthic trawls, regional trawls and offshore wind development surveys. Common sole is listed as a UK BAP and Section 41 Species.
Whiting	Regional	Study area overlaps low intensity spawning and low intensity nursery grounds. Whiting is listed as a UK BAP and Section 41 Species. Of commercial importance to the region. Recorded in site-specific epibenthic trawls, regional trawls and offshore wind development surveys.
Anglerfish	Local	Study area overlaps low intensity nursery grounds.
Lesser weaver	Local	Study area overlaps low intensity nursery grounds. Recorded in site-specific grab samples and water column eDNA samples, and offshore wind development surveys.
Blue whiting	Local	Study area overlaps low intensity nursery grounds.
Ling	Local	Study area overlaps low intensity nursery grounds. Recorded in site-specific epibenthic trawls.
European hake	Local	Study area overlaps low intensity nursery ground.
Pelagic VERs		

VER	Valuation	Justification
Atlantic mackerel	Regional	Study area overlaps spawning grounds and low intensity nursery grounds. Of commercial importance to the region. UK BAP Species, and Section 41 Priority Species. Prey species for birds and marine mammals and forming key components of the ecosystem. Recorded in site-specific water column eDNA samples, regional trawls and offshore wind development surveys.
Sprat	Regional	Study area overlaps a spawning ground. Recorded in site-specific water column eDNA samples and offshore wind development surveys. Of commercial importance to the region. Important prey species for bird and marine mammal species.
European anchovy	Regional	Recorded in site-specific water column eDNA samples. Of commercial importance to the region.
European bass	Regional	Recorded in site-specific water column eDNA samples and offshore wind development surveys. Of commercial importance to the region.
Migratory VERs		
Brown trout	Regional	Recorded in site-specific water column eDNA samples. Section 41 and UK BAP Priority species. Potential for this species to transit the site.
European eel	International	Designated under the Eel Regulations. Listed as UK BAP priority species, listed on the OSPAR List of Threatened and/or Declining Species and Habitats, and European eel is listed as critically endangered on the IUCN Red List. Potential for this species to transit the site.
Atlantic salmon	International	Recorded in site-specific water column eDNA samples and offshore wind development surveys. Annex III of the Bern convention, listed on the OSPAR List of Threatened and/or Declining Species and Habitats, listed on The Conservation of Habitats and Species Regulations (2017), and a UK BAP priority species. Potential for this species to transit the site.
Sea lamprey	International	Annex III of the Bern Convention, listed on the OSPAR List of Threatened and/or Declining Species and Habitats, listed on The Conservation of Habitats and Species Regulations (2017), Schedule 5 of the Wildlife and Countryside Act, UK BAP priority fish species. Potential for this species to transit the site.
River lamprey	National	Annex III of the Bern Convention, listed on The Conservation of Habitats and Species Regulations (2017), Schedule 5 of the Wildlife and Countryside Act, UK BAP priority fish species. Potential for this species to transit the site.

VER	Valuation	Justification
Twaite shad	Regional	Annex II of the Bern Conventions, listed on The Conservation of Habitats and Species Regulations (2017), Schedule 5 of the Wildlife and Countryside Act 1981 and UK BAP priority fish species. Potential for this species to transit the site.
Allis shad	International	Annex II of the Bern Conventions, listed on the OSPAR List of Threatened and/or Declining Species and Habitats, listed on The Conservation of Habitats and Species Regulations (2017), Schedule 5 of the Wildlife and Countryside Act 1981 and UK BAP priority fish species. Potential for this species to transit the site.
Benthopelagic VERs		
Herring	Regional	Spawning and low intensity nursery grounds occur across the study area. UK BAP species and nationally important marine feature. Prey species for birds and marine mammals. Important commercial fish species. Recorded in site-specific water column eDNA samples, regional trawls and offshore wind development surveys. Of commercial importance to the region.
Sandeel (lesser sandeel, great sandeel, smooth sandeel, Raitts sandeel)	Regional	Low intensity spawning and low intensity nursery grounds occur across the study area. Important prey species for fish, birds and marine mammals. UK BAP species and a nationally important marine feature. Recorded in site-specific grab samples, epibenthic trawls and water column eDNA samples, and offshore wind development surveys. Of commercial importance to the region.
Shellfish VERS		
Brown crab	Regional	Important commercial shellfish species in the Project study area. Recorded in site-specific grab samples and epibenthic trawls, and offshore wind development surveys.
European lobster	Regional	Important commercial shellfish species in the Project study area. Recorded in offshore wind development surveys.
Nephrops	Regional	Known spawning ground located within the study area.
Ocean quahog	International	This species is listed on the OSPAR List of Threatened and/or Declining Species and Habitats. It is also a Feature of Conservation Importance for which the Holderness Offshore MCZ is designated. As such these are considered of national importance.
Blue mussel	Regional	Important commercial shellfish species in the Project study area. Recorded in site-specific epibenthic trawls.

VER	Valuation	Justification
Common cockle	Regional	Important commercial shellfish species in the Project study area.
Common whelk	Regional	Important commercial shellfish species in the Project study area. Recorded in site-specific epibenthic trawls.
Brown shrimp	Regional	Important commercial shellfish species in the Project study area. Important prey species. Recorded in site-specific grab samples and epibenthic trawls, and offshore wind development surveys.
Queen scallop	Regional	Recorded in site-specific epibenthic trawls. Important commercial shellfish species in the Project study area.
King scallop	Regional	Recorded in site-specific epibenthic trawls. Important commercial shellfish species in the Project study area.
Elasmobranch VERS		
Thornback ray	International	Study area overlaps low intensity nursery grounds. , Listed on the OSPAR List of Threatened and/or Declining Species and Habitats and listed as near threatened by the IUCN red list. Recorded in site-specific epibenthic trawls and offshore wind development surveys.
Blonde ray	Regional	Blonde ray *Raja brachyura* is included as it has been identified by Lincolnshire Wildlife Trust as a species of concern.
Spotted ray	International	Recorded in site-specific water column eDNA samples and offshore wind development surveys. Listed on the OSPAR List of Threatened and/or Declining Species and Habitats
Common smooth-hound	International	Listed as vulnerable on the IUCN red list. Recorded in offshore wind development surveys.
Starry smooth-hound	Regional	Classed as 'Near Threatened' on the IUCN Red List. Recorded in site-specific water column eDNA samples and offshore wind development surveys.
Small-spotted catshark	Regional	Section 41 priority species. Recorded in site-specific water column eDNA samples and offshore wind development surveys.
Spurdog	International	Study area overlaps low intensity nursery grounds. UK BAP species, listed as vulnerable on the IUCN Red List, listed on the OSPAR List of Threatened and/or Declining Species and Habitats and NERC Species of Principle Importance.
Tope shark	International	Study area overlaps low intensity nursery grounds. UK BAP species and listed as critically endangered by the IUCN red list. Recorded in site-specific water column eDNA samples and offshore wind development surveys.

10.9 Conclusions

138. After consideration of site-specific and regional information over a broad time series, it is concluded that the level of information available is adequate for the purposes of characterising the existing environment in terms of fish and shellfish ecology.

139. With the addition of site-specific PSA analysis, camera transects, grab sampling, epibenthic beam trawls and eDNA sampling, the information presented within this report provides a robust evidence base which is reinforced by historical data.

140. The analysis also describes appropriately the fish community with regards to migratory species, commercial species, and species of conservation importance, such that it is considered a further survey will not identify any additional receptors that may constitute valued ecological receptors for the purposes of undertaking an EIA.

141. The information presented within this technical annex is therefore considered to be an appropriate characterisation of the receiving environment with regards to fish and shellfish receptors. It is concluded that the presence of a combination of site-specific and regional data sets across a range of temporal scales precludes the need for further site-specific surveys.

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