Bowdun Offshore Wind Farm, Offshore EIA Report

Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report

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Glossary

Defined Term	Definition
0-group fish	Fisheries statistics term which refers to fish within their first year of life.
Annex II	Species of community interest whose conservation requires the designation of Special Areas of Conservation (SACs) as identified in Annex II of Habitats Directive (Council Directive 92/43/EEC).
Applicant (the)	Bowdun Offshore Wind Farm Limited (BOWFL).
Array Area	The Array Area is the area in which the Offshore Generation Assets will be located.
Benthic	Living on or in the seabed.
Bowdun Offshore Wind Farm Limited (BOWFL)	A Special-Purpose Vehicle (SPV) (legal entity) for the purpose of developing the Project. BOWFL are the Applicant for the Offshore Application.
Commercial Fishing	Any form of fishing activity legally undertaken where the catch is sold for taxable profit.
Crown Estate Scotland (CES)	Public corporation accountable to Scottish Government, responsible for the management of land and property, including marine assets in Scotland owned by the monarch.
Demersal Fish	Fish which live and feed on or near the seabed.
Diadromous Fish	Fish which move between freshwater and seawater as part of their life cycle.
Digital Aerial Surveys (DAS)	A method for undertaking baseline ornithological and marine mammal data collection surveys. Usually undertaken over a period of 24 months.
Effect	Term used to express the consequence of an impact (i.e. the result of change or changes) on specific environmental resources or receptors. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity of the receptor or resource in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	Process for the assessment of likely significant environmental effects of a project on the physical, biological, and human environment during construction, Operations and Maintenance (O&M) and decommissioning.
European Sites	This term recognises SACs, candidate SACs (cSACs), Sites of Community Importance (SCIs), Special Protection Areas (SPAs), possible SACs (pSACs), potential SPAs (pSPAs) and Ramsar sites (where also designated as another European Site), which protect species and habitats shared across Europe and were originally designated under European legislation.
Export Cable Corridor	The area of seabed seaward of Mean High Water Springs (MHWS) which connects the Array Area with the Landfall within which the Offshore Export Cables will be installed.
Gadoid	A teleost marine fish of the order Gadiformes which includes fish such as cods, hakes and other related fish.
Habitats Regulations Appraisal (HRA)	An assessment carried out under the Habitats Regulations to determine if a plan or project could adversely affect the integrity of a European Site.

Defined Term	Definition
Impact	A change caused by an action that occurs during a project's lifetime.
Inter-Array Cables (IAC)	Cables which link the Wind Turbines to each other and with the Offshore Substation Platforms (OSPs).
Interconnector Cables	Cables which will connect individual OSPs to each other to provide redundancy against cable failure elsewhere.
Intertidal Area	The area between MHWS and Mean Low Water Springs (MLWS).
Landfall	The area in which the Offshore Export Cables make landfall and is also the transitional area between the Offshore Transmission Assets and the Onshore Transmission Assets. Located in the Intertidal Area at Benholm.
Marine Directorate	The Marine Directorate of the Scottish Government, formerly known as Marine Scotland. The planning and licensing authority for Scotland's seas and custodian of Scotland's National Marine Plan (NMP). The Marine Directorate - Licensing Operations Team (MD-LOT) are specifically responsible for managing section 36 Consent and Marine Licence Applications seaward of MHWS.
Marine Directorate – Science, Evidence, Data and Digital (MD-SEDD)	The scientific division of MD, which provides expert scientific, economic and technical advice and services on issues relating to marine fisheries, aquaculture, marine renewable energy, and the aquatic environment and its flora and fauna.
Marine Protected Areas (MPAs)	MPAs are designated under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act (MCAA) 2009. The MPA network protects nationally and internationally important marine wildlife, habitats, geology, and underwater landforms. Scotland's MPAs are significantly important for European, North-East Atlantic, and global MPA networks.
Mean High Water Springs (MHWS)	The average tidal height throughout the year of two successive high waters during those periods of 24 hours when the range of the tide is at its greatest.
Mean Low Water Springs (MLWS)	The average tidal height throughout the year of two successive low waters during those periods of 24 hours when the range of the tide is at its greatest.
Offshore Environmental Impact Assessment (EIA) Report (hereafter, 'Offshore EIA Report')	Document prepared to report the findings of the EIA for the Proposed Development and produced in accordance with the EIA Regulations. The Offshore EIA Report is submitted to support the Offshore Application for the Proposed Development, and to comply with EIA Regulations.
Offshore Export Cables	Subsea cables used to transmit electricity generated offshore by the Wind Turbines from the OSPs to shore. The Transition Joint Bay (TJB) is the location where the Offshore Export Cable terminates, and the onshore cabling begins.
Offshore Scoping Report	The report that presents the findings of the EIA scoping process undertaken for the Proposed Development with the purpose of obtaining a Scoping Opinion. The Offshore Scoping Report defines what is intended to be assessed and reported as part of the EIA.
Offshore Substation Platform(s) (OSPs)	OSPs comprise the support structure, topside and electrical components used for collecting and/or converting electricity generated by the Wind Turbines for transmission by the Offshore Export Cables.

Defined Term	Definition
Operation and Maintenance (O&M)	The phase of the Proposed Development following completion of construction. This phase of development includes routine inspections, repairs and replacement of infrastructure and equipment (including Interconnector Cables and IACs), Scour Protection replenishment or replacement, major component replacement, painting and/or other coating works, removal of marine growth, and replacement of access ladders.
Option Lease Agreement (OLA)	An agreement between CES and a developer, permitting the future development of offshore wind within an agreed area.
Oslo-Paris [Convention] (OSPAR)	Convention for the Protection of the Marine Environment of the North-East Atlantic.
Pelagic Fish	Fish which live within the water column, not on or near the seabed or at the coasts.
Piling	The action of installing piles: installation can use various methodologies, the most common of which are impact piling (in which the piles are struck by a 'hammer') and drilling (during which a hole is drilled into the seafloor, the drilling tool is removed, and the pile is slotted into that hole).
Plan Option Area (POA)	A location identified in the Sectoral Marine Plan (SMP) as a preferred area for commercial scale offshore wind development.
Project (the)	An overarching term for the Bowdun Offshore Wind Farm (Bowdun OWF) comprising the offshore and onshore infrastructure required to generate and transmit electricity from the Array Area to the onshore Grid Connection Point. The Project includes the Offshore Generation Assets, the Offshore Transmission Assets and the Onshore Transmission Assets.
Proposed Development	Term used to define the Offshore Infrastructure associated with the Project seaward of MHWS for which consent is being sought. Further details of the parameters are included in Volume 1, Chapter 3: Project Description.
Qualifying Features	The features for which a European Site has been officially designated to protect.
Report to Inform Appropriate Assessment (RIAA)	The RIAA provides detailed information to support the process of Appropriate Assessment (undertaken by the competent authority) as part of the HRA, which evaluates the potential impacts of a project or plan on European Sites.
Scoping Workshop	A series of sessions preceding the finalisation of the Offshore Scoping Report to provide an opportunity for the Applicant to consult on the draft scope and for stakeholders to request additional information on key issues.
Sectoral Marine Plan (SMP)	A plan developed by the Scottish Government which provides the strategically planned spatial footprint for offshore wind development in Scotland.
Site Boundary	The boundary within which all elements of the Proposed Development will be located. The Site Boundary comprises the Array Area and Export Cable Corridor which ends at MHWS.
Special Areas of Conservation (SACs)	SACs are areas designated for the conservation of certain plant and animal species listed in the Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora.
Statutory Nature Conservation Body (SNCB)	A statutory adviser to the UK and Scottish Governments on Scottish, UK and international nature conservation.

Defined Term	Definition
Study Area	For each environmental topic, the baseline environment will be characterised, and the potential environmental impacts will be described within a topic-specific study area. Specific study areas are defined for each topic and are based on the maximum spatial extent across which potential impacts of the Project may be experienced by the relevant receptors (i.e. Zone of Influence).
Sublittoral	Areas of the marine environment that lie below the low tide mark to the edge of the continental shelf.
Subtidal	Areas of the coastal marine environment that lie below the level of MLWS and are continuously submerged by seawater.
Thistle Wind Partners (TWP)	Company established for the development of the Project.
Wind Turbines	Structures comprising of a tubular tower, rotor blades, and a nacelle which houses the Wind Turbine generator.

Acronyms

Acronym	Definition
ABPmer	ABP Marine Environmental Research
BEIS	Department for Business, Energy and Industrial Strategy
BOWFL	Bowdun Offshore Wind Farm Limited
BTS	Bottom Trawl Survey
Cefas	Centre for Environment, Fisheries, and Aquaculture Science
CIEEM	Chartered Institute for Ecology and Environmental Management
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DAS	Digital Aerial Surveys
DDV	Drop Down Video
DECC	Department of Energy and Climate Change
DNA	Deoxyribonucleic Acid
eDNA	Environmental Deoxyribonucleic Acid
EIA	Environmental Impact Assessment
EMODNet	European Marine Observation and Data Network
ES	Environmental Statement
EU	European Union
FeAST	Feature Activity Sensitivity Tool
HVAC	High Voltage Alternating Current
IAC	Inter-Array Cable
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Seas
IEF	Important Ecological Feature
IHLS	International Herring Larval Survey
IFCA	Inshore Fisheries and Conservation Authority
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MarLIN	Marine Life Information Network
MBA	Marine Biological Association
MD-LOT	Marine Directorate - Licensing Operations Team
MD-SEDD	Marine Directorate - Science, Evidence, Data and Digital
MMO	Marine Management Organisation
MPA	Marine Protected Area
MSS	Marine Scotland Science
NBN	National Biodiversity Network
NNG	Neart na Gaoithe
NOAA	National Oceanographic and Atmospheric Administration

Acronym	Definition
OLA	Option Lease Agreement
OSP	Offshore Substation Platform
OSPAR	Oslo Paris [Convention]
OWF	Offshore Wind Farm
OWFL	Offshore Wind Farm Limited
PMF	Priority Marine Feature
POA	Plan Option Area
PSA	Particle Size Analysis
RIAA	Report to Inform Appropriate Assessment
SAC	Special Area of Conservation
SBL	Scottish Biodiversity List
SMP	Sectoral Marine Plan
SNCBs	Statutory Nature Conservation Bodies
SPI	Species of Principle Importance
SSE	Scottish and Southern Electricity
UK	United Kingdom
ZoI	Zone of Influence

Table of Units

Units	Definition
cm	Centimetre
km	Kilometre
km^2	Square kilometre
m	Metre
m^2	Square Metre
mm	Millimetre
nm	Nautical mile
tonne	Metric tonne
µm	Micrometre
%	Percent
°C	Degrees Celsius

1 Introduction

1.1.1 This Fish and Shellfish Ecology Technical Report presents the baseline characterisation of fish and shellfish ecology for the offshore elements of the Bowdun Offshore Wind Farm (OWF) Project (hereafter referred to as the Proposed Development). The Proposed Development covers the Option Lease Area (OLA) and comprises the Array Area, which is located in the E3 Plan Option Area (POA) detailed in the Scottish Sectoral Marine Plan (SMP) (Scottish Government, 2020), and the Export Cable Corridor. The Array Area is located 38 km from the Aberdeenshire coast at its closest point, covering an area of 187 km^2 (Figure 2.1). The Proposed Development will comprise of Wind Turbines (fixed foundations), Inter-Array Cables (IACs), Offshore Substation Platforms (OSPs), Interconnector Cables, Offshore Export Cables and any necessary scour/cable protection. The Export Cable Corridor will include a maximum of three High Voltage Alternating Current (HVAC) Offshore Export Cables, each with a length of up to 70 km and will make Landfall at Benholm, Aberdeenshire.

1.1.2 Data was collated through a detailed desktop study of existing resources available for fish and shellfish ecology within the Fish and Shellfish Ecology Study Area (Section 2 and Figure 2.1) to gain a historical perspective of species composition and population dynamics at, and surrounding, the Proposed Development. In addition, the results from site-specific surveys for the Proposed Development have also been used to develop the baseline characterisation of fish and shellfish ecology (see Section 4.2).

1.1.3 The information from this report informs the technical baseline and the assessment of the likely significant environmental effects of the Proposed Development on fish and shellfish receptors. This report accompanies the Offshore Environmental Impact Assessment (EIA) Report Volume 2, Chapter 9: Fish and Shellfish Ecology to support the consent application for the Proposed Development.

1.1.4 The aim of this Fish and Shellfish Ecology Technical Report is to:

- characterise the fish and shellfish ecology baseline within, and surrounding, the Site Boundary of the Proposed Development and the wider region;
- identify the occurrence and distribution of any fish and shellfish species of conservation interest; and
- identify the occurrence and distribution of any spawning and nursery habitats for fish and shellfish species.

2 Fish and Shellfish Ecology Study Area

2.1.1 One study area is defined for fish and shellfish ecology: the Fish and Shellfish Ecology Study Area.

2.1.2 The Fish and Shellfish Ecology Study Area is shown in Figure 2.1 and defined as a 100 km buffer around the Proposed Development, including the Export Cable Corridor, and includes the Firth of Forth and Firth of Tay.

2.1.3 The Fish and Shellfish Ecology Study Area was presented to and agreed with Statutory Nature Conservation Bodies (SNCBs) during Scoping and has been defined to fully encompass the large spatial and temporal variability of most fish and shellfish species. The defined Fish and Shellfish Ecology Study Area is therefore large enough to consider the Zone of Influence (ZoI) of all direct and indirect impacts associated with the Proposed Development, such as impacts from subsea noise. It is also an adequate size to characterise the baseline.

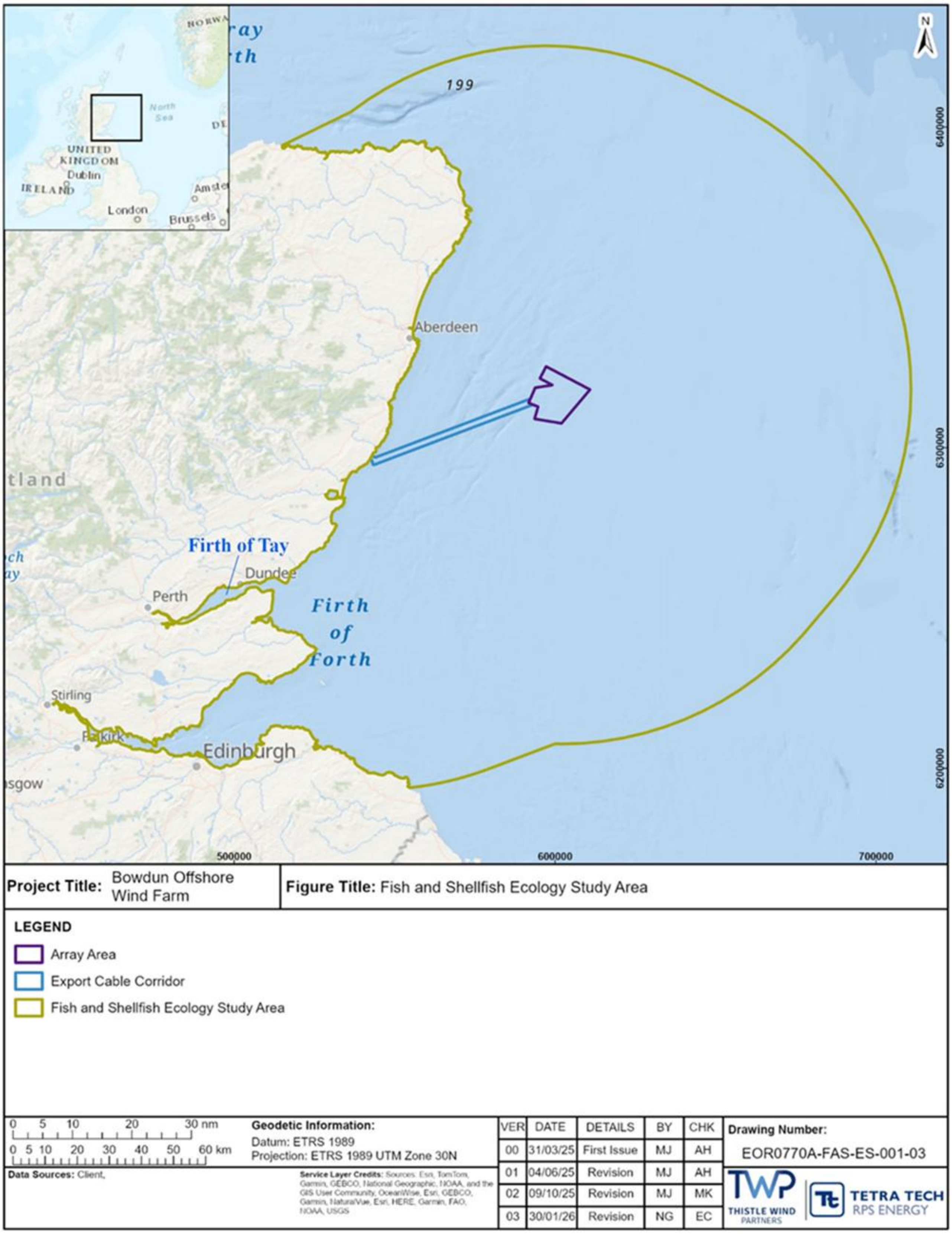


Figure 2.1: Fish and Shellfish Ecology Study Area

3 Methodology

3.1.1 A desktop review has been undertaken to inform the baseline for fish and shellfish ecology. This involves a detailed review of peer-reviewed publications and reports from surveys undertaken to inform other project assessments in the Fish and Shellfish Ecology Study Area (such as other OWFs, see Section 3.2). In addition, the results of relevant site-specific surveys undertaken for the Proposed Development have also been used to inform the baseline characterisation for fish and shellfish ecology. These surveys are described in Section 3.2.

3.1.2 The fish and shellfish ecology baseline presented here has also been informed by Volume 3, Technical Appendix 8.1: Benthic Ecology Technical Report and Volume 3, Technical Appendix 13.1: Commercial Fisheries Technical Report, and should be read in conjunction.

3.2 Desktop Study

3.2.1 Information on fish and shellfish ecology within the Fish and Shellfish Ecology Study Area was collected through a detailed desktop review of existing studies and datasets to inform the baseline; these are summarised in Table 3.1.

Table 3.1: Summary of Key Desktop Datasets and Reports for Fish and Shellfish Ecology

Title	Source	Extent	Author
Marine Protected Area (MPA) Mapper	Joint Nature Conservation Committee (JNCC)	UK waters	JNCC (2025a)
National Biodiversity Network (NBN) Atlas	NBN Atlas	UK waters	NBN Atlas (2025)
The Feature Activity Sensitivity Tool (FeAST)	NatureScot	Scottish waters	NatureScot (2025)
The Marine Life Information Network (MarLIN)	MarLIN and the Marine Biological Association (MBA)	United Kingdom (UK) waters	MarLIN (2025)
International Bottom Trawl Survey (BTS) and International Herring Larvae Survey (IHLS) data	International Council for the Exploration of the Seas (ICES)	UK waters	ICES (2025a), ICES (2025b), ICES (2024c), ICES (2023), ICES (2022)
Diadromous Fish in the Context of Offshore Wind – Review of Current and Future Research	The Scottish Government	Scottish waters	Honkanen *et al.* (2024)
Identifying and Mapping Sandeel Potential Supporting Habitat: An Updated Method Statement	Environmental Resources Management	The North Sea and East English Channel	Reach *et al.* (2024)
Identifying and Mapping Atlantic Herring Potential Spawning Habitat: An Updated Method Statement	Environmental Resources Management	The North Sea and East English Channel	Kyle-Henney *et al.* (2024)

Title	Source	Extent	Author
Scottish Salmon and Sea Trout Fishery Statistics 2023	The Scottish Government	Scottish waters	Scottish Government (2024)
North-East Scotland Salmon and Sea Trout Tracking Array	River Dee Trust and Marine Directorate-Science, Evidence, Data and Digital (MD-SEDD)	Scottish waters	River Dee Trust and Marine Scotland Science (MSS) (2023)
Ossian Array EIA	Ossian Offshore Windfarm Limited (OWFL)	Ossian Offshore Wind farm	Ossian OWFL (2024)
Morven Offshore Wind Array Project EIA Scoping Report	Morven Offshore Wind Limited	Morven Offshore Wind Array	Morven Offshore Wind Limited (2023)
Developing essential fish habitat maps for fish and shellfish species in Scotland	MD-SEDD	Scottish waters	Franco *et al.* (2023)
UK sea fisheries annual report 2022	Marine Management Organisation (MMO)	UK waters	MMO (2023)
Berwick Bank Windfarm Offshore EIA Report: Chapter 9 Fish and Shellfish Ecology	Scottish and Southern Electricity (SSE) Renewables	Berwick Bank Offshore Wind farm	SSE Renewables (2022)
Essential spawning grounds of Scottish herring: current knowledge and future challenges	Reviews in Fish Biology and Fisheries	Scottish waters	Frost and Diele (2022)
UK Offshore Energy Strategic Environmental Assessment 4. Appendix 1a.4 Fish and Shellfish	Department for Business Energy and Industrial Strategy (BEIS)	UK waters	BEIS (2022)
A verified distribution model for the lesser sandeel	Marine Ecology Progress Series	UK waters	Langton *et al.* (2021)
Neart na Gaoithe (NNG) OWF Environmental Statement (ES): Chapter 15 Fish and Shellfish Ecology	NNG OWF	NNG OWF	Mainstream Renewable Power (2019)
Inch Cape OWF Offshore ES, Volume 1B: Biological Environment, Chapter 13 Natural Fish and Shellfish	Inch Cape OWF	Inch Cape OWF	Inch Cape Offshore Limited (2018)
Spawning grounds of whiting *Merlangius merlangus*	ICES Journal of Marine Science	UK waters	González-Irusta and Wright (2017)
Spawning grounds of Atlantic cod *Gadus morhua* in the North Sea	ICES Journal of Marine Science	The North Sea	González-Irusta and Wright (2016a)
Spawning grounds of haddock *Melanogrammus aeglefinus* in the North Sea and West of Scotland	ICES Journal of Marine Science	The North Sea	González-Irusta and Wright (2016b)

Title	Source	Extent	Author
Kincardine OWF ES: Chapter 5 Fish and Shellfish	Kincardine OWF	Kincardine OWF	Kincardine OWF Limited (2016)
Updating Fisheries Sensitivity Maps in British waters	Marine Scotland	UK waters	Aires *et al.* (2014)
Seagreen Environmental Impact Statement Volume 1, Chapter 12 Natural Fish and Shellfish Resource	Seagreen Alpha and Bravo OWFs (have since been renamed to Seagreen 1 and Seagreen 1A)	Seagreen 1 and Seagreen 1A	Seagreen Wind Energy Limited (2012)
Spawning and nursery grounds for selected fish species in UK waters	Centre for Environment, Fisheries, and Aquaculture Science (Cefas)	UK waters	Ellis *et al.* (2012)
Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: Implications for the development of marine renewables	MD-SEDD	Scottish waters	Malcom *et al.* (2010)
North Sea Elasmobranchs: distribution, abundance, and biodiversity	ICES	The North Sea	Daan *et al.* (2005)
Fisheries sensitivity maps in British waters	Cefas	UK waters	Coull *et al.* (1998)

3.3 Site-Specific Surveys

3.3.1 Site-specific benthic subtidal ecology data were collected during spring 2024, the results of which have been included in this report, where relevant. For example, these results include fish and shellfish species recorded during grab sampling and video surveying (Drop Down Video (DDV)). Particle Size Analysis (PSA) was subsequently carried out from samples that were collected as part of the benthic survey with results used to determine spawning habitat suitability for herring *Clupea harengus* and sandeel *Ammodytes* spp. in line with Reach *et al.* (2013) and Latto *et al.* (2013), respectively. Finally, Environmental Deoxyribonucleic Acid (eDNA) analysis recorded fish and shellfish species from samples that were collected as part of the subtidal benthic survey. Similarly, any fish and shellfish species recorded during the Digital Aerial Surveys (DAS), undertaken to record marine mammals and seabirds, are referenced to help inform the baseline.

3.3.2 A summary of the surveys undertaken to inform the fish and shellfish ecology baseline characterisation is outlined in Table 3.2 below. The methodologies for these surveys are provided in Table 3.2 and have not been repeated here for brevity.

Table 3.2: Summary of Site-Specific Surveys Undertaken for Fish and Shellfish Ecology

Title	Extent of Survey	Overview of Survey	Survey Contractor	Date	Reference to Further Information
Benthic Subtidal Ecology Survey	Across the Array Area and Export Cable Corridor	DDV and grab samples for PSA and eDNA analysis	Ocean Ecology Limited	Spring 2024	Ocean Ecology, 2024 Volume 3, Technical Appendix 8.2: Bowdun OWF Benthic Characterisation Survey 2024: Survey Report
DAS	Across the E3 POA Area plus a 12 km buffer (referred to as the 'DAS Area'). This area was extended to the Aberdeenshire coastline during the summer months (April – August) (referred to as the 'Extended DAS Area')	Monthly DAS conducted to characterise the marine mammal and ornithology baseline; however large fish species (such as sharks and tuna) were visible	APEM	March 2022 to February 2024	Volume 3, Technical Appendix 10.2: Marine Mammal Digital Aerial Survey Report

3.4 Data Limitations

3.4.1 The desktop data used were the most up-to-date publicly available information which could be obtained from the applicable data sources as presented in Table 3.1. Data that have been collected are based on existing literature and consultation with stakeholders and SNCBs. It should be noted that some datasets are over a decade old, such as Coull *et al.* (1998), Ellis *et al.* (2012), and Aires *et al.* (2014). However, these are industry standard datasets and have been included and assessed with the caveat that they are now quite dated. Long-term time series of data, such as the International Bottom Trawl Survey (IBTS) and IHLS have demonstrated the continued validity of these datasets, with spawning and nursery grounds continuing to remain broadly consistent with these studies (González-Irusta and Wright, 2016a, González-Irusta and Wright, 2016b, González-Irusta and Wright, 2017). Where available, more recent literature has been consulted, such as Franco *et al.* (2023).

3.4.2 It is possible that all potential fish and shellfish species have not been identified. However, given the detailed desktop study completed, and the precautionary approach adopted, which has included the identification of a broad Fish and Shellfish Ecology Study Area, it is unlikely that key species have been omitted from the baseline characterisation.

4 Baseline Characterisation

4.1 Introduction

4.1.1 The Fish and Shellfish Ecology Study Area is situated within the northern North Sea (Figure 2.1), where a range of different fish and shellfish species are present in this area, which include marine fish (e.g. teleost fish (bony fish) and elasmobranchs (sharks, skates and rays)), diadromous fish (i.e. those which migrate between freshwater and seawater) and shellfish (i.e. commercial crustaceans and molluscs). Commercial and non-commercial species are present within the Fish and Shellfish Ecology Study Area, with a detailed commercial fisheries baseline presented in Volume 3, Technical Appendix 13.1: Commercial Fisheries Technical Report. Although species such as the ocean quahog *Arctica islandica* and horse mussel *Modiolus modiolus* are shellfish, these are considered to be non-commercial species, and are included under Volume 3, Technical Appendix 8.1: Benthic Ecology Technical Report.

4.2 Site-specific Survey Results

Benthic Subtidal Surveys

DDV Surveys

4.2.1 As stated in Section 3.3, a site-specific benthic subtidal survey was conducted across the Array Area and Export Cable Corridor in spring 2024. Fish and shellfish were recorded during DDV imagery collection, with a total of 18 individual fish and shellfish recorded. These are presented in Table 4.1 (with species names given if it was possible to identify them to species level).

Table 4.1: Fish and Shellfish Species Recorded from DDV Sampling during the Site-Specific Benthic Surveys

Species	Number of Individuals Recorded
Fish	
Unidentified bony fish (Class: Actinopterygii)	2
Flatfish (Family: Pleuronectidae)	3
Red Gurnard *Chelidonichthys cuculus*	1
Dragonet (Family: Callionymidae)	1
Gadoid (Family: Gadidae)	1
Plaice *Pleuronectes platessa*	2
Flatfish (Order: Pleuronectiformes)	1
Elasmobranch*	3
Shellfish	
Scallop (Family: Pectinidae)	1
Whelks (Family: Naticidae)	1
Shrimps (Infraorder: Caridea)	1
Edible crab *Cancer pagurus*	1

*These were recorded as egg cases, with individuals recorded in separate samples

Grab Sampling

4.2.2 Fish and shellfish species recorded in the grab samples included shrimp, *Crangon allmanni* (n = 1) and ray-finned fish (class: Actinopterygii) (n = 1), a sandeel was also recorded (Ammodytidae). These were all found within the Array Area. Ray-finned fish eggs (n = 4) were also recorded in four separate grab samples, two within the Array Area and two within the Export Cable Corridor, although not recorded to species level.

eDNA Sampling

4.2.3 Further fish species were identified from the eDNA analysis, although no commercial shellfish species relevant to this baseline (instead see Volume 3, Technical Appendix 8.1: Benthic Ecology Technical Report). The species identified most frequently were: whiting *Merlangius merlangus* (n = 42), haddock *Melanogrammus aeglefinus* (n = 39), Norway pout *Trisopterus esmarkii* (n = 36), common dab *Limanda limanda* (n = 35), lemon sole *Microstomus kitt* (n = 30), herring (n = 29), plaice (n = 28), mackerel *Scomber scombrus* (n = 23), Atlantic cod *Gadus morhua* (n = 19), common dragonet *Callionymus lyra* (n = 19), European sprat *Sprattus sprattus* (n = 14) and northern rockling *Ciliata septentrionalis* (n = 13). Lesser sandeel *Ammodytes tobianus*, *Salmo* spp. and a lamprey species *Lampetra* spp. were also found in the eDNA samples but in lower counts (n = 2 and n = 1, respectively) (Figure 4.1). In Figure 4.1, the circles represent the proportion of Deoxyribonucleic Acid (DNA) sequences within a sample; the larger the circle, the stronger the eDNA signal (Ocean Ecology, 2024; Volume 3, Technical Appendix 8.2: Bowdun OWF Benthic Characterisation Survey 2024: Survey Report).

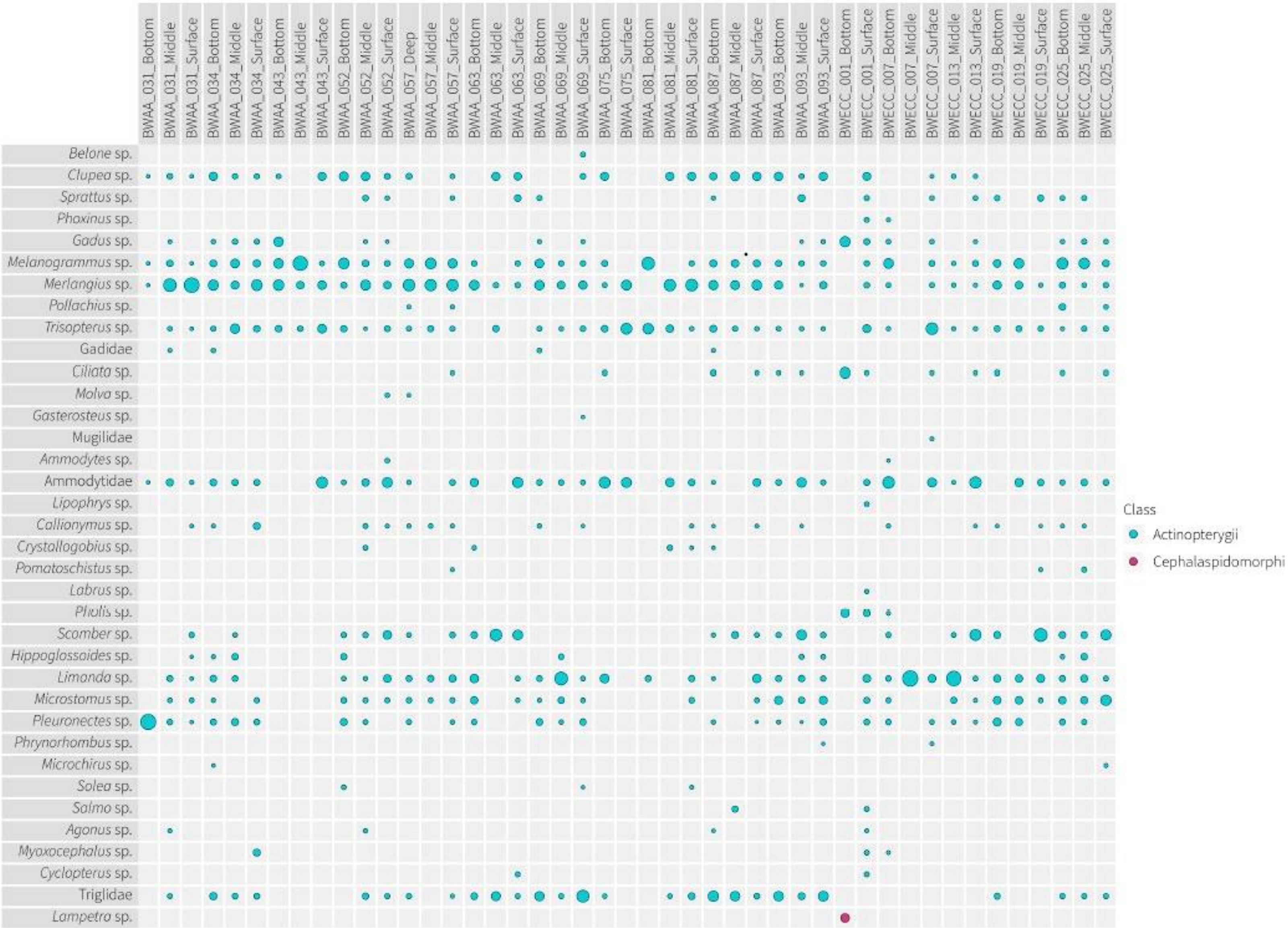


Figure 4.1: All Fish Species Recorded During the Site-Specific eDNA Sampling

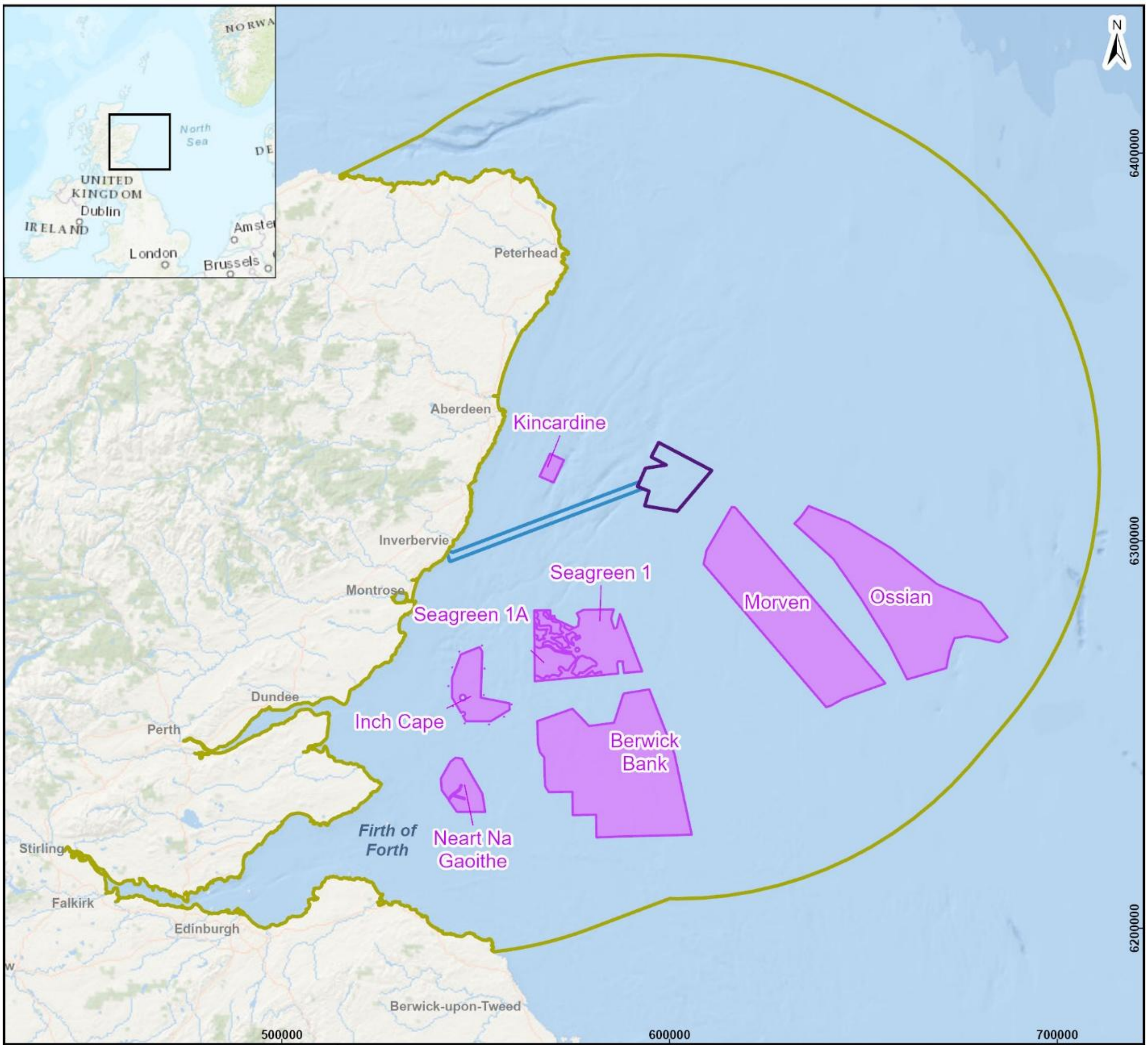
Digital Aerial Surveys

4.2.4 As stated in Section 3.2, DAS were conducted across the POA (plus a 12 km buffer and the Extended DAS Area to the coast in summer months) for marine mammals and seabirds between March 2022 and February 2024. Although these surveys were not primarily designed for fish and shellfish monitoring, there were several fish species recorded. There were five individual fish recorded in total:

- one blue shark *Prionace glauca* recorded in November 2022;
- one basking shark *Cetorhinus maximus* recorded in July 2023;
- two porbeagle shark *Lamna nasus* recorded in September 2023; and
- one Atlantic bluefin tuna *Thunnus thynnus* recorded in October 2023.

Site-Specific Results from Other Offshore Projects

4.2.5 There are several other OWF projects within the Fish and Shellfish Ecology Study Area which have published site-specific survey data (Figure 4.2). Fish and shellfish species recorded during surveys for these other OWF projects have been collated in Table 4.2 and can add further evidence for likely species present within the Fish and Shellfish Ecology Study Area. The species recorded are typical of the North Sea (such as flatfish, gadoids, and sandeel species).



Project Title:	Bowdun Offshore Wind Farm	Figure Title:	Other OWF Projects within the Fish and Shellfish Ecology Study Area with Available Site-Specific Fish and Shellfish Data

LEGEND

- Array Area
- Export Cable Corridor
- Fish and Shellfish Ecology Study Area
- Offshore Wind Farms

Scale: 0 5 10 20 30 nm; 0 5 10 20 30 40 50 60 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

Data Sources: Client, CES

Service Layer Credits: OceanWise, Esri, GEBCO, Garmin, NaturalVue, Esri, HERE, Garmin, FAO, NOAA

VER	DATE	DETAILS	BY	CHK
00	31/03/25	First Issue	MJ	AH
01	04/06/25	Revision	MJ	AH
02	09/10/25	Revision	MJ	MK
03	27/03/26	Revision	NG	CR

Drawing Number: EOR0770A-FAS-ES-002-03

Figure 4.2: Other OWF Projects within the Fish and Shellfish Ecology Study Area with Available Site-Specific Fish and Shellfish Data

Table 4.2: Overview of Fish and Shellfish Species Identified from Other OWFs within the Fish and Shellfish Ecology Study Area

Project	Distance to the Array Area (km)	Distance to the Export Cable Corridor (km)	Overview of Fish and Shellfish Species Recorded	Source
Morven OWF (Now split into Morven North and Morven South)	10.3	22.2	During a 2022 eDNA and grab survey, the following species were recorded: clupeids (herring and sprat), flatfish (common dab, lemon sole, long rough dab *Hippoglossoides platessoides*, plaice and witch *Glyptocephalus cynoglossus*), gadoids (cod, haddock, Norway pout and whiting), gobies (crystal goby *Crystallogobius linearis* and sand goby *Pomatoschistus minutus*), gurnard *Triglidae* spp., mackerel, Norwegian topknot *Zeugopterus norvegicus*, sandeel and thornback ray *Raja clavata*.	Morven Offshore Wind Limited (2023)
Kincardine OWF	20.1	7.6	Flatfish were recorded during DDV sampling for 2013 and 2014 benthic surveys; however, it was not possible to identify these flatfish to species level.	Kincardine Offshore Windfarm Limited (2016)
Ossian OWF	25.4	40.1	16 species were recorded during a 2022 epifaunal trawl survey, with long rough dab being the most common. This was followed by plaice, common dab, Norway pout, Raitt's sandeel *Ammodytes marinus*, lemon sole, and grey gurnard *Eutrigla gurnardus*. Other species recorded in lower abundances were pogge *Agonus cataphractus,* poor cod *Trisopterus minutus*, haddock, cod, transparent goby *Aphia minuta,* sand goby, scaldfish *Arnoglossus laterna*, Lotidae spp. and Argentinidae spp.	Ossian OWFL (2023)
Seagreen 1 and Seagreen 1A OWFs (were previously referred to as Seagreen Alpha and Bravo when the data were collected)	27.9	19.9	A 2011 benthic trawl survey recorded 3,211 fish and shellfish species. Pogge, common dab, goby *Pomatoschistus* spp., sandeel *Ammodytidae* spp., butterfish *Pholis gunnellus,* Norwegian topknot, reticulated dragonet *Callionymus reticulatus*, common dragonet *Callionymus lyra*, lemon sole and bull rout *Myoxocephalus scorpius* were all recorded in at least 50% of the trawls. Common dab, gobies, and sandeel were the most abundant species. Other species observed in lower abundances were cod, cuckoo ray *Leucoraja naevus*, smooth sandeel *Gymnammodytes*	Seagreen Wind Energy Limited (2012)

Project	Distance to the Array Area (km)	Distance to the Export Cable Corridor (km)	Overview of Fish and Shellfish Species Recorded	Source
			semisquamatus and greater sandeel *Hyperoplus lanceolatus*, king scallop *Pecten maximus,* queen scallop *Aequipecten opercularis*, plaice, red gurnard *Chelidonichthys cuculus* and whiting.	
Berwick Bank OWF	46.5	47.7	553 teleost fish across 21 taxa were recorded during a 2021 survey (which included epifaunal trawls, grab samples, and DDV). The most abundant was common dab (n=167), followed by long rough dab, lesser sandeel, pogge, and goby *Pomatoschistus* spp. In addition, cod, lemon sole, plaice, anglerfish *Lophius piscatorius,* and fourbeard rockling *Enchelyopus cimbrius* were also recorded, but at very low abundances.	SSE Renewables (2022)
Inch Cape OWF	56.0	23.4	Otter trawls in 2012 recorded 30 species, with sprat being the most abundant (n= 1,194), followed by herring (n = 161) and cod (n = 15).	Inch Cape Offshore Limited (2018)
Neart Na Gaoithe (NNG) OWF	80.5	51.2	A 2009 benthic survey recorded cod and flatfish such as common dab, long rough dab and plaice. This survey comprised of grab sampling, DDV and epifaunal trawls.	Mainstream Renewable Power (2019)

4.3 Fish and Shellfish Assemblages

4.3.1 Using the data sources presented in Table 3.1 and the results of the site-specific surveys for the Proposed Development and other OWF projects within the vicinity (Section 4.2), the following sections describe the fish and shellfish assemblage of the Fish and Shellfish Ecology Study Area. As stated in Paragraph 4.1.1, this assemblage is comprised of marine fish (e.g. teleosts and elasmobranchs), diadromous fish, and shellfish.

Marine Fish

Teleost Fish

4.3.2 Teleost fish are ray-finned fishes with skeletons made of bone and comprise 96% of all extant fish species. The teleost fish present within the Fish and Shellfish Ecology Study Area include both demersal and pelagic species. Demersal species can be further divided into benthic fish and benthopelagic fish; with benthic fish tending to live on or in the seabed and benthopelagic fish swimming or floating close to the seabed. Typical North Sea demersal fish species include:

- gadoids (e.g. blue whiting *Micromesistius poutassou*, cod, European hake *Merluccius merluccius*, haddock, ling *Molva molva*, Norway pout, saithe *Pollachius virens* and whiting);
- flatfish (e.g. common dab, lemon sole, long rough dab, and plaice);
- sandeels (e.g. lesser sandeel and Raitt's sandeel); and
- other taxa, such as:
    - anglerfish, gobies Gobiidae spp. and gurnards Triglidae spp. (Aires *et al.,* 2014; Coull *et al.*, 1998; Ellis *et al.,* 2012; Franco *et al.*, 2023).

4.3.3 Pelagic fish inhabit the mid-levels of the open ocean, away from the seabed and the shore. Pelagic fish can form large shoals and exhibit highly migratory behaviour. Pelagic species present within the Fish and Shellfish Ecology Study Area include herring, horse mackerel *Trachurus trachurus*, mackerel and sprat (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012; Franco *et al.*, 2023). In addition, there was one Atlantic bluefin tuna recorded during the site-specific DAS (Section 4.2). Atlantic bluefin tuna are large, highly migratory pelagic fish, that have suffered historic population declines due to direct overfishing and indirect overfishing of their prey species (such as herring and mackerel) (Fromentin and Powers, 2005; Mariani *et al.*, 2017; Marine Conservation Society, 2024). However, in recent years, Atlantic bluefin tuna sightings in UK waters have increased, and potential population recovery has been suggested (Dick, 2023; Horton *et al.*, 2018; Mariani *et al.*, 2017; Marine Conservation Society, 2024; McNicholas *et al.*, 2024).

4.3.4 Many of the teleost fish species mentioned above are important prey species (i.e. 'forage fish') for a range of higher trophic level predators, such as marine mammals and seabirds. Forage fish are typically small schooling fish and are important ecologically as they provide the main pathway for energy to flow from the plankton to higher trophic levels (van der Kooij *et al.*, 2021). Important forage fish species within the Fish and Shellfish Ecology Study Area include herring, horse mackerel, sprat and sandeel species.

4.3.5 The IBTS is a historic time series of trawl surveys in the North-East Atlantic and Baltic Seas. The most recently available IBTS trawl data (from 2019 to 2023, inclusive) have been assessed to ascertain the most commonly recorded species and to identify if the species assemblage has shown variation within the last five years (ICES, 2024b). Data from IBTS Survey Area 3 have been used as they are the most spatially relevant to the Fish and Shellfish Ecology Study Area (Figure 4.3). The ten most commonly recorded species between 2019 and 2023 in this dataset were (in descending order):

- Norway pout;
- haddock;
- herring;
- sprat;
- whiting;
- mackerel;
- common dab;
- long rough dab (also known as 'American plaice');
- blue whiting; and
- plaice (ICES, 2024b).

4.3.6 A combination of these species were present within the top ten species per year between 2019 and 2023, with Norway pout, haddock, and herring consistently being among the top three species (ICES, 2024b). These IBTS data show a high level of temporal consistency for the major components of the targeted fish and shellfish assemblage, suggesting that these species are a good indicator of characteristic species within the Fish and Shellfish Ecology Study Area.

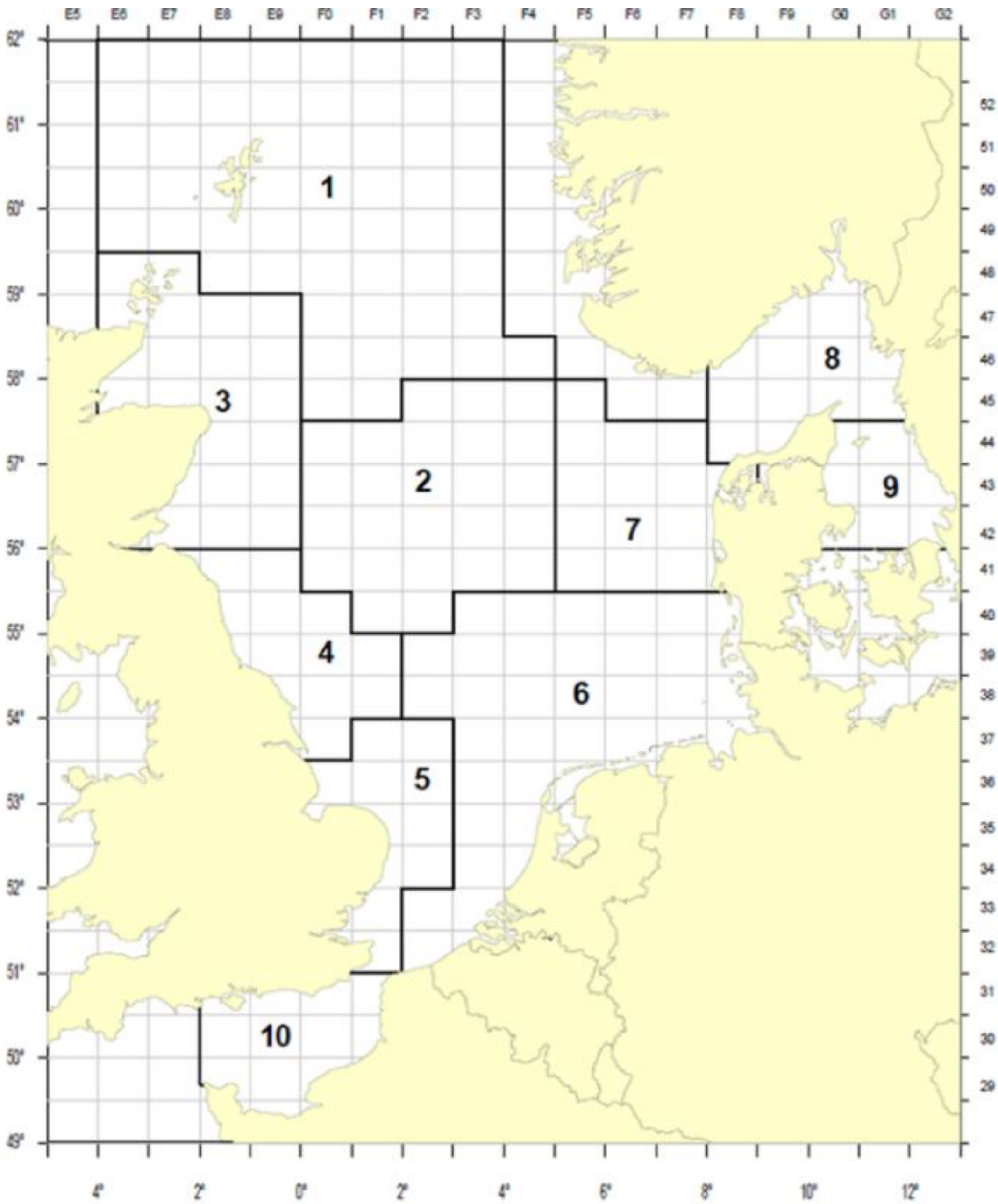


Figure 4.3: IBTS Survey Areas (taken from ICES, 2018b)

Conservation Importance

4.3.7 Some of the teleost fish considered in this baseline are listed on biodiversity action lists (such as Species of Principal Importance (SPI) on the Scottish Biodiversity List (SBL)). Furthermore, cod are listed on the Oslo Paris [Convention] (OSPAR) List of Threatened and/or Declining Species within OSPAR Region II (North Sea). The conservation importance of the species potentially present within the Fish and Shellfish Ecology Study Area is summarised in Table 4.3.

Table 4.3: Conservation Status of Teleost Fish within the Fish and Shellfish Ecology Study Area

Species	OSPAR List of Threatened and/or Declining Species[1]	Scottish Priority Marine Feature (PMF)	SBL	IUCN Status[2]
Anglerfish		✓	✓	LC[3]
Atlantic bluefin tuna	✓		✓	NT[4]
Blue whiting		✓	✓	LC
Cod	✓	✓	✓	LC
European hake			✓	LC
Herring		✓	✓	LC
Horse mackerel		✓		LC in Europe (but vulnerable globally)
Mackerel		✓	✓	LC
Ling		✓	✓	LC
Norway pout		✓	✓	LC
Plaice			✓	LC
Saithe		✓		LC
Sandeel*		✓	✓*	DD[5]
Sole			✓	LC

* Sandeel species included within the SBL include Raitt's sandeel and the lesser sandeel only
[1] Within OSPAR Region II: Greater North Sea, which encompasses the Fish and Shellfish Ecology Study Area
[2] International Union for the Conservation of Nature (IUCN) conservation status for the relevant area (i.e. Europe) wherein a species has multiple assessments worldwide.
[3] LC = Least Concern
[4] NT = Near Threatened
[5] DD = Data Deficient

Species Accounts

Anglerfish

4.3.8 Anglerfish are distributed around all UK coasts from the low intertidal zone down to depths of -550 m. However, they may migrate down to as deep as -2,000 m in offshore waters in order to spawn (Reeve, 2008). Spawning occurs from January to June (Ellis *et al.*, 2012) (see Table 4.12). They are found on a variety of seabed substrates, and use their characteristic lures to attract a wide range of prey, such as sandeels, gadoids, and small elasmobranchs (Laurenson and Priede, 2005; Reeve, 2008).

4.3.9 This species is listed as a Scottish PMF, is on the SBL and has an International Union for Conservation of Nature (IUCN) Status of 'least concern' (Table 4.3; Tyler-Walters *et al.* (2016)).

Flatfish

4.3.10 A range of flatfish species are characteristic of the baseline environment within the Fish and Shellfish Ecology Study Area. These include common dab, lemon sole, long rough dab, plaice, and sole. These are demersal species, which inhabit a range of seabeds and are all widely distributed around the UK (Barnes, 2008a; Fishbase, 2024c; Reeve, 2007; Ruiz, 2007; Ruiz, 2008). Flatfish can be described as being either 'left-eyed' or 'right-eyed', which refers to which side of the body their eyes are on and which side of their body rests against the seabed. Common dab, long rough dab, sole, and plaice are right-eyed, with both eyes on the right side of their bodies (Fishbase, 2024c; Reeve, 2007; Ruiz, 2007; Ruiz, 2008). However, lemon sole are left-eyed, thus appearing the opposite to the other species (Barnes, 2008a).

4.3.11 Flatfish species are typically batch spawners, meaning that females release batches of eggs into the water column during their spawning period (Murua and Saborido-Rey, 2003). Spawning varies between flatfish species with lemon sole spawning occurring from April to September and plaice spawning from January to April (Ellis *et al.*, 2012) (see Table 4.12). The pelagic eggs are then dispersed from their spawning grounds to nursery grounds via hydrodynamic processes (Barbut *et al.*, 2019).

4.3.12 Of the flatfish species, both plaice and sole are listed on the SBL (Table 4.3).

Gadoids

4.3.13 The term 'gadoid' refers to species within the order 'Gadiformes', which are found in circumpolar and temperate waters, mainly in the northern hemisphere (Fishbase, 2012). Most species are demersal or benthopelagic, feeding on smaller fish and invertebrate species (Fishbase, 2012). Within the Fish and Shellfish Ecology Study Area, the following gadoid species are characteristic of the baseline environment: blue whiting, cod, European hake, haddock, ling, Norway pout, poor cod, saithe, and whiting.

4.3.14 Gadoid species share similar ecology, wherein spawning consists of courtship near the seabed and the subsequent release of a large volume of buoyant, pelagic eggs. During spawning, males aggregate on the seabed, where they are joined by females for courtship. Some gadoids, such as cod, use vocalisations during courtship and spawning (Finstad and Nordeide, 2004). Male cod tend to move around their spawning grounds more than females (Robichaud and Rose, 2003). Spawning varies between gadoid species with cod and saithe spawning occurring from January to April and whiting spawning from February to June (Ellis *et al.*, 2012) (see Table 4.12). The buoyant eggs that are released into the water column are carried away by currents (Hutchings *et al.*, 1999). After hatching, juvenile gadoids have a pelagic larval phase where they feed on plankton, before moving down towards the seabed to exploit demersal prey, such as crustaceans and smaller fish (Dipper, 2001).

4.3.15 Gadoids are one of the key groups of exploited demersal fish, and rapid population declines and fisheries collapses have been seen throughout their geographic distributions (Köster *et al.*, 2014). Several gadoid species are listed as a PMFs and/or on the SBL (Table 4.3). In addition, cod are also listed on the OSPAR List of Threatened and/or Declining Species within the North Sea (Table 4.3).

Pelagic Species

4.3.16 As detailed in Paragraph 4.3.3, pelagic fish species inhabit the mid-levels of the open ocean and can form large shoals. Pelagic species present within the Fish and Shellfish Ecology Study Area include Atlantic bluefin tuna, herring, horse mackerel, mackerel, and sprat. Herring require highly specific spawning habitat, and as per standard EIA procedure for OWF projects, a site-specific spawning habitat suitability analysis has been undertaken. Further background information on herring is presented in Paragraphs 4.3.17 to 4.3.19 below.

4.3.17 The pelagic fish species identified are of significant commercial importance (and have all suffered population declines due to overfishing) but are also ecologically important. For example, Atlantic bluefin tuna are apex predators, and an important component of intricate marine food webs (Mariani *et al.*, 2017). The other, smaller, pelagic species, such as herring also play an important role in marine food webs, as a key forage fish species, herring play an important ecological role for numerous fish, marine mammals, and birds, providing the main pathway for energy to flow from the plankton to higher tropic levels (Casini *et al.*, 2004; Fauchald *et al.*, 2011; van der Kooij *et al.*, 2021).

4.3.18 Herring is a pelagic fish population which has experienced pressures such as overfishing which resulted in the collapse of the stock entirely in the 1970s due to overfishing (Scottish Herring, 2023). Since then, stocks have shown signs of recovery, which has been supported by a recovery plan implemented for the North Sea in 1996 and a ban on discards for pelagic fisheries from 2015. However, active management is still required to avoid a recurrence of the collapse (Dickey-Collas *et al.*, 2010).

4.3.19 Herring are listed on the SBL and as a Scottish PMF and are therefore considered a high priority species for conservation actions in Scotland. Atlantic bluefin tuna, horse mackerel, and mackerel are also listed as Scottish PMFs and/or on the SBL, although sprat are not (Table 4.3).

Sandeel

4.3.20 There are five sandeel species present in UK waters, with the most common being the Raitt's sandeel and the lesser sandeel. The three other species are the smooth sandeel, greater sandeel, and Corbin's sandeel *Hyperoplus immaculatus* (NatureScot, 2020). Sandeels are listed as a Scottish PMF and Raitt's sandeel and the lesser sandeel are on the SBL (Table 4.3). This Technical Report refers to sandeel species collectively, unless specified otherwise.

4.3.21 Sandeel are a key forage fish species, linking primary productivity to higher trophic levels and impacts on sandeel can cascade through the food chain. Sandeel feed exclusively on phytoplankton and zooplankton in the water column during the daytime in spring and summer months (Engelhard *et al.*, 2008; Freeman *et al.*, 2004). They tend to actively feed in schools within 10 km of their burying grounds (Wright *et al.*, 2019). This is an adaptation to conserving energy and to avoid predation.

4.3.22 Between September and February sandeel remain buried in the seabed to occasionally emerge between December and February to spawn a single batch of demersal eggs that are deposited on the seabed (van der Kooij *et al.*, 2008). The hatching of larvae then occurs in February to April where they drift with currents within the plankton for ten weeks (Proctor *et al.*, 1998; Régnier *et al.*, 2017; Wright *et al.*, 2019). Larvae metamorphose into juveniles and return to the demersal environment and look for suitable areas of sand to inhabit.

4.3.23 Further detail on sandeels is provided in Section 4.5, where a site-specific habitat suitability assessment has been undertaken.

Elasmobranchs

4.3.24 Elasmobranchs are a group of fish species with skeletons made of cartilage as opposed to bone, such as sharks, skates, and rays. There are over 30 species known to occur in Scottish waters, with the most abundant being the small spotted catshark *Scyliorhinus canicula*, spurdog *Squalus acanthias*, nursehound *Scyliorhinus stellaris*, tope shark *Galeorhinus galeus*, thornback ray, and cuckoo ray (Baxter *et al.*, 2011; BEIS, 2022). These species have the potential to occur within the Fish and Shellfish Ecology Study Area. Other elasmobranchs that may be present within the Fish and Shellfish Ecology Study Area include:

- basking shark;
- blue shark;
- common skate *Dipturis batis*;
- cuckoo ray;
- small spotted catshark;
- spotted ray *Raja montagui*;
- spurdog;
- thornback ray;

- thorny skate *Amblyraja radiata* (also known as the 'starry skate' but is referred to as thorny skate within this Technical Report); and
- tope shark (Coull *et al.,* 1998; Daan *et al.,* 2005; Ellis *et al.,* 2012).

4.3.25 Within the site-specific DAS for the Proposed Development, one basking shark was recorded, along with a blue shark and two porbeagle shark (Section 4.2).

4.3.26 The potential elasmobranch assemblage within the Fish and Shellfish Ecology Study Area can also be informed by data collected by the Shark Trust, who record egg case sightings, either *in situ* or washed ashore. All skate species, and some sharks, lay eggs within egg cases (sometimes referred to as 'mermaid's purses' in the literature and colloquially). The Shark Trust has been conducting the citizen science project the Great Egg Case Hunt since 2003, with 20 years of data presented in Shark Trust (2023). The proportion of egg cases belonging to different species between 2003 and 2023 is presented in Figure 4.4. Within the Fish and Shellfish Ecology Study Area, 1,000 egg cases were recorded with the following species identified:

- small spotted catshark;
- flapper skate *Dipturus intermedius*;
- thorny skate;
- cuckoo ray; and
- spotted ray (Figure 4.4; Shark Trust (2023)).

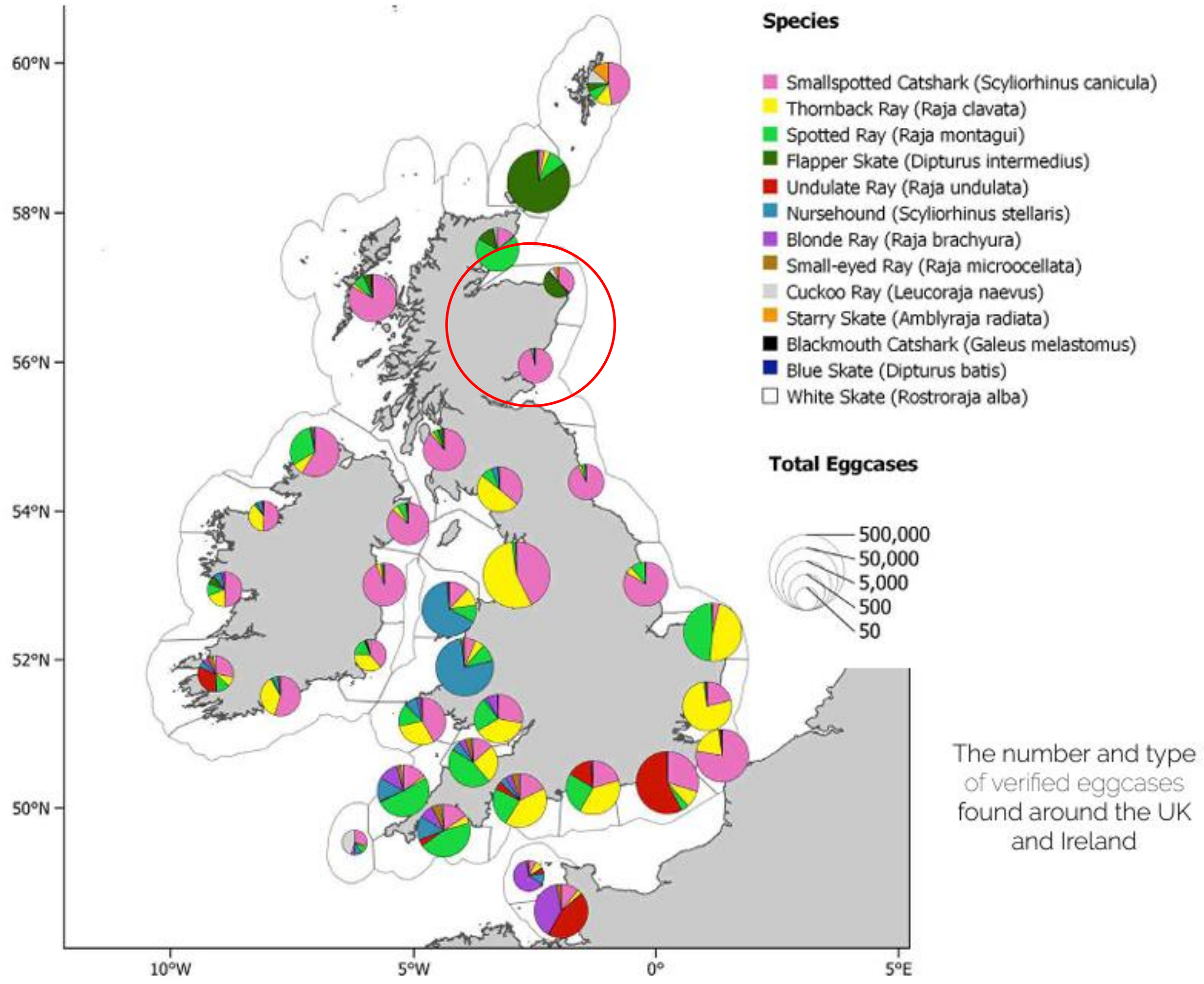


Figure 4.4: Total Egg Cases Recorded Between 2003 to 2023 in the Great Egg Case Hunt (Red Circle Shows the Approximate Location of the Fish and Shellfish Ecology Study Area) (Shark Trust, 2023)

4.3.27 Within the polygon of the Fish and Shellfish Ecology Study Area (Figure 2.1), there were 44 elasmobranchs recorded on the NBN Atlas, from 1954 to 2023 (Table 4.4). The most commonly recorded species was basking shark; however, it should be noted that this does not mean that the other species are less abundant. Given the large size of basking shark, ease of identification, slow nature, and that they are typically near the sea surface, they are more likely to be recorded on boat or shore-based surveys than smaller, faster moving, and potentially more cryptic species.

4.3.28 Further information on elasmobranch species with the potential to occur in the Fish and Shellfish Ecology Study Area is provided in the following sections.

Table 4.4: Number of Elasmobranch Records within the Fish and Shellfish Ecology Study Area on the NBN Atlas (2025)

Species	Individuals Recorded
Basking shark	14
Small spotted catshark	9
Family: Radjidae	7
***Scyliorhinus* spp.**	4
Cuckoo ray	3
Thornback ray	2
Spotted ray	1
Porbeagle shark	1
Thorny skate	1
Angel shark *Squatina squatina*	1
Greenland shark[1] *Somniosus microcephalus*	1
Total	44

[1] It should be noted that two more Greenland shark were recorded in the approximate Fish and Shellfish Ecology Study Area but these were historic records dating back to 1895 and so were excluded.

Conservation Importance

4.3.29 Most elasmobranchs considered in this baseline are protected by various conservation legislations and/or are listed on biodiversity action lists. These include Acts and Wildlife Conventions, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The conservation importance of the species potentially present within the Fish and Shellfish Ecology Study Area is summarised in Table 4.5.

Table 4.5: Conservation Status of Elasmobranchs within the Fish and Shellfish Ecology Study Area

Species	Appendix II or Appendix III of the Bern Convention[1]	Wildlife and Countryside Act 1981[2]	Bonn Convention[3]	Appendix II of CITES	OSPAR List of Threatened and/or Declining Species[4]	Nature Conservation (Scotland) Act 2004	The Sharks, Skates and Rays (Scotland) Order 2012	Scottish PMF	SBL	IUCN Status[5]
Basking shark	✓ Appendix II	✓	✓	✓	✓	✓		✓	✓	EN[6]
Blue shark	✓ Appendix III		✓						✓	NT[7]
Common skate					✓			✓	✓	CR[8]
Cuckoo ray										LC[9]
Flapper skate								✓	✓	CR
Nursehound										VU[10]
Porbeagle shark	✓ Appendix III		✓	✓	✓		✓	✓	✓	CR
Small spotted catshark										LC
Spotted ray					✓					LC
Spurdog			✓		✓		✓	✓	✓	VU
Thornback ray					✓				✓	NT
Thorny skate										VU
Tope shark			✓						✓	CR
Angel shark		✓	✓		✓		✓		✓	CR
Greenland shark							✓			VU

[1] Appendix II covers Strictly Protected Fauna Species and Appendix III covers Protected Fauna Species
[2] Schedule 5 of the Wildlife and Countryside Act 1981 (as amended in Scotland)
[3] Convention on the Conservation of Migratory Species of Wild Animals, Bonn 1979
[4] Within OSPAR Region II: Greater North Sea, which encompasses the Fish and Shellfish Ecology Study Area
[5] IUCN conservation status for the relevant area (i.e. Europe) wherein a species has multiple assessments worldwide. If a species has a more recent global assessment that is of a more severe status than an older European assessment, the global status has been used instead. This was the case for nursehound, thorny skate and tope shark.
[6] EN = Endangered
[7] NT = Near Threatened
[8] CR = Critically Endangered
[9] LC = Least Concern
[10] VU = Vulnerable

Species Accounts

4.3.30 It should be noted that the Greenland shark identified in Table 4.4 is not being considered further, as they are rarely seen or recorded within Scotland and the UK and although they are known to travel long distances the geographic range is thought to be much narrower and they are more likely to be found in Norway (Kulka *et al.* 2020; NBN Atlas, 2025).

4.3.31 The Angel shark, which was identified within the Fish and Shellfish Ecology Study Area on the NBN Atlas (Table 4.4), has also not been assessed further due to research that indicates this species is considered to be locally extinct within the North Sea and is only repeatedly seen on the west coast of the UK. Specifically, important areas have been identified as the west coast of Ireland and coastal waters of Wales and the Irish Sea (Morey *et al.,* 2019; Barker *et al.,* 2022; NBN Atlas 2025).

<u>Basking Shark</u>

4.3.32 Basking shark may migrate throughout the Fish and Shellfish Ecology Study Area and therefore have the potential to be encountered within the Site Boundary. Unlike the other elasmobranchs found in the Fish and Shellfish Ecology Study Area, the basking shark is an obligate ram filter feeder whereby the flow of water across gill rakers within the mouth is controlled by swimming speed (Sims, 1999; Sims, 2008).

4.3.33 In Scottish waters, areas along the west coast, such as Tiree, Coll, and Canna have been described as 'hotspots' for basking shark, due to regular sightings. For example, Drewery (2012) presented 40 years of sighting data between 1970 to 2010, with highest sightings concentrated on these areas and significantly fewer within the Fish and Shellfish Ecology Study Area (Figure 4.5). Tagging studies have been conducted within these areas, which have demonstrated high site fidelity within the summer months, with winter migrations to the west of Ireland, the Bay of Biscay, Iberian Peninsula and North Africa (Witt *et al.*, 2014; Witt *et al.*, 2016). Basking shark migrate over large distances using both the continental shelf and oceanic habitats in the upper 50 m to 200 m of the water column (Doherty *et al.*, 2017).

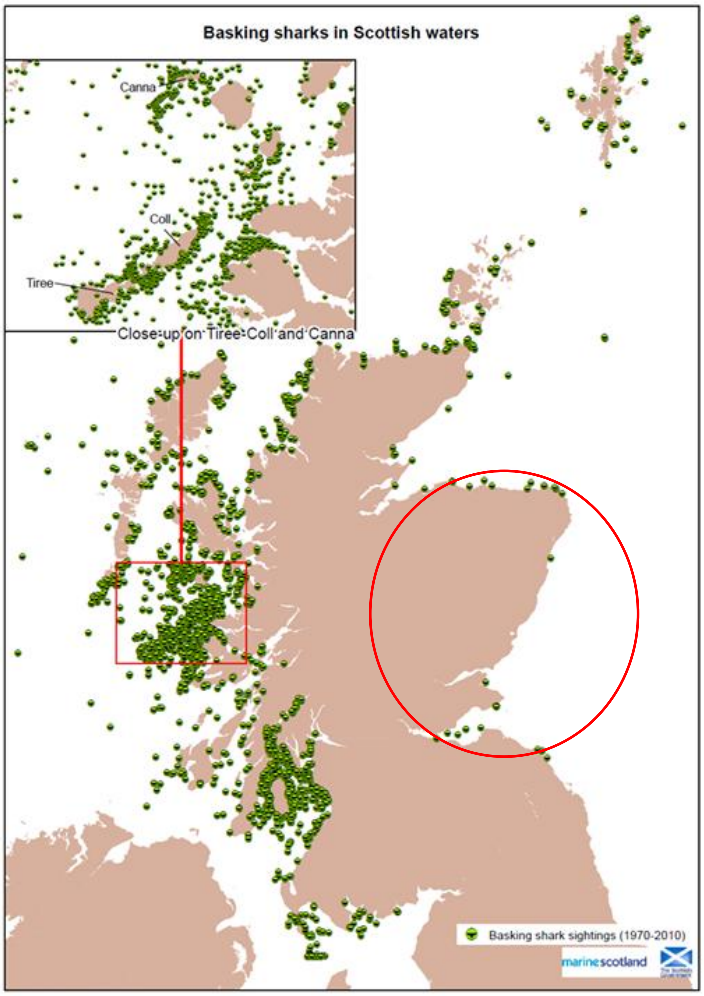


Figure 4.5: Basking Shark Sightings in Scottish Waters Between 1970 to 2010, Showing Hotspots on the West Coast (from Drewery (2012)). The Fish and Shellfish Ecology Study Area is Denoted by a Red Circle

4.3.34 Distribution of the species has been shown to be influenced by a range of environmental conditions (Austin *et al.*, 2019; Witt *et al.,* 2012). Within the Fish and Shellfish Ecology Study Area, high habitat suitability for basking shark has been modelled around the coasts of East Scotland (Austin *et al.*, 2019) (Figure 4.6).

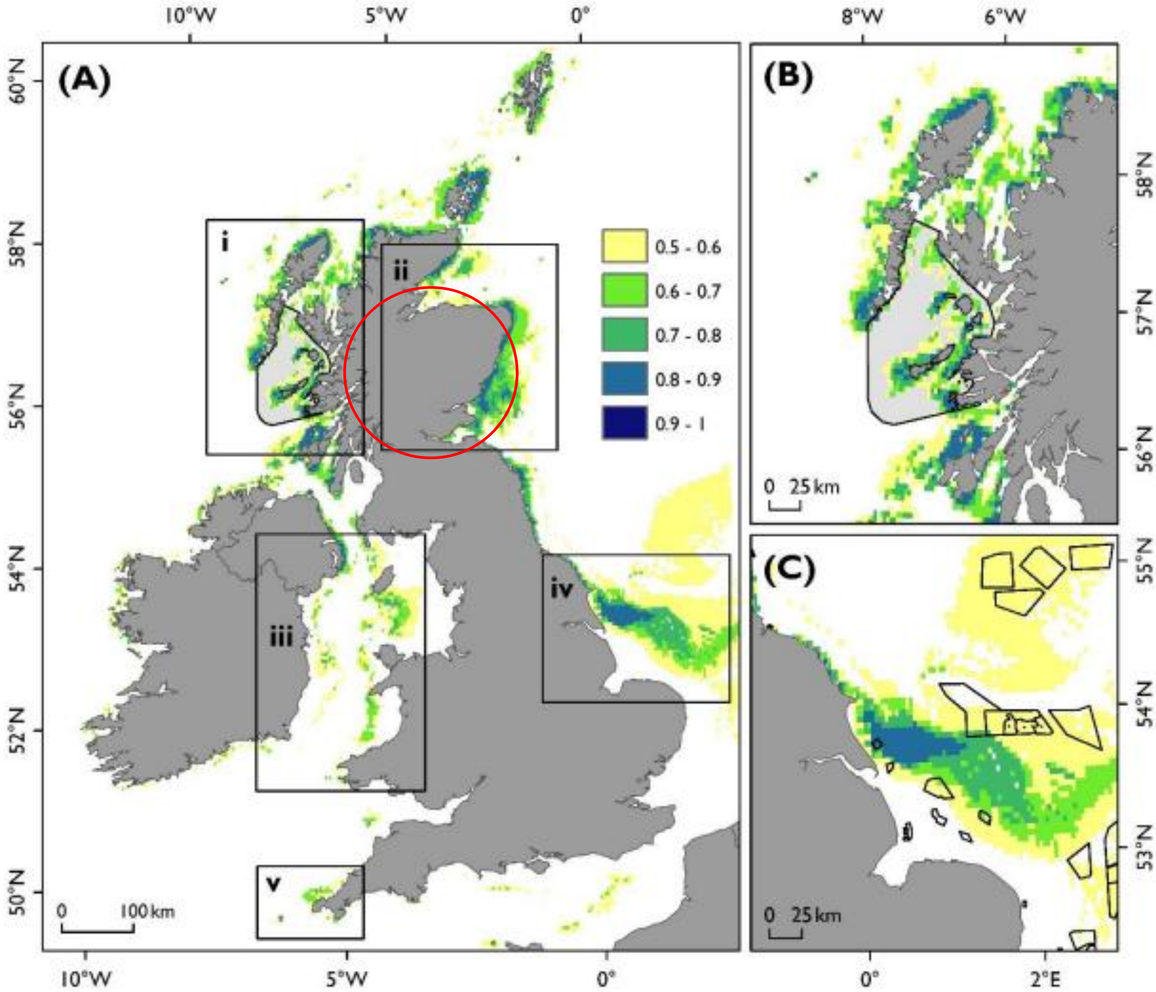


Figure 4.6: Areas of High Relative Habitat Suitability for Basking Shark in the UK (from Austin *et al.* (2019)). The Fish and Shellfish Ecology Study Area is Denoted by a Red Circle

4.3.35 Basking shark have a north to south migration route and therefore may be most likely to be present within the Fish and Shellfish Ecology Study Area during August to October and during the return migration in March to June (Doherty *et al*., 2017). It should be noted that the basking shark sighted in the Kincardine OWF survey was recorded in late October, during the Morven OWF surveys sightings were in November and the one basking shark sighted in the DAS for the Proposed Development was recorded in July 2023 (Table 4.2; Kincardine Offshore Windfarm, 2016; Morven Offshore Wind Limited, 2023).

4.3.36 There is sighting data of basking shark recorded on the east coast of Scotland, including within the Fish and Shellfish Survey Area, although sightings are not as numerous as on the west coast of Scotland. Sightings of basking shark between 1987 to 2020 have been concentrated in the Moray Firth (at the most north-western extent of the Fish and Shellfish Ecology Study Area), Firth of Forth and near St Abbs (the most southern extent of the Fish and Shellfish Ecology Study Area) (see Figure 4.5 from Drewery (2012) and Figure 4.7 from Pikesley *et al.,* (2024)).

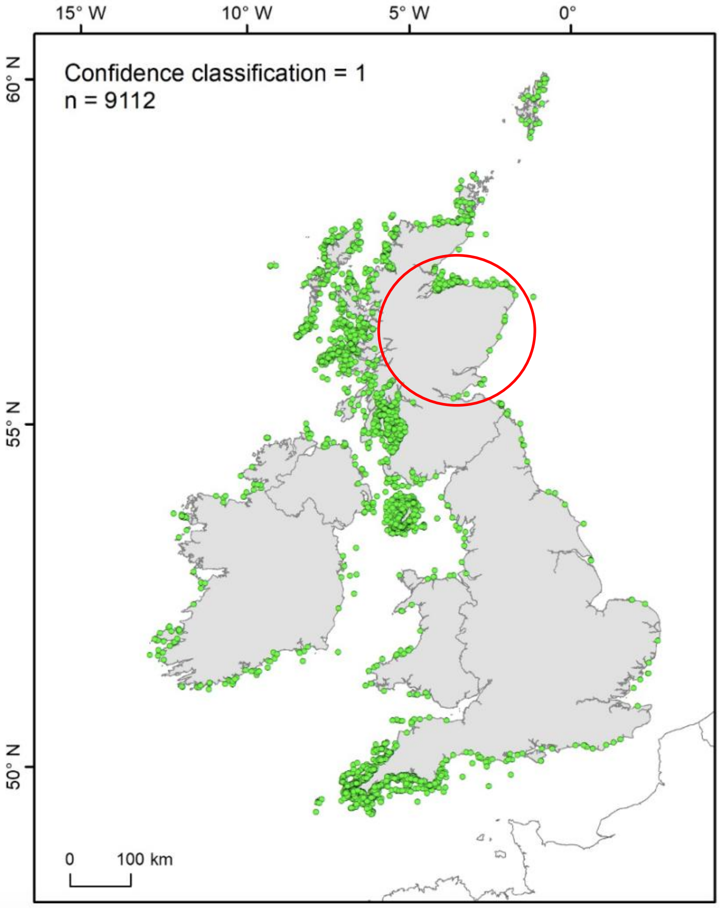


Figure 4.7: Combined Basking Shark Database 01/04/1987 to 27/10/2020: Sightings with Spatial Validation Confidence Classification 1 (Pikesley *et al.*, 2024). The Fish and Shellfish Ecology Study Area is Denoted by a Red Circle

4.3.37 Mating behaviour in basking sharks has never been observed, however it most likely occurs in deep water with courtship-like behaviour as the precursor, particularly where individuals aggregate in food rich waters (Sims, 2008). It is believed that individuals pair and mate in early summer (Sims *et al.*, 2000), and have a gestation period in the range of 12 to 36 months (Parker and Stott, 1965; Sims, 2008). As an ovoviviparous species, female basking shark give birth to live young, which have hatched from eggs within their uterus. Basking shark are a slow growing species with a low fecundity, which suggests that they would be vulnerable to environmental changes and that population recovery would be slow.

4.3.38 With a long history of commercial exploitation, this species is protected under several international conventions and laws (see Table 4.5). They are also listed as endangered on the IUCN Red List (Rigby *et al.*, 2021) and are listed on the OSPAR List of Threatened and/or Declining Species and Habitats (Table 4.5).

Blue Shark

4.3.39 There was one blue shark recorded in the site-specific DAS for the Proposed Development in July 2023. The blue shark is one of the widest ranging sharks in the world, and can be present in the open ocean from the surface to at least -400 m in depth (Queiroz, 2007). Blue sharks are a highly migratory species and are a major constituent of the bycatch in pelagic longline fisheries (Vandeperre *et al.*, 2014; Veríssimo *et al.*, 2017).

4.3.40 The blue shark is protected under the Bern Convention and the Bonn Convention and is listed on the SBL. It has an IUCN Status of 'near threatened' (Table 4.5).

Common Skate Complex

4.3.41 The common skate complex is the largest species of skate in the world, and one of the largest fish species in Scotland (The Wildlife Trust, 2024). The ICES Working Group on Elasmobranch Fishes (ICES, 2020) describes the complex as: *"Dipturus batis, frequently referred to as common skate, has recently been confirmed to comprise of two species being erroneously synonymised in the 1920s (Griffiths et al., 2010, Iglésias et al., 2010). The smaller species (previously described as Dipturus flossada by Iglésias et al. (2010)) is the common blue skate (Dipturus batis) and the larger species may revert to the flapper skate (Dipturus intermedius)."*

4.3.42 Both species (common blue skate and flapper skate) were accepted by Last *et al.* (2016) and are now also accepted on the Catalogue of Fishes and World Register of Marine Species (WoRMS).

4.3.43 The estimated distribution of the common skate complex ranges from the Azores and Portugal and as far north as Iceland and southern Norway, with "hotspots" off the coasts of Ireland and Scotland (Figure 4.8; Bache-Jeffreys *et al.*, 2021). Although the two species largely overlap in their specific distributions, flapper skate tends to inhabit a larger thermal range associated with inshore areas, in comparison to the more offshore common blue skate (Frost *et al.*, 2020).

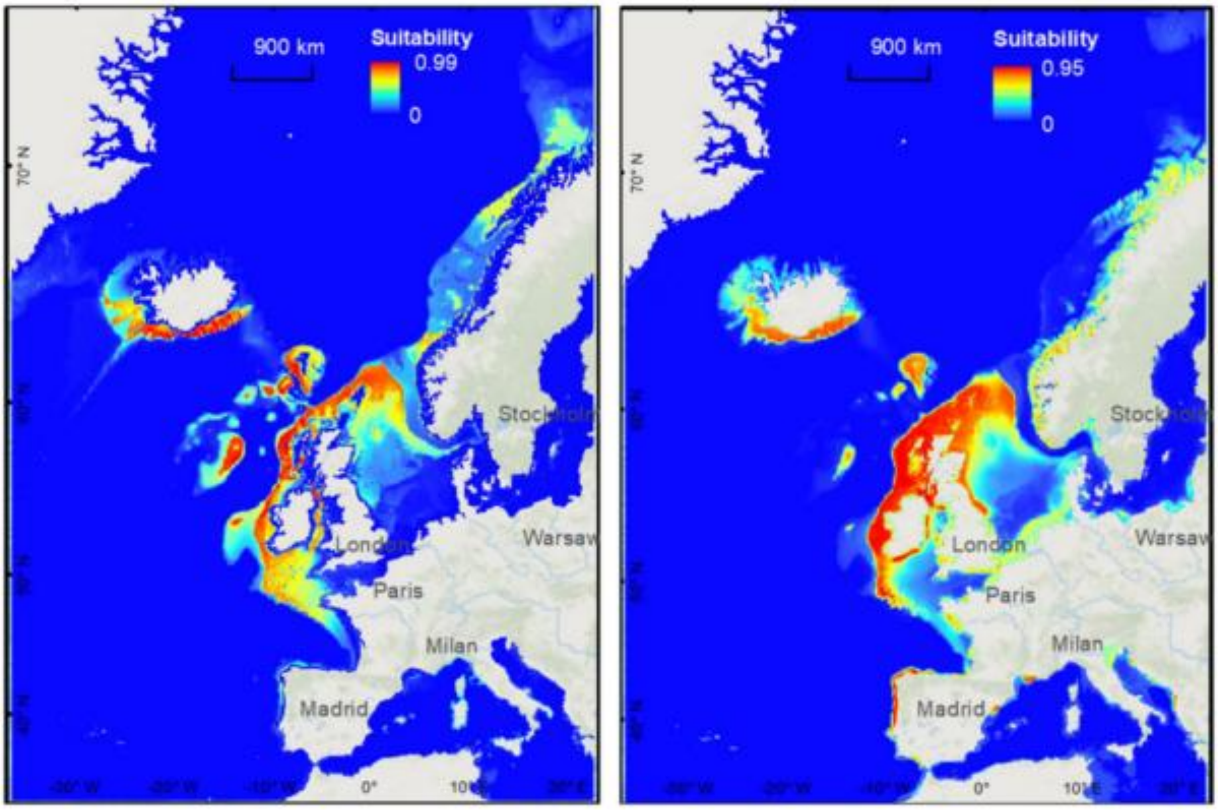


Figure 4.8: Species Distribution Models to Predict the Probability of the Presence of Common Blue Skate (Left) and Flapper Skate (Right) (from Bache-Jeffreys *et al.* (2021))

4.3.44 The common skate complex was once well distributed throughout their range, however fisheries pressures have driven mass population declines and the species is now extirpated from large parts of this range (Dulvy and Reynolds, 2002; Rogers and Ellis, 2000). Their large size and life history traits (slow growth, late maturity and low fecundity) mean they are highly susceptible to overfishing (Griffiths *et al.*, 2010). The common skate complex has been described as the first clear case of a fish species brought to the brink of extinction by commercial fishing (Iglésias *et al.*, 2010). The last remaining population strongholds of common blue skate and flapper skate include continental shelf edge habitat off the western coast of Scotland (The Wildlife Trust, 2024), the western waters of the Celtic Sea (Ellis *et al.*, 2005a), and along the Norwegian coast (Dolgov *et al.*, 2005). Consequently, the common blue skate and flapper skate are listed by the IUCN as critically endangered, and on the SBL. The common blue skate is also listed on the OSPAR List of Threatened and/or Declining Species and as a Scottish PMF, however these designations will likely be applied to flapper skate in the future (Table 4.5).

4.3.45 Although there were no common skate complex species recorded in the site-specific surveys or within the Fish and Shellfish Ecology Study Area on the NBN Atlas, there have been low intensity nursery grounds identified for the common skate complex within the Fish and Shellfish Ecology Study Area and within the Array Area and Export Cable Corridor (see Section 4.4; Ellis *et al.* (2012)). Further, flapper skate egg cases were recorded in one of the sample areas within the northern area of the Fish and Shellfish Ecology Study Area (Figure 4.4; Shark

Trust (2023)), thus consistent with the common skate complex nursery grounds identified by Ellis *et al.* (2012).

Cuckoo Ray

4.3.46 The cuckoo ray is distributed around the North-East Atlantic, usually between -20 m to -250 m depth (Fishbase, 2024d). Cuckoo ray were recorded in the site-specific surveys for Seagreen 1 and Seagreen 1A OWFs and Berwick Bank OWF (Table 4.2).

4.3.47 This species is not protected by any of the conservation designations or included on any of the biodiversity initiatives listed in Table 4.5. The cuckoo ray has an IUCN Status of 'least concern' (Table 4.5).

Nursehound

4.3.48 The nursehound is a large catshark that is found throughout the UK and Northern Atlantic Ocean (Barnes, 2008b). It occurs on both inshore and offshore continental shelves, usually over rough and rocky or coralline grounds and seaweed beds, down to depths of up to -100 m (Barnes, 2008b). In Table 4.4 there were four *Scyliorhinus* spp. identified from NBN Atlas of the Fish and Shellfish Ecology Study Area, although these individuals were not identified to the species level this genus includes the nursehound. An individual nursehound was also identified and recorded to species level by Seasearch Marine Surveys in Scotland within the very north-west of the Fish and Shellfish Ecology Study Area. However, in comparison to the east coast of Scotland there are a higher number of records of this species being identified on the west coast of Scotland (Seasearch, 2022).

4.3.49 Despite an IUCN Status of 'vulnerable', the nursehound is not protected by any of the conservation designations or included on any of the biodiversity initiatives listed in Table 4.5.

Porbeagle Shark

4.3.50 Two porbeagle shark were recorded in the site-specific DAS for the Proposed Development (see Section 4.2.4). The porbeagle shark is a highly migratory, pelagic shark distributed widely in the cold and temperate marine waters of the North Atlantic (Campana and Joyce, 2004; OSPAR Commission, 2008). A tagging study demonstrated that individuals ranged between the sea surface down to -1,600 m depth, but rarely ventured deeper than -700 m (Biais *et al.*, 2017). All of the individuals tagged predominantly occupied the upper 200 m of the water column (Biais *et al.*, 2017). There are distinct day to night differences in depth distribution (diel vertical migration), with tagged porbeagle sharks recorded higher in the water column during the night than in the daytime (Saunders *et al.*, 2011).

4.3.51 Like most pelagic sharks, it is vulnerable to overexploitation and population depletion by fisheries owing to its relatively slow growth rate, low fecundity, and late age at sexual maturity (OSPAR Commission, 2008; Saunders *et al.*, 2011). The species has been heavily exploited by targeted and non-targeted fisheries, and some populations have declined by up to 90% due to overfishing (National Oceanic and Atmospheric Administration (NOAA), 2016).

4.3.52 Consequently, this species is protected under several international conventions and laws (see Table 4.5). They are also listed as endangered on the IUCN Red List for Europe, and vulnerable globally (Ellis *et al.*, 2015) and are listed on the OSPAR List of Threatened and/or Declining Species and Habitats.

Small Spotted Catshark

4.3.53 This species was recorded in the site-specific surveys for Seagreen 1 and Seagreen 1A OWFs (Table 4.2). Further, small spotted catshark egg cases were some of the most commonly recorded in the Fish and Shellfish Ecology Study Area (Figure 4.4; Shark Trust (2023)).

4.3.54 The small spotted catshark (also known as the lesser spotted dogfish) is a common species around the UK, found in the shallow sublittoral zone over muddy, sandy, and rocky substrates down to a depth of -100 m (Pizzolla, 2008). It is distributed throughout the North-East Atlantic from Norway to west coast of Africa, and in the Mediterranean Sea, and is one of the most abundant species of shark in UK waters (Shark Trust, 2020).

4.3.55 This species is not protected by any of the conservation designations or included on any of the biodiversity initiatives listed in Table 4.5. Similarly, the small spotted catshark also has an IUCN Status of 'least concern' (Table 4.5).

Spotted Ray

4.3.56 Spotted ray are widely distributed across the eastern Atlantic from Morocco to the Shetland Isles and Norway (Ellis *et al.*, 2005b). They are found at a depth of -8 m to -530 m, on soft, sandy substratum (Gibson-Hall, 2018).

4.3.57 The species exhibits generational segregation, with juveniles commonly occurring on sandy sediments closer inshore, where they feed on small crustaceans, and adults occurring further offshore on sand and coarse sand-gravel sediments, predating on larger crustaceans and fish (Ellis *et al.*, 2007). Individuals are known to bury themselves to avoid predation and to ambush prey. The spotted ray has the most varied diet, compared to other North-Eastern Atlantic ray species, composed of crustaceans, polychaetes, teleosts, and molluscs (Gibson-Hall, 2018).

4.3.58 The species is listed on the OSPAR List of Threatened and/or Declining Species within the North Sea, however is listed as 'least concern' by the IUCN within European, Mediterranean, and worldwide waters (Table 4.5; Ellis *et al.* (2007)).

4.3.59 Peak spawning of spotted ray occurs from March to July (Ellis *et al.*, 2012) (see Table 4.12). Low intensity nursery grounds for the spotted ray have been identified within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary (see Section 4.4; Ellis *et al.* (2012)). Further, spotted ray egg cases were recorded in the Fish and Shellfish Ecology Study Area (Figure 4.4; Shark Trust (2023)), thus consistent with the nursery grounds identified by Ellis *et al.* (2012).

Spurdog

4.3.60 The spurdog (also referred to as 'spiny dogfish') is found mostly at depths of between -10 m to -200 m, but can be found down to -900 m (Tyler-Walters *et* *al.*, 2016). The spurdog is one of the most abundant shark species in the world, although there have been population declines in some areas of the North-East Atlantic (Tyler-Walters *et al.*, 2016).

4.3.61 This species has been targeted and caught as bycatch in artisanal, industrial, and recreational fisheries as its distribution overlaps with intensive fishing activities (Finucci *et al.*, 2020). However, retention bans implemented in European waters have diminished the large-scale fishing pressure, leading to some considerable recovery for some stocks. Nonetheless, incidental catches continue, and post-release mortality remains high, such as up to 39% for gillnet fisheries (Da Silva *et al.*, 2015; Ellis *et al.*, 2017; ICES, 2018a; Rago and Sosebee, 2014).

4.3.62 The species is protected under the Bonn Convention and listed on the OSPAR List of Threatened and/or Declining Species and on the SBL. This species is also a Scottish PMF. Spurdog has an IUCN Status of 'vulnerable' (Table 4.5).

4.3.63 Spawning of spurdog occurs year-round (Ellis *et al.*, 2012) (see Table 4.12). Low intensity nursery grounds for the spurdog have been identified within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary (see Section 4.4; Ellis *et al.* (2012)).

Thornback Ray

4.3.64 The thornback ray is a medium sized skate widely distributed throughout UK waters at depths down to -300 m, but is most common between -10 m to -60 m. It occurs across a wide variety of seabed types including mud, sand, shingle, and gravel (Snowden, 2008). The species is listed on the OSPAR List of Threatened and/or Declining Species and on the SBL. This species has an IUCN Status of 'near threatened' (Table 4.5).

4.3.65 Spawning of thornback ray occurs from February to September, with peak spawning between March and July (Ellis *et al.*, 2012) (Table 4.12). Low intensity nursery grounds for thornback ray have been identified within the very north-west of the Fish and Shellfish Ecology Study Area (see Section 4.4; Ellis *et al.* (2012)). However, thornback ray egg cases were not recorded in the Fish and Shellfish Ecology Study Area (Figure 4.4; Shark Trust (2023)), highlighting that there are insufficient data on egg cases and egg-bearing females in the spawning season. According to Ellis *et al.* (2012) it is thought that the thornback ray spawning grounds would broadly overlap with nursery grounds within the very north-west of the Fish and Shellfish Ecology Study Area.

Thorny Skate

4.3.66 The thorny skate occurs on both sides of the Northern Atlantic Ocean (NOAA, 2003) in temperate offshore waters on all kinds of seabeds, but mainly sandy and muddy sediments (Fishbase, 2024a). In the north-east Atlantic, the thorny skate is most common between -50 m to -100 m depth, at temperatures of 2°C to 5°C (Fishbase, 2024a).

4.3.67 Verified records of thorny skate egg cases were found within the northern extent of the Fish and Shellfish Ecology Study Area (Figure 4.4; Shark Trust (2023)).

4.3.68 Despite an IUCN Status of 'vulnerable', the thorny skate is not protected by any of the conservation designations or included on any of the biodiversity initiatives listed in Table 4.5.

Tope Shark

4.3.69 Tope shark is a medium-sized shark (up to 200 cm total length) and widespread in temperate waters in most oceans (Colloca *et al.*, 2019). This species is present at depths from nearshore to over -700 m (Fishbase, 2024b; Schaber *et al.*, 2022), but is largely pelagic in the open ocean. Tope shark is a highly migratory species, as evidenced by various tagging studies (Colloca *et al.*, 2019; Holden and Horrod, 1979; McMillan *et al.*, 2019; Schaber *et al.*, 2022).

4.3.70 In most parts of their extensive distribution range, tope shark have been targeted commercially for liver-oil, meat and fins with gillnets and longlines and are also a common bycatch in trawl and other fisheries (Convention on Migratory Species Secretariat, 2020). Tope shark has a particularly low biological productivity with a late age-at-maturity and triennial reproductive cycle. Therefore, its historic overfishing has resulted in mass population declines throughout its range (Walker *et al.*, 2020). In the North-East Atlantic, the subpopulation is estimated to have undergone a reduction of 76% over the past three generation lengths (79 years) (Walker *et al.*, 2020). Due to its historic population decline, the tope shark is protected under the Bonn Convention and listed on the SBL. It is listed as 'Critically Endangered' on the IUCN Red List (Table 4.5).

4.3.71 Spawning of tope shark occurs year-round (Ellis *et al.*, 2012) (see Table 4.12). Low intensity nursery grounds for the tope shark have been identified within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary (see Section 4.4; Ellis *et al.* (2012)).

Diadromous Fish

4.3.72 Diadromous fish are those which migrate between freshwater and seawater habitats in order to complete their life cycle. The term 'diadromous' encompasses species which live in seawater as adults and migrate to freshwater to spawn (anadromous) and those which live in freshwater as adults and migrate to seawater to spawn (catadromous). There are numerous rivers along the coast of the Fish and Shellfish Ecology Study Area, such as the Rivers Deveron, Don, Dee, Esk and Tay. Therefore, diadromous fish species may migrate to and from rivers within the Fish and Shellfish Ecology Study Area and through the Site Boundary throughout the year. Based on historical records in Scottish waters, the following diadromous species have the potential to be in the vicinity of the Site Boundary (Baxter *et al.,* 2011; Honkanen *et al.,* 2024; Malcolm *et al.,* 2010; Malcolm *et al.,* 2015; Newton *et al.,* 2021; Newton *et al.,* 2017; River Dee Trust and MSS, 2023; Smith and Smith, 1997):

- Atlantic salmon *Salmo salar*;
- European eel *Anguilla anguilla*;
- European smelt (also referred to as 'sparling' in the literature) *Osmerus eperlanus*;

- river lamprey *Lampetra fluviatilis*;
- sea lamprey *Petromyzon marinus*;
- sea trout *Salmo trutta*; and
- shads: Allis shad *Alosa alosa* and Twaite shad *Alosa fallax*.

4.3.73 Results from the site-specific surveys for the Proposed Development included records of Atlantic salmon within the eDNA samples, alongside a record of a *Lampetra* spp. (which is likely to be river lamprey) (see Section 4.2.3 and Figure 4.1).

4.3.74 It should be noted that although the designated sites River Teith and River Tay Special Area of Conservation (SAC) (see Section 4.6) are considered due to protected features; Atlantic salmon (and subsequently the freshwater pearl mussel *Margaritifera margaritifera*), sea lamprey and river lamprey, which migrate through the Fish and Shellfish Ecology Study Area, the protected feature of both of these SACs; brook lamprey *Lampetra planeri*, is a feature which is not considered further in this report as they are unlikely to interact with the Bowdun OWF. This is due to their habitat comprising of purely freshwater as the brook lamprey migrates between downstream river habitat to upstream areas to spawn.

4.3.75 Although residing entirely in freshwater, and therefore beyond the spatial scope of this Technical Report, the freshwater pearl mussel shares a symbiotic life history with Atlantic salmon and sea trout (Taeubert and Geist, 2017). Therefore, freshwater pearl mussel populations may be indirectly affected if Atlantic salmon or sea trout are impacted by the Proposed Development. This species has therefore been considered within the assessment on diadromous fish in the Volume 2, Chapter 9: Fish and Shellfish Ecology.

4.3.76 For the purposes of this Technical Report, it is assumed that the aforementioned diadromous species could be present within the Site Boundary during migration. The potential for the Proposed Development to disrupt the migration of these species has been assessed in Volume 2, Chapter 9: Fish and Shellfish Ecology, and in the Report to Inform Appropriate Assessment (RIAA) (TWP-BOW-RPS-ENV-RPT-00012). An overview of key migratory periods is presented in Table 4.6.

Table 4.6: Overview of the Migration Periods for Diadromous Fish Species

Species	Timing of Downstream Migration	Time Spent at Sea	Timing of Upstream Migration	Source
Allis and twaite shad	Autumn	Spends 2 years in estuaries and marine areas and returns to freshwater when sexually mature	April to June	ABP Marine Environmental Research (ABPMer) (2019), Maitland and Hatton-Ellis (2003)
Atlantic salmon	April to June	1 to 4 years	All year, with a peak in late summer and autumn	NatureScot (2023a), ABPMer (2019), Malcolm *et al.* (2015), Malcolm *et al.* (2010)
European eel	June to November	May not return to freshwater, many do not	Varies spatially around Europe, however in Scotland they typically arrive in coastal waters in December and may migrate upstream until June	Malcolm *et al.* (2010)
European smelt	Migrates to estuaries only	Spends time in estuaries	February to April (to spawn in estuaries and large rivers)	NatureScot (2023e)
River lamprey	From late autumn onwards (to feed)	Spends 1 to 2 years in estuaries	Winter and spring when temperatures are <10°C	ABPMer (2019), NatureScot (2023d)
Sea lamprey	From late autumn onwards (to open sea)	18 to 24 months	April to May (to spawn in May to June)	ABPMer (2019), NatureScot (2023d)
Sea trout	Spring	2 or more	April to June	Malcolm *et al.* (2010)

Conservation Importance

4.3.77 All diadromous fish found in UK waters are protected by various conservation legislations and/or are listed on biodiversity action lists. The conservation status of the diadromous fish species (and freshwater pearl mussel) potentially present within the Fish and Shellfish Ecology Study Area is summarised in Table 4.7.

Table 4.7:Conservation Status of Diadromous Fish and Associated Species within the Fish and Shellfish Ecology Study Area

Species	Annex II Species under the Habitats Regulations[1]	Appendix III Species under the Bern Convention	Appendix II of CITES	Bonn Convention	OSPAR List of Threatened and/or Declining Species[2]	Salmon Act[3]	The Wildlife and Countryside Act 1981	PMF[4]	SBL	IUCN Status[5]
Allis shad	✓	✓			✓	✓	✓		✓	LC[6]
Atlantic salmon	✓	✓			✓	✓		✓	✓	EN[7]
European eel			✓	✓	✓	✓		✓	✓	CR[8]
European smelt						✓	✓	✓	✓	LC
River lamprey	✓	✓				✓		✓	✓	LC
Sea lamprey	✓	✓			✓	✓		✓	✓	LC
Sea trout						✓		✓	✓	LC
Twaite shad	✓	✓				✓	✓		✓	LC
Freshwater pearl mussel	✓	✓					✓		✓	CR

[1] The Conservation (Natural Habitats, &c.) Regulations 1994 and the Conservation of Offshore Marine Habitats and Species Regulations 2017
[2] Within OSPAR Region II: Greater North Sea, which encompasses the Fish and Shellfish Ecology Study Area
[3] The Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. This Act applies to not only salmon, but also freshwater fish, defined as "any fish living in fresh water, including trout and eels and the fry of eels but exclusive of salmon and of any kind of fish which migrate between the open sea and tidal waters".
[4] Designated as Scottish PMFs during the marine phase of their life cycles.
[5] IUCN conservation status for the relevant area (i.e. Europe) wherein a species has multiple assessments worldwide
[6] LC = Least Concern
[7] EN = Endangered
[8] CR = Critically Endangered

Species Accounts

4.3.78 Further information on the diadromous fish species with the potential to occur in the Fish and Shellfish Ecology Study Area is provided in the following sections.

Atlantic Salmon

4.3.79 Atlantic salmon can be encountered in clean and healthy rivers throughout the UK. Like other salmonid species, they spawn in the same stretch of river or stream in which they were born (referred to as their natal river). Their juvenile life stage typically lasts between one to four years before they migrate to sea. During their juvenile stage, Atlantic salmon undergo a metamorphosis involving morphological, biochemical, physiological and behavioural changes that preadapt them for life within the marine environment (Hoar, 1988; Høgåsen, 1998; Thorpe *et al.*, 1998). Atlantic salmon are referred to as 'post-smolts' between their migration to sea until the spring of the following year. After one winter at sea, they are then referred to as 'grilse', and individuals that spend one to three years at sea before returning in spring are known as 'spring salmon'.

4.3.80 Atlantic salmon typically spend between one to five years at sea (Klemetsen *et al.*, 2003), where they grow rapidly. After which, adults migrate to their natal rivers to spawn (NatureScot, 2023a). Various cues are involved during this migration, for example, in the early phases, sun position and the earth's magnetic field seem to play a role in oceanic navigation (Hansen and Quinn, 1998). Tidal phase and time of day have also been suggested as important factors for their upstream migration (Smith and Smith, 1997). Upstream migration through estuaries has been observed to be nocturnal, occurring during ebb tides (Smith and Smith, 1997). In the final phase of the upstream migration, Atlantic salmon rely on olfactory cues to direct them up the river (Hasler and Scholz, 1983). It is thought that the adults migrating upstream use environmental cues from the downstream post-smolt migration (Haraldstad *et al.*, 2022). For smolts migrating downstream, migratory activity has been identified to occur at night, while daytime was utilised more for prey detection and predator avoidance (Hedger *et al.*, 2008). Off the north and east coasts of Scotland, post-smolts travel from the North Sea using water currents towards Northern Norway and then into the Norwegian Sea (Jonsson *et al.*, 1993). Further evidence from Scottish Atlantic salmon from the Dee, Tay and North Esk rivers recaptured in Greenland and Faroe Islands waters showed that smolts emigrated west to feed and grow (Malcolm *et al.*, 2010).

4.3.81 Within the most northly area of the Fish and Shellfish Ecology Study Area, the Moray Firth Tracking Project was initiated in spring 2019. During this project, 340 acoustic receivers were deployed within the inner and outer Moray Firth and 800 salmon post-smolts were tagged with acoustic transmitters. The initial results of this study indicated that post-smolts migrated in an easterly direction out of the east coast of Scotland and that currents may be utilised across the North Sea before heading north towards the Norway coast (Newton *et al.*, 2019). Furthermore, migration of smolts was tracked in a study undertaken for the Beatrice OWF (Newton *et al.*, 2017). The study results indicated an eastward migration of the tagged fish along the southern coast of the Moray Firth in the north-east of Scotland. Results also showed the majority of fish remained predominantly within the upper metre of the water column during migration (Newton *et al.*, 2017). Smolt mortality was mainly attributed to predation and there was a strong relationship observed between group survival, early migration and group size (Newton *et al.*, 2017). Other recent evidence from the north-east of Scotland suggests that smolts migrating from their rivers head directly across the North Sea relatively rapidly (Gardiner *et al.*, 2018b).

4.3.82 It is thought that this offshore route, opposed to migrating along the coasts upon leaving their natal rivers, allows post-smolts to take advantage of east flowing currents which cross the North Sea. Similar evidence of a rapid easterly migration out into the North Sea has also been shown for post-smolts from the River Dee in Aberdeenshire (Gardiner *et al.*, 2018a). The same could be assumed for smolts from other east coast rivers (e.g. Tay, Esk, Don and Deveron).

4.3.83 Within the Fish and Shellfish Ecology Study Area, tagging studies of adult Atlantic salmon returning to their natal rivers to spawn suggest an east to west migration route across the Moray Firth south coastline and along the coast within the Fish and Shellfish Ecology Study Area a dominant northly direction of movement persists (Figure 4.9; Malcolm *et al.*, 2010; Youngson, 2017). These migration routes broadly correspond with those initially presented in ABPmer (2014) and reproduced by the Scottish Government (2020b) (Figure 4.10).

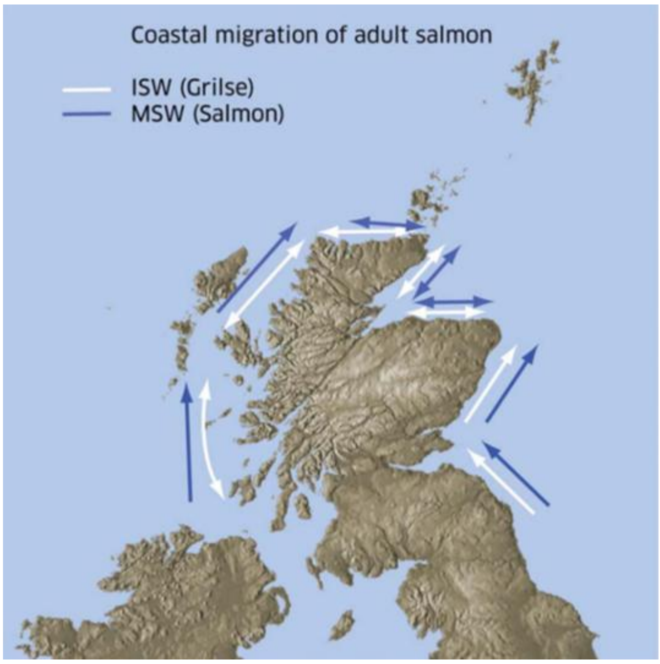


Figure 4.9: Dominant Directions of Travel for Adult Atlantic Salmon (1SW = One Sea Winter (grilse), MSW = Multi Sea Winter) in Scottish Coastal Waters (from Malcolm *et al.* (2010))

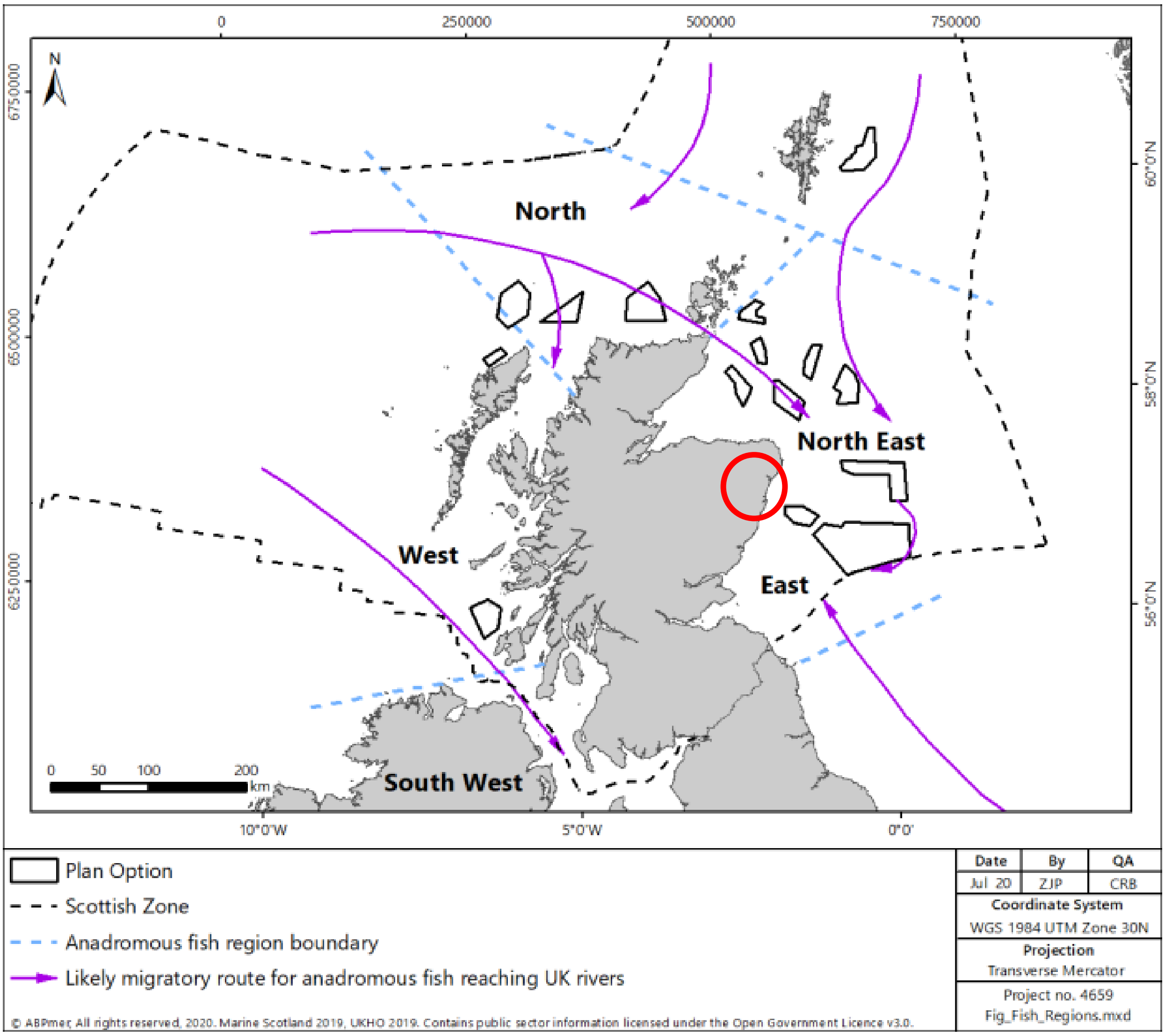


Figure 4.10: Likely Migration Routes of Adult Atlantic Salmon Returning to Scottish Rivers (E3 POA Circled in Red) (ABPmer (2014), Reproduced in Scottish Government (2020b)).

4.3.84 The Scottish Government produce annual reports on fishery statistics of Atlantic salmon, with the most recent data for 2023 available at the time of writing. Overall, the total wild Atlantic salmon catch from rod fishing was 32,477 individuals in 2023, the lowest since records began in 1952 (Scottish Government, 2024). This was a 24% decrease from the 42,404 recorded in 2022, and a 77% decrease of the previous five-year average (Scottish Government, 2024). These results emphasise the decline in Atlantic salmon populations around Scotland. Historically, between 1952 and 2022, total rod catches of Atlantic salmon increased until a peak in 2010 and have sharply declined since then to the current historic low (Scottish Government, 2024). Mortality at sea is believed to be a major cause of the progressive decadal declines of Atlantic salmon that return to Scottish rivers to spawn (Cauwelier *et al.*, 2024).

4.3.85 Rod catch data of Atlantic salmon and sea trout from rivers around Scotland is published annually by the Scottish Government (Marine Scotland, 2024). Data from rivers in the Moray Firth, East, and north-east of Scotland have been considered for the past six years (2018 to 2023, inclusive) and are presented in Table 4.8. For all regions, the 2023 rod catch of 1SW and MSW Atlantic salmon was lower in 2023 than in the five-year average (Table 4.8). These rod catch data provide values for the numbers of Atlantic salmon that are likely to pass through the Fish and Shellfish Ecology Study Area during their migration back to their natal rivers in the Moray Firth and east coast of Scotland.

Table 4.8: Rod Catch Data of 1SW and MSW Atlantic Salmon in Rivers within the Fish and Shellfish Ecology Study Area (Five-Year Average rounded up to whole individuals). Shading Indicates Regions Where the Five-Year Average is Higher than 2023 Counts

Region	Number of Atlantic Salmon Caught per Year							Total from 2018 to 2023
	2018	2019	2020	2021	2022	5 Year Average 2018 to 2022	2023	
1SW Atlantic Salmon								
Moray Firth	3,494	4,444	5,182	4,299	5,026	4,489	3,539	25,984
North-east Scotland	2,063	2,151	2,231	2,077	2,680	2,241	1,362	12,564
East Scotland	2,695	3,272	3,418	2,540	3,283	3,042	2,688	17,896
MSW Atlantic Salmon								
Moray Firth	4,320	6,389	5,512	5,402	5,430	5,411	3,891	30,944
North-east Scotland	3,699	4,104	2,863	3,412	3,278	3,472	2,206	19,562
East Scotland	8,012	8,543	11,585	7,962	9,413	9,103	7,203	52,718

4.3.86 As with sea trout, Atlantic salmon share a complex obligate host-dependant relationship with the freshwater pearl mussel (Taeubert and Geist, 2017; Taskinen and Salonen, 2022).

4.3.87 Atlantic salmon are protected under various conservation designations (Table 4.7) and are a qualifying feature of four SACs within the Fish and Shellfish Ecology Study Area (Section 4.6). A recent review on diadromous fish in the context of Scottish Offshore Wind POAs (including the Proposed Development) concluded that Atlantic salmon are very likely to utilise these areas and are likely to occur in the inshore waters along cable routes (Honkanen *et al.*, 2024).

<u>European Eel</u>

4.3.88 The European eel has a complex and poorly understood life history, involving two stages of metamorphosis. The current range of the species encompasses almost the entire seaboard of Europe, from the Arctic Circle to North Africa, and is regarded as a single stock population (Malcolm *et al.*, 2010). They migrate to the Sargasso Sea (a gyre in the North Atlantic, just east of Bermuda) to spawn, after which, larval eels (leptocephali) cross the Atlantic Ocean towards the continental shelf (Van Ginneken and Maes, 2005). During this stage they metamorphose into a transparent post-larval 'glass eel'. Some individuals will remain at sea, while others (elvers) ascend rivers and move between marine, estuarine and freshwater environments. They develop pigmentation and are referred to as 'yellow eels' during this phase of their life cycle (NatureScot, 2023b). Estimates of the duration of the yellow eel stage are varied in the literature, from three to tens of years before they enter a final metamorphosis into 'silver eels' and return to the Sargasso Sea to spawn (Malcolm *et al.*, 2010; NatureScot, 2023b; Tesch, 1977).

4.3.89 The migratory routes undertaken by European eels are largely unknown. They have been recorded throughout the water column (up to -1,000 m deep; Antunes and Tesch (1997a); Antunes and Tesch (1997b)) and their position in the water column can vary with the time of day and state of tide throughout their life cycle (Cresci, 2020; Cresci *et al.*, 2019; Cresci *et al.*, 2017). For example, larvae have been recorded to exhibit diel vertical migration and were found between -100 m and -150 m during the day and -50 m and -100 m during the night (Castonguay and McCleave, 1987). Upon reaching the European continental slope, larvae are found between -300 m and -600 m during the day and -35 m and -100 m during the night (Tesch, 1980). Diel vertical migration has also been observed in the silver eel life stage, with a mean swimming depth of -344 m during the day and 196 m during the night (Tesch, 1989).

4.3.90 European eels were once widely distributed throughout their range, however, recruitment has declined since the early 1980s and the species has now been classified as critically endangered by the IUCN Red List and is protected under various conservation legislations (see Table 4.7).

<u>European smelt</u>

4.3.91 The European smelt, also known as sparling in Scotland and Northern England, occur within the western coasts of Europe and extend as far as north-west Spain (Maitland and Lyle, 1997). Some populations permanently reside in freshwater, however within the UK this was only observed in a single population in Cheshire, which became extinct in the 1920s (Ellison and Chubb, 1968). The species normally lives within coastal and estuarine habitats, congregating at the mouth of rivers in winter before migrating upstream into rivers to spawn between February and April (Maitland and Lyle, 1997; Barnes, 2008c). Spawning requires gravel, cobble, boulder or vegetation near the tidal limit of the river. Juvenile smelt then migrate downstream to estuaries to mature (NatureScot, 2023e).

4.3.92 The European smelt was once more widespread within Scotland, occupying 15 Scottish rivers, but following declines it is now only recorded in the Cree, Forth and Tay rivers. The reason for decline is attributed to pollution, which hinders successful spawning, migration and reproduction and also to permanent barriers and high weirs, which deny access to spawning grounds. Overfishing is also a reason for decline for some local stocks; this is due to the ease with which they can be caught in large quantities (Maitland and Lyle, 1997; NatureScot, 2023e). Rivers within the Fish and Shellfish Ecology Study Area which have or used to have populations of European smelt are recorded within Table 4.9 from Maitland and Lyle (1997).

Table 4.9 Rivers within the Fish and Shellfish Ecology Study Area Known to Have or Have Had Populations of Smelt (taken from Maitland and Lyle, 1997)

River	Reference	Present status (1997)	Reason if extinct
Almond	Sinclair (1779); Wood (1791)	Extinct	Pollution
Esk	Service (1902)	Extinct	Overfishing
Forth	Parnell (1838)	Extant	-
Tay	Parnell (1838)	Extant	-

4.3.93 Populations within the Forth and Tay rivers have both been the basis of fisheries, with the population in the Forth declining to the point of no catches made between the mid-1950s and 1989. They have since recovered and are now considered common within the estuary (Maitland and Lyle, 1997).

4.3.94 European smelt during the marine phase of their life cycle are listed as PMFs. It is unlikely that the smelt will occupy the waters within and in the vicinity of the Site Boundary due to their preference of inhabiting estuarine waters upon entering the marine environment. It is therefore concluded that this species will not be considered further within the assessment for fish and shellfish ecology.

<u>River Lamprey</u>

4.3.95 The river lamprey are anguilliform (or eel-like) jawless fish, which are distributed throughout Northern and Western Europe in coastal waters, estuaries, and accessible rivers. While some populations permanently reside in freshwater, the species is normally anadromous, and pollution or obstacles can hinder their migration (JNCC, 2024b). In either autumn or spring, river lamprey migrates upstream from nearshore feeding grounds (marine or brackish water) into freshwater to spawn. Spawning occurs in April and May on pre-excavated pits in clean pebble and gravel riverbeds (NatureScot, 2023d). River lampreys migrate to nearshore coastal or estuarine waters after four to five years in freshwater, however, some populations are freshwater resident and do not undertake this migration to the marine environment (Kelly and King, 2001). As adults, anadromous river lamprey are parasitic, and attach themselves to larger fish to consume their flesh (Quintella *et al.*, 2021). Recorded host species of river lamprey include other diadromous fish (such as salmonids and shads), and marine fish, such as cod, herring, mackerel, saithe, and sprat (Quintella *et al.*, 2021).

4.3.96 River lamprey are widespread in UK rivers up to Scotland with a northern limit at the Great Glen. A recent review on diadromous fish in the context of Scottish Offshore Wind POAs (including the Proposed Development) concluded that river lamprey are most likely to overlap with export cable corridors in nearshore and estuarine waters, and noted that there are limited data on the offshore presence of this species (Honkanen *et al.*, 2024).

4.3.97 The populations of river lamprey in the UK are considered of conservation importance at European level (Hume, 2017). River lamprey are protected under various conservation designations (see Table 4.7) and are a qualifying feature of two SACs within the Fish and Shellfish Ecology Study Area (see Section 4.6).

Sea Lamprey

4.3.98 Like river lamprey, sea lamprey are anguilliform jawless fish. During their freshwater life stage, they are found primarily in estuaries and easily accessible rivers. Sea lamprey share a similar life cycle with river lamprey; however, the sea lamprey is larger, and is the largest lamprey species present in the UK (Maitland, 2003).

4.3.99 Sea lamprey are anadromous and spend most of their adult life at sea (JNCC, 2024a). However, there is limited information on the distribution and behaviour of sea lamprey in marine waters (Hume, 2017). During their marine stage, they are parasitic on a number of larger fish species and other marine fauna, with over 50 species recorded as hosts for their parasitism (Quintella *et al.*, 2021; Silva *et al.*, 2014). These hosts range from elasmobranchs, other diadromous fish (such as salmonids and shads), other marine teleost fish (such as cod, haddock, herring, European hake, and saithe), and various marine mammals (Quintella *et al.*, 2021; Silva *et al.*, 2014). Unlike river lamprey, sea lamprey feed on the blood of their hosts, using their specialised mouthparts (Quintella *et al.*, 2021). Like river lamprey, sea lamprey require clean gravel for spawning, preferably in warm waters, and marginal silt or sand for the burrowing of juveniles (ammocoetes). Spawning of sea lamprey coincides with the warmer spring temperatures in Scottish rivers (see Section 4.6; JNCC, (2024a), NatureScot, (2023d)).

4.3.100 Sea lamprey's natural range has declined in the UK due to river pollution and barriers to migration (such as dams and weirs). However, like river lamprey, they remain widespread in UK rivers up to Scotland with a northern limit at the Great Glen (JNCC, 2024a). A recent review on diadromous fish in the context of Scottish Offshore Wind POAs (including the Proposed Development) concluded that sea lamprey are most likely to overlap with export cable corridors in nearshore and estuarine waters, and noted that there are limited data on the offshore distribution of this species (Honkanen *et al.*, 2024).

4.3.101 Sea lamprey are protected under various conservation designations (see Table 4.7) and are a qualifying feature of the River Teith SAC within the Fish and Shellfish Ecology Study Area (see Section 4.6).

Sea Trout

4.3.102 Sea trout occur in rivers, streams and lakes, often preferring cold and well oxygenated waters. They have a similar ecology to Atlantic salmon but are smaller in size. Sea trout spawn in rivers and streams that have swift currents, which are usually characterised by the downward movement of water into gravel, favouring large streams and mountainous areas that have adequate cover. Sea trout spawning season occurs from October to January, with the eggs deposited in redds (small deviations in the riverbed, cut by the female in the river gravel).

4.3.103 While there is limited information regarding sea trout migration patterns in the marine environment, available evidence suggests that this species primarily uses inshore and coastal waters, rather than undertaking extensive offshore migrations like Atlantic salmon (Malcolm *et al.*, 2010; River Dee Trust and MSS, 2023). This is echoed by the results of a recent review on diadromous fish in the context of Scottish Offshore Wind POAs (including the Proposed Development), which highlighted that most research is focussed on nearshore habitat use (Honkanen *et al.*, 2024). However, Honkanen *et al.* (2024) concluded that sea trout are still likely to overlap with most, if not all, of the Scottish POAs. Additionally, overlap was deemed very likely with inshore and estuarine areas along export cable routes, given that this species can spend more time in coastal areas (Honkanen *et al.*, 2024).

4.3.104 The Scottish Government produce annual reports on fishery statistics of sea trout, with the most recent data for 2023 available at the time of writing. Overall, the total wild sea trout catch from rod fishing was 14,823 individuals in 2023, the fifth lowest since records began in 1952 (Scottish Government, 2024). This was a 1% increase from the 14,509 caught in 2022, and 103% of the previous five year average (Scottish Government, 2024). Historically, since 1952, catches of sea trout show a generally decreasing trend (Scottish Government, 2024).

4.3.105 Rod catch data of Atlantic salmon and sea trout from rivers around Scotland is published annually by the Scottish Government (Marine Scotland, 2024). Data from rivers in the Moray Firth, east, and north-east of Scotland have been considered for the past six years (2018 to 2023, inclusive) and are presented in Table 4.10. These data are separated into 'sea trout' and 'finnock', the latter of which refers to sea trout which have spent less than a year at sea before making their first return to fresh water.

4.3.106 There are regions where the catch for 2023 was lower than the five year average (Table 4.10), however this difference was not as pronounced as it was for Atlantic salmon (Table 4.8). These rod catch data provide values on the numbers of sea trout that are likely to pass through the Fish and Shellfish Ecology Study Area during their migration back to their natal rivers in the Moray Firth and east and north-east coasts of Scotland.

Table 4.10: Rod Catch Data of Sea Trout and Finnock in Rivers within the Fish and Shellfish Ecology Study Area. Shading Indicates Regions Where the Five-Year Average is Higher than 2023 Counts.

Region	Number of Sea Trout Caught per Year							Total from 2018 to 2023
	2018	2019	2020	2021	2022	5 Year Average 2018 to 2022	2023	
Sea Trout								
Moray Firth	2,709	2,948	1,393	1,578	1,556	2,037	1,771	11,955
North-east Scotland	2,023	2,211	2,375	2,379	2,869	2,371	2,489	14,346
East Scotland	1,752	3,664	3,362	2,650	2,854	2,857	3,660	17,942
Finnock								
Moray Firth	595	594	323	362	890	553	666	3,430
North-east Scotland	767	1,437	1,873	1,709	1,866	1,530	846	8,498
East Scotland	131	462	164	97	257	223	338	1,449

4.3.107 As with Atlantic salmon, sea trout share a complex obligate host-dependant relationship with the freshwater pearl mussel (Taeubert and Geist, 2017, Taskinen and Salonen, 2022).

4.3.108 Sea trout are protected under various conservation designations (Table 4.7), such as the Salmon Act, SBL, and as a Scottish PMF.

Shads

4.3.109 Allis and twaite shad are both members of the herring family (Clupeidae) and are the only clupeids found in freshwater in the UK (Maitland and Hatton-Ellis, 2003). They are very similar in appearance and are hard to distinguish, with the only reliable way of differentiating the two species, apart from allis shad being usually bigger, is the number of gill-rakers (JNCC, 2024c; JNCC, 2024d). They mainly live in coastal and pelagic habitats, although their behaviour at sea is poorly understood (Maitland and Hatton-Ellis, 2003). There is limited available research surrounding freshwater life cycle phases of allis and twaite shad, which has subsequently resulted in scarce understanding of their spatial ecology during both the marine and freshwater life-phases (Davies *et al.*, 2020).

4.3.110 This was highlighted in a recent review on diadromous fish in the context of Scottish Offshore Wind POAs (including the Proposed Development), which concluded that allis and twaite shad are likely to have the potential to overlap with POAs (including the Proposed Development) (Honkanen *et al.*, 2024). Due to limited studies, particularly in Scotland, it was not possible to estimate this likelihood of offshore overlap with any confidence, however Honkanen *et al.* (2024) concluded that overlap with export cable corridors in the nearshore and estuarine environment are more likely.

4.3.111 Mature shad that have spent most of their lives at sea stop feeding before migrating into estuaries. The males will usually migrate upstream first, followed by females one or two weeks later. They spawn in freshwater pools, with almost all adult allis shad dying afterwards (Maitland and Hatton-Ellis, 2003), however twaite shad may spawn several times in their lives (Forth Rivers Trust, 2024). Both shad species lay eggs in shallow water with coarse gravelly substrate, which hatch four to eight days later (JNCC, 2024c; JNCC, 2024d). The fry are around 10 mm in size when hatched, but grow rapidly and the majority will have travelled downstream into the sea by the end of their first year (Maitland and Hatton-Ellis, 2003).

4.3.112 Allis and twaite shad are protected under various conservation designations (Table 4.7), such as the Habitats Directive, the Bern Convention, Wildlife and Countryside Act 1981, the Salmon Act, and the SBL. Furthermore, allis shad is listed on the OSPAR List of Threatened and/or Declining Species in OSPAR Region II: Greater North Sea, although the twaite shad is not.

Freshwater Pearl Mussel

4.3.113 The freshwater pearl mussel is included within the diadromous fish baseline characterisation as per standard EIA approach due to its reliance on salmonids during its parasitic life stage.

4.3.114 Freshwater pearl mussels are similar in shape to species of marine mussel but grow much larger and have a longer potential lifespan. They can grow to up to 20 cm and live for over 100 years, making them one of the longest-lived invertebrates in the world (Skinner *et al.*, 2003). Freshwater pearl mussels live on the beds of clean, fast flowing rivers, where they can be buried partly or wholly in coarse sand or fine gravel. They are filter feeders, and may very occasionally bear a pearl (NatureScot, 2023c). They have a complex life cycle, living on the gills of young salmonids (such as Atlantic salmon or sea trout), for their first year (Skinner *et al.*, 2003; Taeubert and Geist, 2017).

4.3.115 The species is of significant conservation importance, with population declines dating back to the 18th century. Given its long lifespan, many rivers contain only old individuals with no new recruitment recorded (NatureScot, 2023c; Skinner *et al.*, 2003). The species is of particular importance in Scotland, which is home to almost half of the global population (NatureScot, 2023c). Within the Fish and Shellfish Ecology Study Area there are four rivers which have the freshwater pearl mussel as a qualifying feature (Table 4.15). Of these four rivers the River Esk and Spey is known to support an abundant population, particularly within the middle to lower reaches of the rivers, achieving densities of > 20 m^2 within the River Esk and colonies of 225 m^2 within the River Spey (JNCC, 2025b). Both rivers also hold a large number of juveniles, demonstrating that these populations have successful recruitment and are of great significance (JNCC, 2025b). As such, freshwater pearl mussel are listed on the SBL and are fully protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended). They are also protected under the Habitats Directive and the Bern Convention and listed as critically endangered on the IUCN Red List (Table 4.7).

Shellfish

4.3.116 The shellfish species considered within this report include larger crustaceans and molluscs, primarily those of commercial importance. Smaller crustaceans and molluscs, including sedentary habitat forming species (i.e. horse mussels), are considered within Volume 3, Technical Appendix 8.1: Benthic Ecology Technical Report.

4.3.117 Within the site-specific surveys for the Proposed Development, there were three types of shellfish recorded: scallops (Family: Pectinidae, species indeterminate), shrimp (Infraorder: Caridea, species indeterminate) and edible crab (also referred to as brown crab) (Section 4.2). Within the site-specific surveys for other OWF projects within the Fish and Shellfish Ecology Study Area, king and queen scallops were recorded (Table 4.2). Shrimp such as Pandalidae spp. found within site-specific grab samples are not a key target of commercial fisheries within the area and therefore not considered further.

4.3.118 Information on shellfish distributions around the UK are largely derived from commercial fishing and landings data (Mesquita *et al.*, 2023). Only a limited number of shellfish species have regular stock assessments, therefore, commercial landings data around the Site Boundary provides an overview of species likely to be present. Landings are reported and published annually by the Government and have been used to support this baseline characterisation. At the time of writing, the most recent landings statistics available were from 2022 (MMO, 2023); therefore landings data from 2018 to 2022 (inclusive) have been analysed for the ICES rectangles overlapping with the Site Boundary. The Array Area sits wholly within ICES rectangle 42E8 and 43E8 and the Export Cable Corridor is largely situated within 42E8 and 42E7 (Figure 4.11).

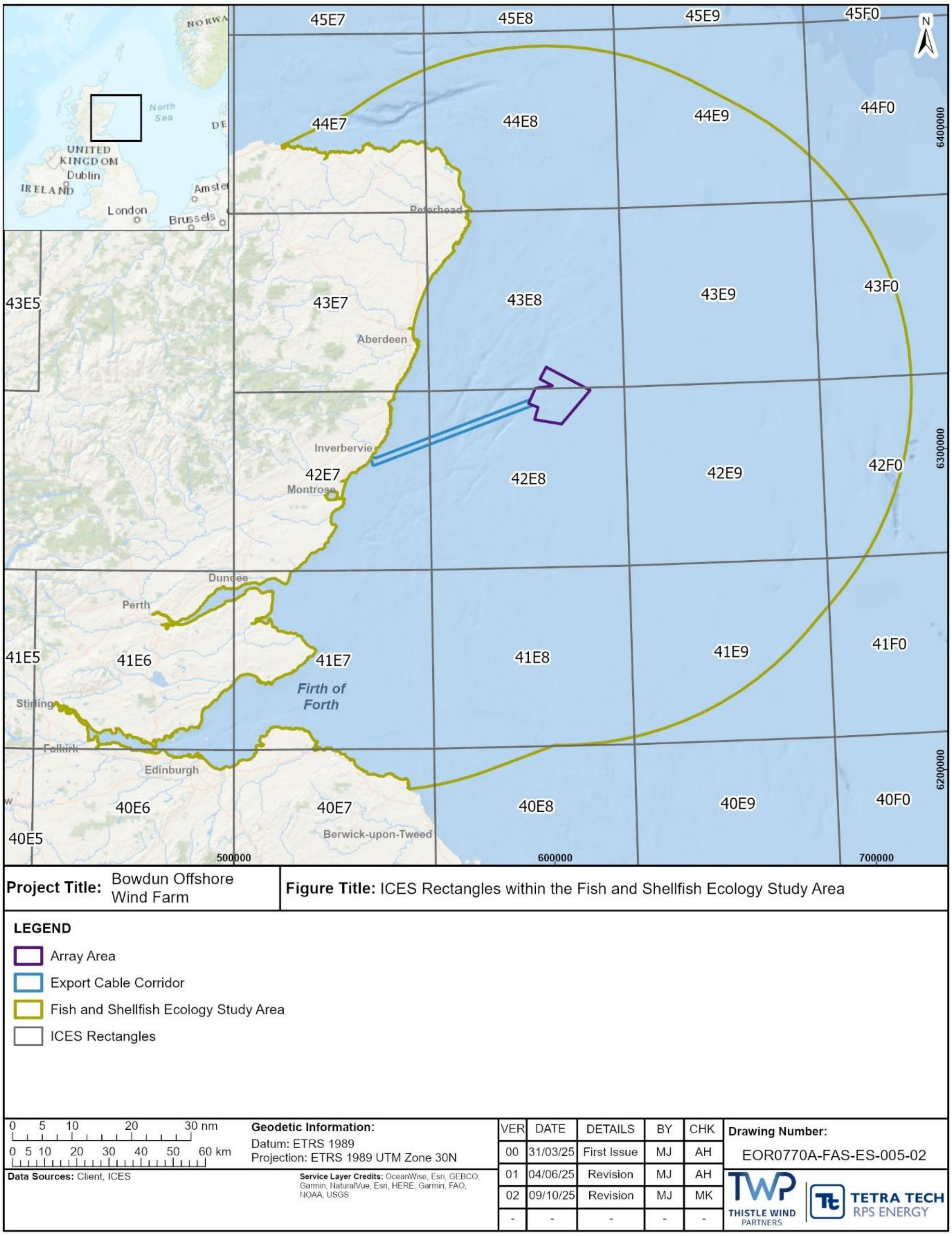


Figure 4.11: ICES Rectangles within the Fish and Shellfish Ecology Study Area

4.3.119 Within these ICES rectangles, between 2018 and 2022, the top three shellfish species in terms of landed weight were king scallop, edible crab and European lobster *Homarus gammarus* (MMO, 2023). There were 3,305 tonnes of king scallop, 2,634 tonnes of edible crab, and 849 tonnes of European lobster (MMO, 2023). Other species landed from these ICES rectangles include:

- velvet swimming crab *Necora puber* (592 tonnes);
- Norway lobster *Nephrops norvegicus* (525 tonnes);
- squid (Families: Loliginidae and Ommastrephidae) (69 tonnes);
- common whelk *Buccinum undatum* (15 tonnes);
- mixed squid and octopi (Families: Loliginidae, Ommastrephidae) (14 tonnes);
- surf clams *Spisula* spp. (11 tonnes); and
- common shore crab *Carcinus maenas* (also referred to as green crab; three tonnes) (MMO, 2023).

4.3.120 The shellfish industry is important to the Scottish economy, with Norway lobster being the most valuable species (Marine Scotland, 2023). For example, in 2022, Scottish vessels landed 19,302 tonnes of Norway lobster, at a value of £83,000,000 throughout the UK (Marine Scotland, 2023). Further detail on landings statistics and values of fish and shellfish in the Fish and Shellfish Ecology Study Area is presented in Volume 3, Technical Appendix 13.1: Commercial Fisheries Technical Report.

Conservation Importance

4.3.121 There are no shellfish species present within the Fish and Shellfish Ecology Study Area listed under conservation legislation or biodiversity lists. Further, none of the shellfish species are listed on the IUCN Red List as higher than 'least concern'. There are also no designated sites protected for shellfish within the Fish and Shellfish Ecology Study Area.

Species Accounts

4.3.122 Species accounts for the shellfish species considered as part of the baseline are provided in the following sections.

King Scallop

4.3.123 King scallops are found around the UK out to depths of -100 m to -110 m on sandy and gravelly substrates (Marshall and Wilson, 2008). The distribution of king scallop is invariably patchy but a higher abundance is seen within habitats with little mud and a good current strength (Marshall and Wilson, 2008). The king scallop's upper shell is predominantly flat and are typically larger overall compared to a queen scallop (Carter, 2009; Marshall and Wilson, 2008).

4.3.124 In Scottish waters, spawning occurs for the first time in the autumn of their second year, and subsequently spawn each year in the spring or autumn (Marine Scotland, 2012). They grow to lengths exceeding 175 mm and can live for

20 years or more. Environmental factors affect growth rates, such as water temperature and food availability (Marine Scotland, 2012).

4.3.125 There were numerous records of king scallop within the Fish and Shellfish Ecology Study Area on the NBN Atlas (NBN Atlas, 2025).

Lobsters: European Lobster and Norway Lobster

4.3.126 The European lobster can be found from Scandinavia to north Africa and throughout UK coasts on rocky substrata, down to depths of -60 m (Wilson, 2008b). European lobster is capable of growing up to 1 m in total length, with 90% of females maturing at a carapace length of 10.2 cm (Hold *et al.*, 2022). They typically live in holes and tunnels within rocky substrates (Wilson, 2008b).

4.3.127 Mating occurs after females moult in the summer, and most females are expected to have a two-year reproductive cycle. Larvae settle on the seabed after spending three to four weeks in the water column (Cefas, 2024b). With such a lengthy planktonic phase, the probability of individual larvae surviving is low and consequently recruitment levels are expected to be variable (Cefas, 2024b). Both sexes are considered fairly sedentary (Øresland and Ulmestrand, 2013), although inshore/offshore and longshore migration is known to take place at some locations (Smith *et al.*, 2001).

4.3.128 The Norway lobster is a slim, orange-pink coloured lobster which grows up to 25 cm long and is considered to be the most commercially important crustacean in Scotland and elsewhere in Europe (Seafood Scotland, 2021). It is widely distributed within the Atlantic, from Icelandic waters to the Mediterranean and the Moroccan coast, and commercially exploited throughout its range (Hill and Sabatini, 2008). They are found within the sublittoral soft sediment, commonly at depths of between -20 m to -800 m, although there are many records of Norway lobster populations at <20 m in lochs (Hill and Sabatini, 2008). They display a strong preference for sediments with more than 40% silt and clay (Bell *et al.*, 2013), as they live in shallow burrows and require fine cohesive mud which is stable enough to support them (Hill and Sabatini, 2008).

4.3.129 They build and spend significant amounts of time in their burrows, and therefore display strong habitat preferences, with higher abundances found on more favourable substrates. They spawn in September, and females carry their eggs under their tails (described as being 'berried') until they hatch in April or May. The larvae develop amongst other plankton before settling to the seabed six to eight weeks later (Coull *et al.*, 1998). Norway lobster are the only shellfish species with spawning and nursery grounds described in Coull *et al.* (1998), although the species is not included within Ellis *et al.* (2012). Spawning and nursery grounds were identified within the Fish and Shellfish Ecology Study Area by Coull *et al.* (1998), which overlap with the Site Boundary (Section 4.4).

4.3.130 There were numerous records of both lobster species within the Fish and Shellfish Ecology Study Area on the NBN Atlas (NBN Atlas, 2025).

Crabs: Common Shore Crab, Edible Crab, Velvet Swimming Crab

4.3.131 The common shore crab (also known as green crab) is found around the UK on all types of shore, from high water to depths of 60 m in the sublittoral, but it is predominantly a shore and shallow water species (Neal and Pizzolla, 2008). Adults are very mobile and have been reported travelling up to 15 km along a coast in six months (Thresher *et al.*, 2003).

4.3.132 The edible crab (also known as brown crab) is distributed around all UK coasts in the lower shore, shallow sublittoral zone, and in offshore waters to depths of around -100 m. They are typically found on bedrock, mixed coarse grounds, offshore muddy sands, and under boulders (Neal and Wilson, 2008). Stock boundaries are not well defined for this species and edible crab undertake wide-ranging migrations out to offshore overwintering grounds and for breeding (Cefas, 2024a; Hunter *et al.*, 2013). For example, Coleman and Rodrigues (2017) tagged adult edible crabs around the Orkney Islands between 2010 and 2016, and recorded the location of the recapture. They observed that females undertook both short inshore migrations, as well as longer offshore migrations, out to 258 km from the original release site (Coleman and Rodrigues, 2017). Males followed a similar pattern, but were not recorded as far from their original release sites, with the maximum distance travelled recorded as 67 km (Coleman and Rodrigues, 2017). These migrations were predominantly in a westward direction from Orkney (Coleman and Rodrigues, 2017).

4.3.133 The velvet swimming crab is a fast moving crab, found around all UK coasts on stony/rocky substrate intertidally and down to depths of -100 m (Howson and Picton, 1997, Wilson, 2008c).

4.3.134 There were numerous records of all three crab species within the Fish and Shellfish Ecology Study Area on the NBN Atlas (NBN Atlas, 2025).

Common Whelk

4.3.135 The common whelk is a marine gastropod mollusc found throughout the North Atlantic Ocean. This species typically inhabits subtidal areas, and have been recorded on all types of seabed substratum including gravel, sand, mud and rock (Haig *et al.*, 2015). They are found down to depths of -1,200 m (Ager, 2008). There were many records of common whelk within the Fish and Shellfish Ecology Study Area on the NBN Atlas (NBN Atlas, 2025).

4.3.136 The common whelk is commercially exploited in the UK, with the majority of the catch exported to East Asia (Eastern Inshore Fisheries and Conservation Authority (IFCA), (2020)). As they are slow growing and slow to reach sexual maturity, common whelk are vulnerable to overexploitation (Eastern IFCA, 2020). In addition, recent studies have shown that growth rates vary by location, which suggests that this species is being caught and landed before it reaches sexual maturity in some areas (Haig *et al.*, 2015; McIntyre *et al.*, 2015). The Eastern IFCA have therefore set a minimum landing size of 55 mm, which is based on the principle that 50% of the population should have reached maturity at this size, although IFCAs in other regions have increased this to 75 mm (Eastern IFCA, 2020).

Squid and Octopi

4.3.137 Loliginid squid, such as the long finned squid *Loligo forbesii*, are reported to be found over sandy and muddy seabeds at a range of depths between -10 m to -400 m (Wilson, 2006a). In Scottish waters, they prey on small fish, other cephalopods, crustaceans, and polychaetes. They have an extended breeding season, from January to May, with a peak in February and March and die shortly after spawning at approximately one to two years old (Guerra and Rocha, 1994; Lum-Kong *et al.*, 1992; Pierce *et al.*, 1994). Ommastrephid (short-fin) squid, such as the lesser flying squid *Todaropsis eblanae*, are also found in muddy and sandy seabeds, at a range of depths between -20 m to -700 m (Roper *et al.,* 2010). Lesser flying squid in the North Sea reproduce mainly in the summer (Barret *et al.,* 2021; Hastie *et al.,* 1994).

4.3.138 Many squids are semelparous, meaning that they will only spawn once and die shortly after (Hendrickson and Hart, 2006). In Scottish waters, squid exhibit distinct seasonal migration patterns, travelling up to 500 km from the west coast of Scotland to the east coast in the winter months (Hastie *et al.*, 2009). In the Moray Firth in particular, fishers have observed the long finned squid laying eggs in shallow areas very close to the shore in December to January, which hatch in late May to early June, with abundant catches of smaller squids (around 4 cm in length) close to the shore, at depths of less than -10 m (Franco *et al.*, 2023). As they grow in size, juveniles gradually move farther from the shore (Franco *et al.*, 2023). Spawning has been recorded for lesser flying squid and another ommastrephid squid; shortfin squid *Illex coindetii* within the North Sea, and specifically off the coast of east Scotland and within the Fish and Shellfish Ecology Study Area, according to a study by Barrett *et al.* (2021).

4.3.139 Loliginid squid species also show diel vertical migration, tending to be demersal during the day, and dispersed within the water column at night (Roper *et al.*, 1984). However, ommastrephid (shortfin) squid species are pelagic and are therefore often under-represented in trawl survey data and fisheries statistics (Roper *et al.*, 1984). Research on squid indicates that they are likely to be batch spawners, however, this can vary depending on species, with some species utilising hard substrate for spawning purposes (Guerra and Rocha, 1994).

4.3.140 Two octopus species are found in Scottish waters: curled octopus *Eledone cirrhosa* and the common octopus *Octopus vulgaris* (Wilson, 2006b; Wilson, 2008a). There are records of the curled octopus within the Fish and Shellfish Ecology Study Area, but far fewer of the common octopus (Wilson, 2006b; Wilson, 2008a). The curled octopus is a small benthic species, typically occurring in shallow coastal waters down to -500 m across a variety of substrata (Wilson, 2008a). The species can live for one to two years, depending on individual growth and maturation rates (Boyle *et al.*, 1988). Females die after spawning, which occurs between July and September (Hastie *et al.*, 2016). The common octopus is larger in size and inhabits rocky coastal areas, but is less likely to be present within the Fish and Shellfish Ecology Study Area (Wilson, 2006b).

4.4 Spawning and Nursery Grounds

4.4.1 Spawning and nursery grounds for many different species are present within the Fish and Shellfish Ecology Study Area. Coull *et al.* (1998) reported the distribution of spawning and nursery grounds in British waters for a range of species. These were updated by Ellis *et al.* (2012) for some species, with added information on the intensity of the mapped spawning and nursery grounds. Species with spawning and/or nursery grounds within the Fish and Shellfish Ecology Study Area are illustrated in Figure 4.12 to Figure 4.22. Species with spawning and/or nursery grounds present within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary are presented in Table 4.11. The spawning and peak spawning periods of these species are presented in Table 4.12.

4.4.2 In particular, the Site Boundary overlaps with undetermined intensity spawning grounds of herring and high intensity spawning grounds of sandeel (Figure 4.14 and Figure 4.19, respectively). While most fish and shellfish species release pelagic eggs that drift within the water column, herring and sandeel are demersal spawners and require specific sediment compositions to spawn successfully. These species are therefore considered substrate-specific and at higher risk from habitat disturbance. Herring require sediment comprised of less than 5% mud and greater than 10% gravel (Reach *et al.*, 2013). Sandeel habitation and spawning requires sediment comprised of less than 10% mud and greater than 70% sand (Latto *et al.*, 2013). As stated in Section 3.3, PSA data collected during the site-specific benthic subtidal ecology survey has been used to assess spawning habitat suitability for herring and sandeel. This is presented in Section 4.5.

Table 4.11: Species with Spawning and Nursery Grounds within the Fish and Shellfish Ecology Study Area (Adapted from Coull *et al.* (1998) and Ellis *et al.* (2012), N/A = Not Applicable)

Species	Spawning Grounds	Spawning Intensity†	Nursey Grounds	Nursery Intensity†
Teleost Fish				
Anglerfish	x	N/A	✓*	Low
Blue whiting	x	N/A	✓*	Low
Cod	✓*	Low	✓*	High
European hake	x	N/A	✓*	Low
Haddock	x	N/A	✓*	Not specified
Herring	✓*	Undetermined	✓*	High
Horse mackerel	x	N/A	✓*	Undetermined
Lemon sole	✓*	Undetermined	✓*	Not specified
Ling	x	N/A	✓*	Low
Mackerel	x	N/A	✓*	Low
Norway pout	✓*	Low	✓*	Not specified
Plaice	✓*	Low	✓*	Low

Species	Spawning Grounds	Spawning Intensity†	Nursey Grounds	Nursery Intensity†
Saithe	x	N/A	✓*	Not specified
Sandeel	✓*	High	✓*	Low
Sprat	✓*	Undetermined	✓*	Not specified
Whiting	✓*	Low	✓*	High
		Elasmobranchs		
Common skate complex	x	N/A	✓*	Low
Spotted ray	x	N/A	✓*	Low
Spurdog	x	N/A	✓*	Low
Tope shark	x	N/A	✓*	Low
Thornback Ray	x	N/A	✓	Low
		Shellfish		
Nephrops	✓*	Undetermined	✓*	Not specified

*Asterisk signifies that grounds overlap with the Site Boundary; no asterisk signifies that grounds are present within the Fish and Shellfish Ecology Study Area but do not overlap with the Site Boundary.
†Colours refer to the intensity of the grounds that overlap with the Site Boundary (if any), otherwise they refer to the intensity of the grounds within the Fish and Shellfish Ecology Study Area if there is no overlap with the Site Boundary.

Table 4.12: Spawning Periods for Species with Spawning and Nursery Grounds within the Fish and Shellfish Ecology Study Area (Adapted from Coull *et al.* (1998) and Ellis *et al.* (2012))

Species	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
	Teleost Fish											
Anglerfish												
Blue whiting				P	P							
Cod		P	P									
European hake		P	P									
Haddock		P	P	P								
Herring (Buchan/Shetland Stock)												
Horse mackerel					P	P						
Lemon sole												
Ling												
Norway pout		P	P									
Plaice	P	P										
Saithe	P	P										

Species	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
	Teleost Fish											
Sandeel												
Sprat					P	P						
Whiting												
Elasmobranchs												
Common skate complex	?	?	?	?	?	?	?	?	?	?	?	?
Spotted ray				?	P	P	P	?				
Spurdog												
Thornback ray			P	P	P	P	P					
Tope shark												
Shellfish												
Nephrops				P	P	P						
Key:	Spawning period				Peak spawning		P		Unknown		?	

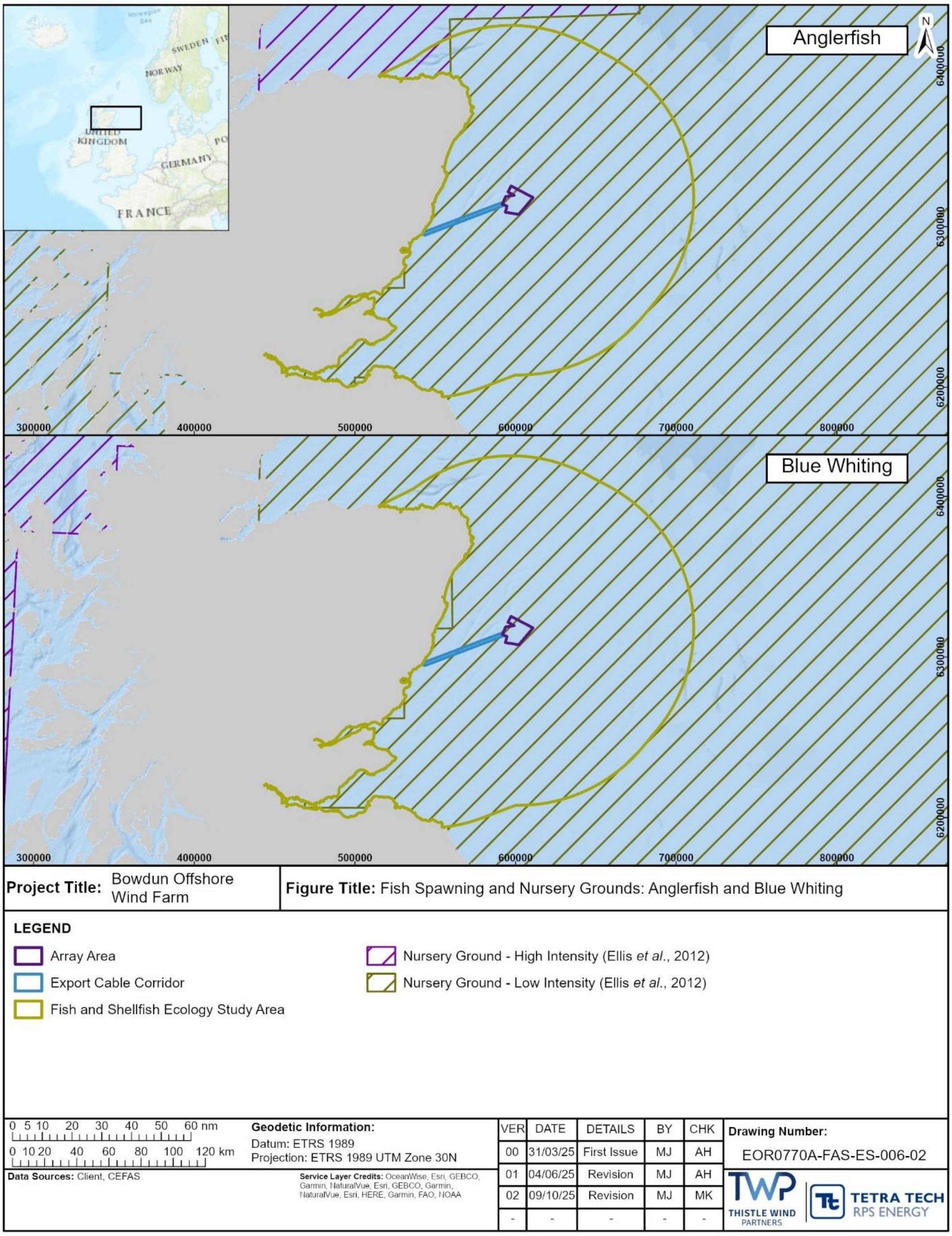
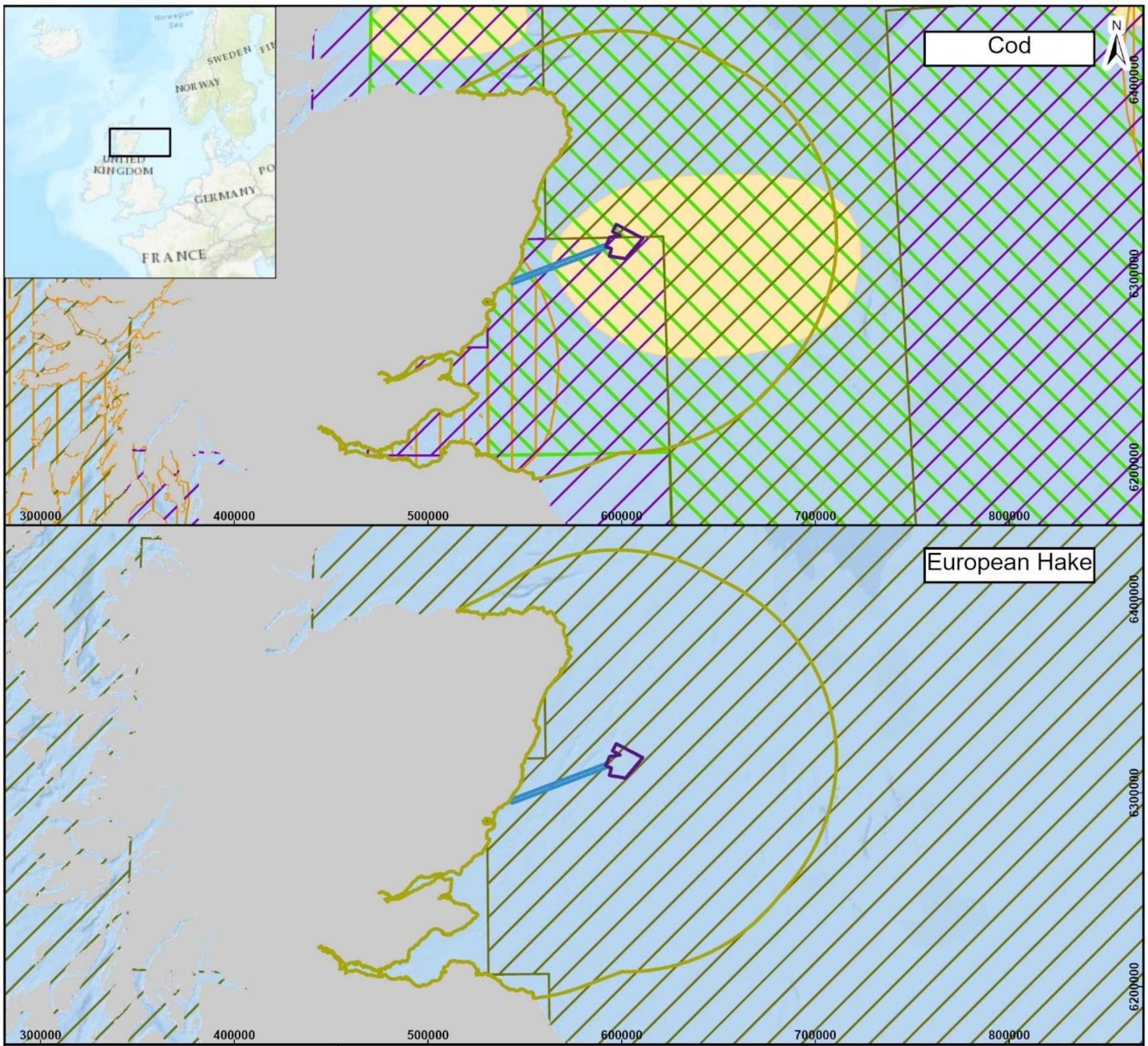


Figure 4.12: Fish Spawning and Nursery Grounds: Anglerfish and Blue Whiting



Project Title: Bowdun Offshore Wind Farm

Figure Title: Fish Spawning and Nursery Grounds: Cod and European Hake

LEGEND

- Array Area
- Export Cable Corridor
- Fish and Shellfish Ecology Study Area
- Nursery Ground - High Intensity (Ellis *et al.*, 2012)
- Nursery Ground - Low Intensity (Ellis *et al.*, 2012)
- Nursery Ground - Intensity Not Specified (Coull *et al.*, 1998)
- Spawning Ground - Low Intensity (Ellis *et al.*, 2012)
- Spawning Ground - Undetermined Intensity (Coull *et al.*, 1998)

0 5 10 20 30 40 50 60 nm
0 10 20 40 60 80 100 120 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

Data Sources: Client, CEFAS

Service Layer Credits: OceanWise, Esri, GEBCO, Garmin, NaturalVue, Esri, GEBCO, Garmin, NaturalVue, Esri, HERE, FAO, NOAA

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00	31/03/25	First Issue	MJ	AH
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02	09/10/25	Revision	MJ	MK
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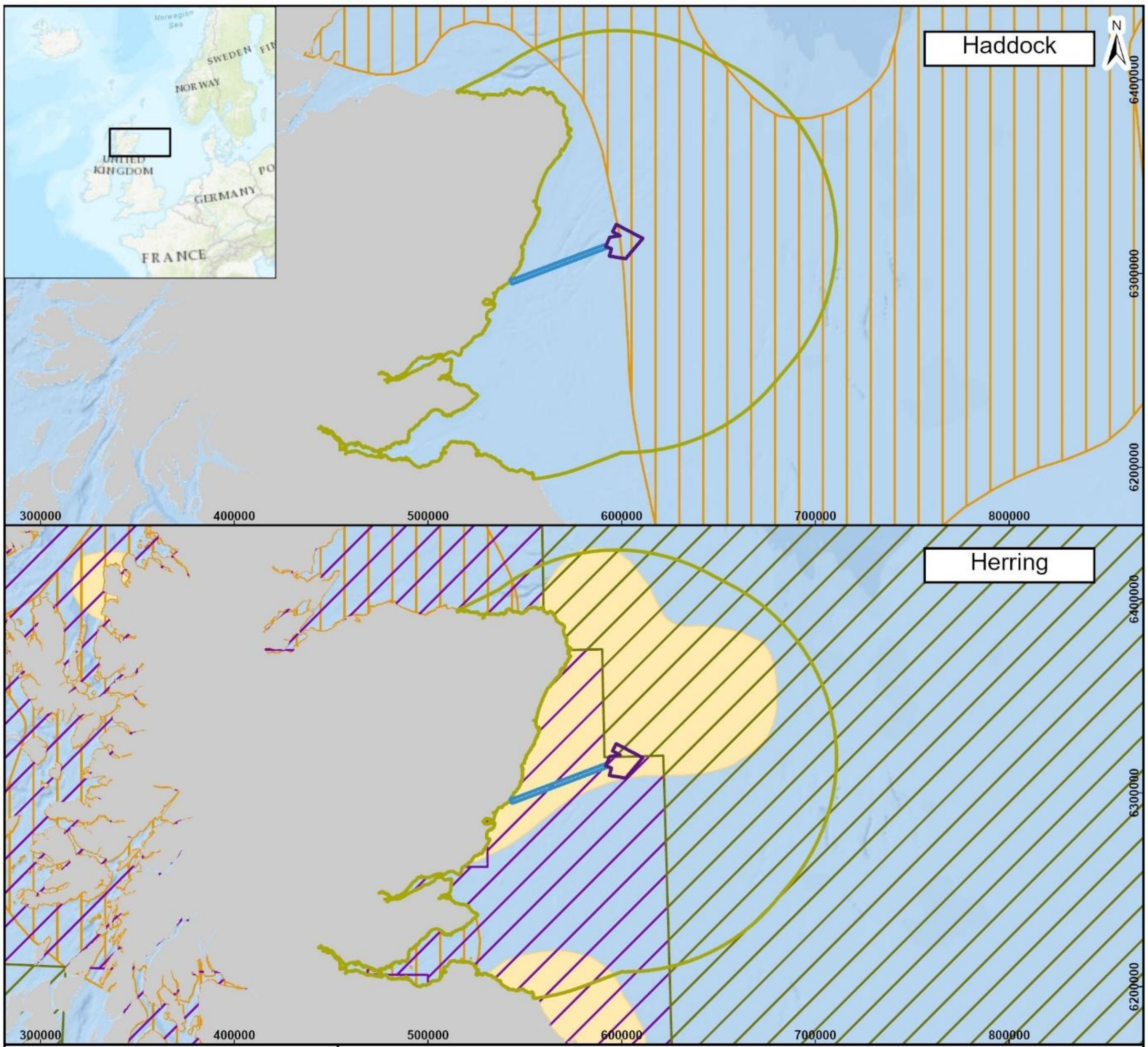
Drawing Number: EOR0770A-FAS-ES-007-02

Figure 4.13: Fish Spawning and Nursery Grounds: Cod and European Hake



Project Title: Bowdun Offshore Wind Farm

Figure Title: Fish Spawning and Nursery Grounds: Haddock and Herring

LEGEND

- Array Area
- Export Cable Corridor
- Nursery Ground - High Intensity (Ellis *et al*., 2012)
- Nursery Ground - Low Intensity (Ellis *et al*., 2012)
- Nursery Ground - Intensity Not Specified (Coull *et al*., 1998)
- Spawning Ground - Undetermined Intensity (Coull *et al*., 1998)

0 5 10 20 30 40 50 60 nm
0 10 20 40 60 80 100 120 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

Data Sources: Client, CEFAS

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Figure 4.14: Fish Spawning and Nursery Grounds: Haddock and Herring

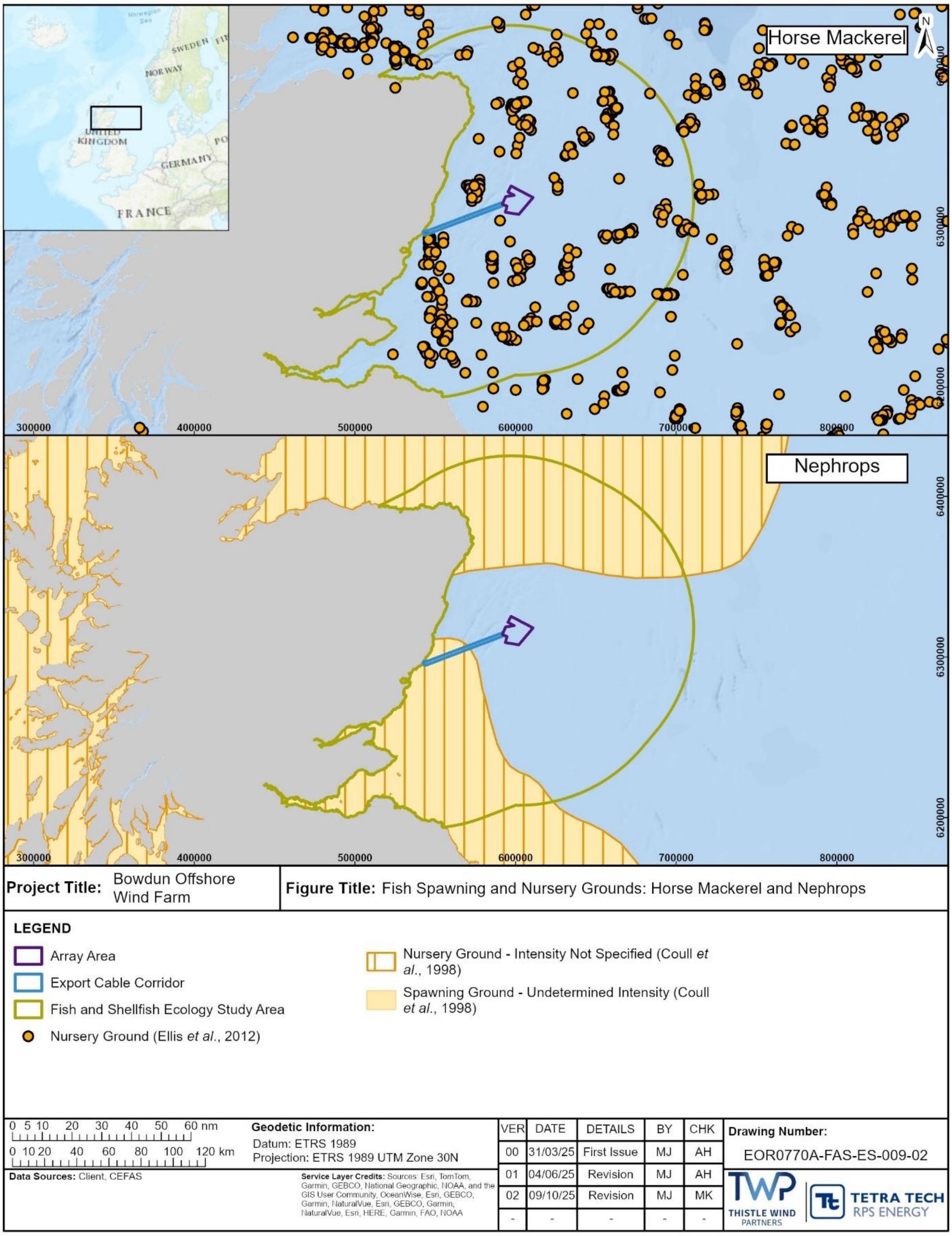
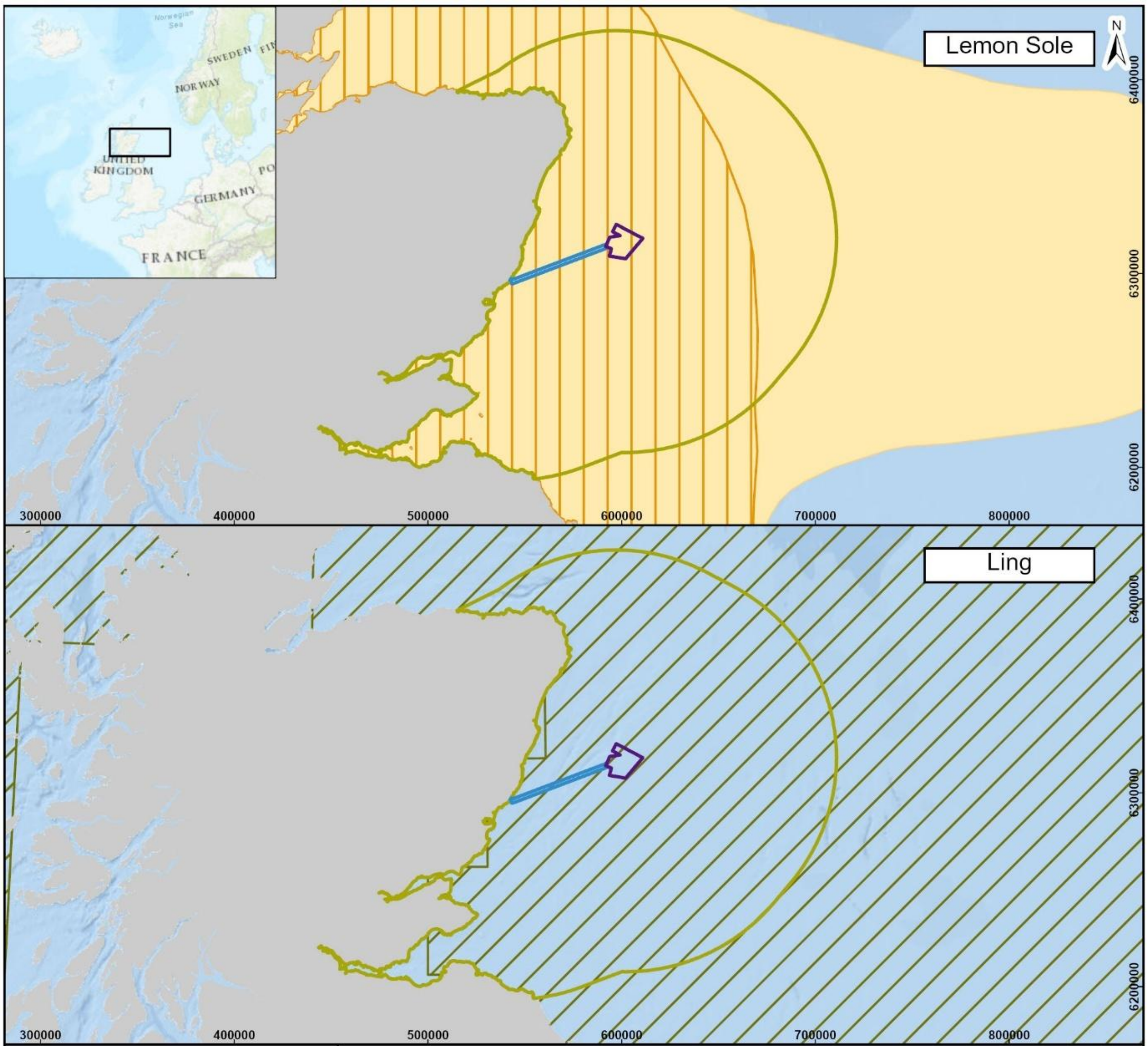


Figure 4.15: Fish Spawning and Nursery Grounds: Horse Mackerel and Nephrops



Project Title: Bowdun Offshore Wind Farm

Figure Title: Fish Spawning and Nursery Grounds: Lemon Sole and Ling

LEGEND

- Array Area
- Export Cable Corridor
- Fish and Shellfish Ecology Study Area
- Nursery Ground - Low Intensity (Ellis *et al.*, 2012)
- Nursery Ground - Intensity Not Specified (Coull *et al.*, 1998)
- Spawning Ground - Undetermined Intensity (Coull *et al.*, 1998)

0 5 10 20 30 40 50 60 nm
0 10 20 40 60 80 100 120 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

Data Sources: Client, CEFAS

Service Layer Credits: OceanWise, Esri, GEBCO, Garmin, NaturalVue, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, HERE, Garmin, FAO, NOAA

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Drawing Number: EOR0770A-FAS-ES-010-02

Figure 4.16: Fish Spawning and Nursery Grounds: Lemon Sole and Ling

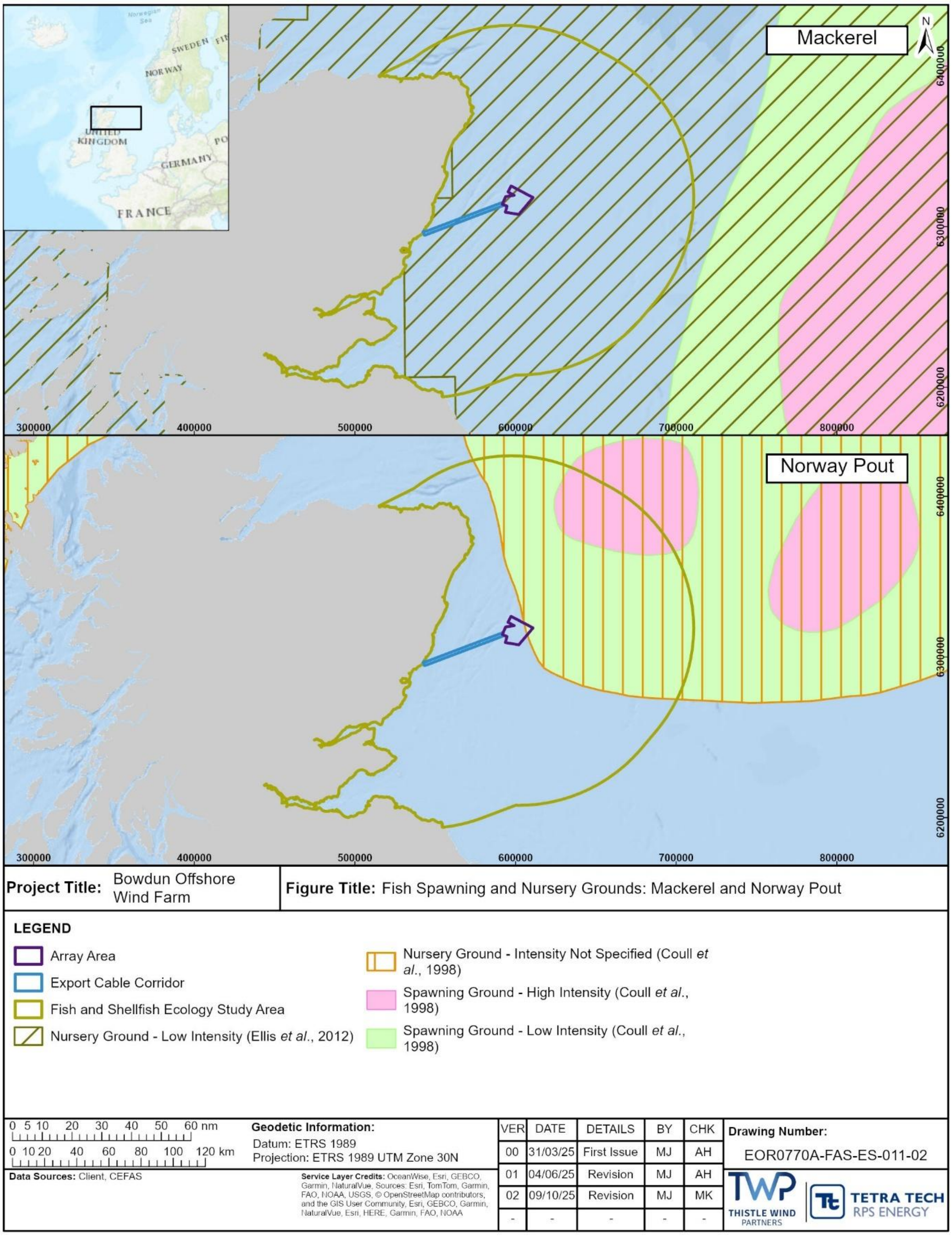


Figure 4.17: Fish Spawning and Nursery Grounds: Mackerel and Norway Pout

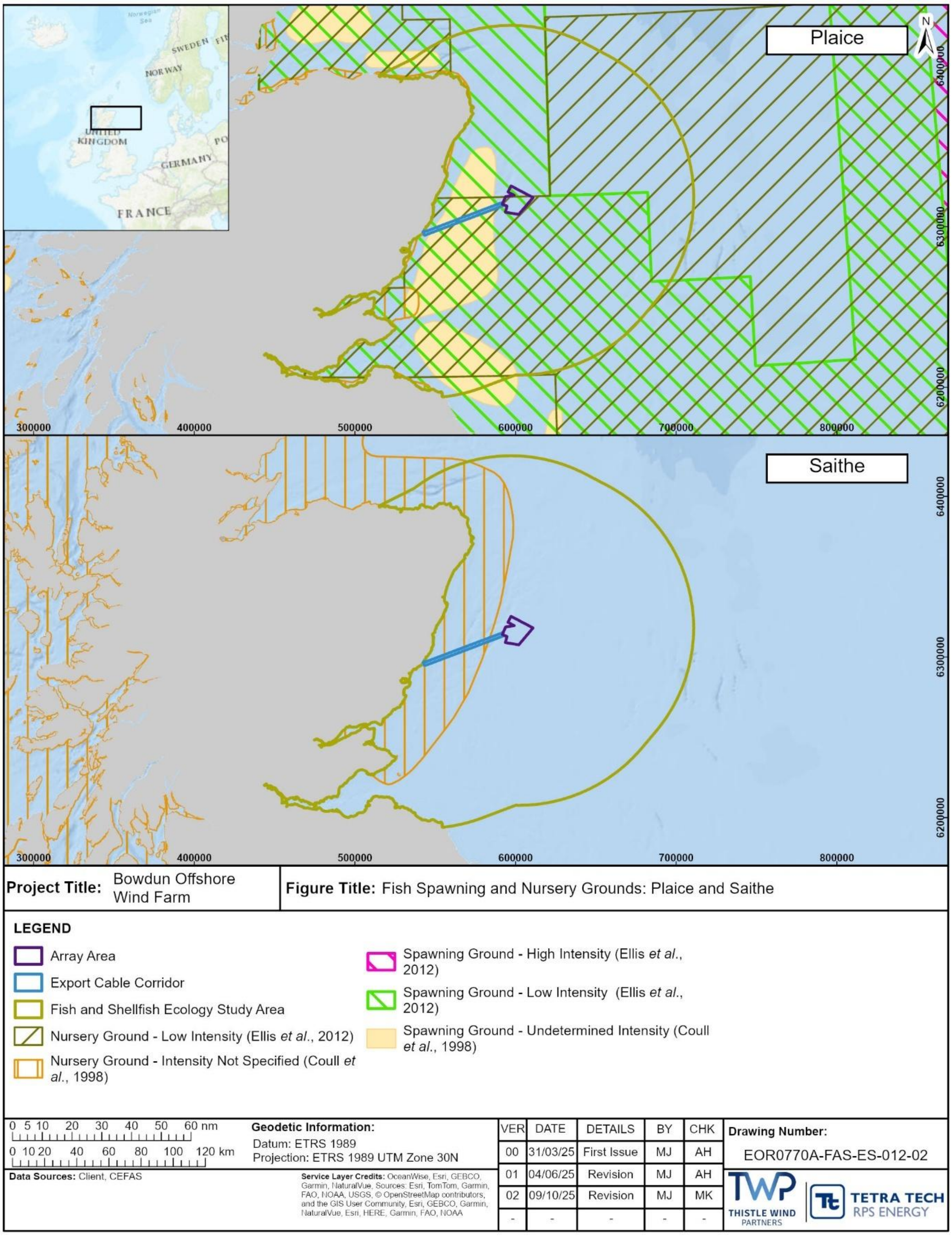


Figure 4.18: Fish Spawning and Nursery Grounds: Plaice and Saithe

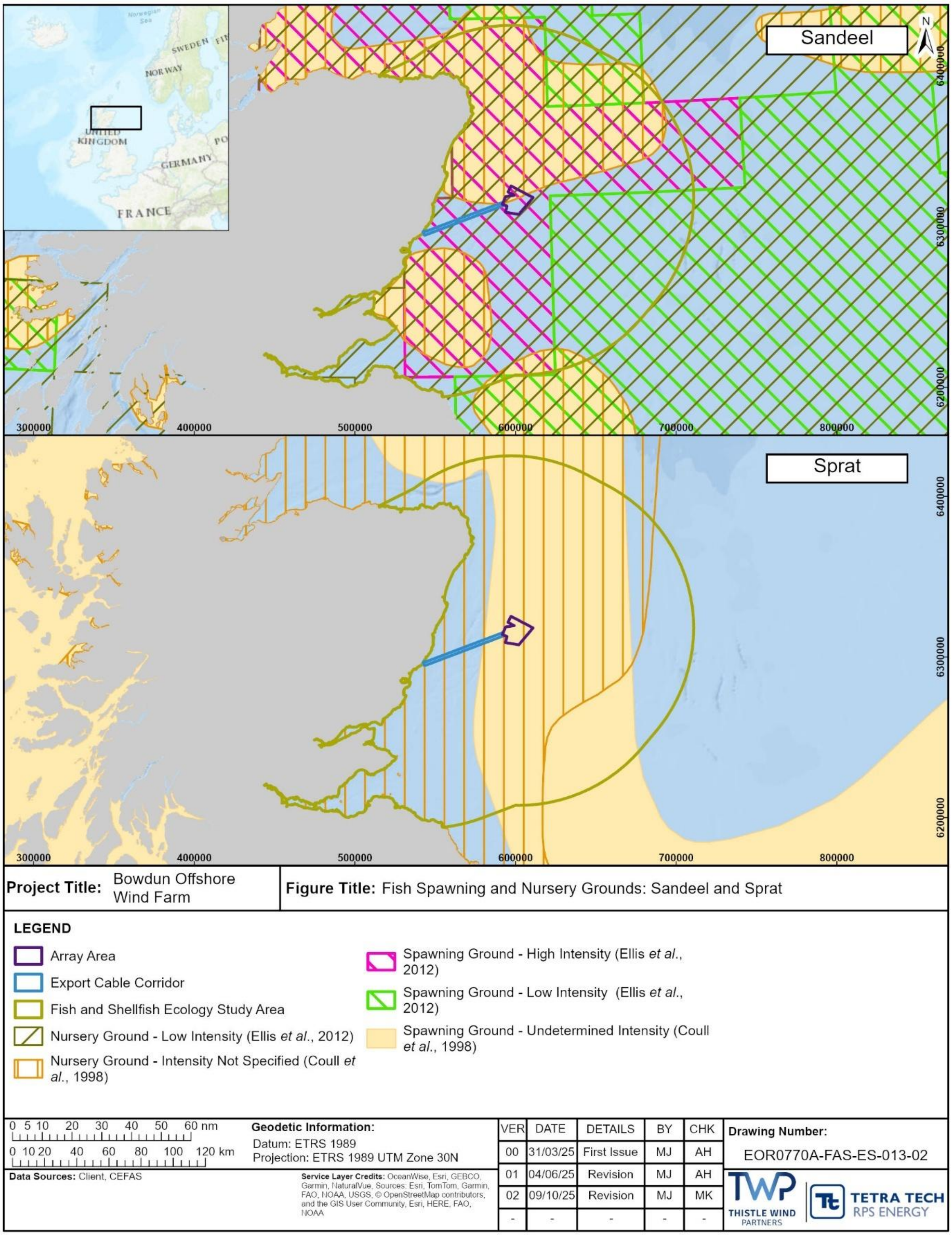
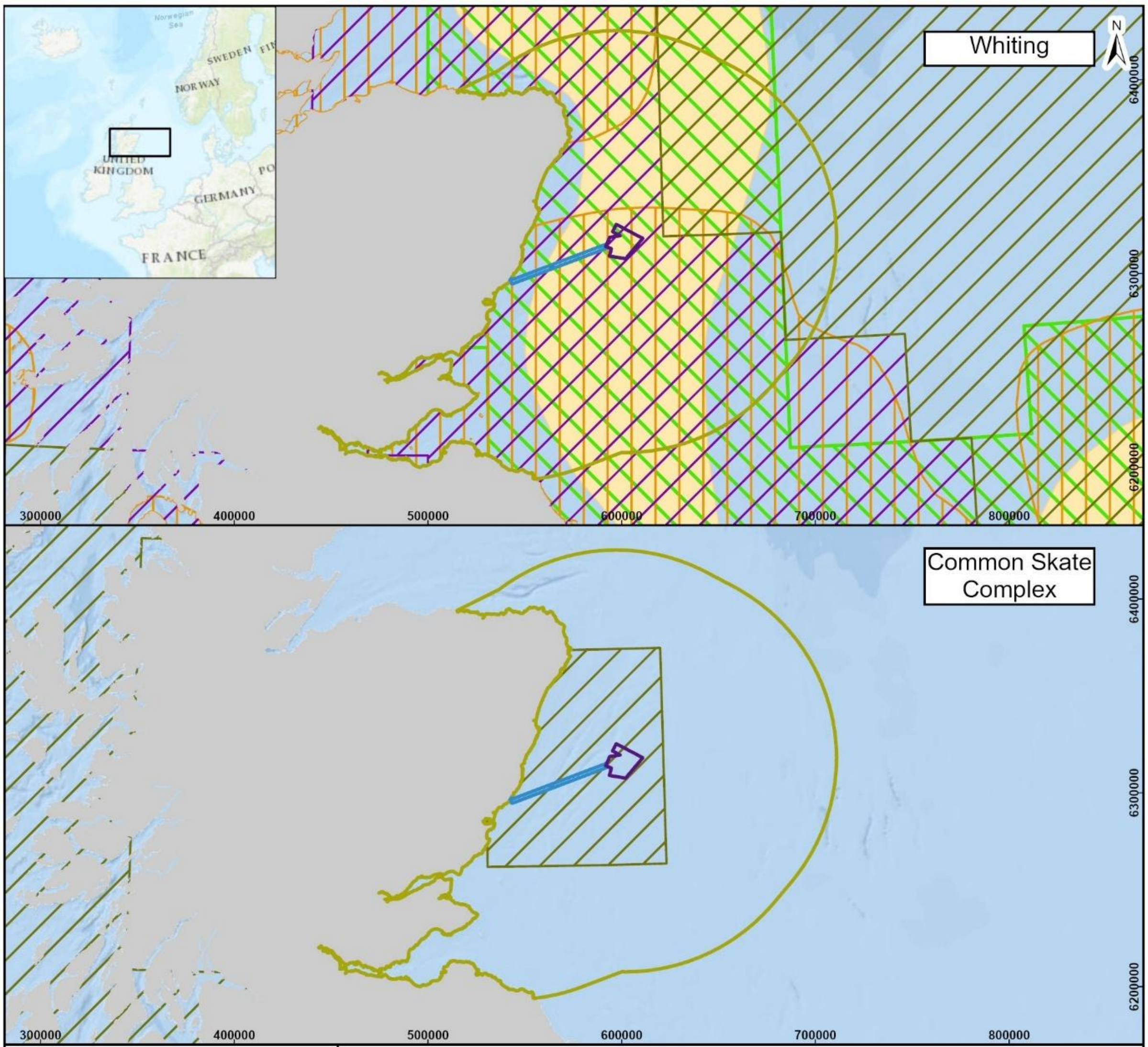


Figure 4.19: Fish Spawning and Nursery Grounds: Sandeel and Sprat



Project Title: Bowdun Offshore Wind Farm	Figure Title: Fish Spawning and Nursery Grounds: Whiting and Common Skate Complex

LEGEND

- Array Area
- Export Cable Corridor
- Fish and Shellfish Ecology Study Area
- Nursery Ground - High Intensity (Ellis *et al.*, 2012)
- Nursery Ground - Low Intensity (Ellis *et al.*, 2012)
- Nursery Ground - Intensity Not Specified (Coull *et al.*, 1998)
- Spawning Ground - Low Intensity (Ellis *et al.*, 2012)
- Spawning Ground - Undetermined Intensity (Coull *et al.*, 1998)

0 5 10 20 30 40 50 60 nm
0 10 20 40 60 80 100 120 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

Data Sources: Client, CEFAS

Service Layer Credits: OceanWise, Esri, GEBCO, Garmin, NaturalVue, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, HERE, FAO, NOAA

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Drawing Number: EOR0770A-FAS-ES-014-02

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Figure 4.20: Fish Spawning and Nursery Grounds: Whiting and Common Skate Complex

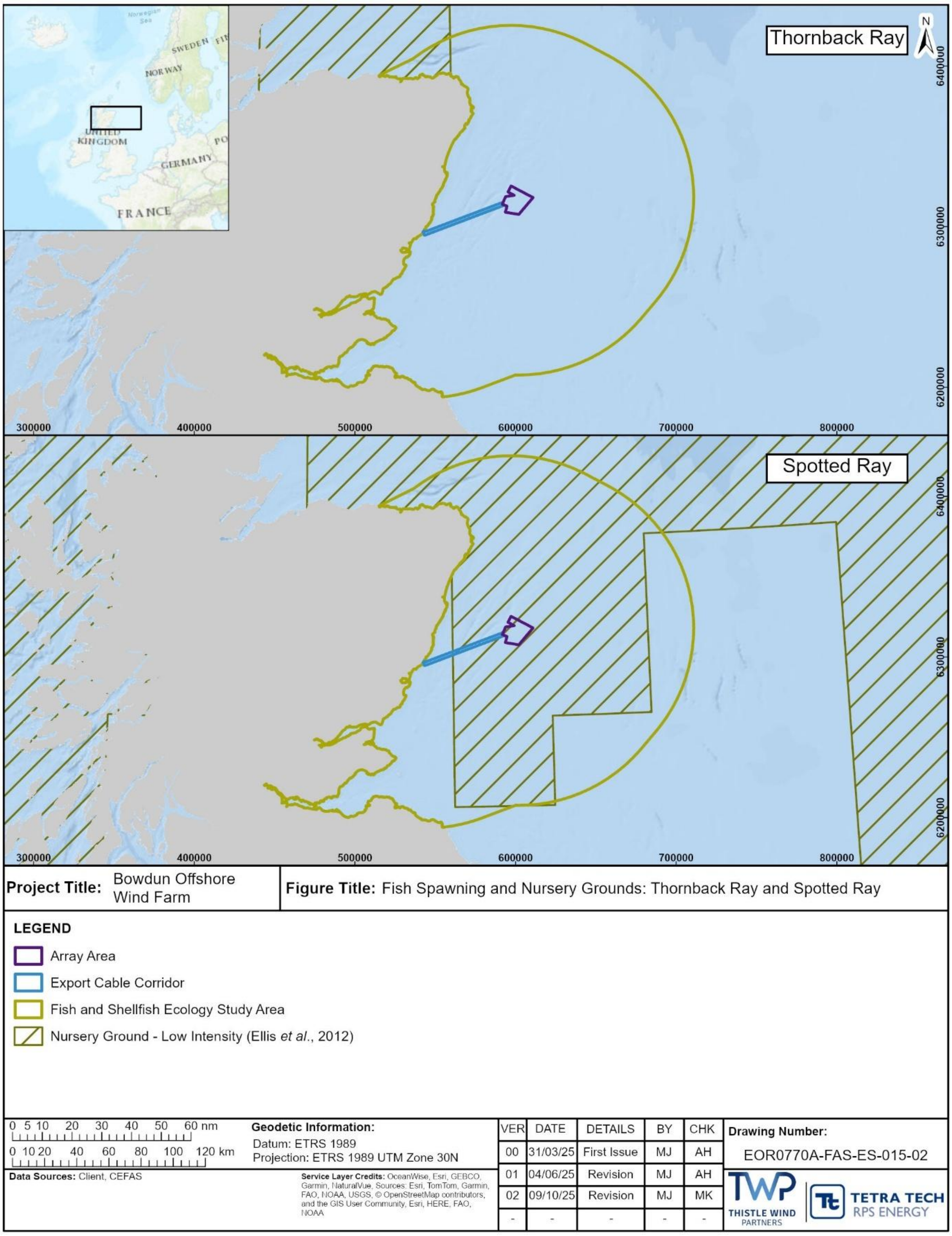


Figure 4.21: Fish Spawning and Nursery Grounds: Thornback Ray and Spotted Ray

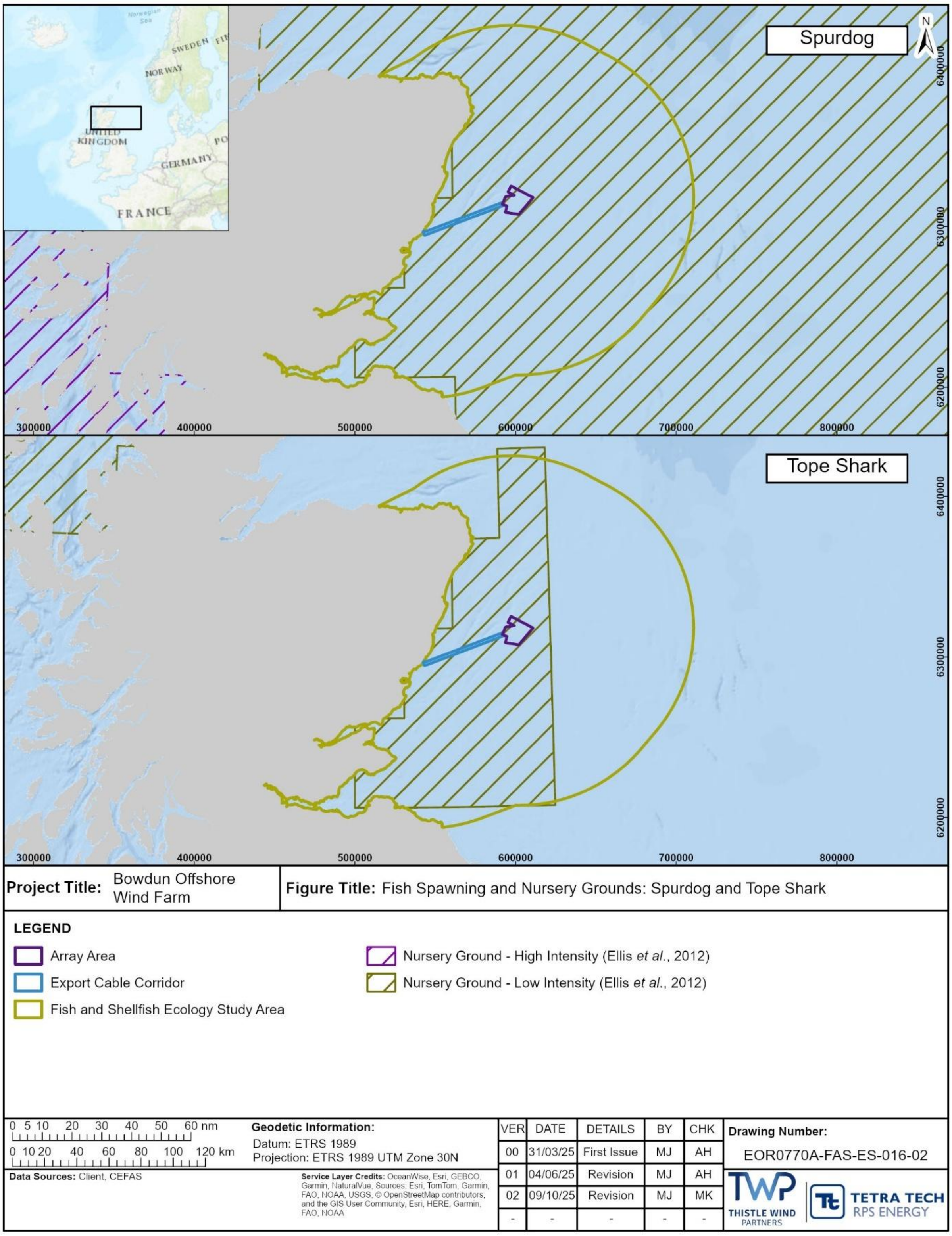


Figure 4.22: Fish Spawning and Nursery Grounds: Spurdog and Tope Shark

4.4.3 Aires *et al.* (2014) collated evidence of the distribution of '0-group' fish (i.e. those within their first year of life) and mapped the probability of abundance of 0-group fish for various species in UK waters. Aires *et al.* (2014) identified a low to medium probability of presence of 0-group fish within the Fish and Shellfish Ecology Study Area was identified for:

- cod;
- haddock;
- herring;
- Norway pout;
- plaice; and
- whiting.

4.4.4 In comparison with the relevant figures above (Figure 4.13, Figure 4.14, Figure 4.17, Figure 4.18 and Figure 4.20) Aires *et al.* (2014) distribution of '0-group' fish do overlap with the mapped nursery and/or spawning grounds within the Fish and Shellfish Ecology Study Area. This suggests that spawning and nursery grounds for these species could be in the vicinity of the Site Boundary, but they may not be of particularly high intensities.

4.4.5 For cod, haddock, and whiting, the spawning grounds established by Coull *et al.* (1998) and Ellis *et al.* (2012) were further researched by González-Irusta and Wright (2016a), González-Irusta and Wright (2016b), and González-Irusta and Wright (2017) using IBTS data and predictive environmental variables. The spawning potential for cod, haddock, and whiting are shown in Figure 4.23, and the following conclusions can be made from these data:

- cod – the Site Boundary overlaps with areas of recurrent spawning grounds, with a sections of unfavourable spawning grounds in the south-east section of the Fish and Shellfish Ecology Study Area and the Firth of Forth;
- haddock – the Site Boundary is largely situated within areas with a medium importance as spawning grounds, however there are areas with higher importance to the north-east of the Array Area; and
- whiting – the Site Boundary largely overlaps with areas considered more important for spawning, with areas of higher suitability further north and grounds unsuitable for spawning further south of the Array Area and Export Cable Corridor.

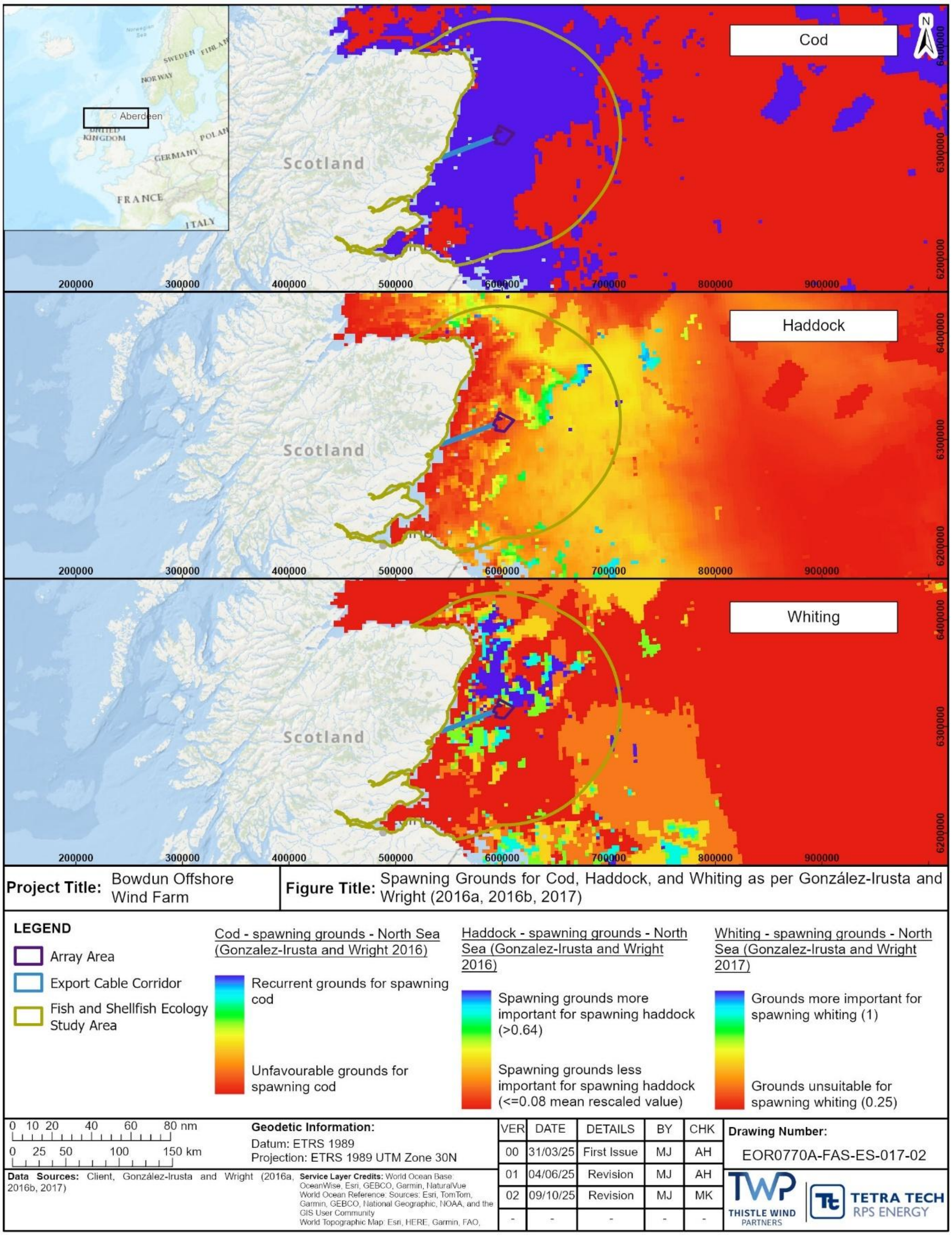


Figure 4.23: Spawning Grounds for Cod, Haddock, and Whiting as per González-Irusta and Wright (2016a; 2016b; 2017)

4.4.6 Franco *et al.* (2023) provides more recent modelled catch data from broadscale fish surveys (from 2010 to 2020) and the associated environmental conditions to map the UK-wide spatial distribution of essential fish habitats for a range of species. They defined essential fish habitats as those which function as refuge for individuals of a species, as a nursery for its juvenile stages or as spawning ground for the spawning adults and the spawn products (eggs), and where these individuals are present in higher abundance (aggregations) compared to other habitats where they also occur.

4.4.7 Through essential fish habitat data-based modelling for offshore waters (beyond a 12 nm limit) modelling was presented UK-wide, there were many discrepancies identified by key stakeholders as part of the study (Franco *et al.*, 2023). For many species, well established and known essential fish habitats were often predicted by the model as having low to no probability of aggregations of juveniles and spawners (Franco *et al.*, 2023). Some examples include the model predicted the absence of lesser sandeel aggregations on protected sandeel grounds, which are well known for their spawning potential (such as the North-West Orkney MPA and Turbot Bank MPA), and the north-east coast of the UK which has recently been declared a sandeel closure zone[1] in order to aid population recovery (Franco *et al.*, 2023).

4.4.8 Overall, the spatial products of this study represented a step forward for an evidence-based understanding of the essential fish habitat distribution in UK waters and the confidence associated with it. However, the authors note that further validation is required before the results can be used in assessments (Franco *et al.*, 2023). Given this, and the discrepancies highlighted above, the results of Franco *et al.* (2023) have not been used to inform the baseline presented here or the assessment presented in Volume 2, Chapter 9: Fish and Shellfish Ecology.

4.5 Herring Spawning and Sandeel Habitat Suitability Analysis

4.5.1 As stated in Paragraph 4.4.2, herring and sandeel are known to be particularly sensitive to seabed disturbance because they spawn in very specific substrates (Latto *et al.*, 2013; Reach *et al.*, 2013). These species are of particular importance because they play a key ecological role as principal prey items for several larger fish, bird, and marine mammal species. Therefore, spawning habitat suitability within the Array Area and Export Cable Corridor has been assessed following the methodology presented in Latto *et al.* (2013) and Reach *et al.* (2013). Data for this assessment have been derived from PSA results of the site-specific benthic sub-tidal ecology survey.

Herring

4.5.2 In UK and Irish waters, herring populations are divided into eight discrete stocks during the breeding season, each with their own spawning and nursery grounds and migration routes (Coull *et al.*, 1998). Most relevant to the Fish and Shellfish Ecology Study Area is the Buchan/Shetlands stock, which spawns off the north-

[1] Under The Sandeel (Prohibition of Fishing) (Scotland) Order 2024

eastern mainland Scotland and Shetland coasts in August and September, and the North-West Scotland stock, which spawns between March to April and August and September (Figure 4.24; Coull *et al.*, (1998)). Herring spawning grounds within the Fish and Shellfish Ecology Study Area identified by Coull *et al.* (1998) are presented in Figure 4.14 and show that the Site Boundary lies within the herring spawning ground.

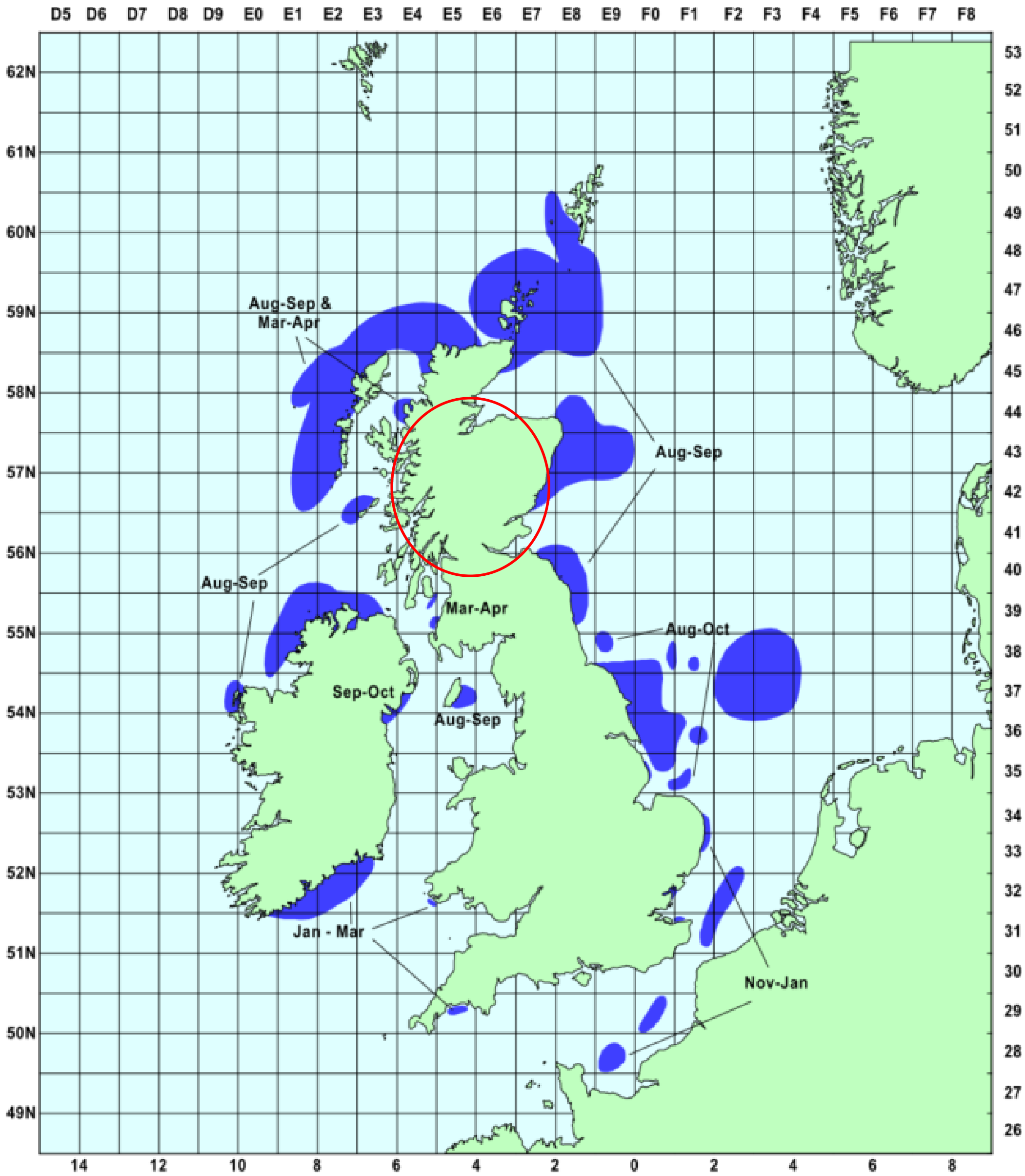


Figure 4.24: Herring Stocks Around the UK and Ireland, with Timings of Spawning (Coull *et al.*, 1998) (Red Circle Illustrates the Fish and Shellfish Ecology Study Area)

4.5.3 Herring spawn in shallow areas between approximately 15 m to 40 m in depth. Females lay sticky eggs once a year in a single batch, with inter-stock variations on number, size and weights of the eggs (Cefas, 2001). For example, a 28 cm female from the Buchan/Shetlands stock could produce approximately 67,000 eggs per year, whereas a similarly sized individual from the Southern

Bight/Downs stock (English Channel) could produce approximately 42,000 eggs (Barreto and Bailey, 2014).

4.5.4 The sticky eggs are deposited on gravel sediments, which has been suggested as their preferred spawning habitat (Reach *et al.*, 2013). Muddy sediments are considered unsuitable as the fine particles can stick to the eggs and prevent oxygen transfer through the pores, resulting in increased egg mortality through asphyxiation.

4.5.5 After incubating for between one and three weeks (dependent on water temperatures), hatched herring larvae become pelagic and drift in the plankton via water currents (Dragesund *et al.*, 1980). Larvae using the Moray Firth as a nursery ground are thought to originate from west Scotland (Department of Energy and Climate Change (DECC), 2004). Herring nursery grounds are widespread around the UK and Ireland (Coull *et al.*, 1998), with higher intensity grounds occurring in coastal waters, where post larval juveniles that are yet to reach sexual maturity remain to feed (Coull *et al.*, 1998; Ellis *et al.*, 2012). Later, juvenile herring migrate further offshore where they feed until reaching sexual maturity (ICES, 2006).

4.5.6 Herring have specific sediment preferences which limits the spatial extent of their spawning grounds. Suitable herring spawning habitat comprises a seabed with a high gravel content with minimal fines and high oxygenation of sediments (Reach *et al.*, 2013). Eggs adhere to the seabed and can form extensive egg beds, meaning they are particularly sensitive to seabed disturbance. Specific substrates on which herring spawn make them sensitive to the impacts from habitat loss and disturbance. In addition, herring are considered to be hearing specialists with increased sensitivity to underwater noise (Enger, 1967; Mann *et al.*, 2005; Popper *et al.*, 2004) and are therefore vulnerable to injury or disturbance from activities which generate underwater noise, such as piling.

4.5.7 Herring spawning grounds can also be identified through monitoring of herring larval abundances combined with sediment composition data. The IHLS conducts monitoring programmes where larvae numbers are recorded around the UK coastline and throughout the North Sea. Small herring larvae are assumed to have been recently hatched and have been sampled in close proximity to the area where eggs were laid (ICES, 2024a). The IHLS presents herring larvae counts by size per m^2, with larvae less than 10 mm in length used as a cut off point for recently hatched larvae (ICES, 2024a).

4.5.8 The most recently available IHLS data were plotted for each year from 2007 to 2016 in Figure 4.25 to Figure 4.27, illustrating the changing spatial distribution of herring spawning relative to areas of historic spawning grounds as identified by Coull *et al.* (1998), in line with guidance from Boyle and New (2018). From 2007 to 2010 (Figure 4.25), Herring larvae <10 mm per square metre fluctuate, but there is a consistent area within the Fish and Shellfish Ecology Study Area just to the north-west of the Array Area and within the Array Area as well as to the south of the Site Boundary of higher numbers of larvae (1,000 – 5,000 <10 mm per square metre). These areas of higher larvae numbers increase in area for the years 2011 to 2016 (Figure 4.26 and Figure 4.27), covering the majority of the Fish and Shellfish Ecology Study Area, and consistent with the herring spawning grounds identified by Coull *et al.* (1998).

4.5.9 Each year of data were also presented cumulatively over the ten-year period between 2007 and 2016 (Figure 4.28) to gain an understanding of where the most common spawning grounds were over the time period. A persistent hotspot of high larval density is present to the north of the Array Area, but the number of herring larvae within the Array Area and the Export Cable Corridor of the Proposed Development in comparison are very low. It should be noted that this is also consistent with the spawning grounds identified by Coull *et al.* (1998), which demonstrates its continued relevance when assessing spawning grounds. Overall, these cumulative results suggests that the Site Boundary is not particularly important for the spawning of herring.

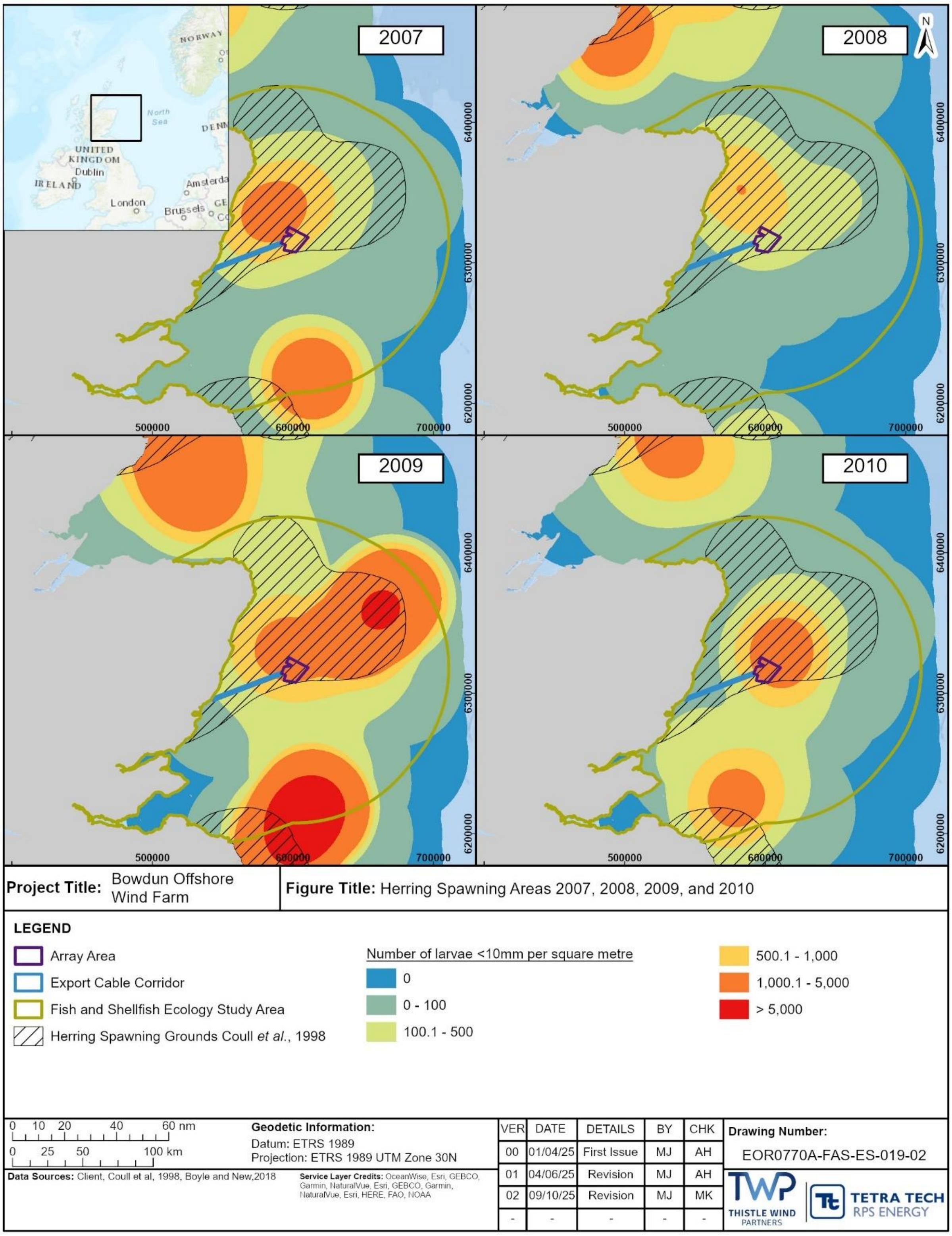
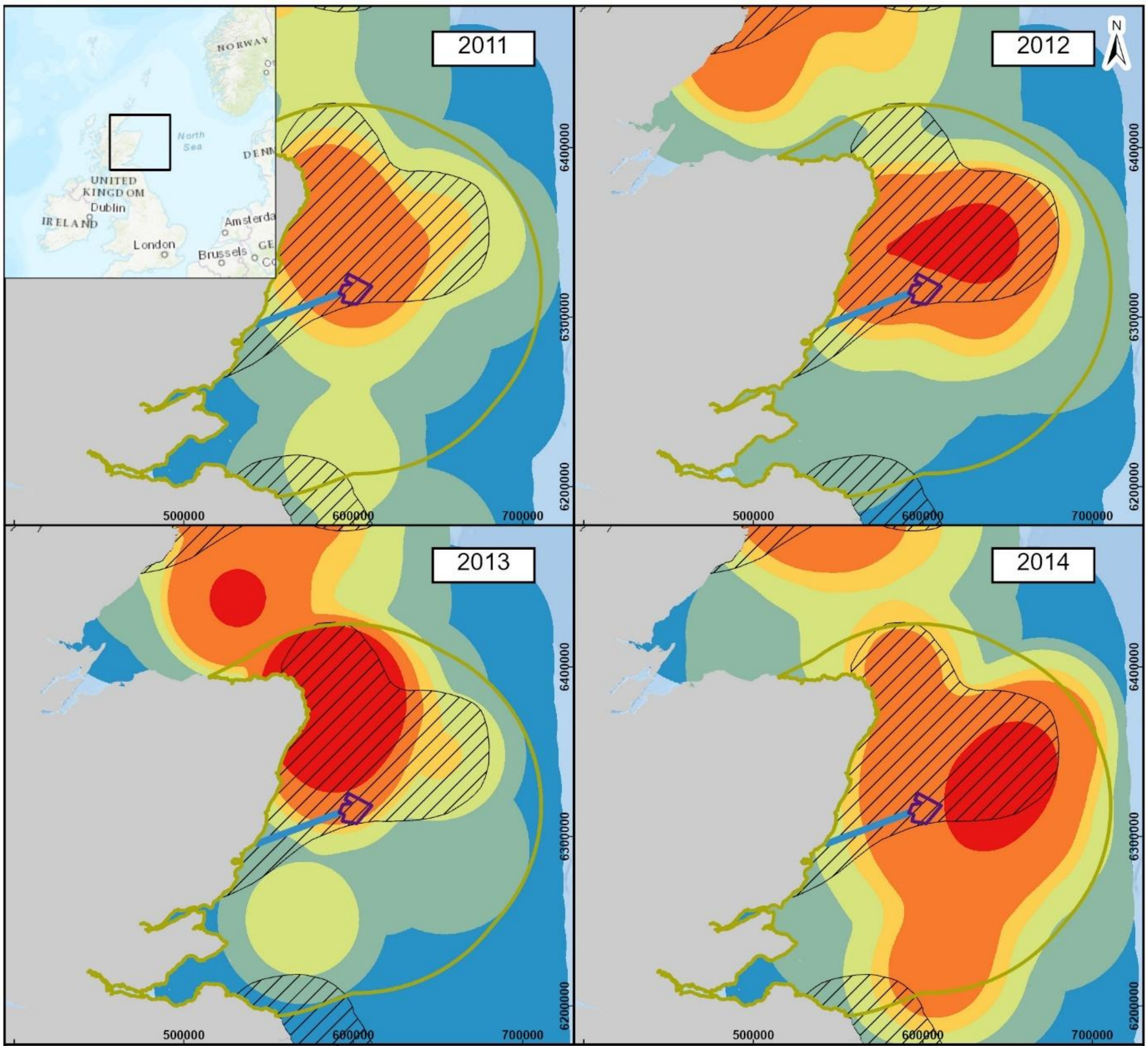


Figure 4.25: Herring Spawning Areas 2007, 2008, 2009, and 2010



Project Title: Bowdun Offshore Wind Farm

Figure Title: Herring Spawning Areas 2011, 2012, 2013, and 2014

LEGEND

- Array Area
- Export Cable Corridor
- Fish and Shellfish Ecology Study Area
- Herring Spawning Grounds Coull *et al.*, 1998

Number of larvae <10mm per square metre

- 0
- 0 - 100
- 100.1 - 500
- 500.1 - 1,000
- 1,000.1 - 5,000
- > 5,000

0 10 20 40 60 nm
0 25 50 100 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

Data Sources: Client, Coull et al, 1998, Boyle and New,2018

Service Layer Credits: OceanWise, Esri, GEBCO, Garmin, NaturalVue, Esri, GEBCO, Garmin, NaturalVue, Esri, HERE, Garmin, FAO, NOAA, USGS

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Drawing Number: EOR0770A-FAS-ES-020-02

Figure 4.26: Herring Spawning Areas 2011, 2012, 2013, and 2014

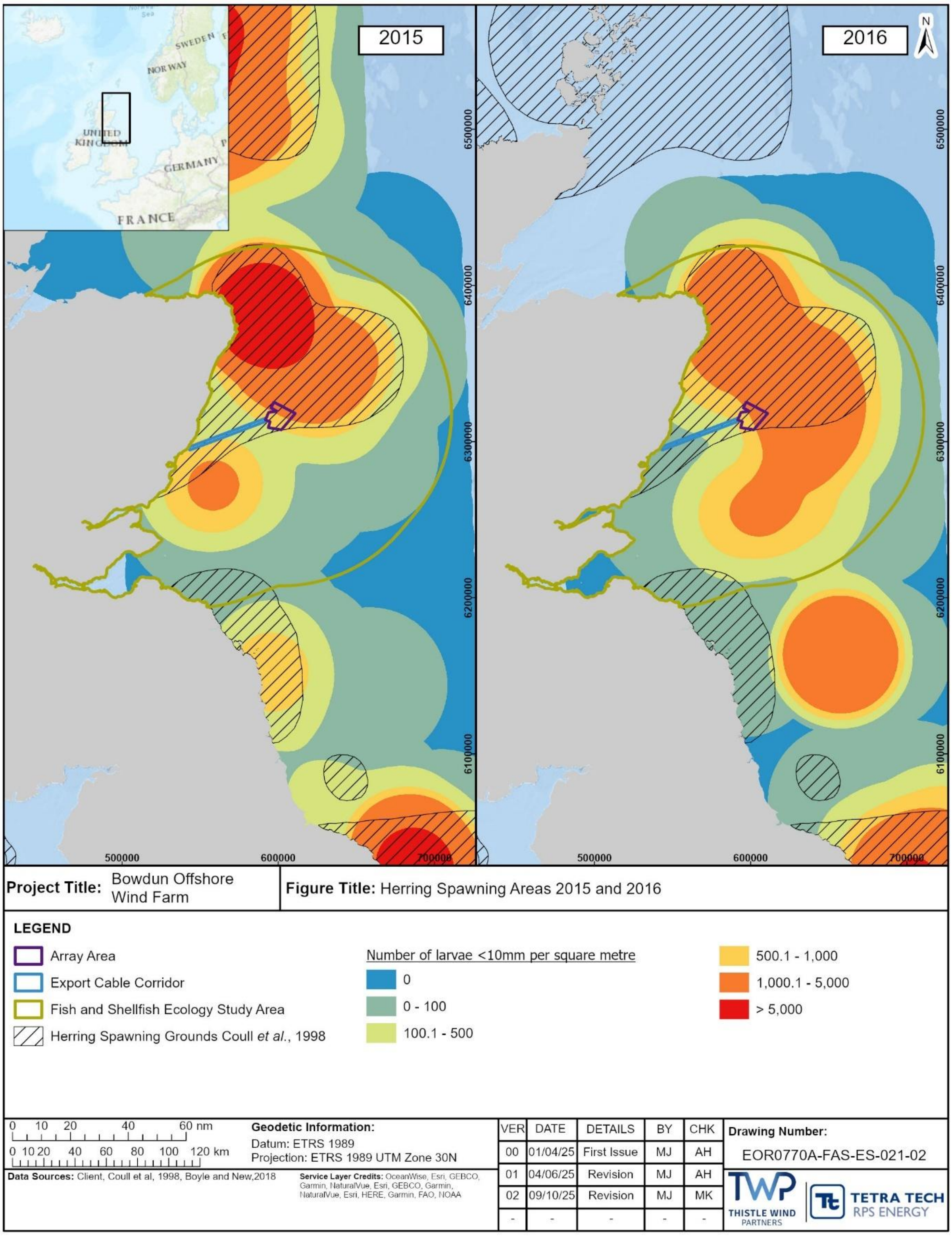
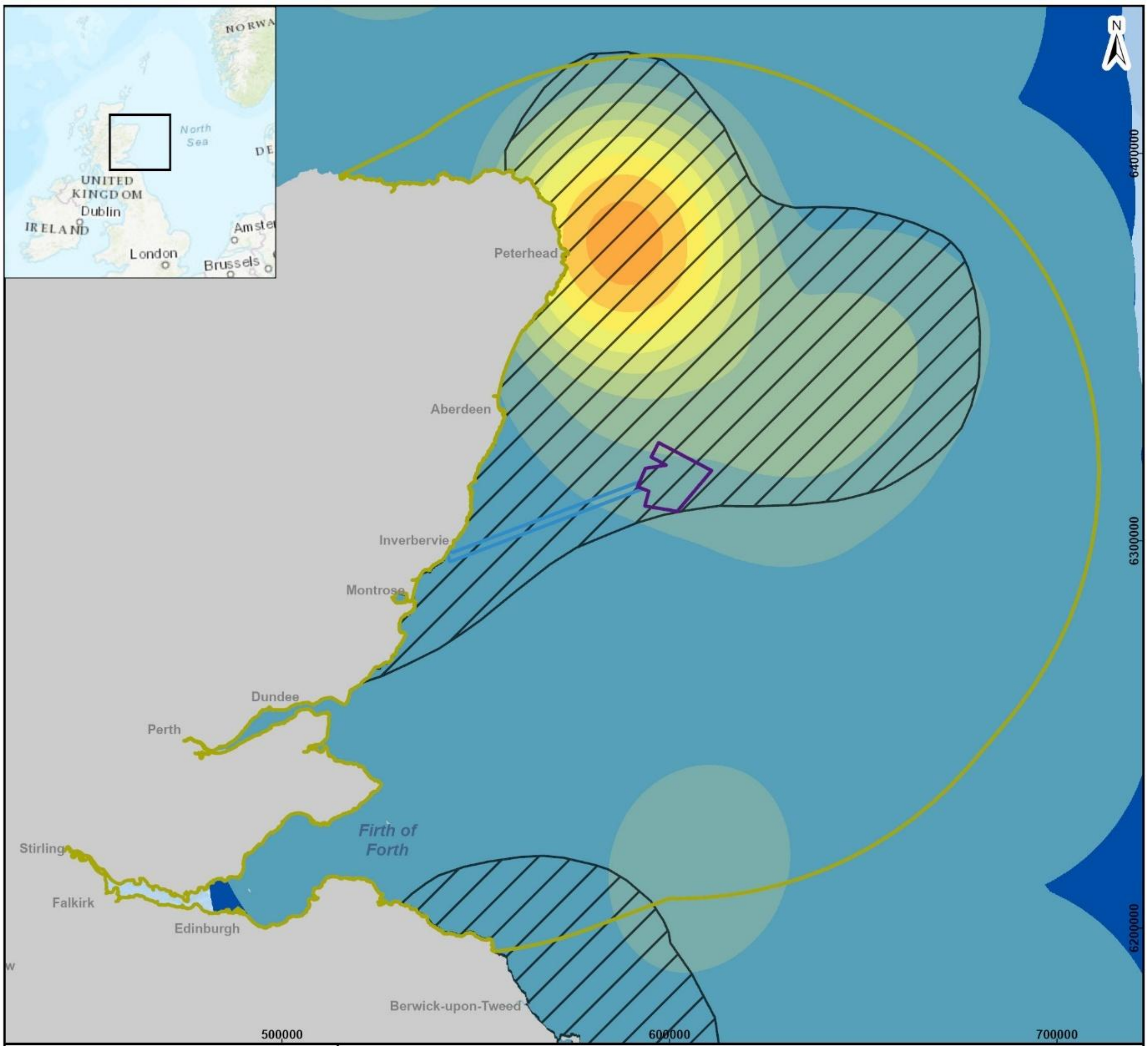


Figure 4.27: Herring Spawning Areas 2015 and 2016



Project Title: Bowdun Offshore Wind Farm

Figure Title: Cumulative Herring Larval Density and Spawning Areas (2007 to 2016)

LEGEND

- Array Area
- Export Cable Corridor
- Fish and Shellfish Ecology Study Area
- Spawning Ground - Undetermined Intensity (Coull *et al.*, 1998)

Number of larvae <10mm per square metre:

- 0
- >0 - 10,000
- >10,000 - 20,000
- >20,000 - 30,000
- >30,000 - 40,000
- >40,000 - 50,000
- >50,000 - 60,000
- >60,000 - 70,000
- >70,000 - 80,000
- >80,000 - 90,000
- >90,000 - 100,000
- >100,000 - 110,000
- >110,000 - 120,000
- >120,000 - 130,000

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

VER	DATE	DETAILS	BY	CHK
00	01/04/25	First Issue	MJ	AH
01	04/06/25	Revision	MJ	AH
02	09/10/25	Revision	MJ	MK
-	-	-	-	-

Drawing Number: EOR0770A-FAS-ES-022-02

THISTLE WIND PARTNERS | TETRA TECH RPS ENERGY

Data Sources: Client, Coull et al, 1998, Boyle and New,2018

Service Layer Credits: OceanWise, Esri, GEBCO, Garmin, NaturalVue, Esri, HERE, Garmin, FAO, NOAA, USGS

Figure 4.28: Cumulative Herring Larval Density and Spawning Areas (2007 to 2016)

4.5.10 There were no relevant IHLS survey data for the Fish and Shellfish Ecology Study Area available for 2017 and 2018. Further, from 2019 there was a change in reporting strategy from the IHLS, and more recent herring larvae data were not available for analysis. However, yearly reports are published by ICES as part of their working group on ichthyoplankton in the North Sea (ICES, 2022; ICES, 2023; ICES, 2024c). The most recent reports (for the years 2020 to 2023) have been used to provide more recent context to the IHLS data presented in Figure 4.25 to Figure 4.27. Within the whole of the Fish and Shellfish Ecology Study Area, there were consistently low numbers of newly hatched herring larvae in the 2020 survey, except for larger quantities which were concentrated around Buchan, north of the Proposed Development (Figure 4.29) (ICES, 2022).

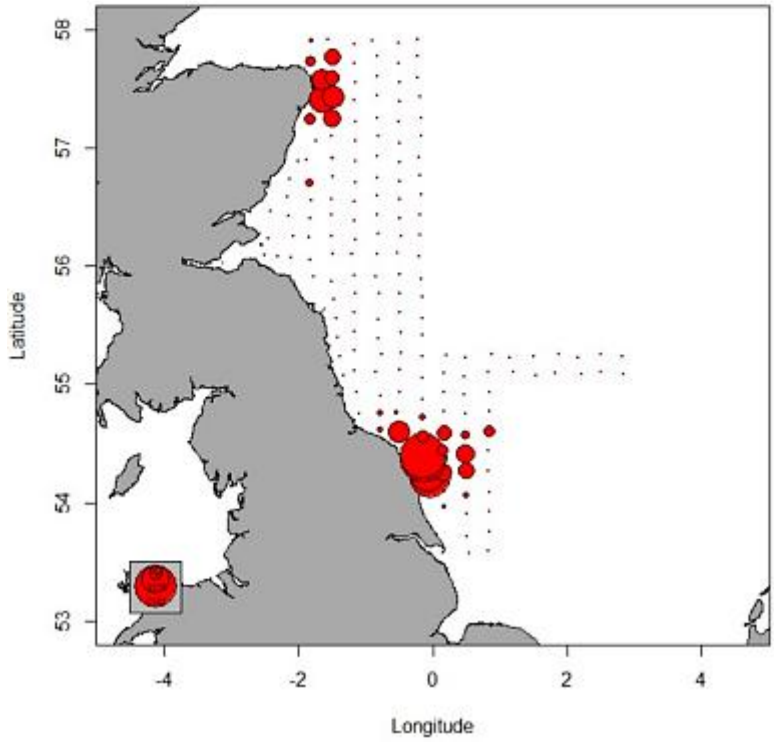


Figure 4.29: Abundance of Herring Larvae < 10 mm (per m²) in the Buchan and Central North Sea Area, Second Half of September 2020 (Maximum Circle Size = 7,100 Larvae per m²) (ICES, 2022)

4.5.11 In 2021 IHLS around Buchan revealed larvae hatched in lower quantities at the Buchan area (Figure 4.30) than in the 2020 survey (Figure 4.29). Figure 4.30 illustrates this 2021 data, with the largest circle representing ~1,500 larvae per m^2 recorded around Buchan, in comparison to the maximum of ~2,500 larvae per m^2 in the same area in the 2020 survey (see Figure 4.29).

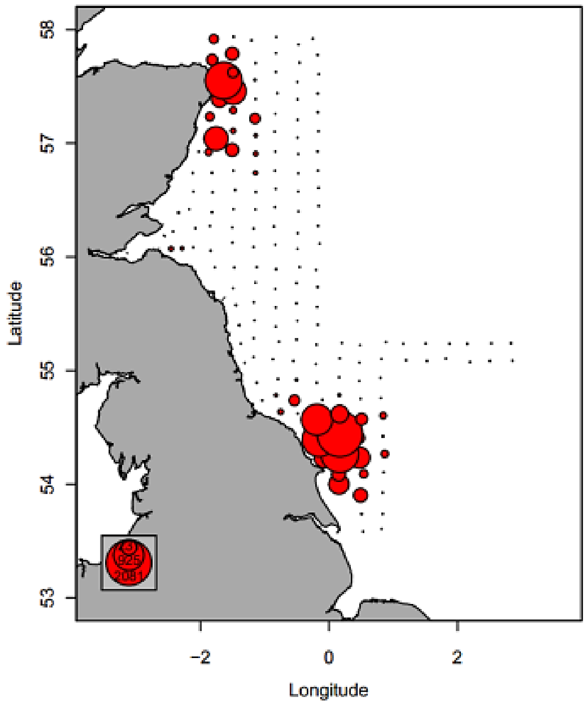


Figure 4.30: Abundance of Herring Larvae < 10 mm (per m²) in the Buchan Area and the Central North Sea, Second Half of September 2021 (Maximum Circle Size = 2,081 Larvae per m²) (ICES, 2023).

4.5.12 The most recent IHLS in September 2022 (Figure 4.31) showed similar quantities of newly hatched herring larvae recorded around Buchan compared to the 2021 but lower than that of 2020 (Figure 4.29 and Figure 4.30). The distribution of larvae was also more southern compared to previous years (Figure 4.29 and Figure 4.30) (ICES, 2024c).

4.5.13 Using data from the ICES (2024a), the trends in larval abundance from 2007 to 2022 at the Buchan area is presented in Figure 4.32. The data illustrates that the IHLS data from 2007 to 2016 (as mapped in Figure 4.25 to Figure 4.28) in the Buchan area was in the same order of magnitude as in more recent years. Therefore, it can be assumed that there are no significant changes from the results presented in Figure 4.25 to Figure 4.28 for 2007 to 2016 outside of normal annual variations. Finally, the most recent survey data shown in Figure 4.29 to Figure 4.31 highlight the persistent presence of the spawning grounds identified by Coull *et al.* (1998).

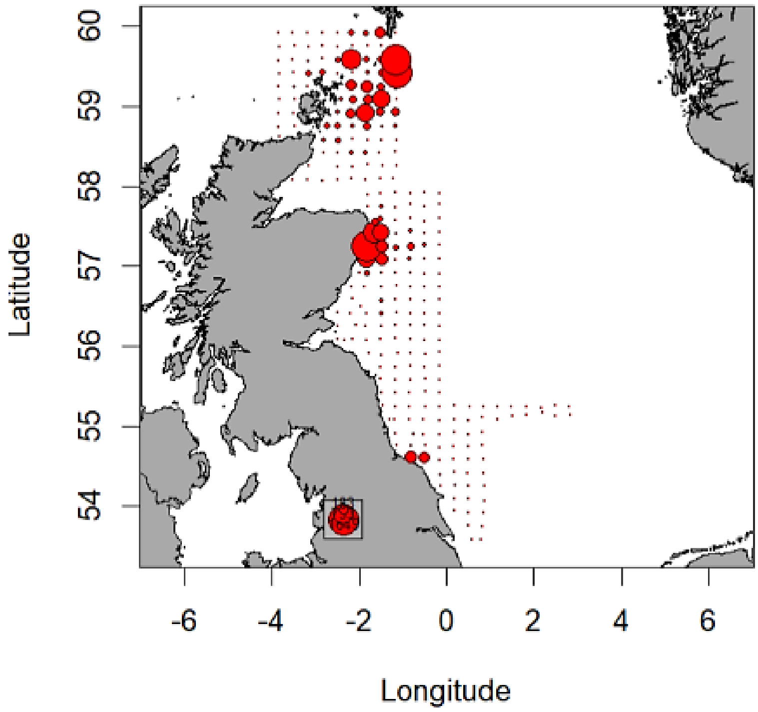


Figure 4.31: Abundance of Herring Larvae <10 mm (per m²) in the Orkney/Shetlands, the Buchan and the Central North Sea Area, Second Half of September 2022 (Maximum Circle Size = 1,650 Larvae per m²) (ICES, 2024c)

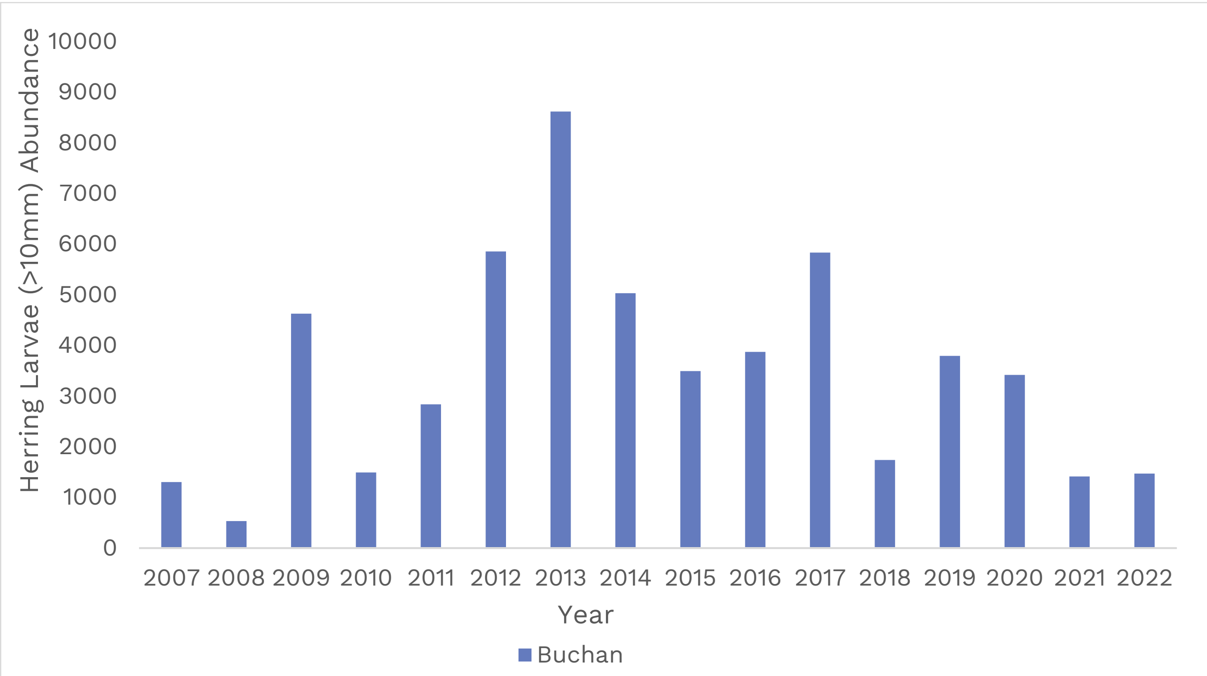


Figure 4.32: Abundance of Herring Larvae (<10 mm) at Buchan from 2007 to 2022. Created Using Data from ICES (2024a). Larval Abundance is Expressed as Average Numbers per ICES Rectangle * 10⁹.

4.5.14 Lastly, Frost and Diele (2022) recently reviewed essential spawning grounds for herring in Scottish and Northern Irish waters. Figure 4.33 presents spatial data relevant to herring spawning activity that were collated and reviewed by Frost and Diele (2022). As illustrated, there is evidence of herring spawning throughout the Fish and Shellfish Ecology Study Area but is also widespread around Scotland as a whole.

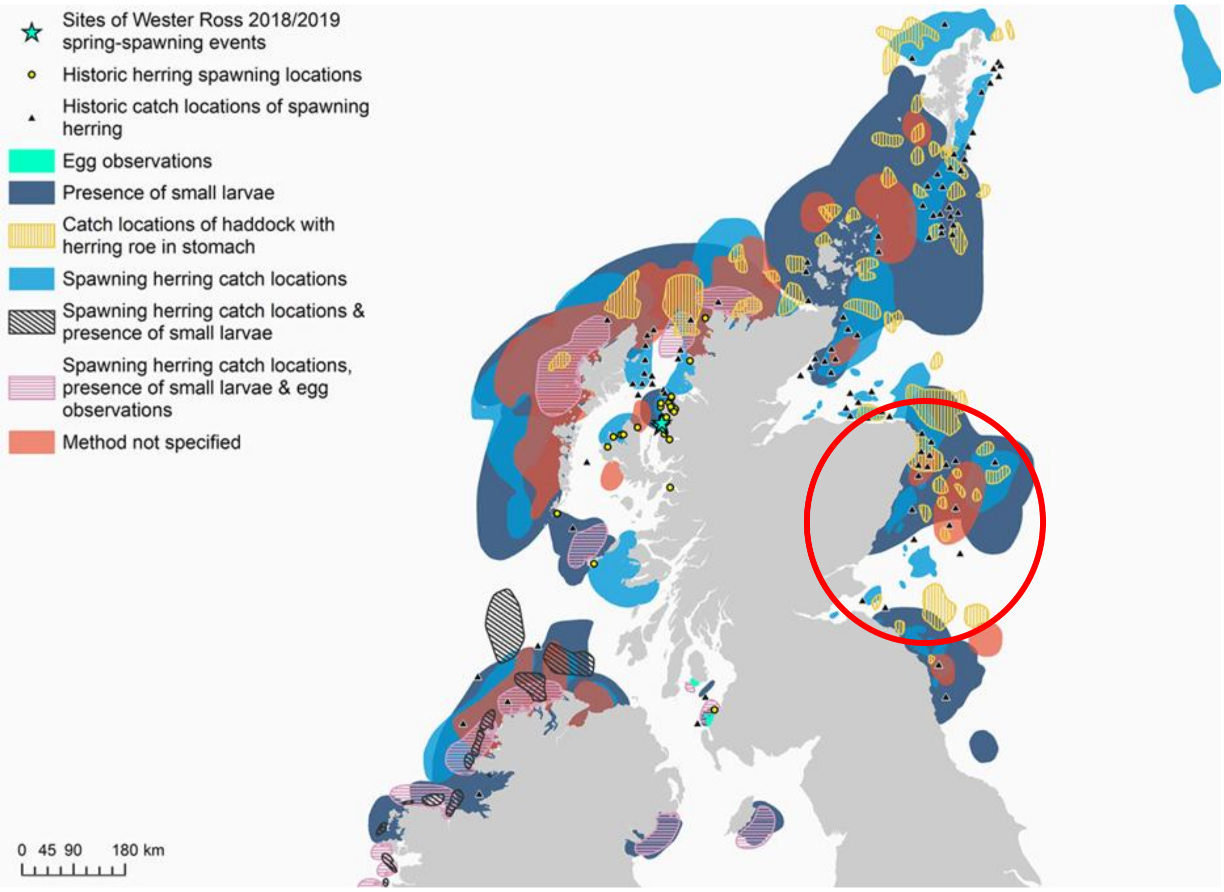


Figure 4.33: Available Spatial Data on Herring Reproduction, Spawning Grounds, and Larval Occurrences (from Frost and Diele, 2022). The Approximate Offshore Location of the Fish and Shellfish Ecology Study Area is Indicated by the Red Circle.

4.5.15 As stated in Section 3.3, site-specific PSA was conducted following the subtidal benthic survey, which allowed classification of the sediment types according to Reach *et al.* (2013) (see Table 4.13).

Table 4.13: Herring Potential Spawning Habitats Sediment Classification (Adapted from Reach et al. (2013))

Particle Contribution (Muds = clays and silts <63 µm)	Habitat Sediment Classification (Adapted from Reach et al. (2013))	Habitat Sediment Preference (Adapted from Reach et al. (2013))
<5% muds, >50% gravel	Prime	Preferred
<5% muds, >25% gravel	Sub-prime	Preferred
<5% muds, >10% gravel	Suitable	Marginal
>5% muds, <10% gravel	Unsuitable	Unsuitable

4.5.16 A total of 90 successful grab samples were collected, the PSA results indicate that the majority of grab sample sites comprised of sediments unsuitable for herring spawning (n = 80 samples; 88.8% of total grab samples) (Figure 4.34). Of the total successful grab samples, 37 samples (46.3% of the total grab samples) had mud compositions that were too high, with an average of 12.8% mud content. Grab samples with too low a gravel content totalled 43 samples (53.8% of the total grab samples); these grab samples had an average of 2.8% gravel. These 80 samples were largely comprised of sand. Seven out of 90 samples were classified as suitable (therefore a marginal sediment habitat preference: Table 4.13), and two out of 90 samples were classified as sub-prime (therefore a preferred sediment habitat: Table 4.13). There was only one sample that met the Reach *et al.* (2013) classification of 'prime' (therefore a preferred sediment habitat: Table 4.13). These grab samples defined as preferred sediment habitat were within the Proposed Development's Array Area, see Figure 4.34 below.

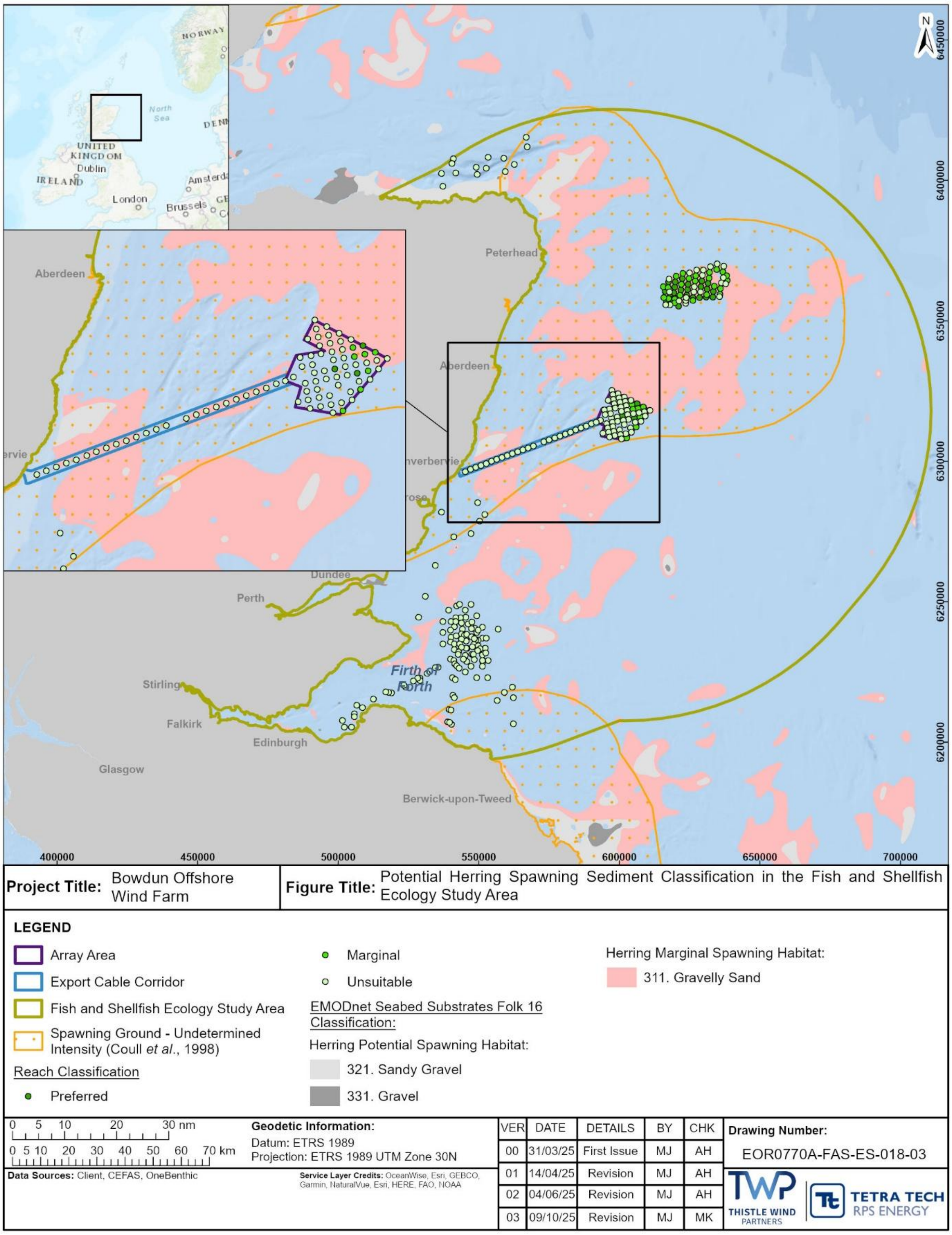


Figure 4.34: Potential Herring Spawning Sediment Classification in the Fish and Shellfish Ecology Study Area

4.5.17 As presented in Figure 4.34, the grab sampling sites which represented preferred or marginal spawning habitat suitability were located in the east of the Array Area. All sampling locations located along the Export Cable Corridor were classified as unsuitable spawning habitat, as were those in the west of the Array Area.

4.5.18 Figure 4.34 also presents PSA data available on the One Benthic Data Portal (Cefas, 2024c) to characterise the Fish and Shellfish Ecology Study Area further. These data were assessed using the same methodology as described for the site-specific grab samples. There were 237 available data points within the Fish and Shellfish Ecology Study Area on the One Benthic Data Portal (Cefas, 2024c) at the time of writing. These points were largely concentrated in the northern area of the Fish and Shellfish Ecology Study Area within the Turbot Bank MPA and were classified as mostly preferred and marginal spawning habitat, with fewer samples presenting unsuitable habitat. Samples south of the Site Boundary presented mostly unsuitable herring spawning habitat (Figure 4.34).

4.5.19 All of the preferred or marginal samples from site-specific surveys as well as from One Benthic Data Portal (Cefas, 2024c) intersect with areas of gravelly sand substrates (Folk 16 Classification from European Marine Observation and Data Network (EMODnet) (EMODnet (2024)), from the EMODnet broadscale seabed habitat map for Europe (EMODnet, 2024). It is worth noting that the EMODnet seabed substrate data is of lower resolution and accuracy than the results of the site-specific survey data, due to interpolation between known data points, but provides an overall broadscale picture of the surrounding substrate within the region.

4.5.20 These EMODnet seabed substrates fit the spawning suitability classifications from Reach *et al.* (2013), as well as the majority of site-specific grab samples showing that within the Site Boundary there is unsuitable substrates for herring spawning which supports the conclusion that there is herring spawning in the region, but within the majority of the Site Boundary there is low suitability for herring spawning habitat compared to the hotspot to the north.

Sandeel

4.5.21 During the night and winter months, sandeel bury in the sediments, and the high site fidelity that they present puts sandeel under potential threat of direct habitat loss (Jensen *et al.*, 2011; Latto *et al.*, 2013). Sandeel are therefore limited to areas of very specific sediment composition, where penetration into the sediment is possible.

4.5.22 Studies from both natural settings (Holland *et al.*, 2005) and laboratory (Wright *et al.*, 2000) have focussed on identifying the sediment characteristics most suitable for sandeel. Both studies reported similar results; sandeel preferred sediments with a high percentage of medium to coarse grained sand (particle size 0.25 mm to 2 mm) and avoided sediment containing >4% silt (particle size <0.063 mm) and >20% fine sand (particle size 0.063 mm to 0.25 mm). As the percentage of fine sand, coarse silt, medium silt and fine silt (particles <0.25 mm in diameter) increased, sandeel increasingly avoided the habitat (Holland *et al.*, 2005; Wright *et al.*, 2000). Conversely, as the percentage of coarse sand and medium sand (particles ranging from 0.25 mm to 2.0 mm) increased, sandeel showed an increased preference for this substrate (Holland *et al.*, 2005; Wright *et al.*, 2000).

4.5.23 Work by Greenstreet *et al.* (2010) drew on the research by Holland *et al.* (2005) to define four sandeel sediment preference categories, using hydro-acoustic seabed surveys and nocturnal grab surveys. Greenstreet *et al.* (2010) merged fine sand, three silt grades and two coarser sand grades, to define two particle size classes, 'silt and fine sand' and 'coarse sand', and then examined the combined effect of these two size grades of sediment particles on the percentage of grab samples with sandeel present. This was built upon by Latto *et al.* (2013), along with that described above by Wright *et al.* (2000) to produce four sandeel sediment preference categories, which were defined as: Prime, Sub-prime, Suitable and Unsuitable (refer to Table 4.14). To align with the Folk (1954) categories presented within the EUSeaMap seabed substrates layer, shown in Figure 4.35, these categories have been presented as preferred (prime and sub-prime), marginal (suitable) and unsuitable substrate classifications, taken from Latto *et al.* (2013) (Table 4.14).

Table 4.14: Sandeel Potential Habitat Sediment Classification (Adapted from Latto *et al.* (2013))

Particle Contribution (Muds = clays and silts <63 µm)	Habitat Sediment Classification (Adapted from Latto et al. (2013))	Habitat Sediment Preference (Adapted from Latto et al. (2013))
<1% muds, >85% sand	Prime	Preferred
<4% muds, >70% sand	Sub-prime	Preferred
<10% muds, >50% sand	Suitable	Marginal
>10% muds, <50% sand	Unsuitable	Unsuitable

4.5.24 Of the 90 successful grab samples collected, the PSA results indicate that just under half of the grab sample sites comprised sediments that were preferred for sandeel habitation, with the majority classified as sub-prime and therefore preferred habitat (n = 41 samples; 45.5% of total grab samples), closely followed by sediment classified as suitable (n = 34 samples; 37.7% of total grab samples), which is classified as a marginal sediment habitat preference (Table 4.14). The remainder of the results were classified as unsuitable for sandeel spawning (16.6% of total grab samples) which had an average of 23.8% mud. Higher mud content prevents sandeel from maintaining their burrows as the burrows are more likely to collapse and can also reduce respiration due to fine particulates clogging their gill tissues. There were no samples that met the Latto *et al.* (2013) classification of 'prime' (Table 4.14). As illustrated in Figure 4.35, the areas of gravelly sand from EMODnet (2024) are where preferred sediment samples were identified within the Site Boundary, with the site-specific grab samples showing that the samples classified as preferred are mostly located in the Array Area and the nearshore section of the Export Cable Corridor.

4.5.25 Figure 4.35 also presents PSA data available on the One Benthic Data Portal (Cefas, 2024c). To characterise the Fish and Shellfish Ecology Study Area further, this data was assessed using the same methodology as described above for the site-specific grab samples. There were 237 available data points within the Fish and Shellfish Ecology Study Area on the One Benthic Data Portal (Cefas, 2024c) at the time of writing. The majority of preferred sandeel habitat were largely concentrated within the Turbot Bank MPA (Figure 4.35).

4.5.26 Langton *et al.* (2021) more recently developed a predicted distribution model for sandeel, producing predicted density and probability of occurrence around the UK and Ireland. This modelling was undertaken based on the dependence of sandeel on particular habitat types, with the four main explanatory variables within the model being silt, depth, sand and slope, and was supported by sandeel fisheries data (e.g. data from Jensen *et al.* (2011)). Figure 4.36 presents the results from Langton *et al.* (2021) and highlights areas of importance for sandeel populations in the Fish and Shellfish Ecology Study Area and Northern North Sea. Based on Langton *et al.* (2021), a low probability of buried sandeel is present across most of the Fish and Shellfish Ecology Study Area, with probability increasing in the nearshore area of the Export Cable Corridor and a small section of the Array Area, and higher probabilities within the Moray Firth and the south of the Fish and Shellfish Ecology Study Area (Figure 4.36). The same trend can be seen in the predicted density of buried sandeel (Figure 4.36).

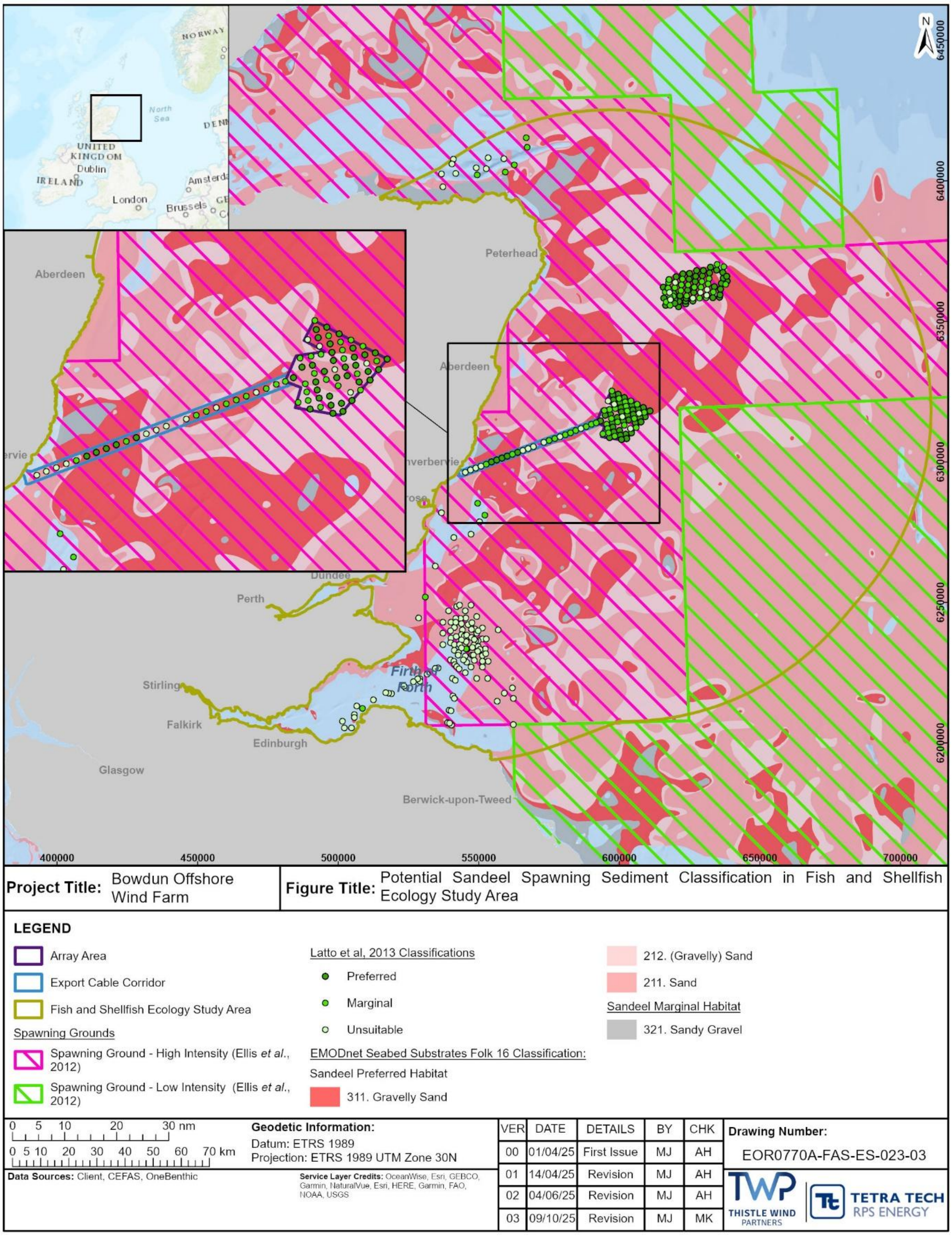


Figure 4.35: Potential Sandeel Habitat Classification within the Fish and Shellfish Ecology Study Area

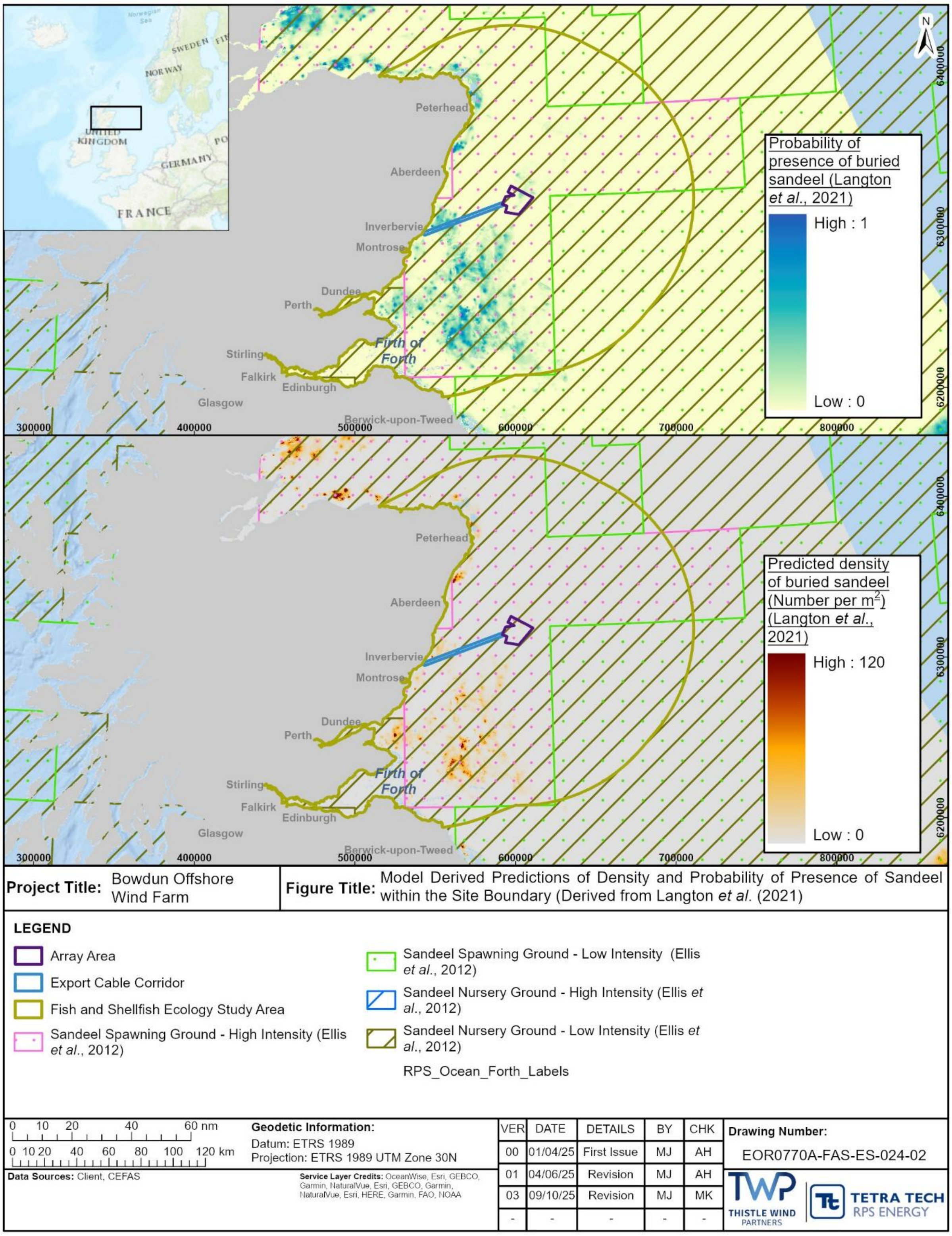


Figure 4.36: Model Derived Predictions of Density and Probability of Presence of Sandeel within the Site Boundary (Derived from Langton *et al.* (2021)

4.6 Designated Sites

4.6.1 There are five designated sites with fish and shellfish qualifying features within the Fish and Shellfish Ecology Study Area (Figure 4.37). These include one MPA and several SACs (Table 4.15). Atlantic salmon, sea lamprey, river lamprey and freshwater pearl mussel are listed as Annex II qualifying features under the Habitats Directive (Council Directive 92/43/EEC), which provides them with protection and ensures their populations and habitats are maintained or restored through the designation of a SAC. These species are listed as qualifying features of the four SACs within the Fish and Shellfish Ecology Study Area (Table 4.15). Further details on the assessments against the conversation objectives of each SAC and each qualifying feature is presented in the RIAA Part 2: Special Areas of Conservation (TWP-BOW-RPS-ENV-RPT-00014).

4.6.2 Although not within the Fish and Shellfish Ecology Study Area, the River Tweed SAC and River Spey SAC (Figure 4.37) have also been included here based on consultation during the Scoping Workshop on the 25 April 2024. The River Tweed SAC has been considered for Atlantic salmon, due to this species' potential for northward migration through the Fish and Shellfish Ecology Study Area (Table 4.15). The River Spey SAC has only been considered for Atlantic salmon (and freshwater pearl mussel based on their dependence on salmonids) due to this species' potential for eastward migration out of the Moray Firth and into the Fish and Shellfish Ecology Study Area.

4.6.3 There is one designated site for sandeel; the Turbot Bank MPA (Table 4.15). Further detail on the potential effects on relevant fish and shellfish features of MPAs has been presented in Volume 3, Technical Appendix 8.3: Marine Protected Area Assessment.

Table 4.15: Designated Sites within the Fish and Shellfish Ecology Study Area with Relevant Qualifying Features

Designated Site	Distance to Proposed Development Array Area (km)	Distance to Proposed Development Export Cable (km)	Relevant Qualifying Interest Feature(s)
River South Esk SAC	71.14	20.3	Annex II Atlantic salmon and freshwater pearl mussel
River Dee SAC	39.6	29.9	Annex II Atlantic salmon and freshwater pearl mussel
Turbot Bank MPA	35.8	46.9	Sandeel (Scottish PMF)
River Tay SAC	130.42	83.9	Annex II Atlantic salmon, freshwater pearl mussel, and river lamprey
River Teith SAC	206.74	169.4	Annex II Atlantic salmon, sea lamprey, and river lamprey
River Tweed SAC*	136.8	120.9	Annex II Atlantic salmon

Designated Site	Distance to Proposed Development Array Area (km)	Distance to Proposed Development Export Cable (km)	Relevant Qualifying Interest Feature(s)
River Spey SAC*	147.9	155.4	Annex II Atlantic salmon and freshwater pearl mussel

*Note that although these designated sites are outside of the Fish and Shellfish Ecology Study Area the relevant species have been included (see Paragraph 4.6.2).

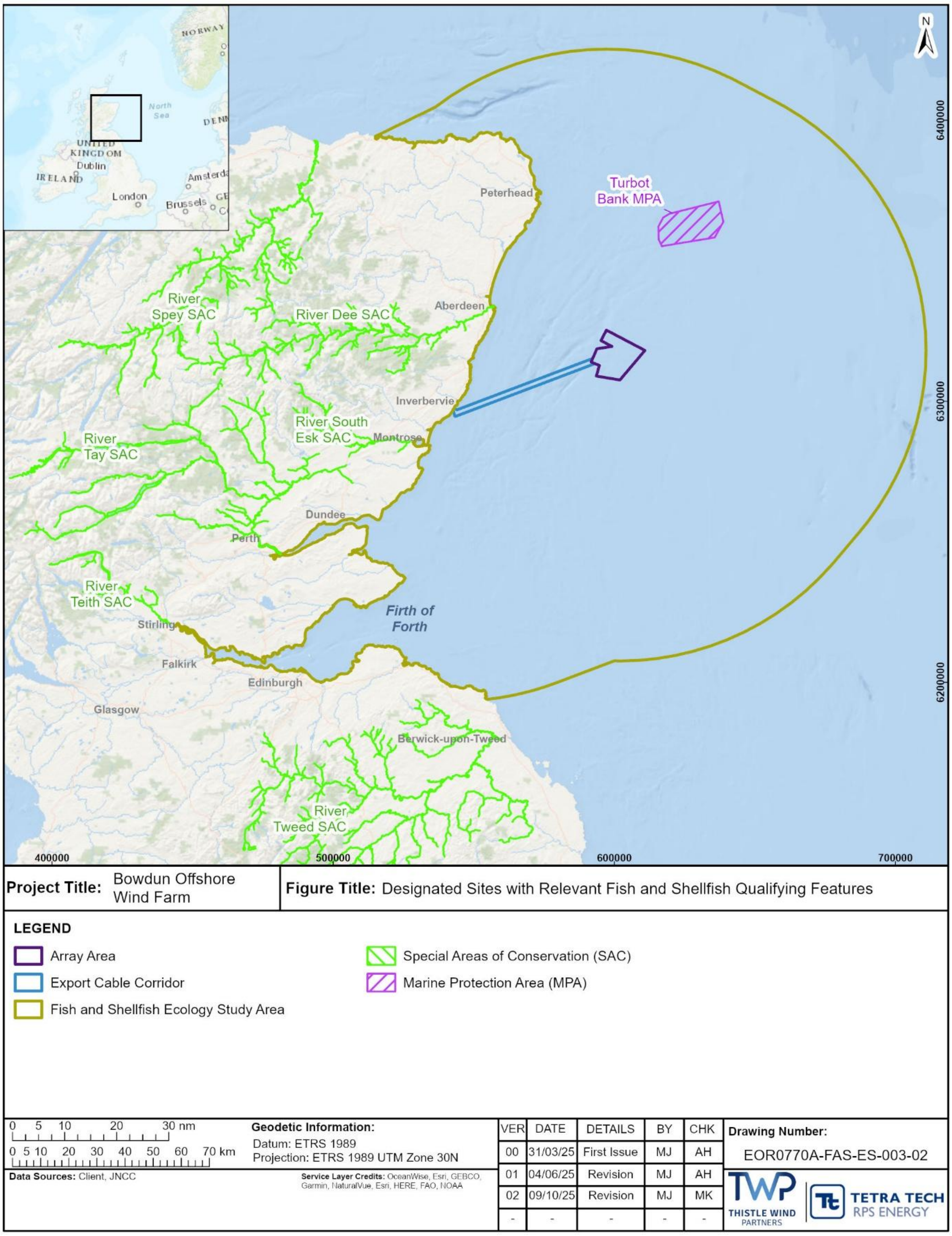


Figure 4.37: Designated Sites with Relevant Fish and Shellfish Qualifying Features

5 Summary

5.1.1 The following sections provide an overview of the baseline characterisation for fish and shellfish ecology and detail the relevant Important Ecological Features (IEFs) to be taken forward for assessment within the Offshore EIA Report.

5.1 Overview of the Fish and Shellfish Ecology Study Area

5.1.1 The fish and shellfish assemblage within the Site Boundary and wider Fish and Shellfish Ecology Study Area is typical of the Northern North Sea. This has been confirmed through a detailed desktop review and also through the results of site-specific surveys for the Proposed Development and other OWF projects within the vicinity. The fish and shellfish assemblage contains a mix of marine fish (e.g. teleosts and elasmobranchs), diadromous fish, and shellfish, which have been described in detail.

5.1.2 The marine fish assemblage included a range of gadoids, flatfish, pelagic schooling species, and elasmobranchs, although this is not exhaustive. The conservation importance of these species has been discussed and considered to determine their inclusion as IEFs in the Offshore EIA Report (Section 5.2). Seven species of diadromous fish were identified as having the potential to be present within the Fish and Shellfish Ecology Study Area and were all deemed as potentially present within the Site Boundary as a precaution. The conservation importance of these diadromous species was also discussed. Shellfish species identified include: common whelk, various crabs, European lobster and Norway lobster, king scallop, and cephalopods, which are all targeted by commercial fisheries in the locality.

5.1.3 There are spawning and nursery grounds for many species within the Fish and Shellfish Ecology Study Area, with some overlapping with the Site Boundary. Spawning grounds for herring and sandeel were researched further using the PSA data collected during the site-specific benthic subtidal ecology survey. For herring, there are spawning stocks around Buchan, which is in the north of the Fish and Shellfish Ecology Study Area. The site-specific PSA data supports very low proportions of the Site Boundary being suitable herring spawning grounds (as per Reach *et al.* (2013)), with only ten out of 90 sites sampled fitting the criteria for either preferred or marginal habitat. However, for sandeel, the PSA results indicated that 75 out of 90 sample sites had either marginal or preferred habitat suitability, as per Latto *et al.* (2013).

5.2 Important Ecological Features

5.2.1 IEFs are important habitats, species and ecosystems, potentially impacted by the Proposed Development. Fish and shellfish ecology IEFs have been defined using the Chartered Institute for Ecology and Environmental Management (CIEEM) 2022 guidance. IEFs have been attributed to individual species (such as plaice) or species groups (such as ‘other flatfish species’). IEFs are then assigned an importance value based on their commercial, ecological or conservation (PMFs, SAC features, etc.) importance. The criteria used for determining the value of IEFs are provided in Table 5.1. Based on these criteria, the fish and shellfish ecology IEFs are presented in Table 5.2 alongside the justification behind their defined value (based upon Table 5.1).

Table 5.1: Criteria Used to Define the IEFs for Fish and Shellfish Ecology

Value	Defining Criteria
International	• Species protected under international law that are listed as a qualifying feature of an internationally designated site within the Fish and Shellfish Ecology Study Area (e.g. Annex II species); • Species listed under Appendix I and II of the Bonn Convention; • Species listed under Annex II (strictly protected fauna) or Annex III (protected fauna) of the Bern Convention; and • Species listed under Appendices of CITES.
National	• Species protected under national law (e.g. SPIs listed on the SBL, species listed as qualifying features of MPAs, Wildlife and Countryside Act 1981); • PMF species; • Species listed on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea that have nationally important populations within the Fish and Shellfish Ecology Study Area; • Species listed on the IUCN Red List as 'vulnerable' or higher that have nationally important populations within the Fish and Shellfish Ecology Study Area; and • Species that have spawning and/or nursery areas within or in the immediate vicinity of the Site Boundary that are nationally important (e.g. may be primary spawning/nursery areas for that species).
Regional	• Species that provide key prey items for other species of conservation value (e.g. forage fish); • Species listed on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea that have regionally important populations within the Fish and Shellfish Ecology Study Area; • Species listed on the IUCN Red List as 'vulnerable' or higher that have regionally important populations within the Fish and Shellfish Ecology Study Area; and • Species with spawning and/or nursery areas within the Fish and Shellfish Ecology Study Area which are important regionally (i.e. they may spawn elsewhere, but these are key spawning/nursery areas).
Local	• Species which are not protected under any conservation legislation and may be common in UK waters but form a key component of

Value	Defining Criteria
	the biodiversity within the Fish and Shellfish Ecology Study Area; and • Species with spawning and/or nursery grounds within the Fish and Shellfish Ecology Study Area.

Table 5.2: Fish and Shellfish Ecology IEFs to be Taken Forward for Assessment in the Offshore EIA Report

IEF	Value	Justification
Marine Fish: Teleosts		
Anglerfish	National	Scottish PMF. There are also low intensity nursery grounds for anglerfish overlapping with the Site Boundary.
Atlantic bluefin tuna	National	OSPAR List of Threatened and/or Declining Species and are listed as a SPI on the SBL.
Blue whiting	National	Scottish PMF and listed as a SPI on the SBL. There are low intensity nursery grounds for blue whiting overlapping with the Site Boundary.
Cod	National	OSPAR List of Threatened and/or Declining Species, Scottish PMF and listed as a SPI on the SBL. There are also low intensity spawning and high intensity nursery grounds within the Fish and Shellfish Ecology Study Area and in the immediate vicinity of the Site Boundary.
European hake	National	Listed as a SPI on the SBL. There are low intensity nursery grounds for European hake overlapping with the Site Boundary.
Haddock	Regional	Haddock have high intensity and low intensity nursery areas within the Fish and Shellfish Ecology Study Area and with high intensity nursery areas in the immediate vicinity of the Site Boundary.
Herring	National	Scottish PMF, listed as a SPI on the SBL, and has high intensity nursery grounds overlapping the majority of the Project Development with spawning grounds in the immediate vicinity of the site boundary (around Buchan) which are nationally important. Further, herring are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds).

IEF	Value	Justification
Horse mackerel	National	Scottish PMF. Further, horse mackerel are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds). There are nursery grounds for horse mackerel overlapping with the Site Boundary.
Lemon sole	Regional	Lemon sole spawning and nursery areas have been identified within the Fish and Shellfish Ecology study Area, which also overlap with the site boundary. These are of undetermined intensity, so it is not determined if these are important regionally. As a precaution, lemon sole have been concluded to have 'regional' importance.
Ling	National	Scottish PMF and listed as a SPI on the SBL. There are also low intensity nursery grounds for ling overlapping with the Site Boundary.
Mackerel	National	Scottish PMF and listed as a SPI on the SBL. There are also low intensity nursery grounds for mackerel overlapping with the site boundary. Further, mackerel are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds).
Norway pout	National	Scottish PMF and listed as a SPI on the SBL. There are nursery and low intensity spawning grounds for Norway pout within the Fish and Shellfish Ecology Study Area with a minor overlap with the Site Boundary.
Other flatfish species (common dab, long rough dab)	Local	These species are not protected under any conservation legislation and are typically common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Plaice	National	Listed as a SPI on the SBL. There are spawning and nursery grounds for plaice within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary.

IEF	Value	Justification
Poor cod	Local	This species is not protected under any conservation legislation and is typically common in UK waters but forms a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Saithe	National	Scottish PMF. There are also nursery grounds for saithe overlapping with the Site Boundary.
Sandeel species	National	Scottish PMF, listed as a SPI on the SBL, and a feature of an MPA within the Fish and Shellfish Ecology Study Area. Further, sandeels are key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds). There are also high intensity spawning and low intensity nursery grounds for sandeel overlapping with site boundary, and the PSA results suggest that this area could largely be preferred spawning habitat substrate.
Sole	National	Listed as a SPI on the SBL.
Sprat	Regional	Sprat have spawning and nursery areas within the Fish and Shellfish Ecology study Area that overlap with the site boundary. These may be important regionally. Further, sprat are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds).
Whiting	National	Scottish PMF and listed as a SPI on the SBL. There are low intensity spawning grounds and high intensity nursery grounds overlapping with the Site Boundary.
	Marine Fish: Elasmobranchs	
Basking shark	International	Listed under Appendix II of the Bern Convention, under the Bonn Convention, and CITES. Basking shark are also protected under the Wildlife and Countryside Act 1981 and listed on the OSPAR List and SBL. This species is also a Scottish PMF. Basking shark has an IUCN Status of 'Endangered'.
Blue shark	International	Listed under Appendix III of the Bern Convention and under the Bonn Convention. Blue shark are also listed on the OSPAR List and the SBL, and have an IUCN status of 'Near Threatened'.

IEF	Value	Justification
Common skate	National	Listed on the OSPAR List, the SBL, and as a Scottish PMF. Common skate also has an IUCN status of 'Critically Endangered'. There are also low intensity nursery grounds for this species overlapping with the Site Boundary.
Cuckoo ray	Local	Cuckoo ray are not protected under any conservation legislation and are common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Flapper skate	National	Flapper skate is listed as a SPI on the SBL and has an IUCN status of 'Critically Endangered'. Distribution models shows that there is a high suitability for presence of flapper skate and presence of egg cases recorded within the Fish and Shellfish Ecology Study Area. It should also be noted that the various other conservation designations for common skate could be extrapolated to flapper skate, as the two species have only recently been recognised as separate species.
Nursehound	Regional	Nursehound are not protected under any conservation legislation but are listed on the IUCN Red List as 'vulnerable' and likely have regionally important populations within the Fish and Shellfish Ecology Study Area.
Porbeagle shark	International	Listed under Appendix III of the Bern Convention, under the Bonn Convention, and CITES. Porbeagle shark are also listed on the OSPAR List and SBL. This species is also a Scottish PMF. Porbeagle shark has an IUCN Status of 'Critically Endangered'.
Small spotted catshark	Local	Small spotted catshark are not protected under any conservation legislation and are common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area, with egg cases being found within the Fish and Shellfish Study Area.

IEF	Value	Justification
Spotted ray	Regional	Spotted ray are listed on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea and likely have regionally important populations within the Fish and Shellfish Ecology Study Area. There are also low intensity nursery grounds for this species overlapping with the site boundary and egg cases have been found within the Fish and Shellfish Study Area.
Spurdog	International	Spurdog are protected under the Bonn Convention. Spurdog are also listed on the OSPAR List and SBL. This species is also a Scottish PMF. Spurdog has an IUCN Status of 'Vulnerable'. There are also low intensity nursery grounds for this species overlapping with the Site Boundary.
Thornback ray	National	Thornback ray are listed as a SPI on the SBL, and on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea. There are also low intensity nursery grounds for this species within the Fish and Shellfish Ecology Study Area.
Thorny skate	Local	Thorny skate are not protected under any conservation legislation and are common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area. This species is also listed as 'Vulnerable' on the IUCN Red List, but there are no nationally or regionally important or recognised populations within the Fish and Shellfish Ecology Study Area.
Tope shark	International	Tope shark are protected under the Bonn Convention. Spurdog are also listed as a SPI on the SBL. Spurdog has an IUCN Status of 'Critically Endangered'. There are also low intensity nursery grounds for this species overlapping with the Site Boundary.
Diadromous fish and associated species		

IEF	Value	Justification
Allis shad	International	Listed under Annex II of the Habitats Regulations but not as a qualifying feature of any SACs within the Fish and Shellfish Ecology Study Area, and under Appendix III of the Bern Convention. Allis shad are also protected under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and the Wildlife and Countryside Act 1981. This species is listed on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea and as a SPI on the SBL.
Atlantic salmon	International	Listed under Annex II of the Habitats Regulations and as a qualifying feature of SACs within the Fish and Shellfish Ecology Study Area. Atlantic salmon are also listed under Appendix III of the Bern Convention and under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. Atlantic salmon are also on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea and a PMF.
European eel	International	Listed under Appendix II of CITES and the Bonn Convention. European eel are also listed under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. European eel are also on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea and a PMF. This species has an IUCN status of 'Critically Endangered'.
River lamprey	International	Listed under Annex II of the Habitats Regulations but not as a qualifying feature of any SACs within the Fish and Shellfish Ecology Study Area. River lamprey are also listed under Appendix III of the Bern Convention and under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. River lamprey are also a PMF.

IEF	Value	Justification
Sea lamprey	International	Listed under Annex II of the Habitats Regulations and as a qualifying feature of SACs within the Fish and Shellfish Ecology Study Area. Sea lamprey are also listed under Appendix III of the Bern Convention and under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. Sea lamprey are on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea and are also a PMF.
Sea trout	National	Sea trout are protected under national legislation: the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. Sea trout are also a PMF.
Twaite shad	International	Listed under Annex II of the Habitats Regulations but not as a qualifying feature of any SACs within the Fish and Shellfish Ecology Study Area. Listed under Appendix III of the Bern Convention. Twaite shad is also protected under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and the Wildlife and Countryside Act 1981. This species is also listed as a SPI on the SBL.
Freshwater pearl mussel	International	Listed under Annex II of the Habitats Regulations and as a qualifying feature of SACs within the Fish and Shellfish Ecology Study Area. Freshwater pearl mussel are also listed under Appendix III of the Bern Convention and under the Wildlife and Countryside Act 1981. Freshwater pearl mussel are also listed as a SPI on the SBL. This species has an IUCN status of 'Critically Endangered'.
Shellfish		
Common whelk	Local	Common whelk are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.

IEF	Value	Justification
Crabs	Local	The crab species described in the shellfish baseline are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Lobsters	Local	The lobster species described in the shellfish baseline are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area. Norway lobster also has spawning and nursery grounds within the Fish and Shellfish Ecology Study Area.
King and queen scallop	Local	King and queen scallop are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Squid and octopi	Local	The squid and octopi species described in the shellfish baseline are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.

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