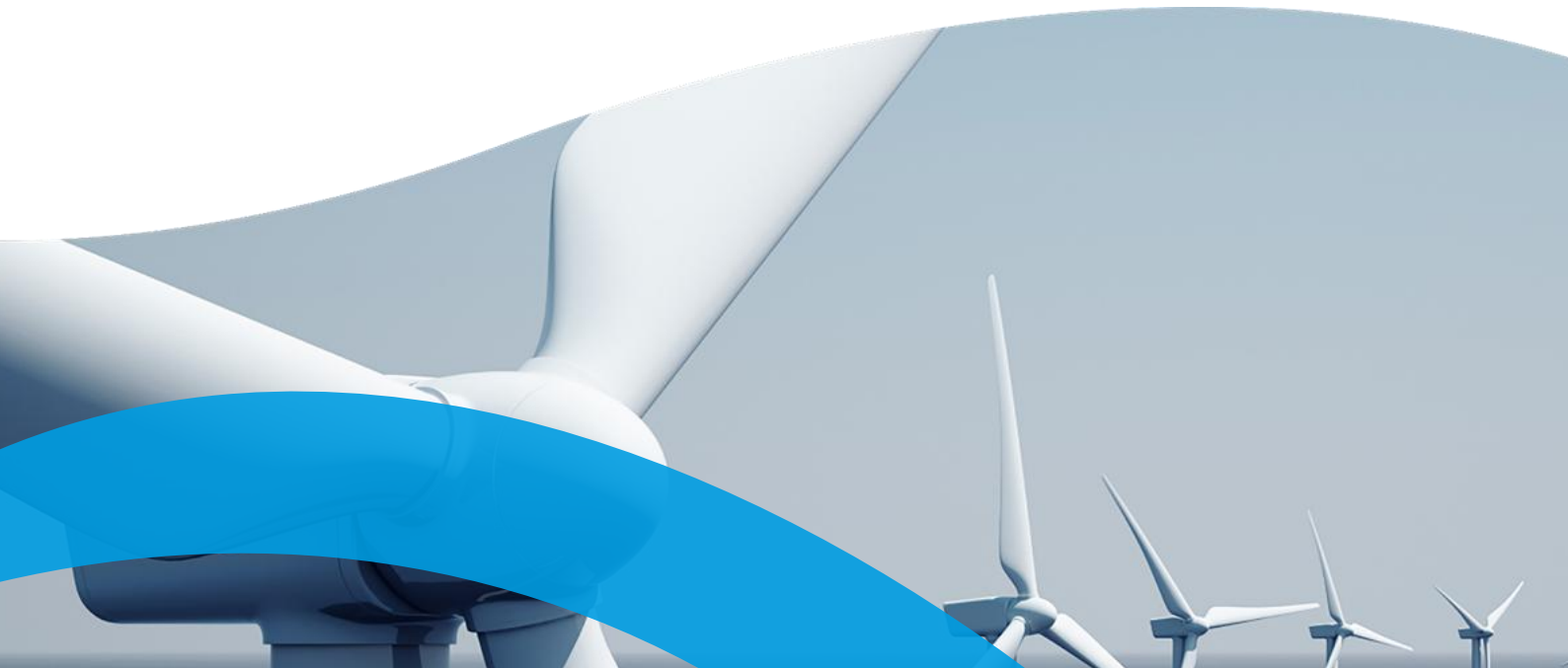
Muir Mhòr Offshore Wind Farm

Environmental Impact Assessment Report

Volume 3, Appendix 10.1: Fish and Shellfish Technical Report



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Glossary

Term	Definition
Array Area	The area in which the generation infrastructure (including Wind Turbine Generators and associated foundations, and inter-array cables) and Offshore Electrical Platform(s), and interconnector cable will be located.
Baseline	The status of the environment at the time of assessment without the development in place.
Demersal	Relating to the seabed and area close to it. Demersal spawning species are those which deposit eggs onto the seabed.
Developer	Muir Mhòr Offshore Wind Farm Limited
Elasmobranch	Cartilaginous fishes such as sharks, rays, and skates.
Fish larvae	The developmental stage of fish which have hatched from the egg and receive nutrients from the yolk sac until the yolk is completely absorbed.
Floating Foundations	The floating structures on which the Wind Turbine Generators are installed.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Inter-array cables	Cables which link the Wind Turbine Generators to each other and the Offshore Electrical Platform(s).
Interconnector cable	Cable which links the Offshore Electrical Platform(s) to one another, allowing for power to be transferred between the platforms.
Landfall	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS) where the offshore export cables are brought onshore.
Offshore Electrical Platform (OEP)	Offshore platform consisting of High Voltage Alternative Current (HVAC) equipment, details depending on the final set up of the Project.
Offshore Export Cable Corridor (ECC)	The area within which the offshore export cables will be installed.
Offshore export cables	The subsea electricity cable circuits running from the Offshore Electrical Platform(s) to the landfall which will transmit the electricity generated by the offshore wind farm to the onshore export cables for transmission onwards to the onshore substation and the national electrical transmission system along with auxiliary cables such as fibre optic cables.
Pelagic	Any part of the water column (i.e., the sea from surface to bottom sediments) that is not close to the seabed. Pelagic spawning species release their eggs into the upper layers of the sea.
Project	Muir Mhòr Offshore Wind Farm – comprises the wind farm and all associated offshore and onshore components.
Proposed Development	The offshore Muir Mhòr Offshore Wind Farm project elements to which this Offshore EIA Report relates.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
Spawning	The release or deposition of eggs and sperm, usually into water, by aquatic

Term	Definition
	animals
Study Area	Area(s) within which environmental impact may occur – to be defined on a receptor-by-receptor basis by the relevant technical specialist.
Wind Turbine Generator (WTG)	The wind turbines that generate electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment.

Acronyms

Term	Definition
BAP	Biodiversity Action Plan
BGS	British Geological Survey
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CIEEM	Chartered Institute of Ecology and Environmental Management
DDV	Drop Down Video
ECC	Export Cable Corridor
eDNA	Environmental DNA
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Reports
EMF	Electromagnetic Fields
EMODnet	European Marine Observation and Data Network
EUNIS	European Nature Information System
FeAST	Feature activity sensitivity tool
FOCI	Features of Conservation Interest
GPS	Global Positioning System
G	Gravel
gS	Gravelly sand
IBTS	International Bottom Trawl Survey
ICES	The International Council for the Exploration of the Sea
IHLS	International Herring Larval Survey
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MBES	Multi-Beam Echo Sounder
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MPA	Marine Protected Area
NCMPA	Nature Conservation Marine Protected Area
NEPS	National Electrofishing Programme for Scotland
NERC	Natural Environment and Rural Communities
NMPi	National Marine Plan Interactive
OEP	Offshore Energy Platform

Term	Definition
ORJIP	Offshore Renewable Joint Industry Project
OSPAR	Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic)
OWF	Offshore Wind Farm
PSA	Particle Size Analysis
PMF	Priority Marine Features
S	Sand
sG	Sandy gravel
SAC	Special Area of Conservation
SBP	Sub-Bottom Profiler
SSS	Side Scan Sonar
UHRS	Ultra-High Resolution Seismic
UK	United Kingdom
UWN	Underwater Noise
VER	Valued Ecological Receptor
VMS	Vessel Monitoring System
WTG	Wind Turbine Generator
ZoI	Zone of Influence

1. INTRODUCTION

1.1. BACKGROUND

1.1.1. Muir Mhòr Offshore Wind Farm Limited (hereafter referred to as 'the Developer') is proposing to develop the Muir Mhòr Offshore Wind Farm (hereafter 'the Project'). The Project is made up of both offshore and onshore components. The subject of this offshore Environmental Impact Assessment Report (EIAR) is the offshore infrastructure of the Project seaward of Mean High-Water Springs (MHWS) which is hereafter referred to as 'the Proposed Development'.

1.1.2. The Muir Mhòr Array Area covers an area of approximately 200 km^2 and is located approximately 63 km east of Peterhead on the east coast of Scotland. The offshore infrastructure of the Proposed Development includes Wind Turbine Generators (WTGs) and associated floating foundations, the Offshore Electrical Platform(s) (OEP(s)) and associated foundations, the inter-array cables, interconnector cable, offshore export cables and landfall.

1.1.3. GoBe Consultants Limited was commissioned by the Developer to produce this technical report to present the fish and shellfish ecology baseline characterisation for the Proposed Development. Specifically, this technical report details the baseline for fish (both pelagic and demersal, including elasmobranch and diadromous species) and shellfish (molluscs and crustaceans) ecology in the vicinity of the Proposed Development as well as the wider surrounding area.

1.2. PURPOSE OF THIS DOCUMENT

1.2.1. The purpose of this report is to provide a contemporary and comprehensive analysis of site-specific and regional fish and shellfish ecology data within the study area defined for the Proposed Development.

1.2.2. The remainder of this document is structured in the following way:

- An overview of the scope and methodology including a description of the proposed study area and an outline of data sources used to inform the characterisation;
- A review of the baseline conditions of the Array Area and the offshore export cable corridor (ECC) and the wider surrounding area;
- Identification of fish and shellfish Valued Ecological Receptors (VERs) for the Proposed Development; and
- Conclusion.

1.2.3. It is important to note that this document accompanies Volume 2, Chapter 10 (Fish and Shellfish Ecology) and should be read in conjunction with:

- Volume 2, Chapter 7 (Marine and Coastal Processes);
- Volume 3, Appendix 7.1 (Marine and Coastal Processes Technical Report);
- Volume 3, Appendix 7.2 (Marine Processes Modelling Report);
- Volume 2, Chapter 9 (Benthic Subtidal and Intertidal Ecology);
- Volume 3, Appendix 9.1 (Offshore Baseline Survey Reports);
- Volume 2, Chapter 13 (Commercial Fisheries); and
- Volume 3, Appendix 13.1 (Commercial Fisheries Technical Report).

2. SCOPE AND METHODOLOGY

2.1. OVERVIEW

2.1.1. This report presents a baseline characterisation of the current fish and shellfish environment. It encompasses the results of a desktop study that compiles regional datasets, as well as industry-specific monitoring and EIARs conducted for several offshore wind farms in the vicinity of the Proposed Development. Additionally, the report incorporates site-specific data from the Proposed Development Array Area and offshore ECC.

2.1.2. The following aspects are considered, where appropriate, for fish and shellfish in the area:

- Spawning grounds;
- Nursery grounds;
- Overwintering areas for crustaceans;
- Feeding grounds;
- Species of commercial importance;
- Migratory species and migration routes;
- Species of conservation importance; and
- Designated sites of which fish and shellfish are a feature of importance.

2.2. FISH AND SHELLFISH STUDY AREAS

2.2.1. For the purposes of this report, the fish and shellfish study areas are presented in Figure 2-1 and have been defined at three spatial scales as follows:

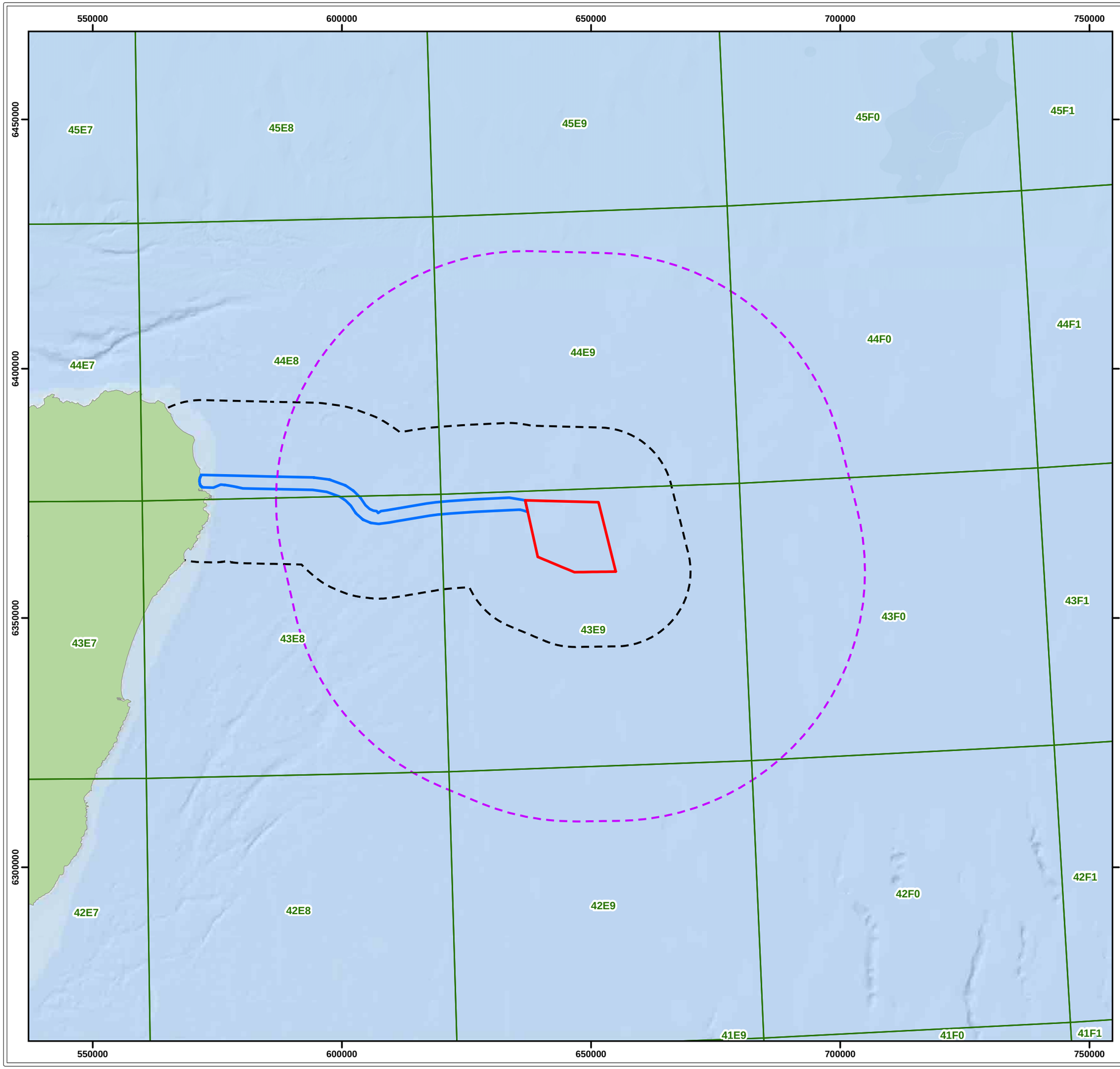
- For primary impacts, the study area comprises the footprint of the Array Area and offshore ECC of the Proposed Development, shown in Figure 2-1. The term "primary impacts" refers to the direct effects on fish and shellfish species within the Array Area and offshore ECC boundaries including factors such habitat disturbance and habitat loss.
- The term “secondary impacts” refers to the indirect effects on fish and shellfish that arise from changes to the physical environment, particularly increased suspended sediment and sediment deposition. For secondary impacts, a wider Zone of Influence (ZoI) has been used, encompassing the area over which suspended sediment might travel following disturbance as a result of the Proposed Development works. This secondary ZoI represents a buffer around the Proposed Development defined by the mean spring tidal excursion. This represents the expected maximum distance that suspended sediments may be transported on a mean spring tide in a flood and/or ebb direction, although most suspended sediments are expected to be deposited much closer to the disturbance activity. The tidal excursion distances surrounding the Array Area and the offshore ECC range from 12 to 15 km from the Proposed Development (see Volume 3, Appendix 7.1 (Marine and Coastal Processes Technical Baseline)). Therefore, as a precautionary measure, the secondary ZoI has been defined as a 15 km buffer from the Muir Mhòr Array Area and offshore ECC. The secondary ZoI is shown in Figure 2-1.
- The largest ZoI relates to underwater noise (UWN) from piling in the Array Area. Until recently, fish were assumed to flee the noise stimulus at a rate of 1.5 m/s, however, recent projects (Awel y Môr Offshore Wind Farm (OWF)), Sheringham Shoal and

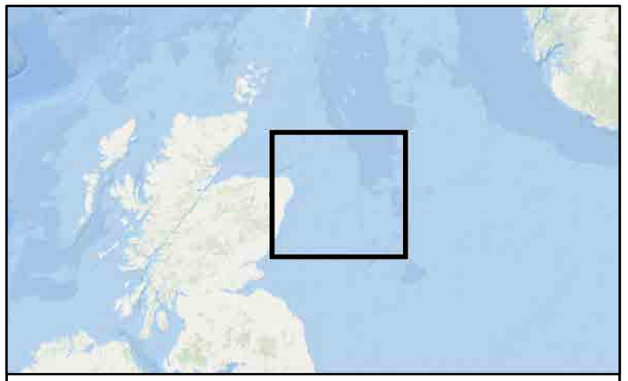
Dudgeon OWF Extension Projects, Hornsea Four OWF and Norfolk Boreas OWF) have been advised to also consider stationary receptor modelling for some species groups. The maximum impact ranges for both stationary (e.g., spawning Atlantic herring *Clupea harengus,* or spawning sandeel spp.) and fleeing receptors from recent OWF applications have been presented in Table 2-1 below. Taking the maximum impact ranges as informed by underwater noise modelling for recent OWF projects, a 50 km ZoI for underwater noise impacts is deemed suitably precautionary for the Proposed Development. The underwater noise ZoI is shown in Figure 2-1. The exact extents over which noise effects thresholds will be reached will also be determined though detailed underwater noise modelling. The 50 km ZoI for underwater noise will be reviewed during the assessment stage to determine if it is still an appropriate size and updated should a larger ZoI be required to.

Table 2-1 Maximum impact ranges for fleeing and stationary receptors from recent OWF applications

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

2.2.2. The species and habitats found throughout the study areas and the wider northern North Sea biogeographic region have been considered, as well as data available on the spawning and nursery grounds within these areas.





Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- ICES Statistical Rectangles

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Fish and Shellfish Ecology Study Area

Figure:	Drawing No:		
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Revision:	**Date:**	**Drawn:**	**Checked:**
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Map scale 1:750,000 @ A3

0 10 20 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM

A joint venture between Fred. Olsen Seawind & Vattenfall

2.3. DATA SOURCES

2.3.1. A detailed desktop review was carried out to establish the baseline of information available on fish and shellfish populations in the study areas for the Proposed Development. Information was sought on fish and shellfish ecology in general, and on spawning and nursery behaviour and habitats for key species. Species of commercial importance were identified through reference to Volume 3, Appendix 13.1 (Commercial Fisheries Technical Report).

2.3.2. Data to support the baseline characterisation of the study areas were extracted from the sources listed in Table 2-2 below. These data sources have been taken forward and used to inform the EIA, alongside additional site-specific data collected for the Proposed Development.

2.3.3. An environmental baseline survey was completed in 2023 in the Array Area and offshore ECC. This included a geophysical survey comprising the use of Multi-Beam Echo Sounder (MBES) bathymetry, Side Scan Sonar (SSS), Sub-Bottom Profiler (SBP) and Ultra-High Resolution Seismic (UHRS) and magnetometer (see Annex 1 of Volume 3, Appendix 9.1 (Offshore Baseline Survey Reports)), and environmental sampling (e.g., environmental DNA (eDNA) data collection, grab sampling, analyses of contaminants and particle sizes, as well as video and still photography) (see Volume 3, Appendix 9.1 (Offshore Environmental Baseline Survey Reports)). The survey results are used to support the baseline characterisation in this report.

Table 2-2 Key sources of fish and shellfish data

Data Source, Author, and Year	Summary	Coverage of Array Area and offshore ECC and associated study areas
Existing OWF Data		
Hywind Scotland Pilot Park: EIAR, Chapter 10: Fish and Shellfish Ecology (Statoil, 2015)	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	The Hywind Scotland OWF overlaps with the Muir Mhòr primary fish and shellfish study area.
Hywind Scotland Pilot OWF Benthic and Geophysical Survey Report (MMT, 2013)	Site-specific survey report characterising the benthic and geophysical environment of the Hywind Scotland Pilot OWF study area.	
Moray East OWF EIAR Technical Appendices – Fish and Shellfish Ecology Technical Report (Moray Offshore Renewables Limited, 2011)	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	The Moray East OWF lies approximately 50 km from the Muir Mhòr primary study area in the Moray Firth, with no direct overlap with the study areas. These data are used to provide information on the wider biogeographic region.
Moray East OWF EIAR Technical Appendices – Sandeel Survey Report (Moray Offshore Renewables Limited, 2012)	Site-specific survey report investigating and detailing the distribution of sandeels within the Moray East OWF area.	
Moray East OWF EIAR – Chapters 7.2 and 10.2: Fish and Shellfish Ecology (Moray Offshore Renewables Limited, 2011)	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	
Moray West OWF EIAR – Chapter 8: Fish and Shellfish Ecology (Moray OWF (West) Limited, 2018)	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	The Moray West OWF lies approximately 77 km from the Muir Mhòr primary study area in the Moray Firth, with no direct overlap with the study areas. These data are used to provide information on the wider biogeographic region.
Beatrice OWF EIAR – Annex 11A: Fish and Shellfish Ecology Technical Report (Beatrice OWF Ltd, 2012a)	Details the fish and shellfish ecology baseline for the Beatrice OWF development.	The Beatrice OWF lies approximately 84 km from the Muir Mhòr primary study area in the Moray Firth, with no direct overlap with the study areas. These data are used to provide information on the wider biogeographic region.
Beatrice OWF EIAR – Chapter 11: Fish and Shellfish Ecology (Beatrice OWF Ltd, 2012b)	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	
Beatrice OWF Farm Pre-Construction Baseline Sandeel Survey – Technical	Pre-construction monitoring reports describing the sandeel distributions within the Beatrice OWF area, through data	

Data Source, Author, and Year	Summary	Coverage of Array Area and offshore ECC and associated study areas
Report (Beatrice OWF Ltd, 2014)	collection (modified shellfish dredge).	
Beatrice OWF Farm Post-Construction Baseline Sandeel Survey – Technical Report (Beatrice OWF Ltd, 2021)	Post-construction monitoring reports describing the sandeel distributions within the Beatrice OWF area, through data collection (modified shellfish dredge).	
Beatrice OWF – Pre-Construction Cod (*Gadus morhua*) Spawning Survey – Technical Report (Beatrice OWF Ltd, 2015)	Pre-construction monitoring reports describing the degree of cod spawning activity throughout the Beatrice OWF area.	
Beatrice OWF – Post-Construction Cod (*G. Morhua*) Spawning Survey – Technical Report (Beatrice OWF Ltd, 2021)	Post-construction monitoring reports describing the degree of cod spawning activity throughout the Beatrice OWF area.	
Beatrice OWF Pre-Construction Baseline Herring Larval Surveys Summary Technical Report (Beatrice OWF Ltd, 2016)	Pre-construction monitoring report to form a baseline data set of herring larvae density within the Beatrice OWF area during spawning.	
Beatrice OWF – Atlantic Salmon Salmo Salar smolt movements survey (Beatrice OWF Ltd, 2017)	Survey on Atlantic Salmon (*S. Salar*) smolt movements in the Cromarty and Moray Firths.	
Publicly available datasets		
International Council for the Exploration of the Sea (ICES) North Sea International Bottom Trawl Survey (IBTS) (2019-2023) (ICES, 2023c)	Data of the species caught during a North Sea Bottom Trawl survey. Surveys cover the greater North Sea regions.	Full coverage of the fish and shellfish ecology study areas and across the northern North Sea.
ICES Offshore Beam Trawl Surveys (2019-2023) (ICES, 2023b)	Data of the species caught during a beam trawl survey. Surveys cover the greater North Sea regions.	
UK sea fisheries annual statistics reports (Marine Management Organisation (MMO), 2022)	Information on landings of the UK fishing fleet, and the status of commercial fish stocks.	
European Marine Observation and Data Network (EMODnet) broad scale seabed habitat map for Europe (EUSeaMap) (EMODnet, 2023)	EUSeaMap is a predictive habitat map covering the North Sea. Habitats are described in the European Nature Information System (EUNIS) 2019 classification system.	

Data Source, Author, and Year	Summary	Coverage of Array Area and offshore ECC and associated study areas
Fisheries datasets available from the National Marine Plan Interactive (NMPi)[1], including ScotMap data	An interactive map providing a data overview of the Scottish marine environment.	
British Geological Survey (BGS) Marine Sediment Particle Size Analysis (PSA) dataset sourced from the BGS GeoIndex Offshore portal[2]	National PSA dataset.	
The International Herring Larval Survey (IHLS) data (ICES), 2007-2023[3]	Herring larvae surveys were conducted across the North Sea and adjacent areas to provide quantitative estimates of herring larval abundance used as a relative index of changes in herring spawning stock biomass.	
IFISH (Integrated Fisheries System Holding) Database[4]	Fisheries data, including landings and fishing effort data.	
Centre for Environment, Fisheries and Aquaculture Science (Cefas) research publications and broad scale survey data[5]	Broadscale national trawl survey data.	
Boyle and New. (2018) Offshore Renewable Joint Industry Programme (ORJIP) Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options.	The study report presents a spatial analysis of the IHLS herring larval data collected over a ten-year period.	
North Sea fish spawning and nursery grounds (Coull *et al.*, 1988; Ellis *et al.*, 2012)	These studies map the distribution of North Sea fish and/ or shellfish species' spawning and nursery grounds using various survey data.	
Information on species of conservation	Species specific data, of native species of conservation	

[1] https://marinescotland.atkinsgeospatial.com/nmpi/

[2] https://mapapps2.bgs.ac.uk/geoindex_offshore/home.html?_ga=2.180987503.950258115.1631718927-1084102068.1631718927

[3] https://obis.org/dataset/94829f49-bab5-48a5-9a64-38425f8ec640

[4] https://data.cefas.co.uk/search/1/ifish

[5] https://data.cefas.co.uk/

Data Source, Author, and Year	Summary	Coverage of Array Area and offshore ECC and associated study areas
interest (Joint Nature Conservation Committee (JNCC), 2007)[6]	interest. This data source provides species specific data on native species of conservation interest.	
A verified distribution model for the lesser sandeel, (*Ammodytes marinus)* (Langton *et al.*, 2021)[7]	The model focuses on the distribution patterns of this specific species, providing valuable insights into its habitat and ecological preferences	
ICES Reports and Research Publications[8]	International research reports and publications.	Reports and publications to inform the assessment. No spatial coverage.
Feature Activity Sensitivity Tool (FeAST) (NatureScot, 2020)[9]	The FeAST tool by NatureScot is a web-based tool that assesses the sensitivity of marine features in Scotland's seas to human activities. It helps evaluate the impact of various activities on marine ecosystems, aiding conservation efforts, development planning, and regulatory decisions. The FeAST tool categorises sensitivity levels of marine features to support assessments required by the Marine (Scotland) Act and inform management strategies for Marine Protected Areas (MPA) and Priority Marine Features (PMF).	Reports and publications to inform the assessment. No spatial coverage.
Site-specific data		
Muir Mhòr Offshore Geophysical Survey (EGS, 2023a) - Annex 1 of Volume 3, Appendix 9.1 (Offshore Baseline Survey Reports)	EGS carried out geophysical surveys, providing detailed information on underwater topography, seabed features, geological layers, and sediment composition within the study area. These surveys collectively enabled a comprehensive characterisation of the geophysical environment, crucial for assessing habitat suitability and LSE on fish and shellfish ecology.	Full coverage of the primary fish and shellfish ecology study area.
Muir Mhòr Offshore Environmental Survey (EGS, 2023b) - Volume 3, Appendix 9.1 (Offshore Baseline Survey Reports)	EGS collaborated with Benthic Solutions Ltd (BSL) to assist in conducting an environmental survey focused on characterising the benthic environment in specific lots to identify habitats of conservation significance and gather	

[6] https://hub.jncc.gov.uk/assets/98fb6dab-13ae-470d-884b-7816afce42d4#UKBAP-priority-fish.pdf

[7] https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/Marine_Scotland_FishDAC_12377

[8] https://www.ices.dk/Science/publications/Pages/Scientific-reports.aspx

[9] https://www.nature.scot/professional-advice/protected-areas-and-species/priority-marine-features-scotlands-seas/feature-activity-sensitivity-tool-feast

Data Source, Author, and Year	Summary	Coverage of Array Area and offshore ECC and associated study areas
	baseline data. The survey utilised sediment grab samplers, high-resolution cameras, and water samplers for eDNA analysis. Sediment grab samplers were used, along with seabed video footage for habitat evaluation. Water samples collected for eDNA analysis provided valuable insights into fish and shellfish species diversity without disturbing their habitats directly. The high-resolution cameras also assisted in characterising the fish and shellfish assemblage by capturing visual data on species present within the study area.	

2.4. SURVEY METHODOLOGY

2.4.1. Site-specific environmental surveys were conducted in Array Area and offshore ECC in September 2023. These included a geophysical survey, an eDNA survey, sediment grab sampling, camera transects and the collection of Drop-Down Video (DDV) footage to inform the baseline for fish and shellfish ecology.

EDNA SURVEYS

2.4.2. An eDNA survey is a non-intrusive sampling technique utilised to detect species presence by analysing the DNA present in water and sediment samples. This method entails collecting eDNA (e.g., from excretions or secretions) rather than directly sampling the organism itself. In eDNA sampling, "reads" indicate the frequency of detecting a specific DNA sequence in a sample. Haplotype variation reflects the genetic diversity within a gene or DNA region. Analysing different haplotypes in a population helps to understand the genetic structure of fish species. This genetic information enables the estimation of population size by detecting haplotypes, offering crucial insights for assessing fish abundance and population dynamics. Haplotype variation serves as a valuable indicator of fish species abundance, the more distinct haplotypes detected, the more abundant the species is. For more details, see Volume 3, Appendix 9.1 (Offshore Baseline Survey Reports).

2.4.3. For both the Array Area and offshore ECC area, species assignment was undertaken to a minimum 50% confidence level, based on the similarity of a genetic sequence to library references for a particular species.

GRAB SAMPLING AND DROP-DOWN VIDEO TRANSECTS

2.4.4. The sampling strategy was designed to reflect habitats/changes of habitats identified through the interpretation of the acquired SSS/MBES data. Sampling density was increased in areas of greater habitat change and reduced in areas of suspected homogenous sediment. The Array Area and offshore ECC environmental sampling strategy plan consisted of 41 camera transects within the ECC, and 64 within the Array Area (50 were co-located with grab-sampling locations, and 14 were targeted suspected sediment boundaries or features of interest) ranging from between 40 m to 380 m in length. In terms of DDV locations, 30 were taken within the ECC and 48 in the Array Area. These sampling locations are shown in Figure 3-1.

IHLS DATA

2.4.5. IHLS data was downloaded from the ICES Eggs and Larvae data pages for the last twelve available years (2011-12 to 2023-24 data) for all larval size classes <11 mm, to provide an updated analysis of herring larvae distribution. The time range of data utilised provides an up-to-date proxy for the distribution of spawning activity, whilst also reducing any skewing of the data which could occur for data covering a shorter period of time. The data were categorised by spawning season (August and September for the Buchan/Shetland stock) (Table 3-2), imported into a database, where queries were run to extract the total amount of larvae per m^2 by spawning season, and as the whole ten-year dataset (with trawl replicates removed).

2.4.6. The query outputs were separate annual spawning season datasets, and a dataset for the full period (2007/08 – 2020/21) which contained single records for each trawl showing the total larvae per m^2 caught in the trawl. The data were then represented as point data on a map in ArcGIS, with each point retaining the larval counts per m^2; the data were then used to create heat maps in QGIS, reflecting this parameter. A radius of 50 km was used to allow sufficient overlap between the data points, so that the extrapolation of the heat maps covers the full IHLS survey area.

2.4.7. Rasters (a matrix of cells (or pixels) organised into rows and columns (or a grid) where each cell contains a value representing abundance information) produced were then categorised in ArcGIS, using the methodology summarised in Figure 2-2.

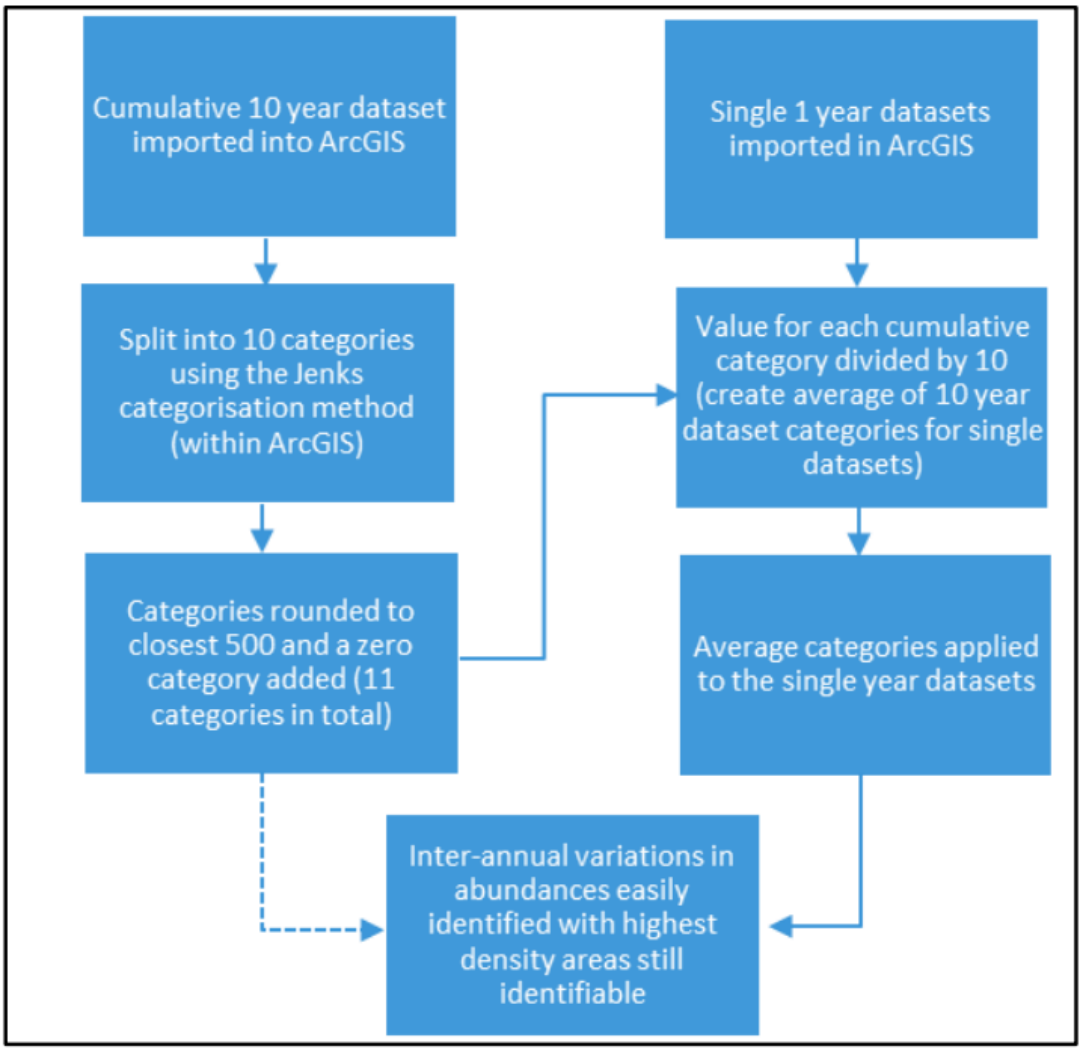


Figure 2-2 Data categorisation methodology (reproduced from Boyle and New (2018)).

2.4.8. The categorisation of the raster data in this way allows the comparison of relative abundance between the annual larvae abundances, and the determination of any variation in the relative importance of each spawning area in any one year.

2.4.9. The heat maps produced for this desktop study have taken the best available up to date data and present the herring larvae data to show 'hot spots' for particular stocks of herring within the study area, acting as proxy for the identification of the most important and active spawning grounds. The data have then been presented alongside the more broadscale Coull *et al.* (1998) fish sensitivity maps, that show historic and potential spawning sites and nursery areas. The results of this analysis are shown in Figure 3-11.

SPAWNING HABITAT SUITABILITY HEAT MAPS

2.4.10. Herring and sandeel are considered particularly sensitive to offshore developments due to their distinct reliance on specific seabed substrates for spawning. Herring require coarse, gravelly sediments where their eggs can adhere and develop, while sandeel prefer fine to medium sand substrates to burrow and deposit their eggs. As a result, the methodologies

described in the following paragraphs have been adopted in order to fully capture the potential presence of these species and their spawning grounds within the defined study areas.

HERRING

2.4.11. Areas of potential herring spawning habitat have been identified using site-specific PSA data collected as part of benthic characterisation surveys (Volume 3, Appendix 9.1 (Offshore Baseline Survey Reports)), and EMODnet 1:250,000 sediment maps, which show the distribution of sediment classes. These data have been classified in accordance with MarineSpace *et al.* (2013a) (adapted from Reach *et al.* (2013)) classifications as summarised in Table 2-3, for their suitability as herring spawning habitat based on substrate type, to further refine the understanding of areas of potential herring spawning habitat within the footprint of the Proposed Development.

Table 2-3 Herring habitat sediment classifications (Sources from MarineSpace et al. (2013a) (adapted from Reach et al. (2013))

Folk Class (Folk, 1954)	Fractional composition	Habitat sediment preference	Habitat sediment classification
Gravel and part sandy gravel	<5% muds, >50% gravel	Prime	Preferred
Part sandy gravel and part gravelly sand	<5% muds, >25% gravel	Sub-prime	Preferred
Part gravelly sand	< 5% muds, >10% gravel	Suitable	Marginal
Everything excluding gravel, part sandy gravel and part gravelly sand	>5% muds, <10% gravel	Unsuitable	Unsuitable

2.4.12. Following the MarineSpace *et al.*, (2013a) methodology, potential herring spawning substrates and active spawning areas have been further investigated through the overlap of data layers deemed to be indicative of herring spawning habitats and activity. These data have been presented spatially in Figure 3-12; where a greater number of data sources overlap, a higher 'heat' has been applied, which represents a higher confidence that the seabed may be suitable for spawning. These data utilised to construct the heat map are summarised in Table 2-4 alongside their representative confidence scores (based on a confidence assessment of the data).

Table 2-4 Confidence assessment for individual herring spawning data sources

Data Source	Data theme	Data notes	Confidence score	Justification of confidence score
EMODnet 1:250,000 seabed	Preferred sediment	Preferred sediment consists of Gravel (G) and sandy gravel (sG)	3	As detailed in Reach *et al.* (2013), herring are known to prefer G and sG substrates for

Data Source	Data theme	Data notes	Confidence score	Justification of confidence score
sediment maps	Marginal sediment	Marginal sediment consists of Gravelly sand (gS)	2	spawning; and have a marginal habitat sediment class of gS. The Folk sediment classification therefore provides a spatially variable indicator to spawning and hence the level of confidence is also variable (MarineSpace, 2013a).
IHLS (ICES, 2007-2020)	High number of small larvae (per m^2)	0-11 mm length of larva[10]. The highest number recorded over period 2007-2020 for each survey station. Score applied within contoured area.	5	Highest score assigned as it is a direct indicator of presence/absence of larvae at in the water column above the spawning habitat.
Identified historic spawning grounds (Coull *et al*, 1998)	Identified herring spawning grounds	Historic herring spawning grounds.	3	Whilst the Coull *et al.* (1998) layer has specifically been developed to show spawning grounds, the methods reported do not detail what types of data were used, lowering the confidence score assigned. In addition, this is a relatively old dataset.

2.4.1. The outputs of this heatmapping exercise are detailed in Section 3.3, and are presented in Figure 3-12.

SANDEEL

2.4.2. Areas of potential sandeel spawning habitat have been identified using site-specific PSA data collected as part of benthic characterisation surveys (Volume 3, Appendix 9.1 (Offshore Baseline Survey Reports)), and EMODnet 1:250,000 sediment maps, which show the distribution of sediment classes. These data have been in accordance with the MarineSpace *et al.* (2013b) classifications (adapted from Latto *et al.* (2013)) as summarised in Table 2-5, for their suitability as sandeel habitat based on substrate type, to further refine the understanding of areas of potential sandeel habitat within the footprint of the Proposed Development.

Table 2-5 Sandeel potential habitat sediment classifications (Sources from MarineSpace et al. (2013b) (adapted from Latto et al., 2013))

Folk Class (Folk 1954)	Fractional composition	Habitat sediment preference	Habitat sediment classification
Part s, part slightly gS and part gS	<1% muds, >85% sand	Prime	Preferred

[10] 0-11 mm larval length. Herring larvae of <10 mm size generally with yolk-sac still attached and associated with the benthos; or just post yolk-sac and liberating into the plankton.

Folk Class (Folk 1954)	Fractional composition	Habitat sediment preference	Habitat sediment classification
Part sG and part gS	<4% muds, >70% sand	Sub-prime	Preferred
Part gS and part sG	<10% muds, >50% sand	Suitable	Marginal
Everything excluding G, part sG and part gS	>10% muds, <50% sand	Unsuitable	Unsuitable

2.4.3. Following the method similar to that described by MarineSpace Ltd *et al.* (2013b), potential sandeel habitat has been further assessed through the overlap of data layers that are deemed indicative of sandeel presence. The greater the number of overlapping data layers then the greater the 'heat' mapped and the higher the confidence that the seabed may be suitable and sandeels are present. The data layers used and the scores they contribute to the heat map, based on a confidence assessment of the data are presented in Table 2-6.

Table 2-6 Confidence assessment for individual sandeel spawning data sources

Data Source	Data theme	Data notes	Confidence score	Justification of confidence score
EMODnet 1:250,000 seabed sediment maps	Preferred sediment	Preferred sediment consists of Sand (S) and gS.	3	As detailed in Latto *et al.* (2013), sandeel is known to prefer S and gS substrates for spawning; and also have a marginal habitat sediment class of sG. The Folk sediment classification therefore provides a spatially variable indicator to spawning and hence the level of confidence is also variable (MarineSpace, 2013b).
	Marginal sediment	Marginal sediment consists of sG.	2	
Sandeel fishing grounds (Jensen *et al.* 2011)	Sandeel Fishing Grounds	Mapping of sandeel habitat based on Global Positioning System (GPS) and Vessel Monitoring System (VMS) records of sandeel fishing vessels, and maps provided by fishers.	2	This dataset has been developed with the aim to identify sandeel fishing grounds. These data have therefore been used as a proxy for the presence of sandeel aggregations, lowering the confidence score assigned. In addition, this is a relatively old dataset.
Identified historic spawning grounds (Coull *et al*, 1998)	Identified herring spawning grounds	Historic herring spawning grounds.	3	Whilst the Coull *et al.* (1998) layer has specifically been developed to show spawning grounds, the methods reported do not detail what types of data were used, lowering the confidence score assigned. In addition, this is a relatively old dataset.

2.4.1. The outputs of this heatmapping exercise are detailed in Section 3.3, and are presented in Figure 3-16.

2.5. DATA LIMITATIONS

2.5.1. Mobile species, such as fish, exhibit varying spatial and temporal patterns. Surveys were conducted to provide a semi-seasonal description of the fish and shellfish assemblages in the vicinity of the Proposed Development. The data collected during these surveys represent snapshots of the fish and shellfish assemblage at the time of sampling, which may vary considerably, both seasonally and annually. Even if species are absent from these surveys, they are still included in the baseline characterisation, which draws upon wider scientific literature and available information to ensure a more comprehensive and precautionary baseline, identifying all likely present species within the study areas.

2.5.2. The efficiency of the surveys varies depending on the nature of the survey methods used and the species recorded. For example, a semi-pelagic otter trawl would not collect pelagic species (e.g., herring and sprat (*Sprattus sprattus*)) as efficiently as a pelagic trawl, and a 2-metre scientific beam trawl would not be as efficient at collecting sandeel and shellfish species as other methods used commercially in the study areas (e.g., sandeel or shrimp trawls and shellfish potting). This limits the data utility in capturing the relative abundances of species within the area. To minimise this limitation caused by survey methodology, sensitive receptors have been chosen based on their presence or absence in survey data, rather than whether that species contributes more significantly to the fish assemblage in the survey data.

2.5.3. Coull *et al.* (1988) and Ellis *et al.* (2012) are key references for providing broadscale overviews of the potential spatial extent of spawning grounds and the relative intensity and duration of spawning, both based on a collection of various data sources. Many of the conclusions drawn by Coull *et al.* (1988) are based on historic research and data do not necessarily account for more recent changes in fish distributions and spawning behaviour. Ellis *et al.* (2012) is also limited by the wide scale distribution of sampling sites used for the annual international larval survey data, consequently resulting in broadscale grids of spawning and nursery grounds. The spatial extent of the spawning grounds and the duration of spawning periods indicated in these studies are therefore considered likely to represent the maximum theoretical extent of the areas and periods within which spawning will occur. Spawning grounds may therefore be smaller in extent and display shorter spawning periods, and in some cases spawning grounds indicated by these sources may no longer be active. Where available, additional research publications and data have been drawn upon to provide the best, most contemporary and site-specific information. When considering demersal spawners which display substrate dependency (e.g., herring and sandeel), site-specific PSA and geophysical data have been used to ground truth the Coull *et al.* (1988) and Ellis *et al.* (2012) datasets.

2.5.4. Broadscale marine habitat data (EMODnet, 2023) have also been used to identify preferred sandeel and herring spawning habitats. It should be acknowledged that this dataset is somewhat limited by the broadscale nature of the data, as it does not account for small-scale, localised differences in seabed sediments, unlike these data obtained from site-specific grab sampling. In this case it is important to review all the datasets presented to develop a clear overview of preferred sandeel and herring habitats.

2.5.5. The site-specific PSA data has been used to ground truth the broadscale data from Coull *et al.*, (1988), Ellis *et al.*, (2012) and EMODnet, (2023). These data have been classified in accordance with the Latto *et al.*, (2013) and Reach *et al.*, (2013) classifications to identify areas of preferred spawning habitat for sandeel and herring, respectively. The use of PSA data and broadscale habitat mapping is intended to provide a proxy for the presence of spawning sandeel and herring in these locations (based on the suitability of habitats, i.e., the potential for spawning rather than actual contemporary spawning activity). Whilst grab

samples provide detailed information on the sediment types, they cannot cover wide swaths of the seabed and consequently only represent point samples. The PSA data are therefore interpreted in combination with additional PSA data across the study areas, sourced from the BGS (BGS, 2015), to provide the most comprehensive cover of the fish and shellfish study areas.

2.5.6. It is important to note, that although the data used in the characterisation of the fish and shellfish baseline conditions span a long time period, with some sources published over a decade ago, the information presented represents a long-term dataset. This allows for a detailed overview of the fish and shellfish assemblages in the study areas, drawing from historical data. The diversity and abundance of many species, particularly demersal fish species, is linked to habitat types, which have remained relatively constant in the study areas, indicating no major shift in the fish and shellfish communities over the time period of the data used in this report.

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

2.5.8. Recent studies suggest that eDNA has limitations in detecting elasmobranch and similar species that usually occupy the upper-level trophic position, as naturally their density is reduced compared to species occupying lower trophic levels (Merten Cruz *et al.*, 2023). Therefore, eDNA methods may not fully capture the diversity of elasmobranch species, leading to the underestimation of their presence (Ip *et al.*, 2021; Merten Cruz *et al.*, 2023). This is due to factors such as the lack of universal primers for comprehensive detection, and the need for multiple markers to minimise bias in eDNA results. Additionally, the use of eDNA metabarcoding is still subject to inherent biases and limitations, such as a lack of information on the spatial origin of eDNA and the size, age, or sex of the detected species.

2.5.9. Despite the data limitations detailed within this Section of the report, the data as included in Table 2-2 is considered a robust and sufficient evidence base to inform the fish and shellfish baseline characterisation and underpin the assessment process.

3. BASELINE CONDITIONS

3.1.1. The following Section describes the fish and shellfish communities present within the study areas (Figure 2-1). The baseline description draws on site-specific data collected within the Array Area and offshore ECC, regional datasets and industry specific accounts and monitoring studies undertaken for several of the existing or proposed OWFs in the northern North Sea region. This is structured as follows:

- Fish and Shellfish Assemblage;
- Spawning and Nursery Grounds;
- Species of Commercial Importance;
- Diadromous Species;
- Elasmobranchs; and
- Species of Conservation Importance and Designated Sites.

3.1.2. The datasets include both a snapshot of the current species composition across the northern North Sea and within the study areas, alongside long-term time series data (e.g., bottom trawl surveys), which show the species composition to have remained consistent, subject to natural variation over time. Therefore, the data presented are considered both spatially, and temporally appropriate for the purposes of undertaking an EIA.

3.2. FISH AND SHELLFISH ASSEMBLAGE

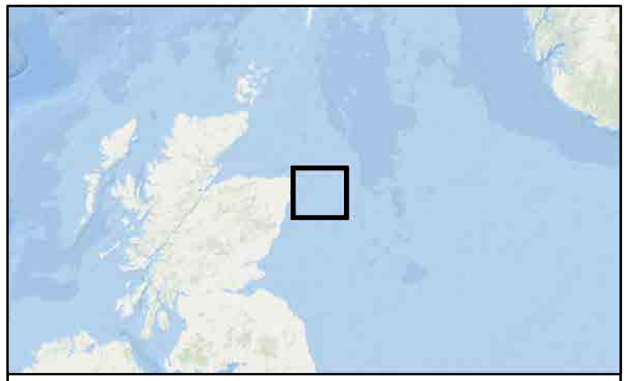
SITE-SPECIFIC SURVEYS

EDNA SURVEYS

3.2.1. Site-specific eDNA surveys were conducted in the Array Area and offshore ECC in September 2023. The methodology used to inform the following results is described in Section 2.4. From the samples collected in the Array Area, the most prevalent fish species was whiting (*Merluccius merluccius*), showcasing nine distinct haplotypes detected in seven out of the 27 samples and lesser sand eel appeared in low abundances, as depicted by haplotype data. In the offshore ECC, the most abundant fish species was the Atlantic herring, with 13 distinct haplotypes recorded in nine of the 19 samples. No invasive species were detected in the Array Area or the offshore ECC study area.

3.2.2. The total number of fish species observed at the different sampling locations is illustrated in Figure 3-1. The highest species richness in the Array Area is observed to the north-west, with up to 21 species detected. The number of fish species detected in the offshore ECC varied, with the highest richness observed in the central area, where up to 32 species were detected.

575000
600000
625000
650000
6400000
6375000
6350000



Legend:

- Array Area
- Offshore Export Cable Corridor
- Sampling Location

No. Species

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

Depth (m)

- 20
- 120

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Number of Fish Species per Sample

Figure: 3.1	Drawing No: GoBe-0104		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:300,000 @ A3

0 5 10 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM

A joint venture between Fred. Olsen Seawind & Vattenfall

3.2.3. The site-specific eDNA surveys identified the presence or absence of species of conservation importance within both the offshore ECC and the Array Area. This information is presented in Table 3-1.

Table 3-1 Presence/absence of fish species of conservation importance identified in the eDNA dataset.

Species Recorded	Array Area	Offshore ECC	Protection Status
Atlantic herring	✓	✓	Scottish Biodiversity List PMF Scotland
Whiting	✓	✓	Scottish Biodiversity List PMF Scotland
European hake *(Merluccius merluccius)*	✓	✓	Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic) (OSPAR) List of Threatened and Declining Species Scottish Biodiversity List
Brown trout	X	✓	Scottish Biodiversity List PMF Scotland
Atlantic mackerel	✓	✓	Scottish Biodiversity List PMF Scotland
Norway pout *(Trisopterus esmarkii)*	X	✓	Scottish Biodiversity List PMF Scotland
Lesser sandeel	✓	X	Scottish Biodiversity List PMF Scotland
Porbeagle (*Lamna nasus*)	X	✓	Species listed as a Feature of Conservation Interest (FOCI) OSPAR Threatened and/or Declining Species Scottish Biodiversity List PMF Scotland 'Vulnerable' – International Union for Conservation of Nature (IUCN) Red List
Starry smoothhound *(Mustelus asterias)*	X	✓	'Near Threatened' on the IUCN Red List

GRAB SAMPLING AND DROP-DOWN VIDEO (DDV) TRANSECTS

3.2.4. Sediment grab sampling and high-resolution DDV footage were taken across the offshore ECC and Array Area in September 2023 to aid the characterisation of fish and shellfish assemblage across the primary study area (sampling locations shown in Figure 3-1).

3.2.5. In the grab samples taken within the Array Area, one ocean quahog (*Arctica islandica*) siphon was recorded, and another observed in DDV footage. These findings indicate the presence of ocean quahog individuals, but there is no indication that they are widely distributed within the survey area. In the offshore ECC, no ocean quahog siphons were observed in the video transects, and no specimens were found in the grab samples. Queen scallops (*Aequipecten opercularis*) were observed in both the Array Area and offshore ECC through DDV.

3.2.6. In the Array Area, sandeels were only observed on a single camera transect and no sandeels were found in grab samples at any station. It should be noted that even optimal habitats may not be occupied by sandeels if populations are below the carrying capacity of the area (Holland *et al.*, 2005). Thornback ray was also recorded within the survey area through DDV.

OFFSHORE WIND DEVELOPMENT SURVEYS

3.2.7. The characterisation of the species assemblages found within the fish and shellfish ecology study areas has been completed by drawing upon work that was undertaken in support of various OWF projects in the vicinity of the Proposed Development as well as wider information from publicly available sources (Table 2-2), as the species and habitats found within these areas are likely to be broadly similar.

3.2.8. Hywind Scotland Pilot OWF is located approximately 35.6 km from the Muir Mhòr Array Area and overlaps with the offshore ECC. The Moray West OWF, Moray East OWF and the Beatrice OWF are located 85.5 km, 77.6 km, and 94.7 km, respectively, from the closest point of the Proposed Development.

3.2.9. The Hywind Scotland Pilot OWF EIAR (Statoil, 2015) described assemblages principally made up of the pelagic species, herring, Atlantic mackerel, and sprat. Demersal fish assemblages consisted of; lesser sandeel *(Ammodytes tobianus)*, cod, haddock, whiting, plaice, lemon sole (*Microstomus kitt*), anglerfish, ling *(Molva molva*), European hake *(Merluccius merluccius*), Norway pout and saithe (*Pollachius virens)* (Statoil, 2015).

3.2.10. As part of the Hywind Scotland Pilot OWF benthic survey (MMT, 2013), samples taken throughout the offshore ECC identified the presence of ocean quahog. The following shellfish species were also present within the project area (as informed by landings data); veined squid (*Loligo forbesi*), brown crab (*Pagurus cancer*), velvet crab (*Necora puber*), scallop (*Pecten maximus*), Norway lobster (*Nephrops norvegicus*, hereafter *Nephrops*) and European lobster (*Homarus gammarus*). Grab samples taken throughout the Hywind Scotland Pilot OWF offshore ECC also identified the presence of Raitt's sandeel (*Ammodytes marinus*) and lesser sandeel.

3.2.11. The Hywind Scotland Pilot OWF EIAR (Statoil, 2015) also described the following diadromous migratory species as having the potential to transit through the Hywind project area and surrounding area; Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), European eel (*Anguilla anguilla*), river lamprey (*Lampetra fluviatillis*) and sea lamprey (*Petromyzon marinus*), all of which are PMFs. In terms of elasmobranchs, The Hywind Scotland Pilot OWF EIAR (Statoil, 2015) described the presence of spotted ray, common skate (*Dipturus batis*), spurdog and tope shark (*Galeorhius galeus)* within the study area. A boat survey subcontracted to inform the Hywind Scotland Pilot EIAR, recorded no basking shark (*Cetorhinus maximus*) observations (NRP, 2015).

3.2.12. Epibenthic beam trawl surveys conducted in the Moray West OWF site between May and June 2017 (Moray OWF (West) Limited, 2018) revealed a species assemblage typical of this area of the northern North Sea. The fish community was largely characterised by demersal species recorded in abundance during surveys, including dragonet (*Callionymus lyra*), dab (*Limanda limanda*), plaice, lemon sole, pogge (*Agonus cataphractus*) and grey gurnard (*Eutrigla gurnardus*). Raitt's sandeel and lesser sandeel were also identified from these surveys. Typically, areas with higher diversity tended to be recorded in more heterogenous seabed habitats often present in these areas which included patches of coarser mixed sediment, gravels and stones/cobble and a similar trend was evident at both the Moray East and Beatrice OWF surveys (Beatrice OWF, 2012; Moray Offshore Renewables Limited, 2011). Other fish species recorded included anglerfish, Norwegian topknot (*Phrynorhombus norvegicus*) and sandeel (unspecified species).

3.2.13. Epibenthic beam trawl surveys conducted in the Moray West OWF site between May and June 2017 (Moray OWF (West) Limited, 2018) revealed a species of cuckoo ray (*Leucoraja naevus*) and lesser spotted dogfish, (Moray OWF (West) Limited, 2018)

3.2.14. Otter trawl surveys conducted in March 2021 to identify cod distributions across the Beatrice OWF site revealed haddock was the most abundant species accounting for the majority of the total by-catch, followed by whiting and squid, whilst cod abundance was relatively low (Beatrice OWF, 2021b).

3.2.15. Sandeel surveys were undertaken by both Moray East OWF and Beatrice OWF, in 2012 and 2014 respectively. Both surveys reported similar findings, indicating patchy sandeel distribution across the sites, with sandeel recorded in relatively low numbers and Raitt's sandeel being the most prevalent species (Beatrice OWF, 2014; Moray OWF Renewables Ltd, 2012). Post-construction monitoring at Beatrice OWF undertaken in 2021 reported significant increases in sandeel numbers when compared to the 2014 pre-construction surveys (Beatrice OWF, 2014; Beatrice OWF, 2021b). The Beatrice OWF post-construction survey consequently concluded that there was no indication that the construction of the Beatrice OWF resulted in negative impacts on the local sandeel population (Beatrice OWF, 2016b, 2021b).

3.2.16. Pre-construction herring larvae surveys were undertaken by Beatrice OWF Limited in 2014 and 2016 (Beatrice OWF, 2014; Beatrice OWF, 2016a), as well as for the Moray East OWF (Moray East OWF, 2019). The data collected across Beatrice OWF identified larvae in the north of the Beatrice OWF Array Area, with the larvae originating from well-established spawning grounds located around Orkney and Shetland, transported south with the tides and currents. Larval spatial distributions reported in the Moray East OWF identified lower larval densities in the vicinity of the Moray East array and offshore ECC compared to areas around Shetland and Orkney. The spatial distribution of herring larvae indicated the highest distributions were found north-east of the Moray East OWF Array Area. However, the smallest larvae were generally found to the south of the array and the largest were found to the north of the Moray East OWF Array Area (Moray OWF Renewables Ltd, 2012).

REGIONAL SURVEYS

3.2.17. Bottom trawl and beam trawl surveys were undertaken throughout the northern North Sea, from 2019 and 2023 as part of the North Sea IBTS and the North Sea Beam Trawl Surveys (ICES, 2023c). The trawl surveys identified assemblages consisting of haddock, whiting, herring, Norway pout (*Trisopterus esmarkii*), cod, Atlantic mackerel, plaice, anglerfish (*Lophiiformes*) and raitt's sandeel (*Ammodytes marinus*).

3.2.18. Various elasmobranch species are also known to be present in the Moray Firth area (Scottish Government, 2011). An extensive literature review by Ellis *et al.* (2004) found that elasmobranch populations identified within this region include spurdog (*Squalus acanthias*), lesser spotted dogfish (*Scyliorhinus canicular*), starry ray (*Amblyraja radiata*), cuckoo ray, Thornback ray and spotted ray (*Raja montagui*).

3.2.19. The FeAST Tool (NatureScot, 2020) is a web-based geographic information system (GIS) that provides detailed information on the natural environment and potential sensitivities for offshore development projects in Scotland. Information from this source on the northern North Sea indicates that ocean quahogs (a species listed as a Feature of Conservation Importance by the Scottish Government (2010)) have been impacted by beam trawls, with reports indicating around 20% mortality from a single pass of the gear. This activity has been linked to a decline in abundance in the south-eastern North Sea over the past century. In the northern North Sea, primarily fished by otter trawls, populations have not shown the same decline as in southern regions. While otter trawl doors may bring ocean quahogs to the surface, there is insufficient evidence to assess the overall mortality caused by this gear at a population level. The effects of shellfish dredging on ocean quahogs are likely similar to those of beam trawls due to similar physical impacts on seabed sediments. Static gears are less likely to impact this species due to their insensitivity to sub-surface abrasion. Despite vulnerability to trawling damage, ocean quahogs can repair shell cracks, with a medium tolerance level assigned considering potential damage and mortality, which is size-dependent with larger individuals more affected, warranting a medium recovery assessment.

3.3. SPAWNING & NURSERY GROUNDS

3.3.1. The spawning and nursery grounds of several fish and shellfish are known to be located within or in close proximity to the defined fish and shellfish study areas (Coull *et al.*, 1988; Ellis *et al.*, 2012). Spawning grounds for cod, sandeel, plaice, Norway pout, lemon sole, *Nephrops*, herring, sprat and whiting overlap with the study areas as well as extending over much of the North Sea (Figure 3-2, Figure 3-3 and Figure 3-4) (Coull *et al.*, 1988; Ellis *et al.*, 2012).

3.3.2. The study areas also overlap with low intensity spawning grounds for plaice, whiting and Norway pout (Coull *et al.*, 1988; Ellis *et al.*, 2012). As well as spawning grounds of undetermined intensity for lemon sole, *Nephrops* and sprat (Coull *et al.*, 1988; Ellis *et al.*, 2012).

3.3.3. The study areas are situated within a high intensity nursery ground for whiting (Figure 3-6) and low intensity nursery grounds for multiple species, including tope shark, spurdog, spotted ray, sandeel, plaice, anglerfish, blue whiting *(Micromesistius poutassou*), saithe, ling, mackerel and European hake (Figure 3-7, Figure 3-8 and Figure 3-9) (Coull *et al.*, 1988; Ellis *et al.*, 2012). Other species nursery grounds present across the study areas include lemon sole, haddock, *Nephrops*, Norway pout, saithe, and sprat (Coull *et al.*, 1988; Ellis *et al.*, 2012).

3.3.4. The study areas overlap with a low intensity cod spawning predominantly occurring in winter months (Coull *et al.*, 1988; Ellis *et al.*, 2012). Cod are of particular importance due to their sensitivity to noise (cod possess a swim bladder which is involved in hearing (Popper *et al.*, 2014)). Cod spawning surveys were conducted across the Moray East OWF in 2013 (Brown and May Marine, 2013) and more recently otter trawl surveys were conducted for pre- and post-construction monitoring of the Beatrice OWF (Beatrice OWF, 2015, 2021a). Results from these surveys found spawning cod densities to be very low across the sites. The study areas also overlap with a low intensity nursery ground for cod (Coull *et al.*, 1988; Ellis *et al.*, 2012).

Additionally, there is an area to the northeast of the Array Area which supports a high intensity cod nursery, as shown in Figure 3-6 (Ellis *et al.*, 2012).

3.3.5. In a broader context, the study areas have a spatially limited interaction with a small portion of the overall spawning sites and nursery grounds for the mentioned species. The spawning and nursery grounds of these species in the study areas form part of far greater spawning and nursery grounds within the North Sea system.

3.3.6. These spawning and nursery grounds identified within and in proximity to the Proposed Development are presented in Figure 3-2 to Figure 3-9 and Table 3-3, with Table 3-2 providing a summary of spawning timings for the identified spawning grounds.

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

3.3.8. Sandeel, as their name suggests, spawn in coarse sands to gravelly sands, whilst herring prefer to spawn in coarser sediments comprising sandy gravels to gravel. Data from Coull *et al.*, (1988) and Ellis *et al.*, (2012) suggests that the fish and shellfish study areas lie within both sandeel and herring spawning grounds. Spawning grounds for sandeel are significant in size, identified across much of the northern North Sea (Ellis *et al.*, 2012). Herring spawning grounds are patchier, with a significant area overlapping with both the Array Area and offshore ECC. (Coull *et al.*, 1988).

3.3.9. Due to the heightened sensitivity of herring and sandeel spawning activities, a thorough examination of these has been addressed in subsequent Sections (paragraph 3.3.10 *et seq.*).

Table 3-2 Summary of spawning timings (Coull et al., 1998) in the northern North Sea for fish species known to have spawning habitats in the study area (Light blue indicates spawning period, dark blue indicates peak spawning period).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plaice												
Whiting												
Atlantic cod												
Sandeel												
Atlantic herring (Buchan/Shetland Stock)												
Lemon sole												
Sprat												
Norway pout												
Nephrops												

Table 3-3 Summary of fish and shellfish spawning and nursery grounds within the fish and shellfish study areas (Coull et al. (1998) and Ellis et al. (2012))

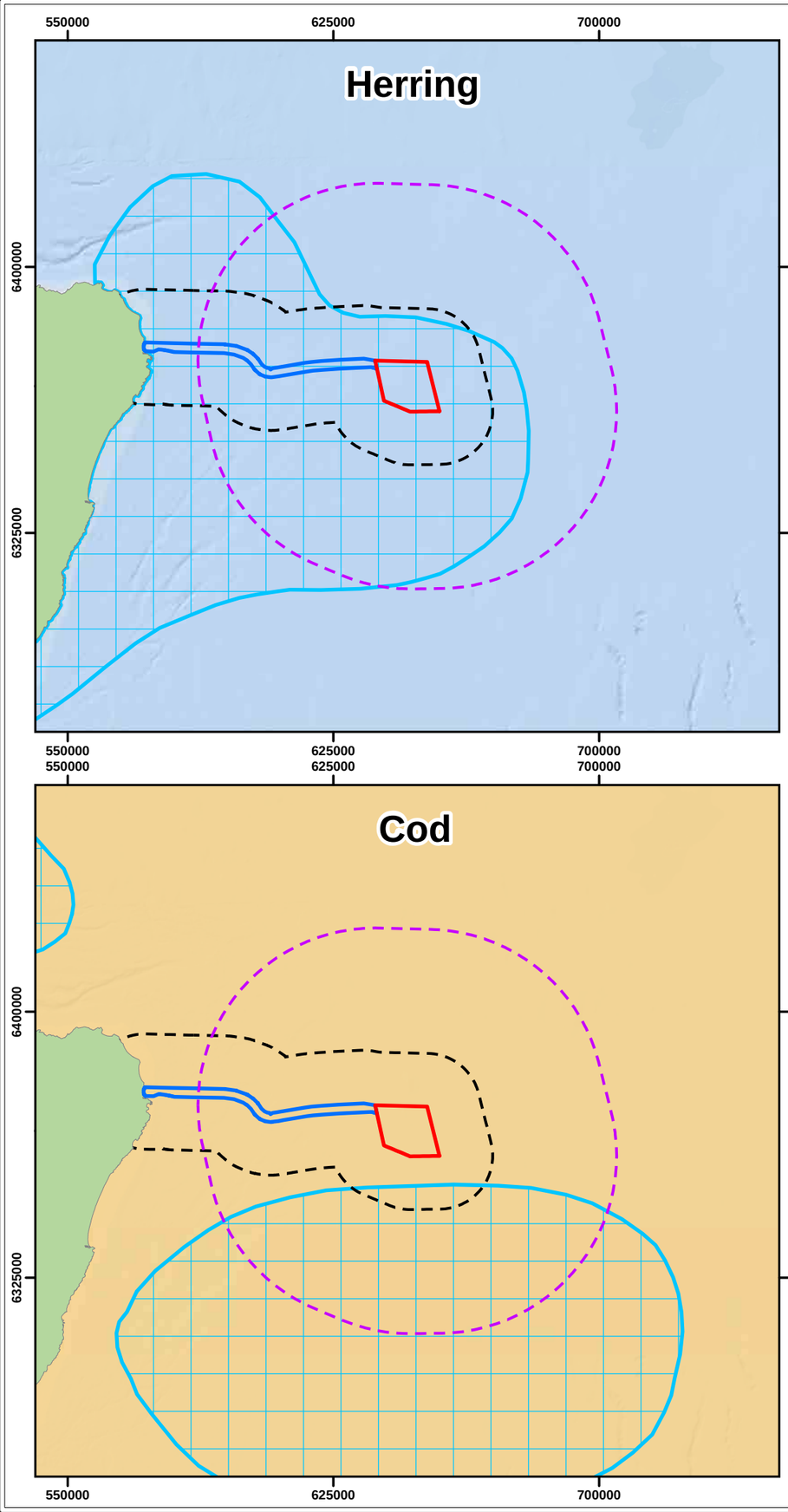
	Spawning Grounds			Nursery Grounds		
Receptor	**Description**	**Distance from the study areas**	**Figure reference**	**Description**	**Distance from the study areas**	**Figure reference**
Herring	Spawning grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Spawning grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-2	High intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC. High intensity nursery grounds overlap with the secondary ZoI, a few km to the south of the offshore ECC from the coastline to around 50 km west of the Array Area.	Figure 3-6
Sandeel	High intensity spawning grounds overlap with the footprint of the Proposed Development.	High intensity spawning grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-2	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-6
Cod	Low intensity spawning grounds overlap with the footprint of the Proposed Development.	Low intensity spawning grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-2	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC. High intensity nursery grounds overlap with a small portion of the UWN ZoI to the south-west of the Array Area.	Figure 3-6
Plaice	Low intensity spawning grounds overlap with the	Low intensity spawning grounds overlap the offshore ECC, from the	Figure 3-2	Low intensity nursery grounds overlap with the	Low intensity nursery grounds overlap the primary study area, both	Figure 3-6

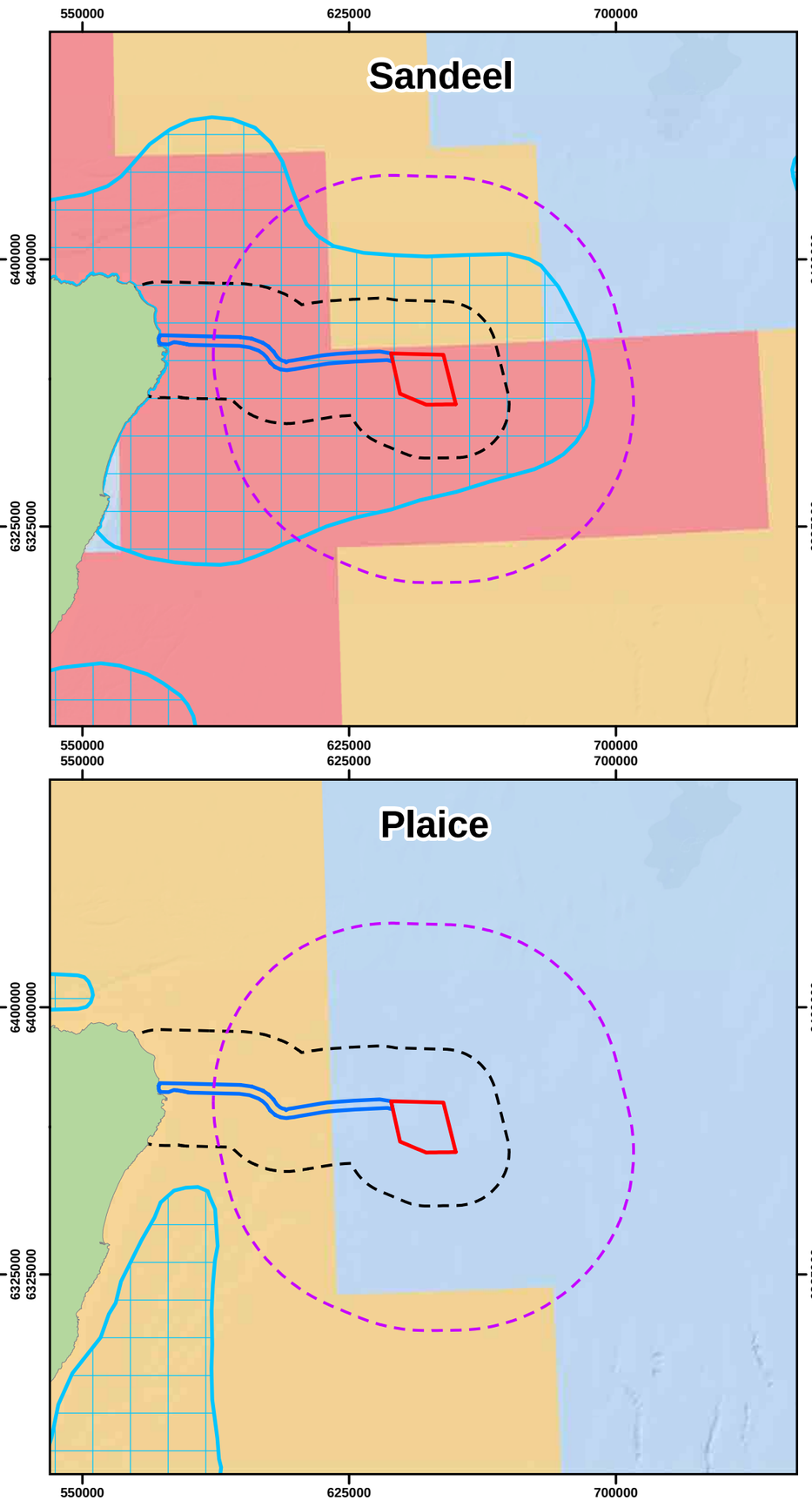
	Spawning Grounds			Nursery Grounds		
Receptor	**Description**	**Distance from the study areas**	**Figure reference**	**Description**	**Distance from the study areas**	**Figure reference**
	footprint of the Proposed Development.	coastline to around 20 km west of the Array Area.		footprint of the Proposed Development.	the Array Area and the offshore ECC.	
Whiting	Low intensity spawning grounds overlap with the footprint of the Proposed Development.	Low intensity spawning grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-3	High intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC. High intensity nursery grounds overlap with the offshore ECC, from the coastline to around 20 km west of the Array Area.	Figure 3-6
Norway pout	High intensity spawning grounds overlap with the footprint of the Proposed Development.	Low intensity spawning grounds overlap the primary study area, both the Array Area and the offshore ECC. High intensity spawning grounds overlap the Array Area but do not overlap the offshore ECC.	Figure 3-3	Nursery grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-6
Lemon sole	Spawning grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Spawning grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-3	Nursery grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-6
Nephrops	Spawning grounds of undetermined intensity overlap with the footprint of the Proposed	Spawning grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-3	Nursery grounds of undetermined intensity overlap with the footprint of the Proposed	Nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-6

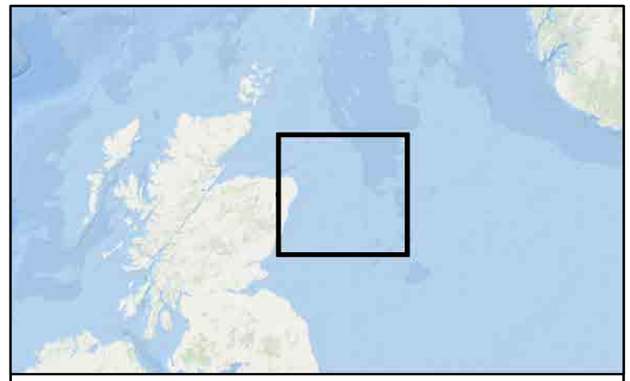
	Spawning Grounds			Nursery Grounds		
Receptor	**Description**	**Distance from the study areas**	**Figure reference**	**Description**	**Distance from the study areas**	**Figure reference**
	Development.			Development.		
Sprat	Spawning grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Spawning grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-4	Nursery grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-7
Haddock	No known spawning grounds overlap with any of the study areas.	N/A	-	Nursery grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-7
Tope	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the offshore ECC and are located 20 km west of the Array Area.	Figure 3-7
Spurdog	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-7
Spotted ray	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-8

	Spawning Grounds			Nursery Grounds		
Receptor	**Description**	**Distance from the study areas**	**Figure reference**	**Description**	**Distance from the study areas**	**Figure reference**
Anglerfish	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC. High intensity nursery grounds are located ~50km north of the primary study area.	Figure 3-8
Blue whiting	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-8
Saithe	No known spawning grounds overlap with any of the study areas.	N/A	-	Nursery grounds of undetermined intensity overlap with the footprint of the Proposed Development.	Nursery grounds overlap the primary study area offshore ECC and are located 40 km west of the Array Area.	Figure 3-8
Ling	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-9
Mackerel	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-9

	Spawning Grounds			Nursery Grounds		
Receptor	**Description**	**Distance from the study areas**	**Figure reference**	**Description**	**Distance from the study areas**	**Figure reference**
Hake	No known spawning grounds overlap with any of the study areas.	N/A	-	Low intensity nursery grounds overlap with the footprint of the Proposed Development.	Low intensity nursery grounds overlap the primary study area, both the Array Area and the offshore ECC.	Figure 3-9







Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence

Spawning Grounds

(Coull *et al.*, 1998) - Intensity

- Undetermined

Spawning Grounds

(Ellis *et al.*, 2012) - Intensity

- Higher
- Lower

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Spawning Grounds within the Fish and Shellfish Ecology Study Area (Coull et al., 1998; Ellis et al., 2012)

Figure: 3.2	Drawing No: GoBe-0105		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,500,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM

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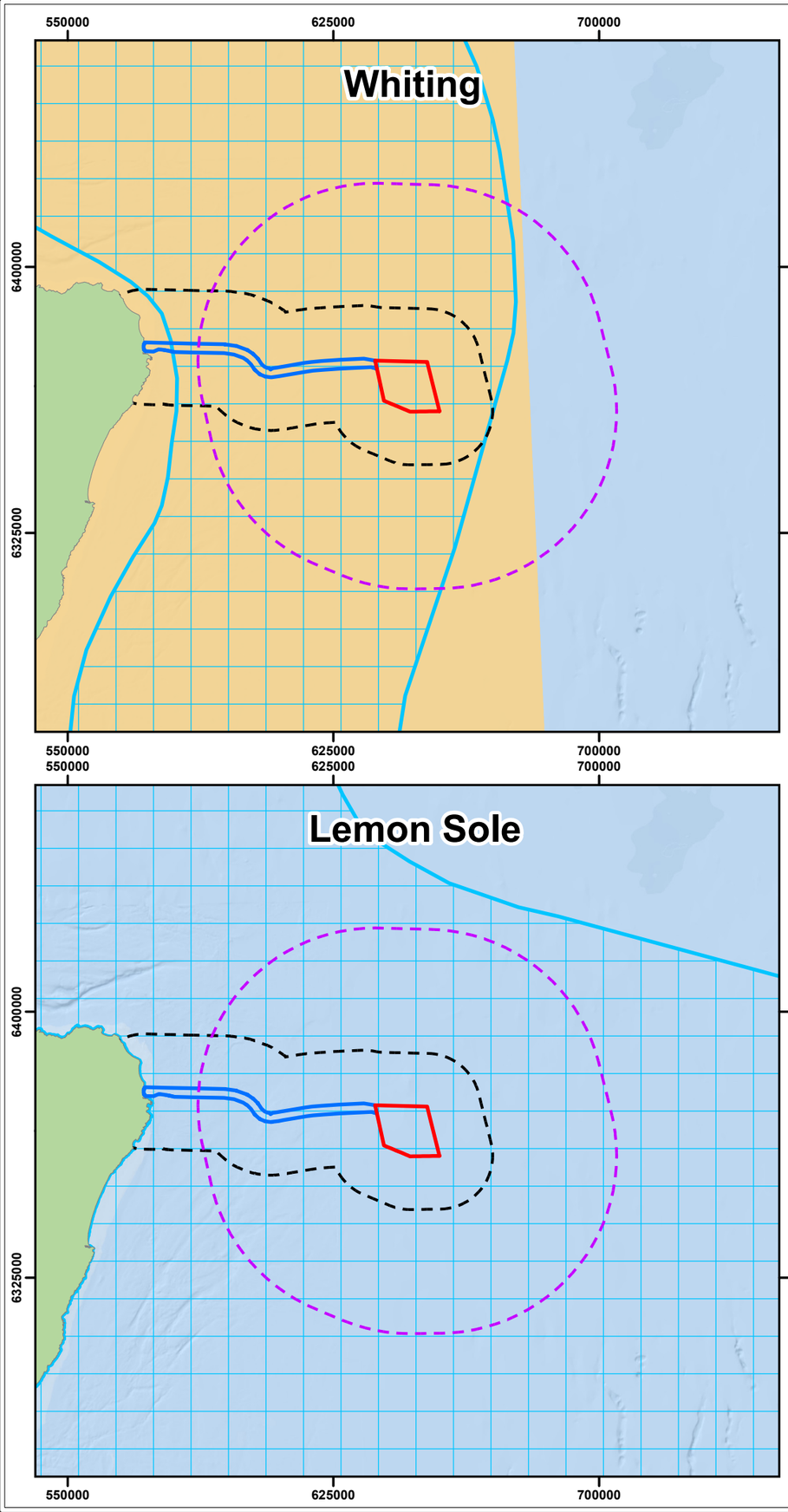

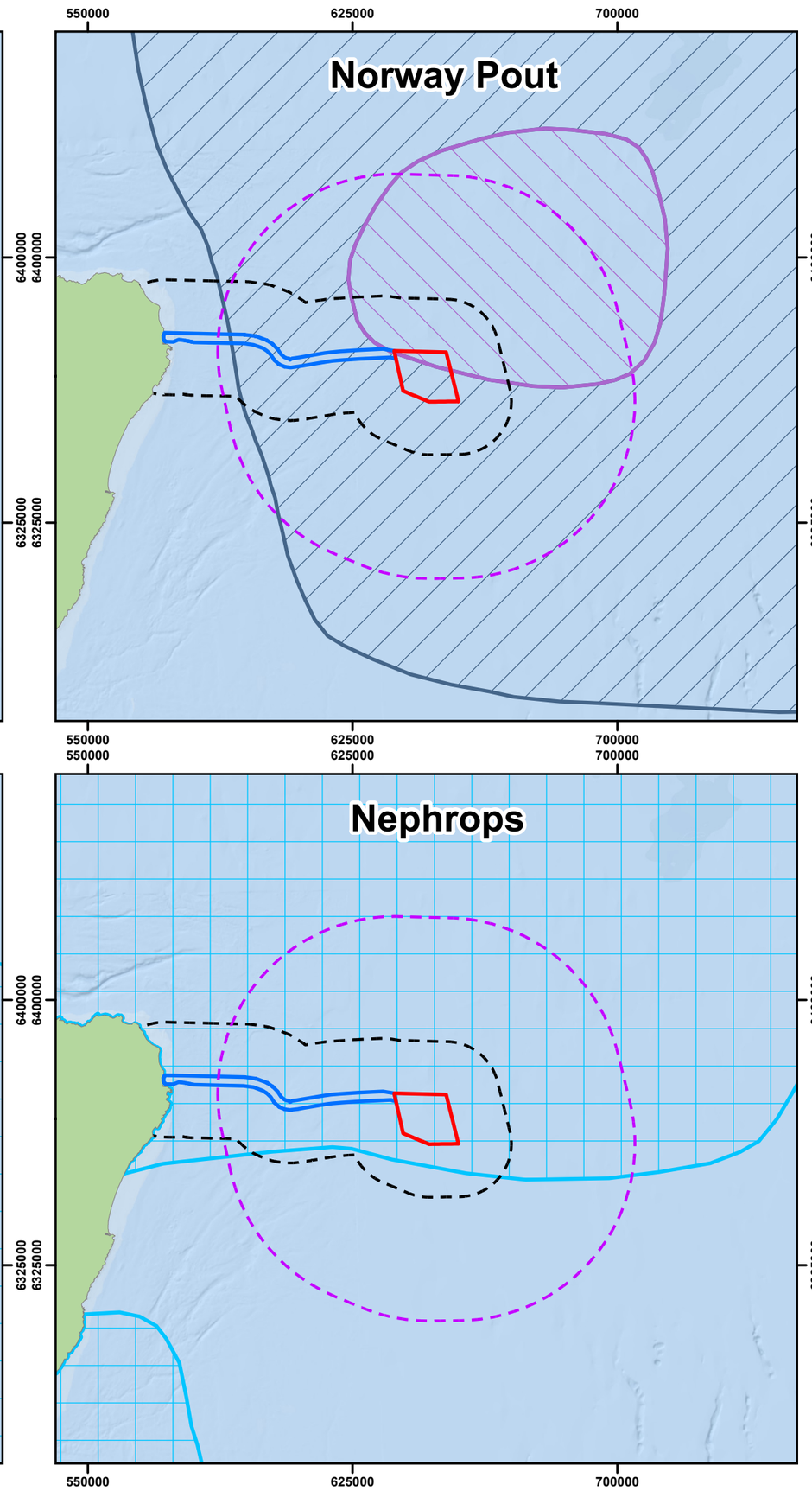

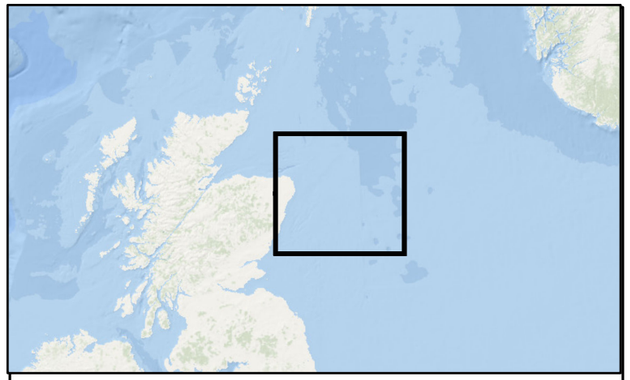

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence

Spawning Grounds

(Coull *et al.*, 1998) - Intensity

- Higher
- Lower
- Undetermined

Spawning Grounds

(Ellis *et al.*, 2012) - Intensity

- Lower

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Spawning Grounds within the Fish and Shellfish Ecology Study Area (Coull *et al.*, 1998; Ellis *et al.*, 2012)

Figure: 3.3	Drawing No: GoBe-0106		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,500,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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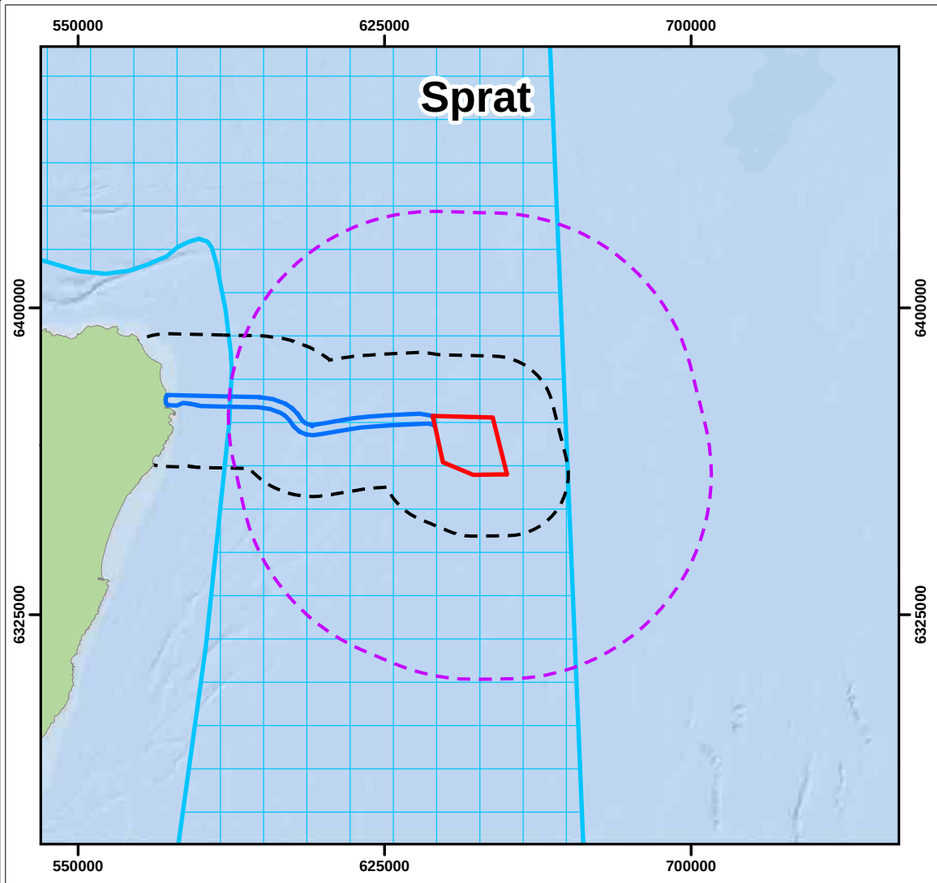

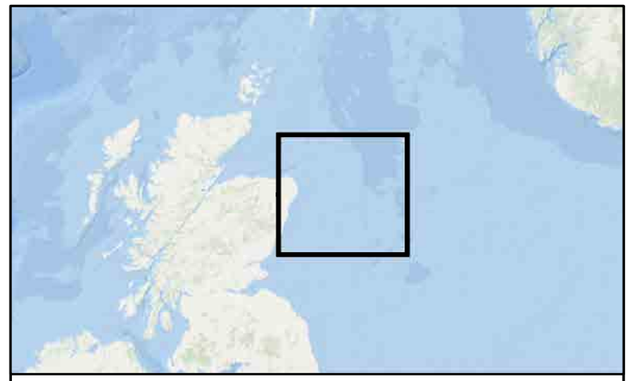

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence

Spawning Grounds

(Coull *et al.*, 1998) - Intensity

- Undetermined

Project: Muir Mhòr	Report: Fish and Shellfish Technical Report

Spawning Grounds within the Fish and Shellfish Ecology Study Area (Coull et al., 1998; Ellis et al., 2012)

Figure: 3.4	Drawing No: GoBe-0107		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale: 1:1,500,000 @ A3

0 10 20 30 40 km

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Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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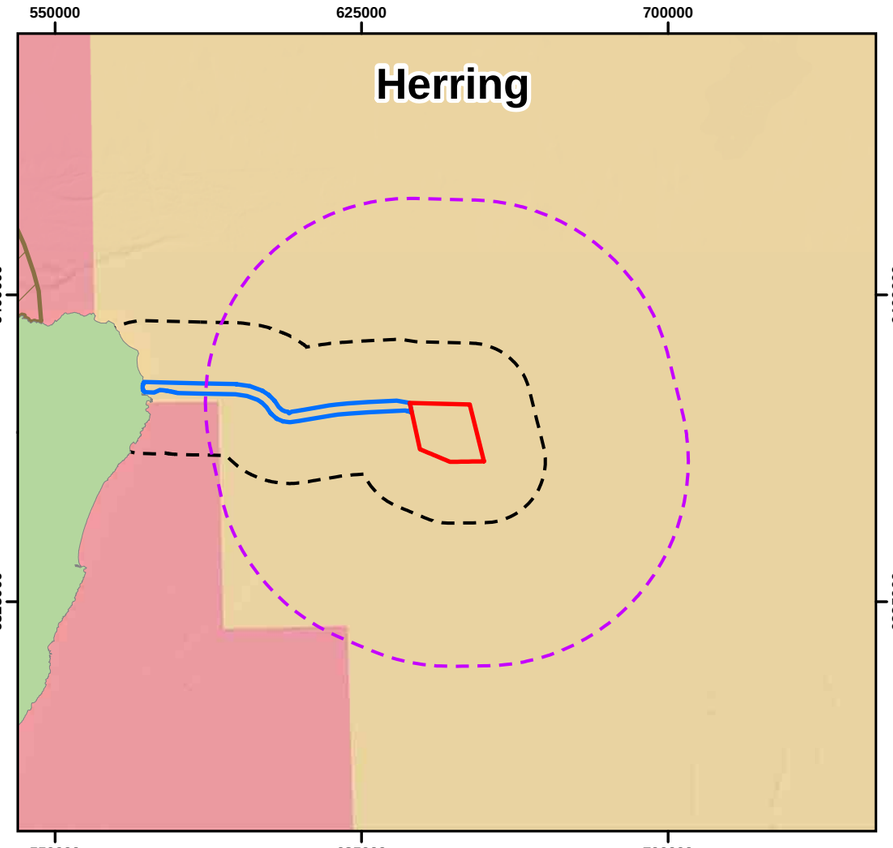

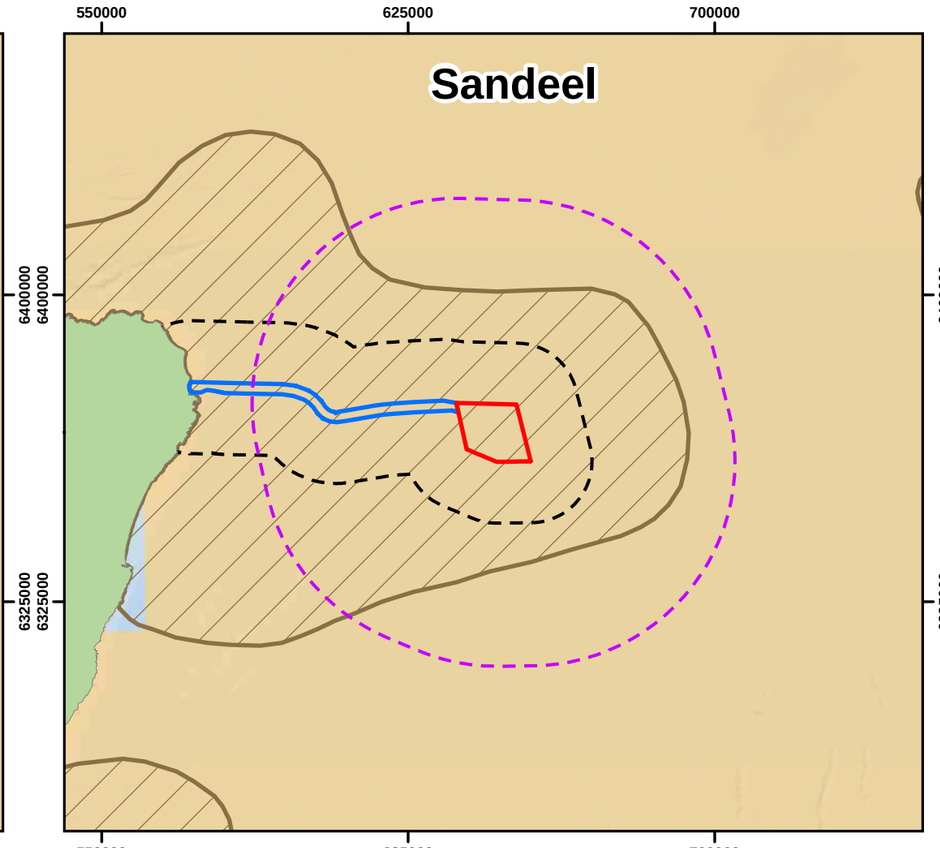

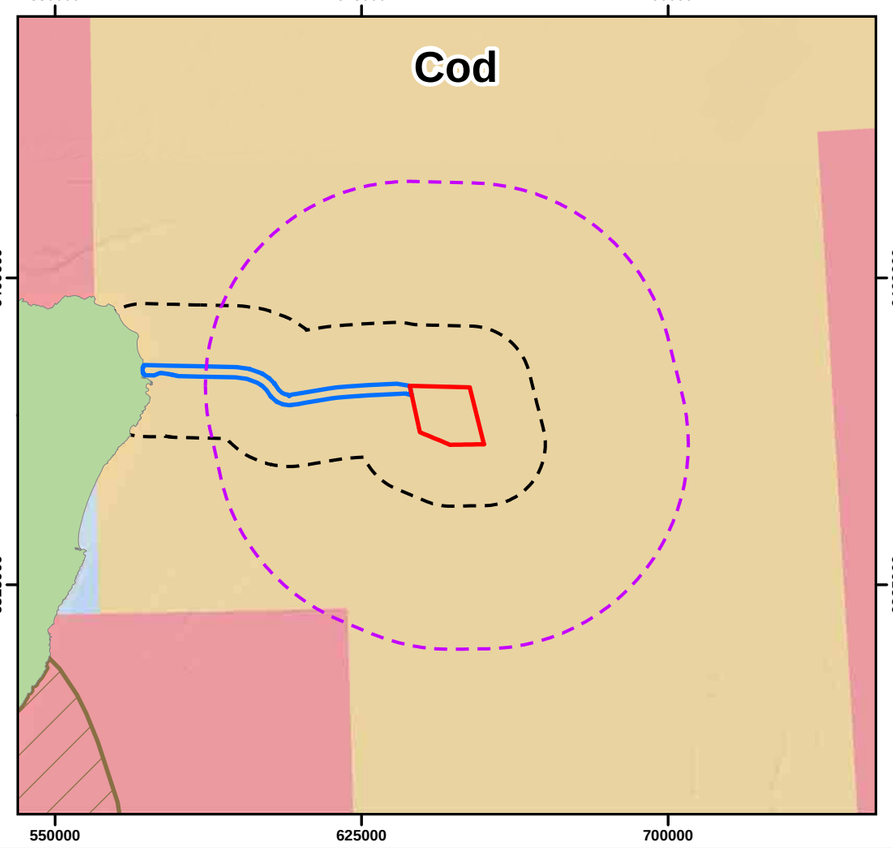

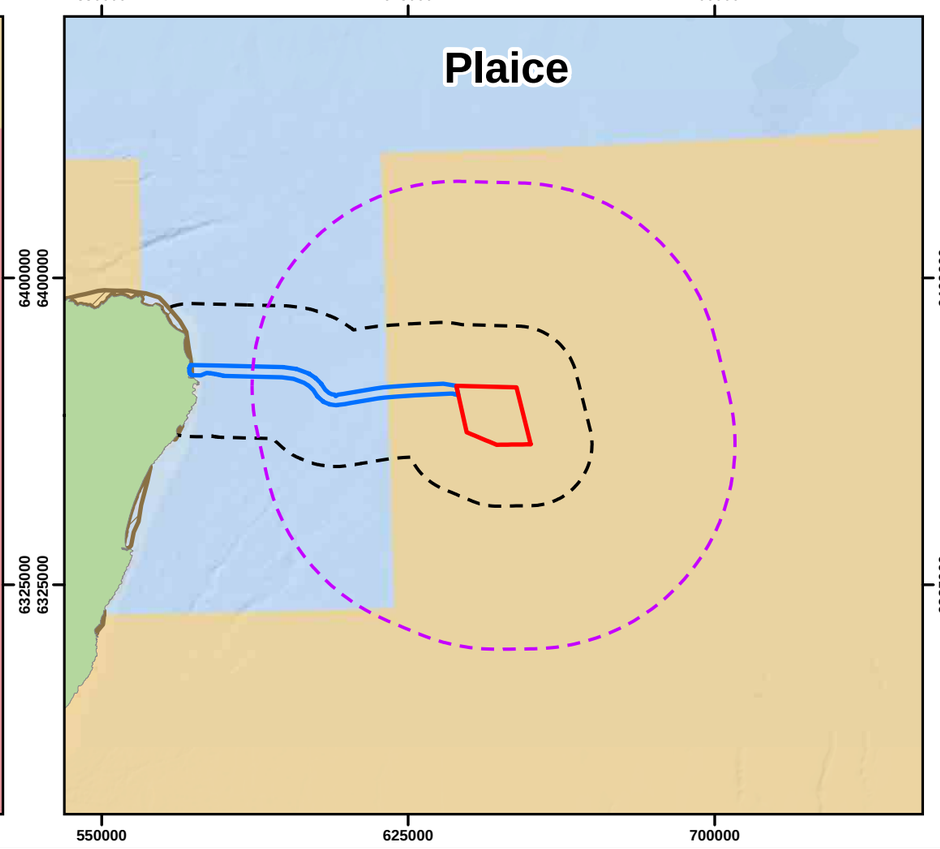

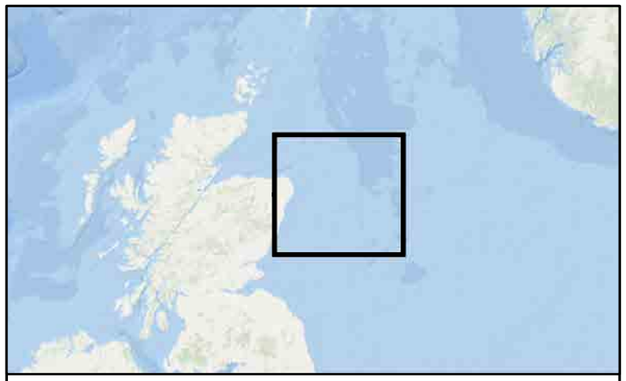

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Nursery Grounds (Coull *et al.*, 1998)

Nursery Grounds

(Ellis *et al.*, 2012) - Intensity

- Higher
- Lower

Project: Muir Mhòr	Report: Fish and Shellfish Technical Report

Nursery Grounds within the Fish and Shellfish Ecology Study Area (Coull et al., 1988; Ellis et al., 2012)

Figure: 3.5	Drawing No: GoBe-0108		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,500,000 @ A3

0 10 20 30 40 km

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Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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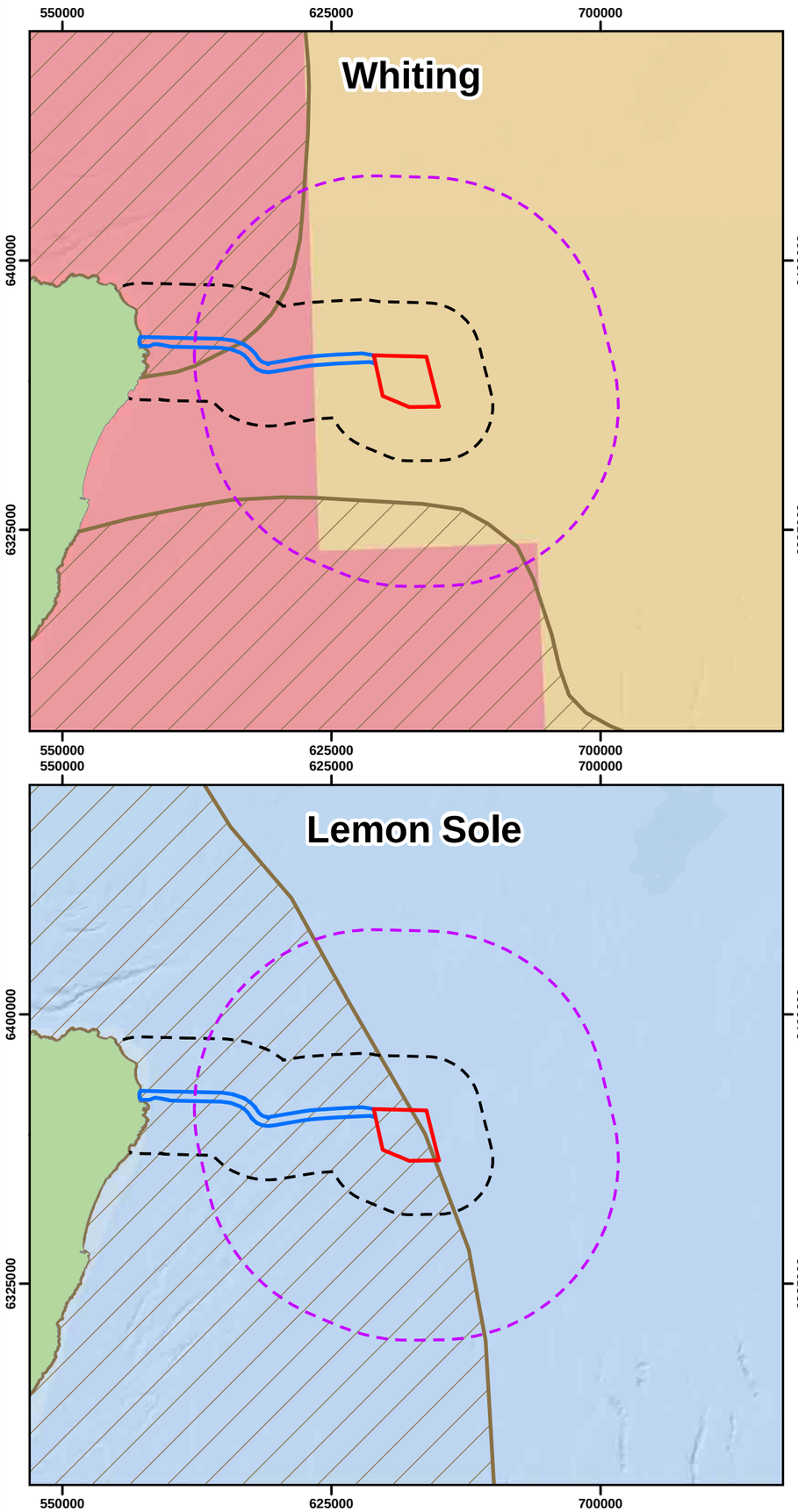

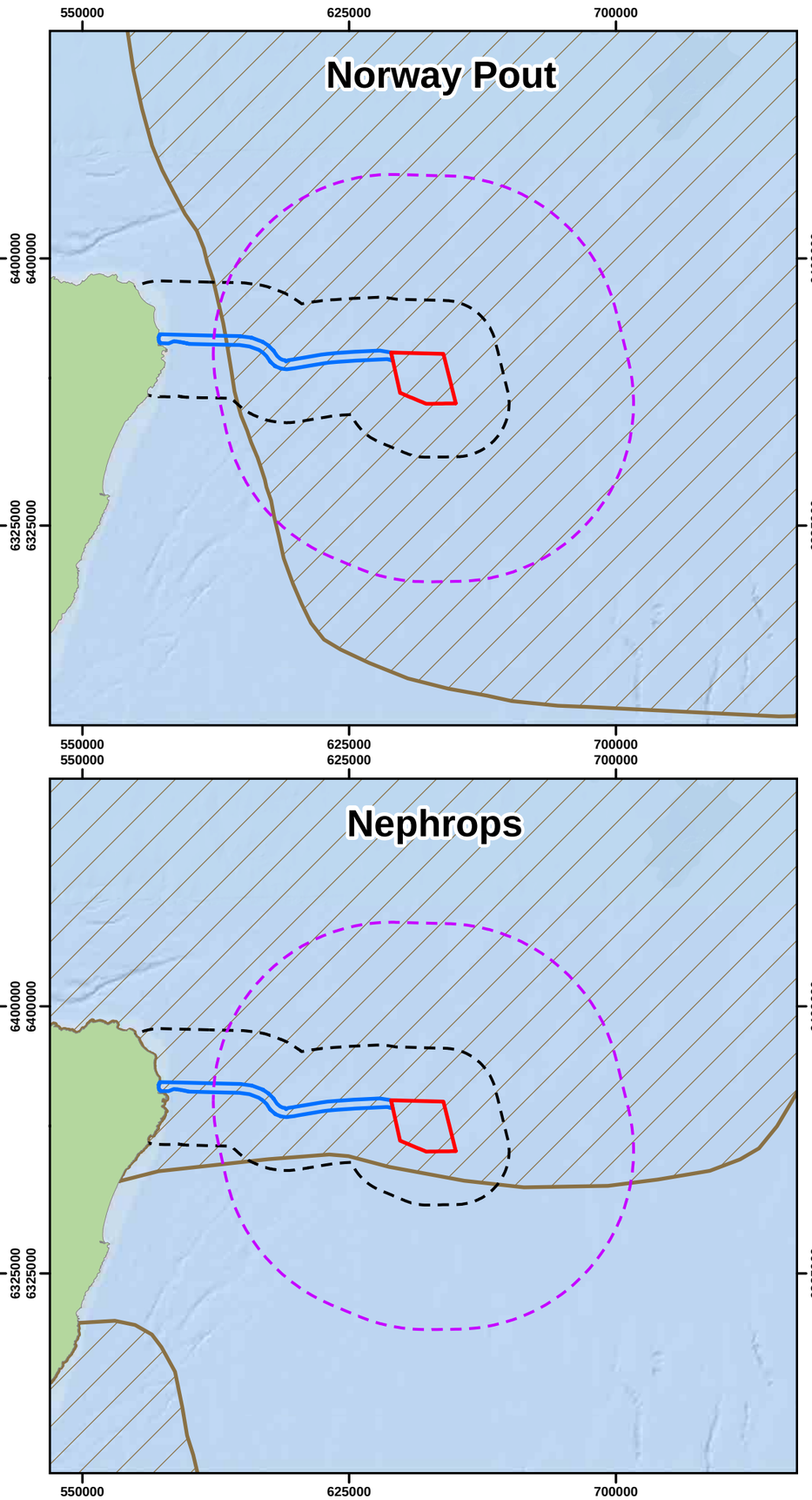

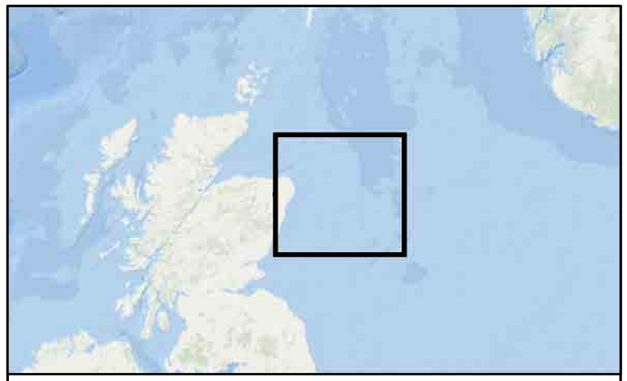

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Nursery Grounds (Coull *et al.*, 1998)

Nursery Grounds

(Ellis *et al.*, 2012) - Intensity

- Higher
- Lower

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Nursery Grounds within the Fish and Shellfish Ecology Study Area (Coull et al., 1988; Ellis et al., 2012)

Figure: 3.6	Drawing No: GoBe-0109		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,500,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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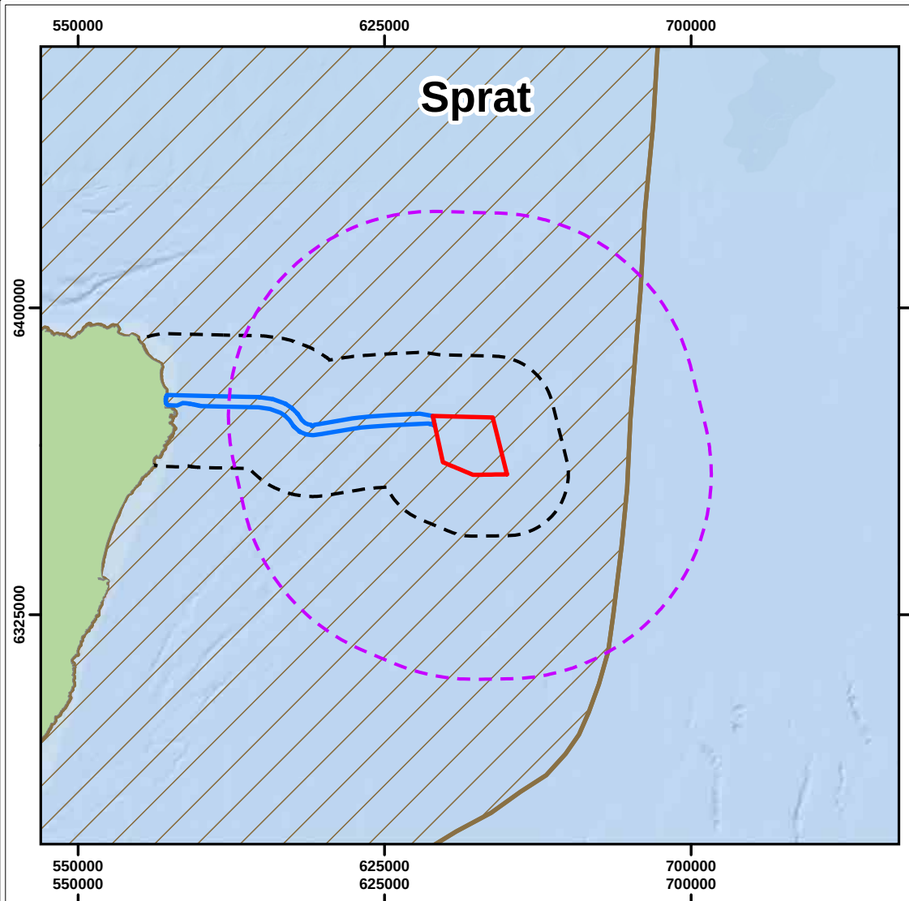
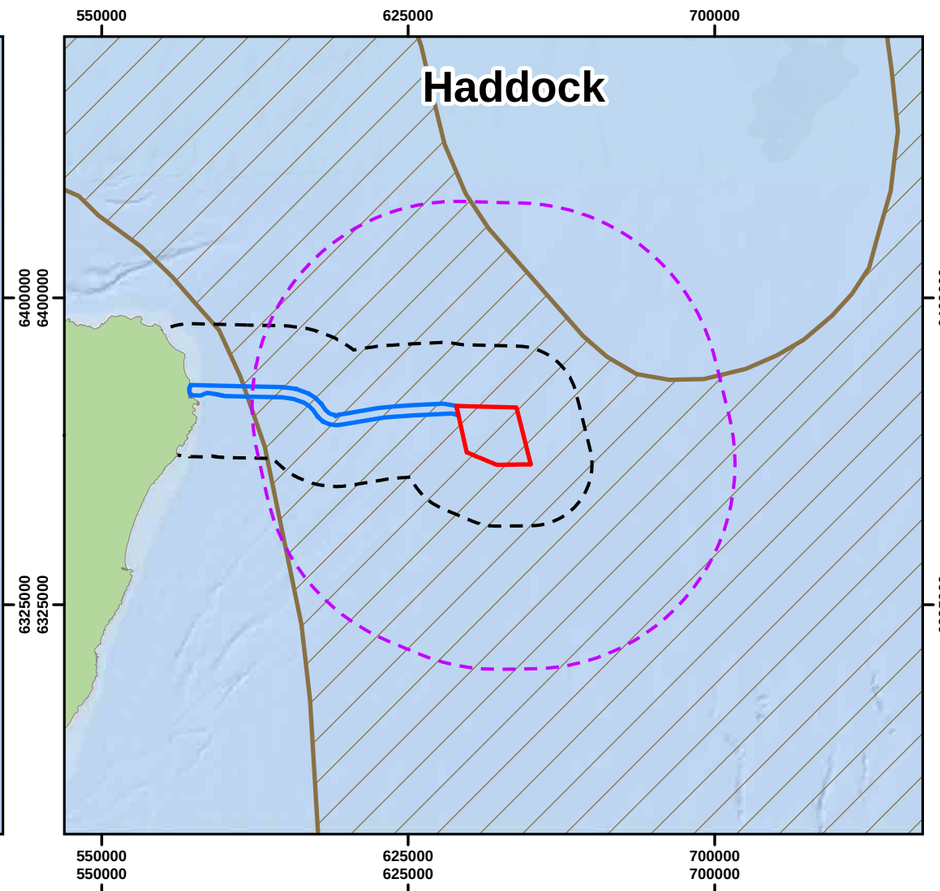
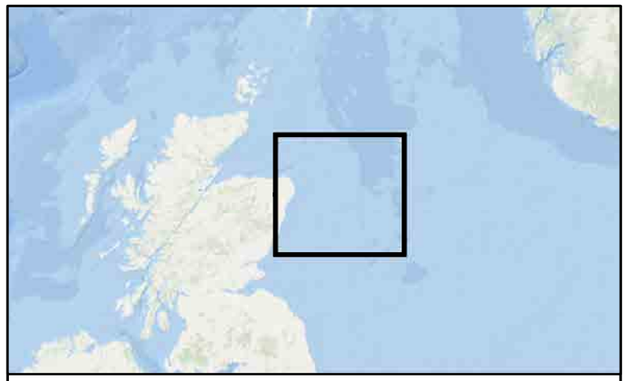






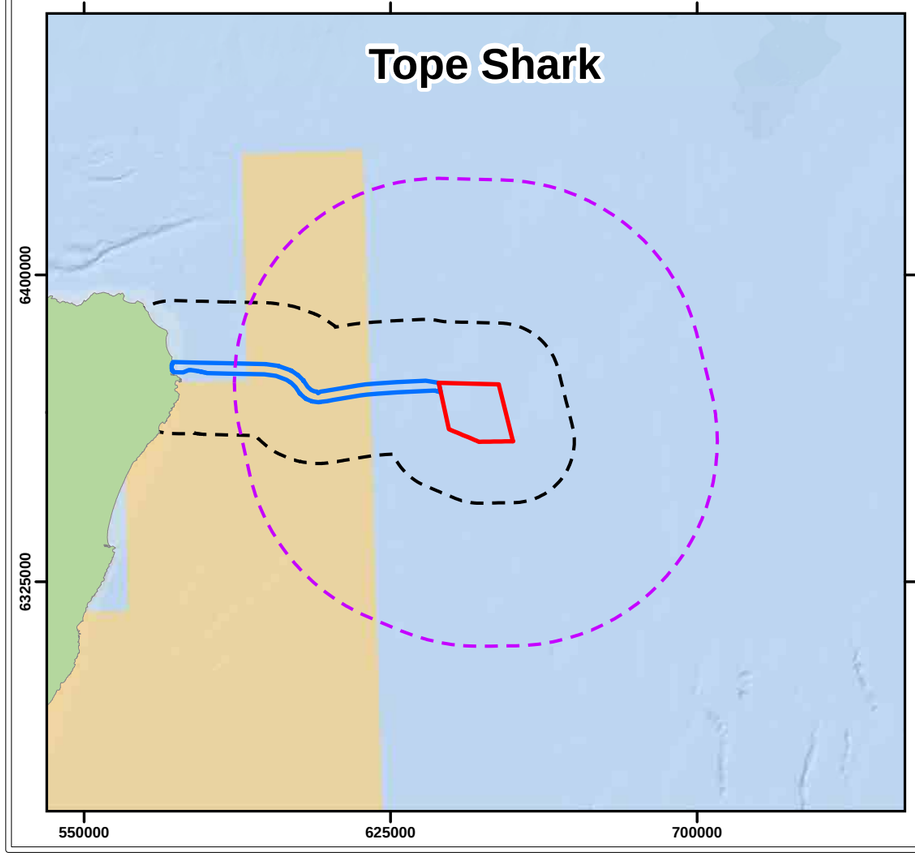
Legend:

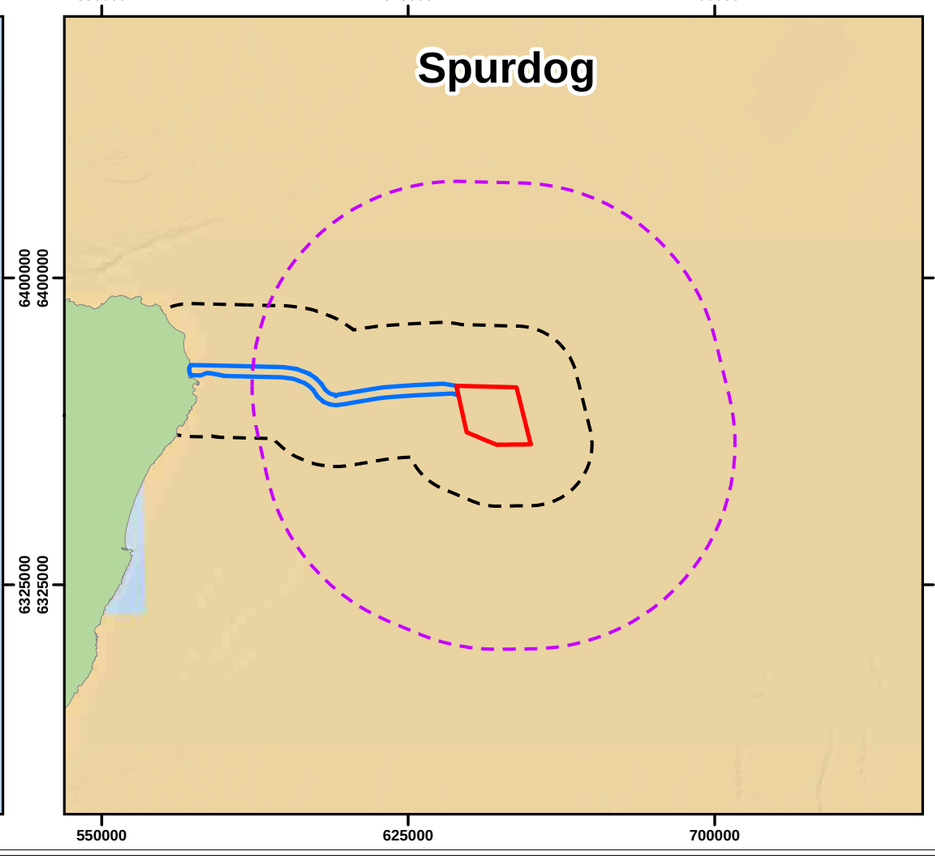
- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Nursery Grounds (Coull *et al.*, 1998)

Nursery Grounds

(Ellis *et al.*, 2012) - Intensity

- Lower





Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Nursery Grounds within the Fish and Shellfish Ecology Study Area (Coull *et al.*, 1988; Ellis *et al.*, 2012)

Figure: 3.7	Drawing No: GoBe-0110		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,500,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM

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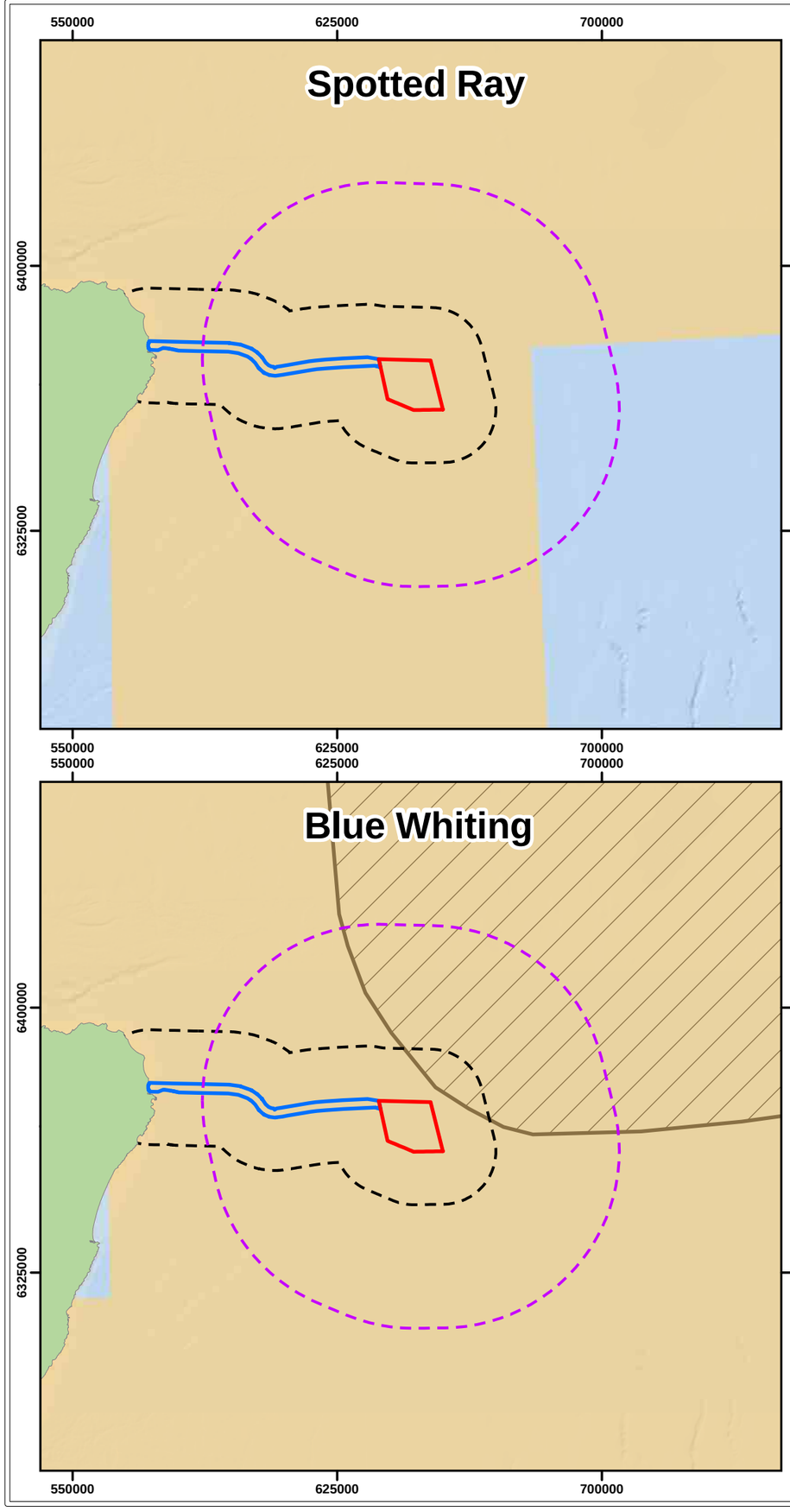

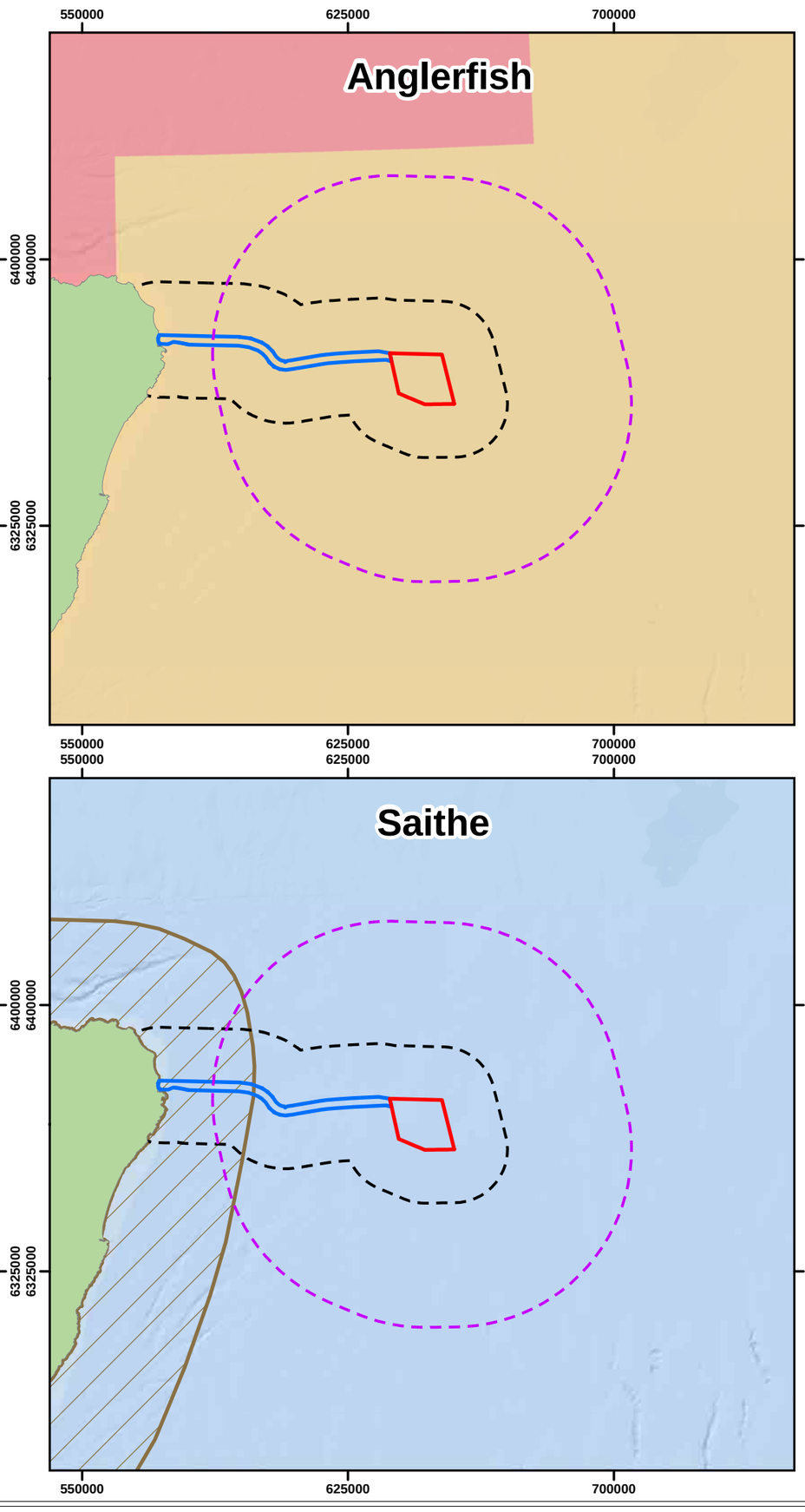

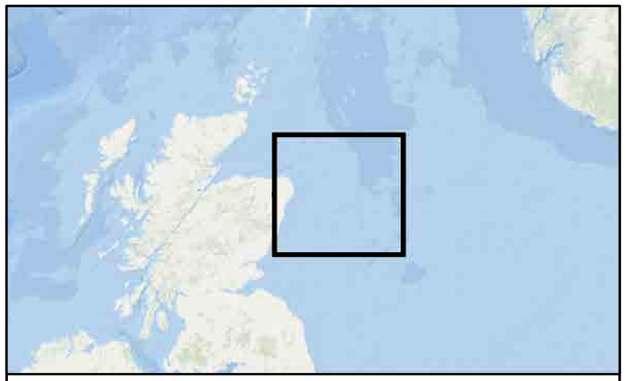

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Nursery Grounds (Coull *et al.*, 1998)

Nursery Grounds

(Ellis *et al.*, 2012) - Intensity

- Higher
- Lower

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Nursery Grounds within the Fish and Shellfish Ecology Study Area (Coull et al., 1988; Ellis et al., 2012)

Figure: 3.8	Drawing No: GoBe-0111		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale: 1:1,500,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM

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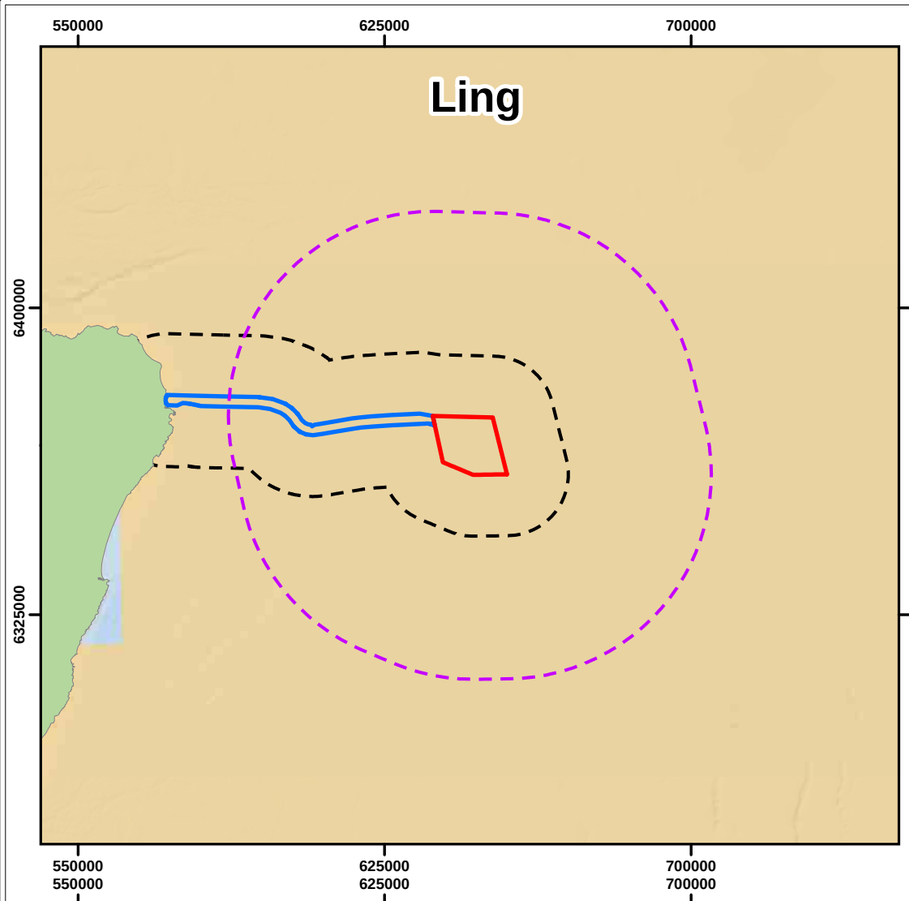

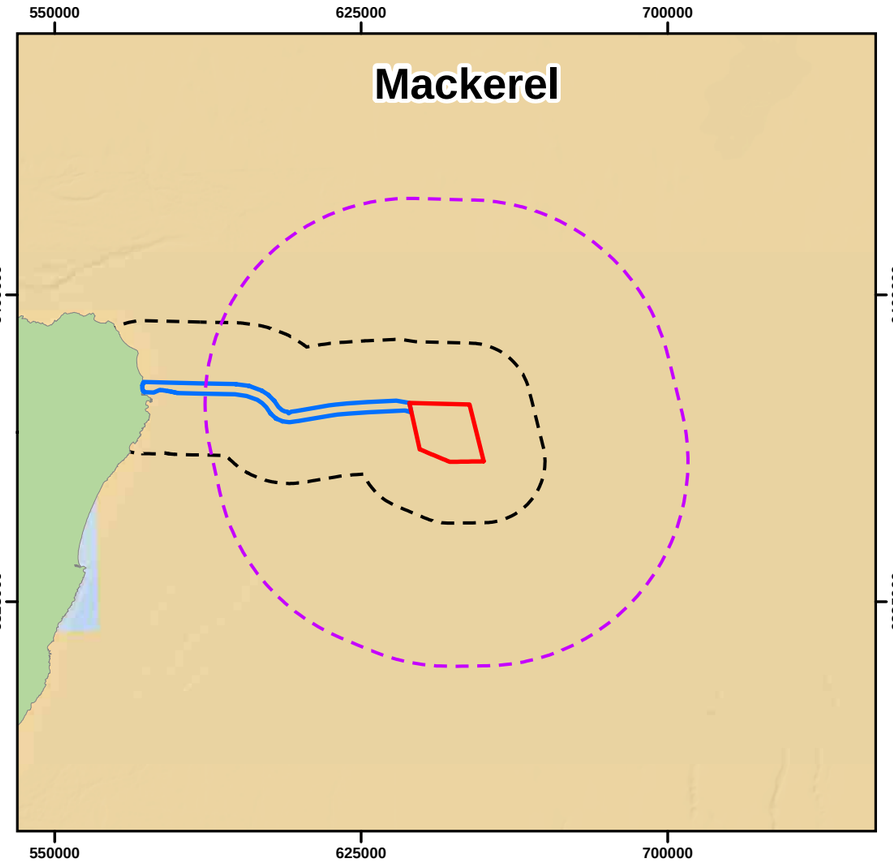

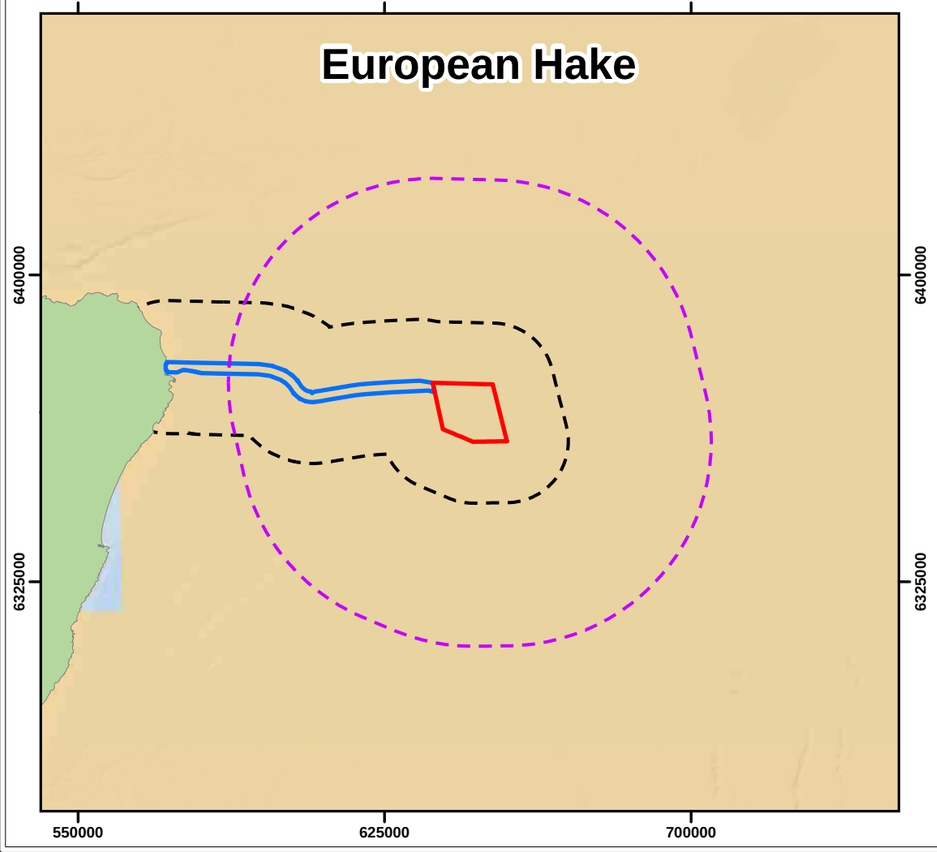

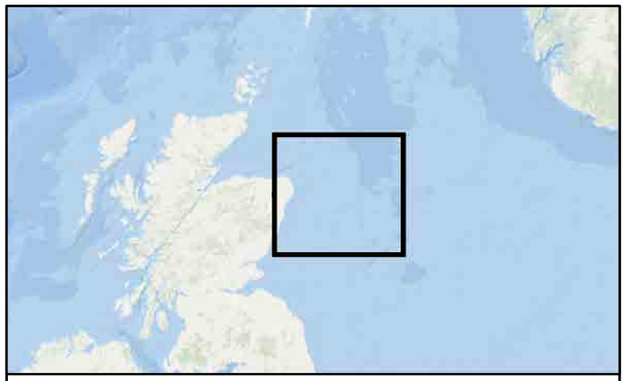

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence

Nursery Grounds

(Ellis *et al.*, 2012) - Intensity

- Lower

Project: Muir Mhòr	Report: Fish and Shellfish Technical Report

Nursery Grounds within the Fish and Shellfish Ecology Study Area (Coull *et al.*, 1998; Ellis *et al.*, 2012)

Figure: 3.9	Drawing No: GoBe-0112		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,500,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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HERRING

3.3.10. There is a large Buchan/Shetland herring stock spawning ground that runs along much of the east coast of Scotland and extends offshore, which intercepts the Muir Mhòr offshore ECC and Array Area, shown in Figure 3-2 (Coull *et al.*, 1988). Herring are particularly sensitive to noise impacts as they have swim bladders involved in hearing (Popper *et al.*, 2014). Herring spawning, which occurs in August and September (Buchan/Shetland stock), requires well-oxygenated sediments for their eggs to gestate. They are demersal spawners that lay their eggs onto or into seabed sediments, limited to specific sediment types, such as unimodal, unmixed very coarse sands and gravels with a low proportion of fines.

3.3.11. As described in paragraph 3.2.16 *et seq.*, pre-construction herring larvae surveys by Beatrice OWF Limited in 2014 and 2016, and Moray East OWF in 2019, showed larvae from Orkney and Shetland moved south with tides. Larvae were recorded to the north of the Beatrice OWF Array Area, while the surveys recorded lower densities near the Moray East OWF Array Area. Herring larvae were most abundant northeast of the Moray East OWF, with smaller larvae recorded to the south of the OWF, and larger larvae recorded to the north. Cefas identified herring spawning grounds and nursery grounds in the northern North Sea on the east coast of Scotland (Cefas, 2020). According to Coull *et al.* (1988) and Ellis *et al.* (2012), the study area is situated within low-intensity nursery grounds and lies in close proximity to high-intensity nursery grounds. The Array Area and offshore ECC also overlap with some spawning grounds of undetermined intensity (Coull *et al.*, 1988), as shown in Figure 3-2.

3.3.12. The results from the particle size distribution analysis of stations within the Array Area deemed the majority of the area to be 'Unsuitable', suggesting a very low likelihood of herring spawning, as shown in Figure 3-10. This is attributed to the presence of >5% mud or <10% gravel at these grab sampling stations. Approximately a quarter of samples within the Array Area, within the south west part of the Array Area have been classified as either 'Marginal' or 'Preferred', corresponding to where habitats were categorised as either 'Offshore Circalittoral Mixed Sediment' or 'Offshore Circalittoral Coarse Sediment' (EMODnet, 2023).

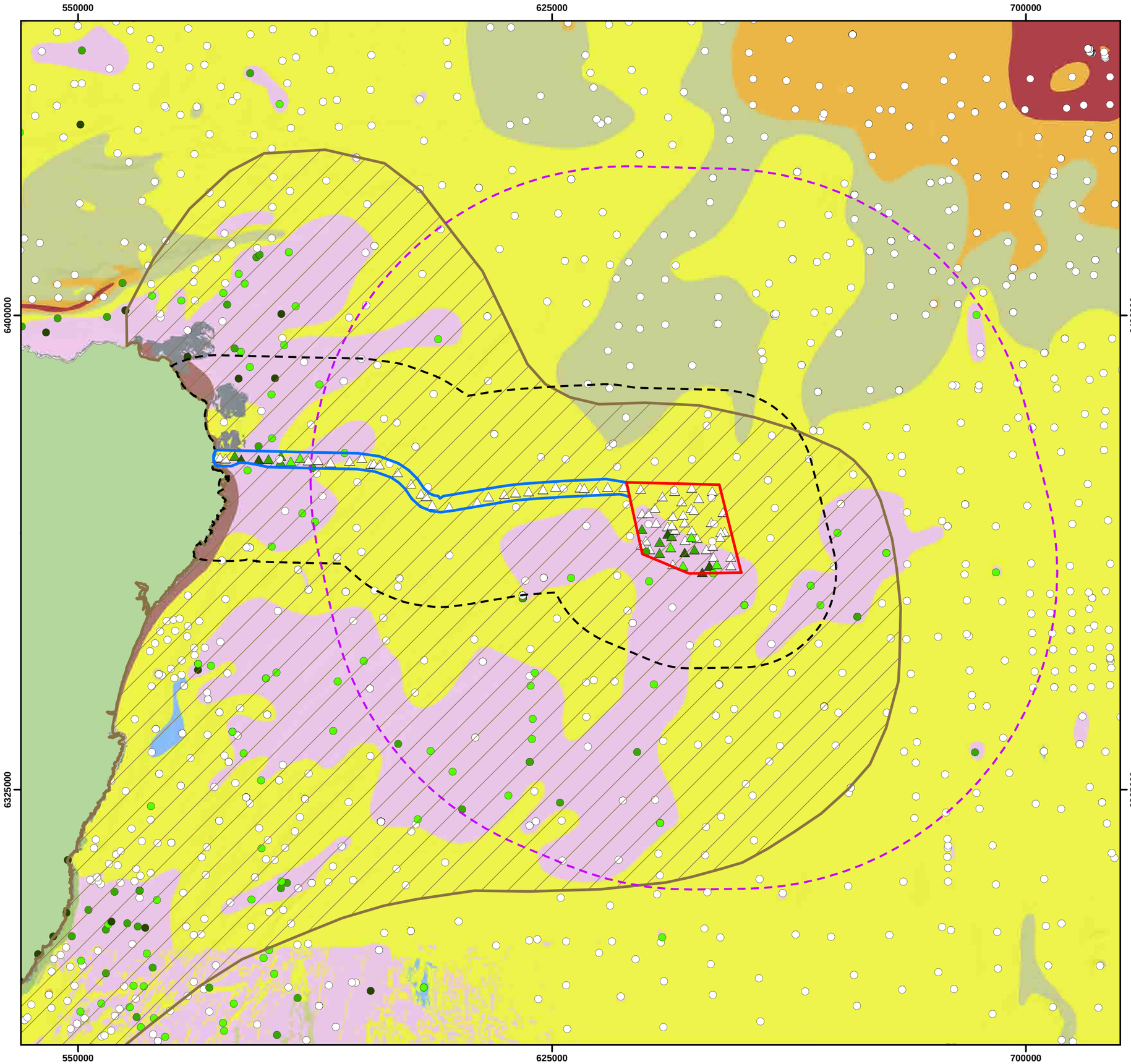
3.3.13. The analysis of the particle size distribution at stations within the offshore ECC indicated that most sites were categorised as 'Unsuitable', with the majority having a <10% gravel or >5% mud content. However, the nearshore portion of the offshore ECC showed a higher likelihood of herring spawning due to a higher gravel content and lower fines content; two discrete areas in the ECC were classified as 'Suitable/Marginal', while four other nearshore locations were classified 'Sub-prime/Preferred'. Additionally, two sediment samples in the nearshore were classified as 'Prime/Preferred' due to their high gravel content.

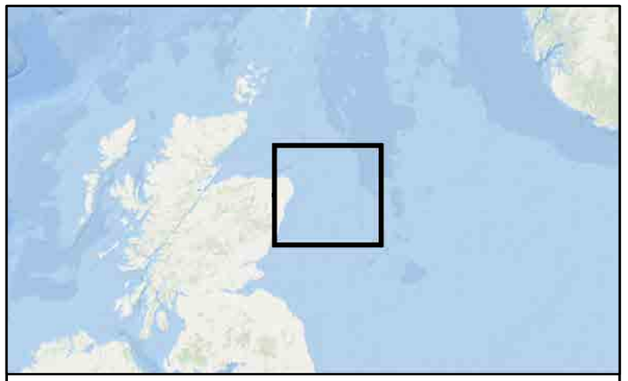
3.3.14. It should be noted that MarineSpace *et al.* (2013a) acknowledge that habitat sediment classification is not the only parameter that indicates potential spawning habitat. There are other environmental (physical, chemical and biotic) parameters such as: oxygenation, siltation, overlap with range of spawning populations, micro-scale seabed morphological features e.g., ripples and ridges, which all contribute to the suitability of seabed habitat to be used as spawning beds by herring. As such the habitat sediment classes alone will always over-represent the range of habitat with the potential to support spawning events (MarineSpace *et al.* 2013a).

3.3.15. The IHLS data presented for seasons 2011-12 to 2023-24 (Figure 3-11) indicates that the main spawning is located just north of the offshore ECC, approximately 20km offshore of Seatown (based on distribution and density of larvae) and then a lower density spawning area to the south of the Array Area. The heat map of herring spawning potential (Figure 3-12) indicates that the majority of the secondary ZoI area, which includes all of the Array Area and the offshore ECC area are of ‘High’ potential. Within the larg`er underwater noise ZoI, areas

to the south and west of the area are of ‘High’ potential and areas to the north and east are of ‘Medium’ potential.

3.3.16. In summary, Muir Mhòr offshore ECC and Array Area intersect the Buchan/Shetland stock spawning ground (Coull *et al.*, 1988), however the likelihood of spawning in these areas varies based on sediment composition. In the Array Area, most stations were deemed 'Unsuitable' for herring spawning due to high mud content or low gravel content, indicating a low likelihood of spawning. However, some areas in the southern part of the Array Area were classified as 'Marginal' or 'Preferred', offering more favourable conditions. In the offshore ECC, most sites were also categorised as 'Unsuitable' for herring spawning due to low gravel content and high mud content. Some nearshore locations in the offshore ECC showed a higher likelihood of herring spawning, with classifications ranging from 'Suitable/Marginal' to 'Prime/Preferred' based on gravel content. The IHLS data indicates that the main spawning is located just north of the offshore ECC, approximately 20km offshore of Seatown, with a lower density spawning area to the south of the Array Area. The heat map of herring spawning potential indicates that the majority of the secondary ZoI area, which includes all of the Array Area and the offshore ECC area are of ‘High’ potential.





Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Herring Spawning Grounds (Coull et al., 1998)

Herring Habitat Suitability (Reach et al., 2013)

- Prime, Preferred
- Sub-Prime, Preferred
- Suitable, Marginal
- Unsuitable

Data Source:

- BGS, 2015
- EGS International Ltd and Benthic Solutions Ltd (BSL), 2023

Seabed Substrate (EUSeaMap; EMODnet)

- Sand
- Sandy mud
- Fine mud
- Muddy sand
- Seabed
- Coarse substrate
- Sediment
- Mixed sediment
- Rock or other hard substrata

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Herring Spawning Substrates Relative to the Fish and Shellfish Ecology Study Area

Figure: 3.10	Drawing No: GoBe-0113		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:600,000 @ A3

0 10 20 km

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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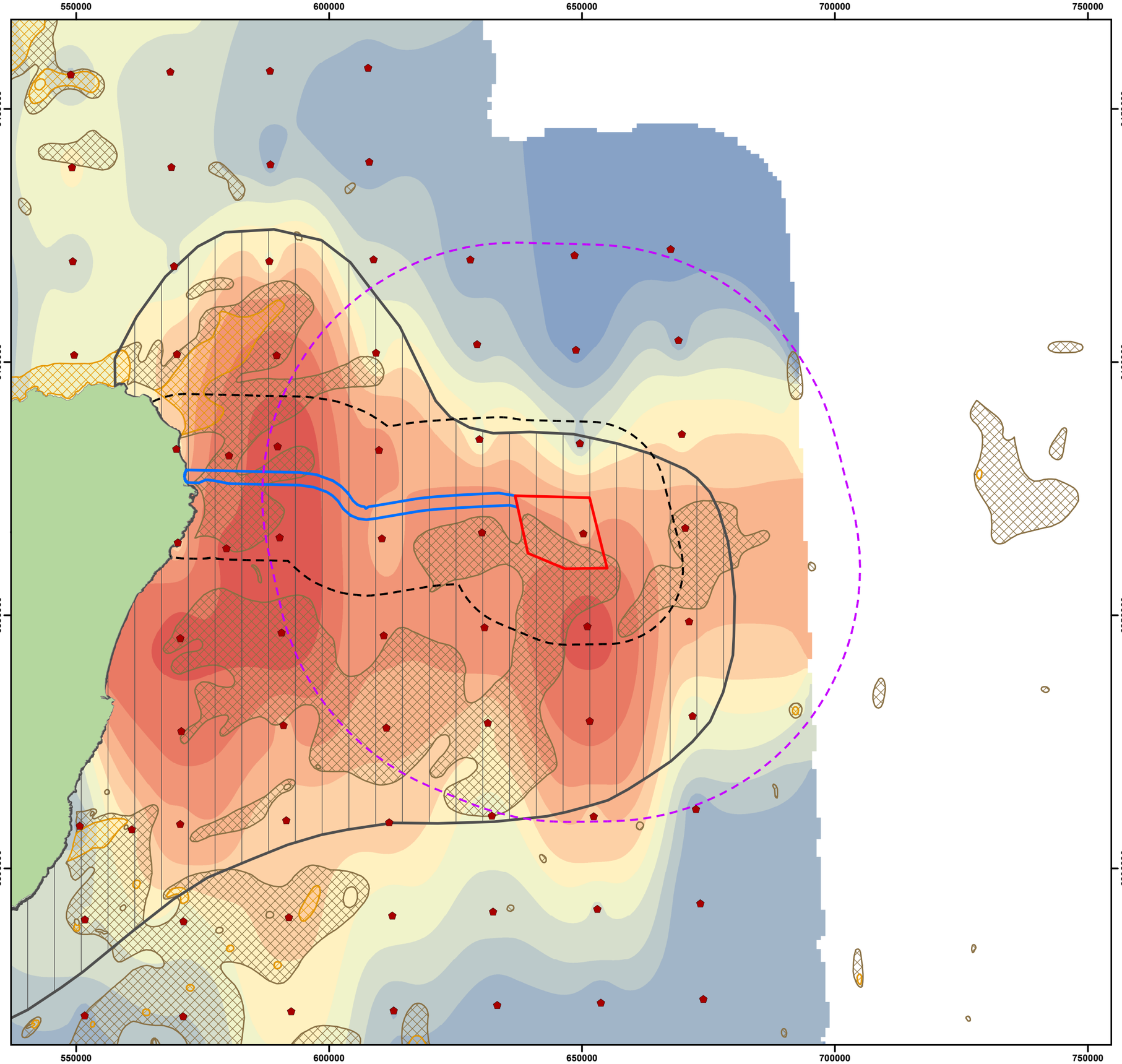

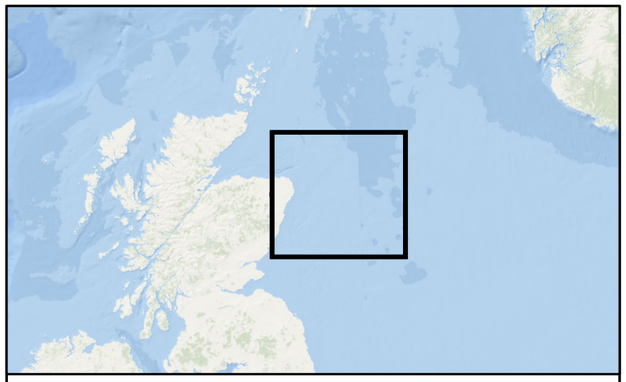

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Herring Spawning Grounds (Coull et al., 1998)

International Herring Larvae Survey

- Sample Location (2011 - 2024)

EMODnet Sediment Class

Herring Habitat Suitability

- Marginal Sediment
- Preferred Sediment

IHLS 2010/2011-2023/2024 Data

Total Larval Abundance Per m^2

- 0
- 0.1 - 750
- 750.1 - 2,500
- 2,500.1 - 5,000
- 5,000.1 - 10,000
- 10,000.1 - 18,500
- 18,500.1 - 30,000
- 30,000.1 - 52,000
- 52,000.1 - 90,000
- 90,000.1 - 175,000
- 175,000.1 - 295,000
- 295,000.1 - 465,000

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Indicative Herring Spawning Data

Figure: 3.11	Drawing No: GoBe-0114		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:750,000 @ A3

0 10 20 km

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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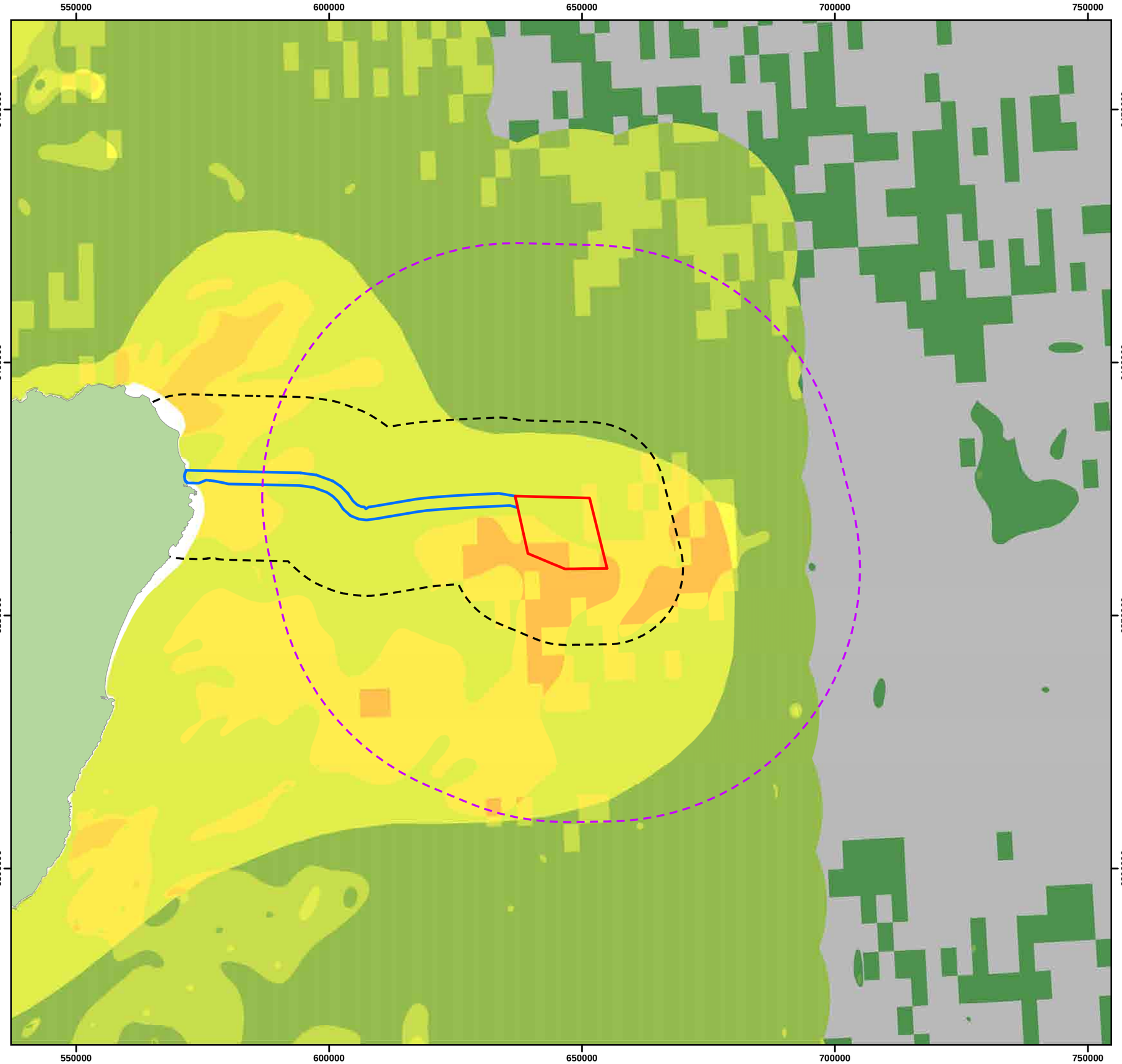

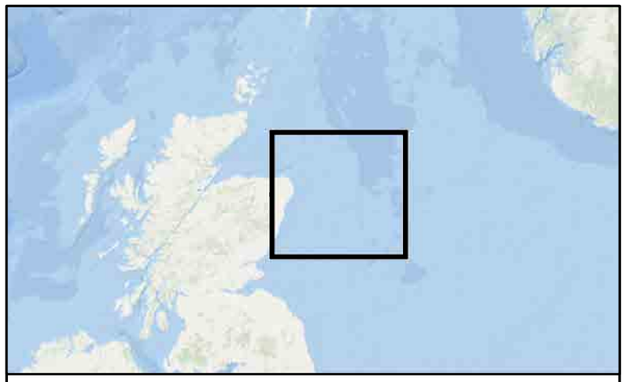

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence

Herring Spawning Habitat Confidence

- 0
- 2 (Low)
- 3 (Low)
- 4 (Low)
- 5 (Medium)
- 6 (Medium)
- 7 (Medium)
- 8 (Medium)
- 9 (High)
- 10 (High)
- 11 (High)
- 12 (High)
- 13 (Very High)
- 14 (Very High)
- 15 (Very High)
- 16 (Very High)

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Herring Spawning Potential Heat Map

Figure: 3.12	Drawing No: GoBe-0115		
Revision:	Date:	Drawn:	Checked:
01	14/07/24	EV	BPHB

Map scale 1:750,000 @ A3

0 10 20 km

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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SANDEEL

3.3.17. Both the offshore ECC and Array Area overlap with high intensity sandeel spawning grounds. Low intensity spawning grounds are present to the north and south of the underwater noise study area (Figure 3-2) (Coull *et al.*, 1988; Ellis *et al.*, 2012). Sandeel are of relevance when considering sedimentary disturbance impacts as they are demersal spawners that lay their eggs onto or into seabed sediments.

3.3.18. Sandeels are a group of shoaling fish which lie buried in seabed sediments at night and feed on planktonic prey such as copepods and crustacean larvae in mid-water during daylight hours (Rowley, 2008). Sandeels are an important trophic link in the North Sea food chain, between zooplankton and sandeel predators including piscivorous fish, most seabirds and mammals. As many marine predators rely on sandeels, coupled with their vulnerability to changes in habitat, sandeels are of increasing conservation interest and listed as a species of principal importance in the UK, designated as a nationally important marine feature (Barnes, 2008c) and a Scottish PMF.

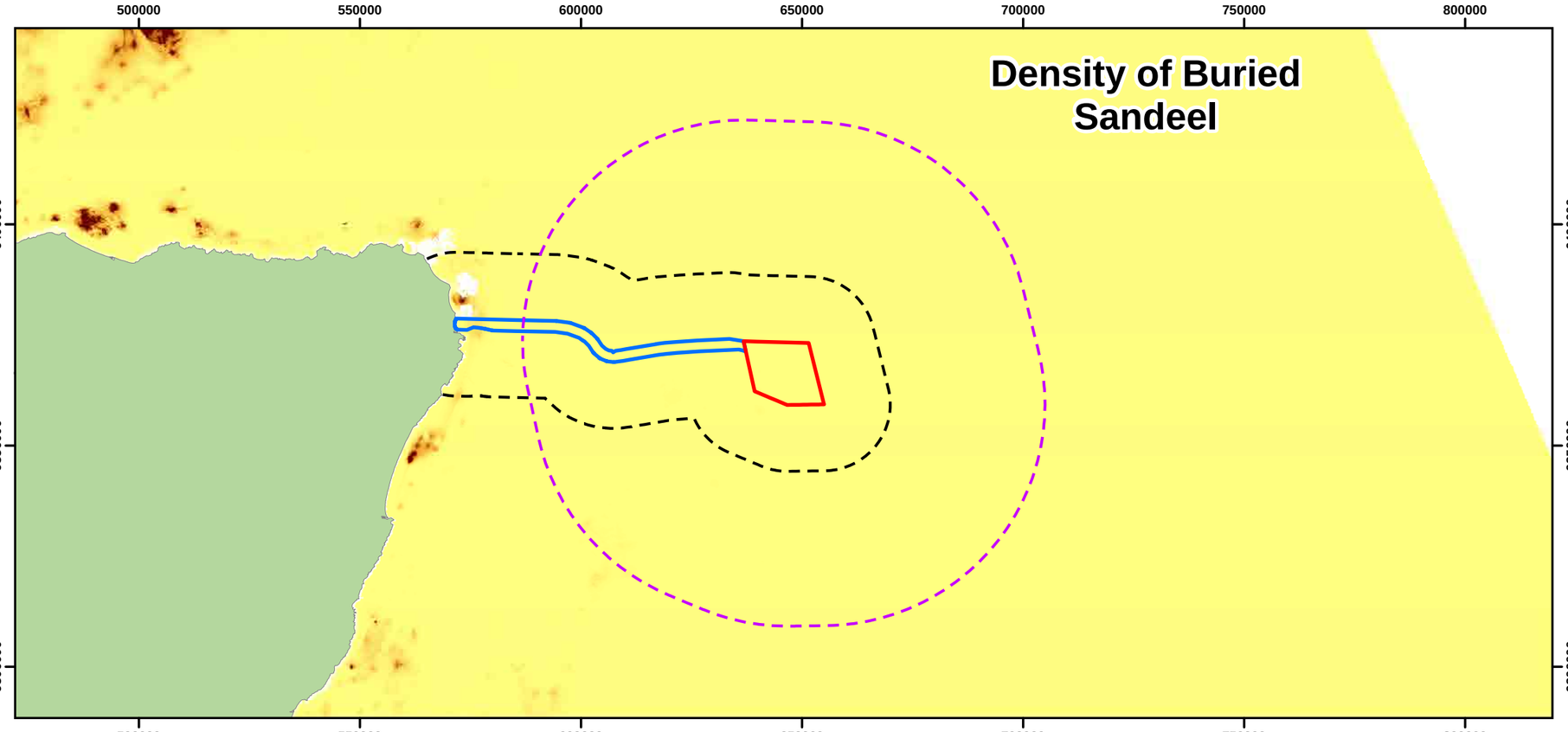
3.3.19. Sandeel spawn in coarse sediments although, their preferred spawning habitats are sandier than those of herring. Sandeel prefer habitats composed of sand to gravelly sand but will tolerate sandy gravels as a marginal spawning habitat. Sandeel are highly substrate specific (Wright *et al.*, 2000); after an initial larval dispersal period, sandeel display a degree of site fidelity (Jensen *et al.*, 2011) so their settled distribution reflects the distribution of preferred habitat. Sandeel rarely occur in sediments where the silt content (particle size <0.63µm) is greater than 4%, and they are absent in substrates with a silt content greater than 10% (Holland *et al.*, 2005, Wright *et al.*, 2000).

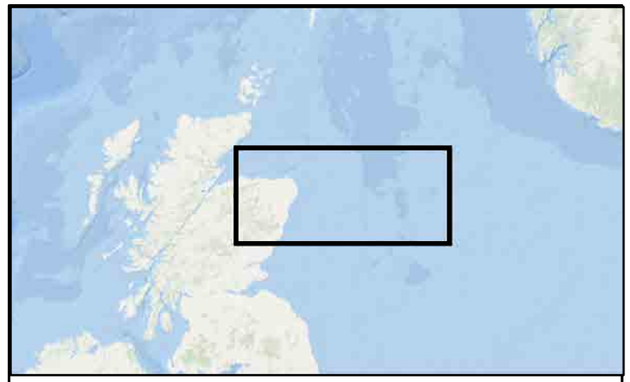
3.3.20. Within the Array Area, stations showed varying dominance between sands and gravels and were categorised into three habitats: 'Circalittoral Muddy Sand', 'Offshore Circalittoral Coarse Sediment', or 'Offshore Circalittoral Mixed Sediment' (Figure 3-14). The majority of the Array Area (71%) was identified as having 'Preferred' sediments, while patches predominantly to the south of the Array Area (22%) were classified as 'Marginal' and a smaller portion (6%), in the central Array Area, classified as 'Unsuitable' using the method outlined by MarineSpace Ltd *et al.* (2013b). According to the lesser sandeel distribution models developed by Langton *et al.* (2021), the probability of finding buried sandeel within the Array Area is zero. This suggests that there is a very low likelihood of encountering buried sandeel populations in the Array Area based on the verified species distribution model (Figure 3-13). There is an area south-west of the array, within the secondary zone of influence (ZoI), where the probability of finding buried sandeel is higher. The model estimates a 25% probability of sandeel presence in this specific location. This area overlaps with the Turbot Bank Nature Conservation MPA, which has been designated for the presence of sandeel and their importance as a prey species.

3.3.21. The majority of the offshore ECC area is classified as “Preferred” habitats for sandeel, with gravelly sand substrates making up a large majority of the samples (Figure 3-14). Marginal habitats, characterised by sandy gravel, are found nearshore in the ECC at around 25-50 m water depth, while some "Unsuitable" habitats of gravelly muddy sands are located further offshore at around 100 m depth. The Langton *et al.* (2021) species distribution model for lesser sandeel predicts that the probability of finding buried sandeel within the offshore ECC, around 3 km from shore, is approximately 0.5 or 50%. The model also estimates that the density of sandeel in this area would be between 30 to 60 individuals per square meter. This indicates that there is a moderate to high likelihood of encountering buried sandeel within the offshore ECC based on the verified distribution model (Figure 3-13).

3.3.22. The offshore ECC and Array Area overlap with high intensity sandeel spawning grounds (Coull *et al.*, 1988; Ellis *et al.*, 2012). However, the likelihood of spawning in these specific areas is influenced by sediment composition. According to the method outlined by MarineSpace Ltd *et al.* (2013b), both the offshore ECC and Array Area were predominantly covered by 'Preferred' sediments, with a small number of Sections classified as 'Marginal' or 'Unsuitable'. Conversely, the Langton *et al.* (2021) models indicate a zero probability of sandeel presence in the Array Area, however there is a 0.5 probability of lesser sand eel presence around 3km from the shore, within the proposed offshore ECC area, with a density estimated at around 30 – 60 per m^2. In summary, the likelihood of sandeel spawning in the footprint of the Proposed Development is high, especially in the offshore ECC. The sandeel spawning potential heat map also indicates medium to high potential within the Array Area (Figure 3-16).

Density of Buried Sandeel





Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence

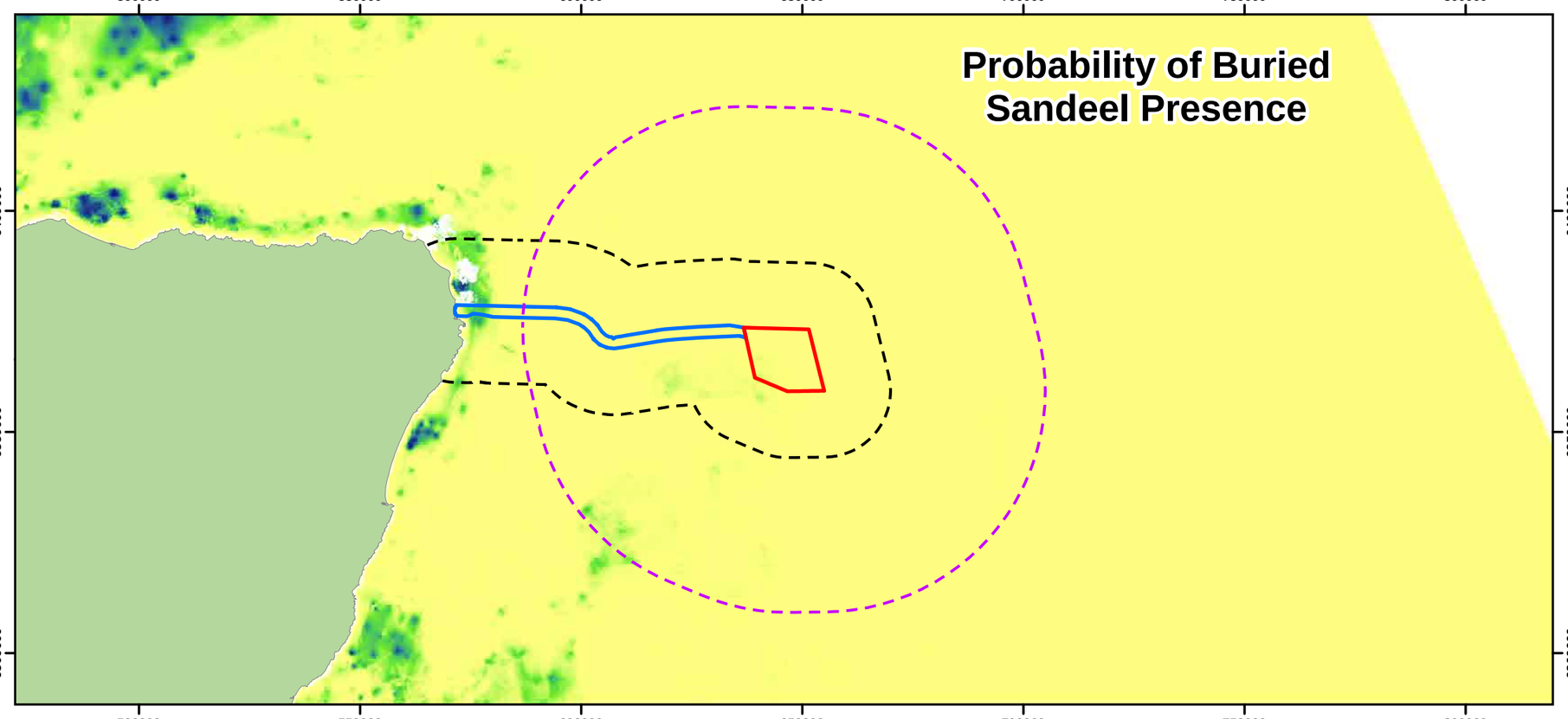
Density of Buried Sandeel

- 0 per sq m
- 30 per sq m
- 60 per sq m
- 90 per sq m
- 120 per sq m or greater

Probability of Buried Sandeel Presence

- 0 (Less Probable)
- 0.25
- 0.5
- 0.75
- 1 (More Probable)

Probability of Buried Sandeel Presence



Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Density and Probability of Presence of Buried Sandeel in the Fish and Shellfish Ecology Study Area (Bangt on et al. (2021)

Figure: 3.13	Drawing No: GoBe-0116		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,200,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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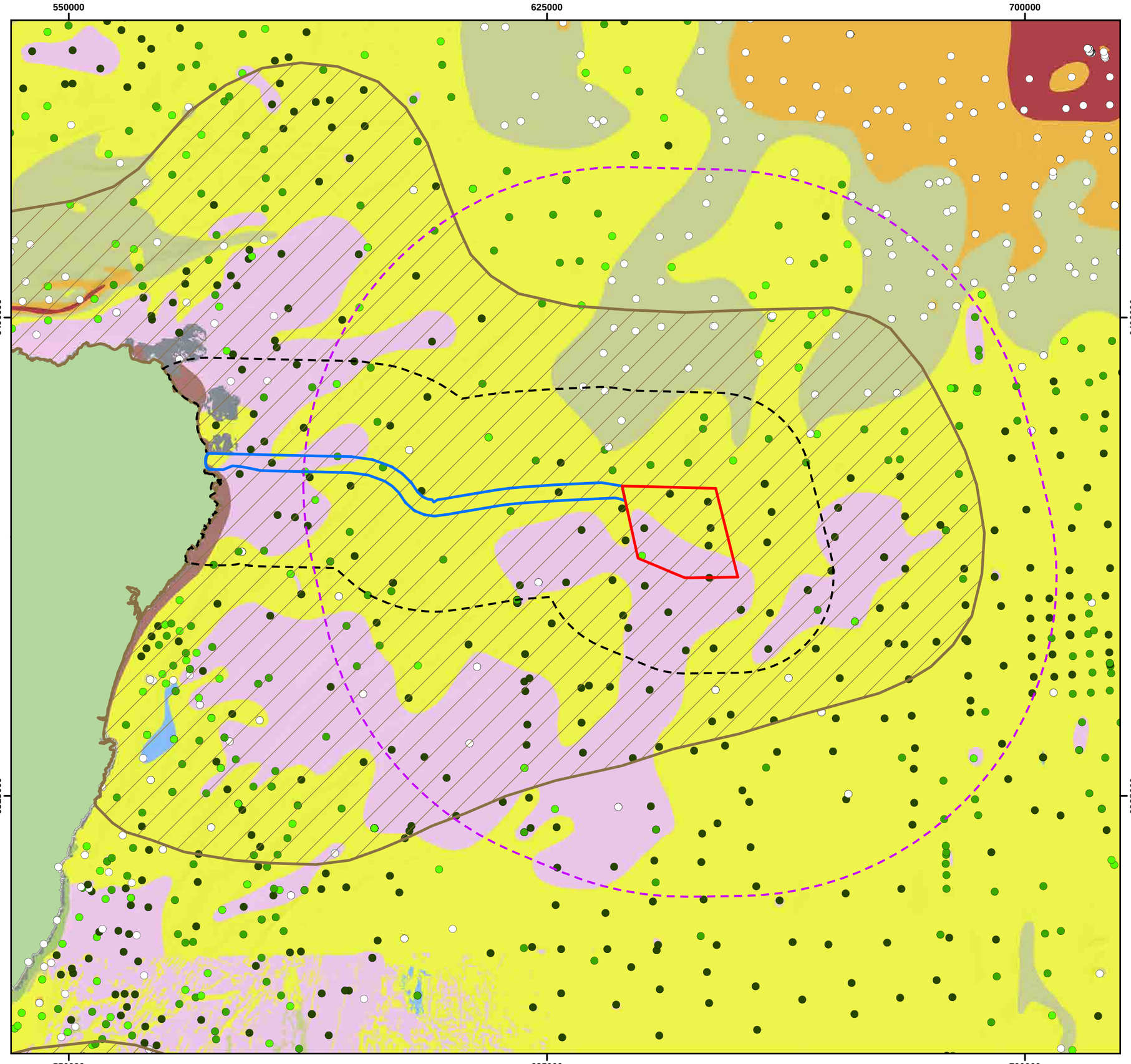

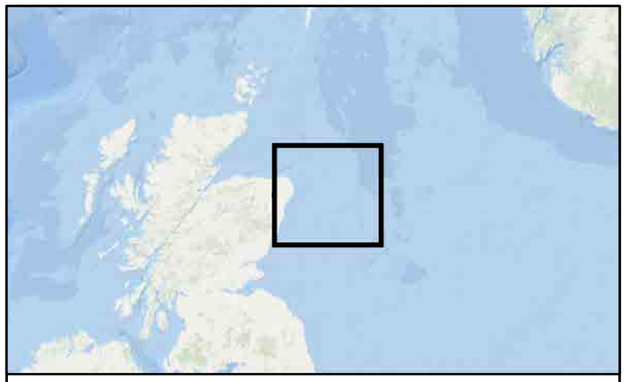

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Sandeel Spawning Grounds (Coull et al., 1998)

Sandeel Habitat Suitability (Latto et al., 2013)

- Prime, Preferred
- Sub-Prime, Preferred
- Suitable, Marginal
- Unsuitable

Data Source:

- BGS, 2015

Seabed Substrate (EUSeaMap; EMODnet)

- Sand
- Sandy mud
- Fine mud
- Muddy sand
- Seabed
- Coarse substrate
- Sediment
- Mixed sediment
- Rock or other hard substrata

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Sandeel Substrates Relative to the Fish and Shellfish Ecology Study Area

Figure:	Drawing No:
3.14	GoBe-0117

Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:600,000 @ A3

0 10 20 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM

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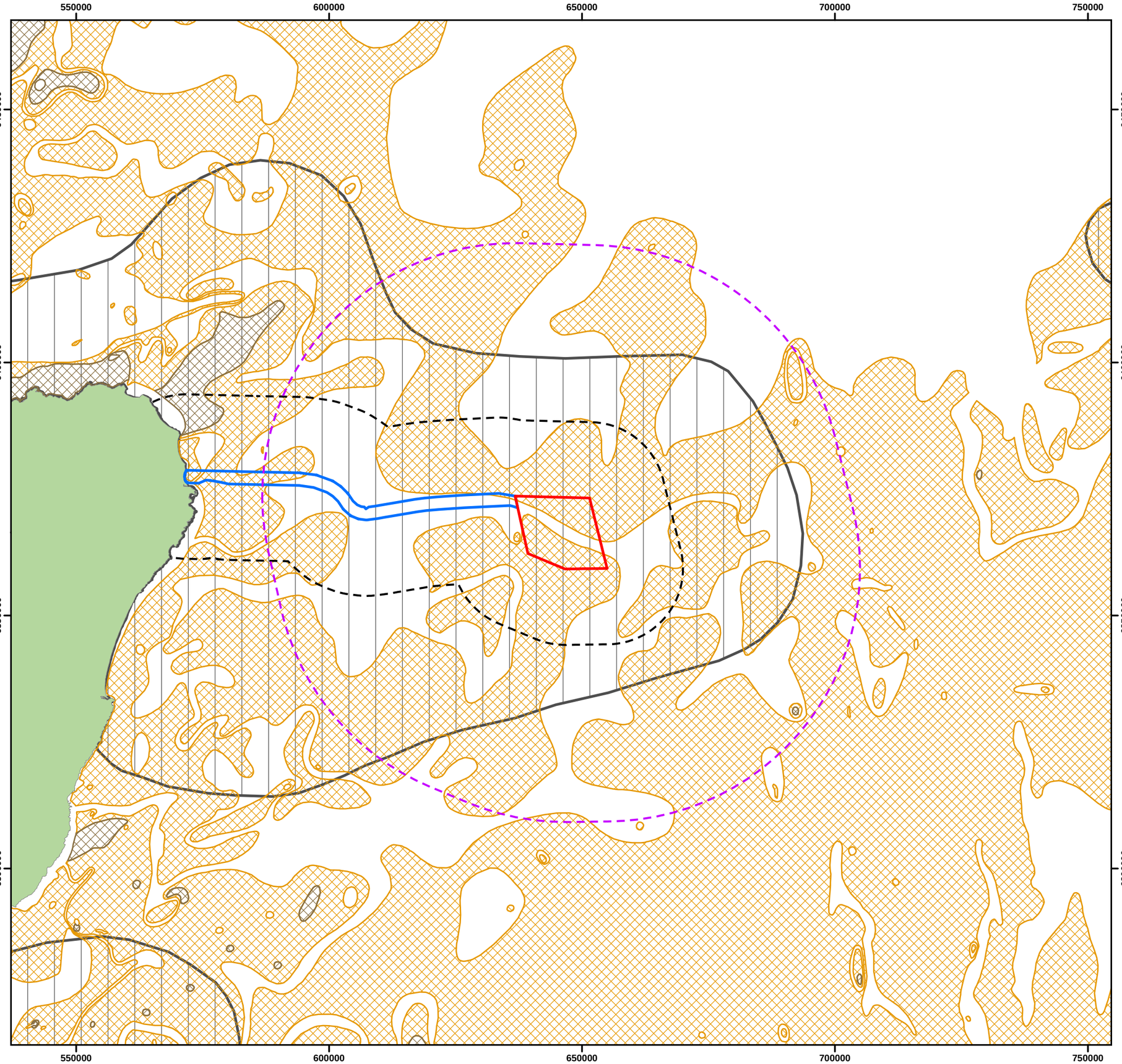
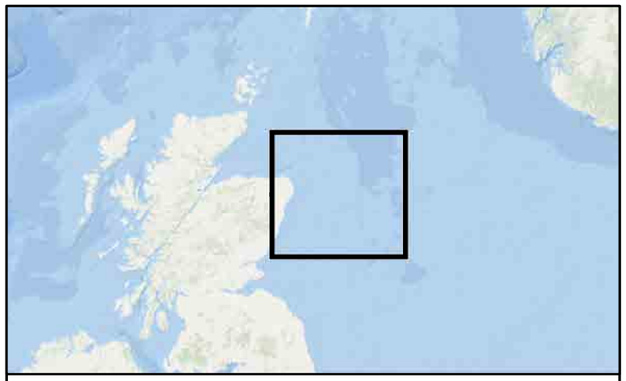
Service Layer Credits: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors





Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Sandeel Spawning Grounds (Coull et al., 1998)

EMODnet Sediment Class
Sandeel Habitat Suitability

- Marginal Sediment
- Preferred Sediment

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Indicative Sandeel Spawning Data

Figure: 3.15	Drawing No: GoBe-0118		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:750,000 @ A3

0 10 20 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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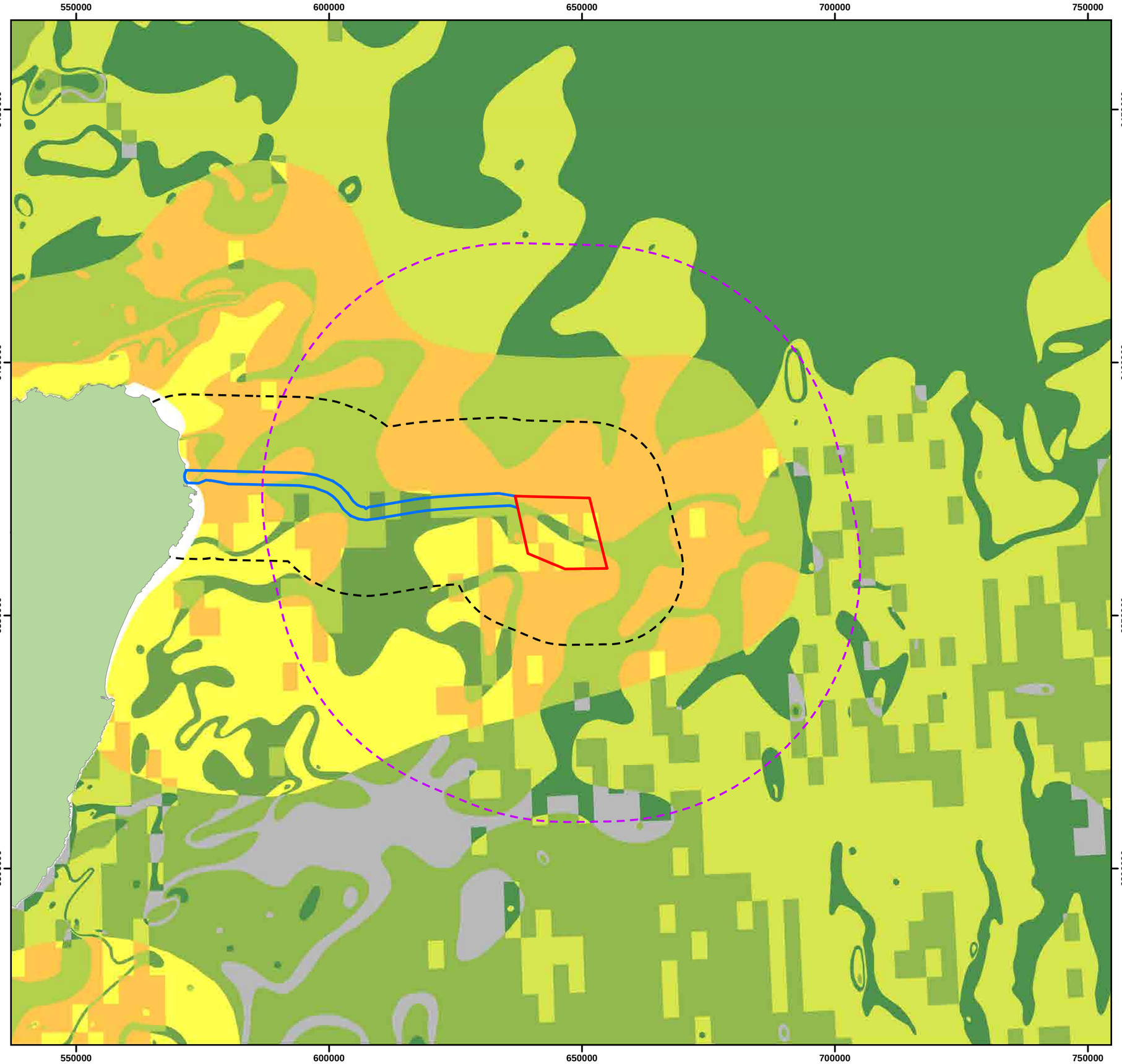

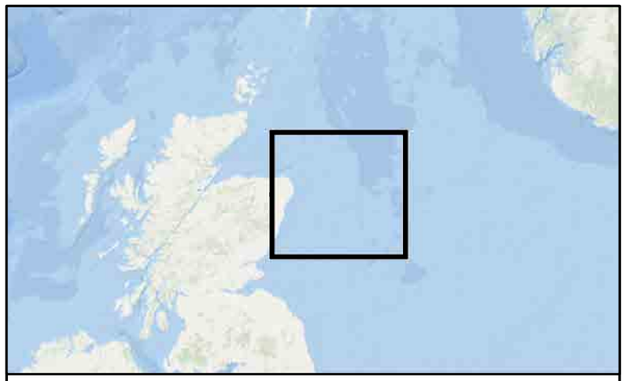

Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence

Sandeel Spawning Habitat Confidence

- 0
- 2 (Low)
- 3 (Low)
- 4 (Low)
- 5 (Medium)
- 6 (Medium)
- 7 (Medium)
- 8 (Medium)
- 9 (High)
- 10 (High)
- 11 (High)
- 12 (High)

Project:	Report:
Muir Mhòr	Fish and Shellfish Technical Report

Sandeel Spawning Potential Heat Map

Figure: 3.16	Drawing No: GoBe-0119		
Revision:	Date:	Drawn:	Checked:
01	14/07/24	EV	BPHB

Map scale 1:750,000 @ A3

0 10 20 km

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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3.4. SPECIES OF COMMERCIAL IMPORTANCE

3.4.1. Detailed information on species of commercial importance is provided in Volume 3, Appendix 13.1 (Commercial Fisheries Technical Report). Landings within the northern North Sea region by UK vessels in 2022 were dominated by shellfish and pelagic fish species. Specifically, landings were dominated in both quantity (tonnage) and value by *Nephrops*, scallops, crab spp. and squid spp. Landings of fish species were dominated by mackerel and herring (MMO, 2022). Landings of demersal species within the region from 2016 to 2021 were dominated by haddock, whiting, sandeel and anglerfish species, whilst shellfish landings largely consisted of scallops (*Pecten maximus* and *Aequipecten opercularis*), *Nephrops* and brown crabs (MMO, 2021).

3.4.2. The key commercial fisheries receptors identified within the commercial fisheries study areas from Volume 3, Appendix 13.1 (Commercial Fisheries Technical Report) are identified as follows:

- Mackerel;
- Herring;
- Haddock;
- Anglerfish/Monkfish;
- Brown crab;
- European lobster;
- *Nephrops*; and
- King scallop.

SHELLFISH

3.4.3. Shellfish are considered to be potentially sensitive to activities associated with the Proposed Development, based on their limited mobility and therefore are considered less able to avoid potential disturbances compared to more mobile species.

NEPHROPS

3.4.4. *Nephrops,* also known as Norwegian lobster, have a wide distribution across the Eastern Atlantic and North Sea. They are present at depths between 20 and 800 m, in sublittoral soft sediment. *Nephrops* are the most valuable shellfish fishery in the Scottish North Sea, with over 19,302 tonnes landed by Scottish Vessels in 2022, worth £82.8 million (Scottish Fisheries Statistics, 2022).

3.4.5. *Nephrops* are opportunistic predators and feed primarily on other crustaceans, but have been known to feed on molluscs, echinoderms and polychaetes, and their growth rate can vary depending on food availability (Hill & Sabatini, 2008). They leave their burrows at dawn and dusk to forage, exhibiting diel feeding patterns. They do not reach sexual maturity until 2-3 years and have an annual reproductive cycle, where sexually mature individuals moult towards the end of spring, and mating takes place before the females' exoskeleton has hardened. Fertilised eggs are carried on the female's abdomen for 8-9 months. Females tend to remain within their burrows during this time. The fecundity of the species varies geographically, and larval mortality rates can be high. Potential recruitment from other populations of *Nephrops* is low as larvae do not have a high dispersal potential, and adult *Nephrops* show no evidence of migration (Hill & Sabatini, 2008).

BROWN CRAB

3.4.6. Brown crab is one of the most economically important crab species in UK waters. The Scottish Fisheries Statistics (2022) show that 7,670 tonnes of edible crab were landed in 2022, worth £19.1 million. A brown crab stock status assessment undertaken in 2019 by Cefas, reported a high exploitation rate of brown crab in the North Sea, East of Scotland, Orkney, and some stocks on the west coast of Scotland, with anecdotal information suggesting a recent expansion of fishing activity in both pot numbers and distribution (Cefas, 2019).

Brown crab inhabit a range of intertidal and subtidal habitats, including bedrock, under boulders, mixed coarse grounds, and offshore muddy sands, up to depths of approximately 100m (Neal & Wilson, 2008). Brown crab populations have a wide range, extending from Scandinavia to Portugal (Bridges, 2018), with adult crabs known to undertake extensive migrations, to offshore overwintering grounds, where eggs are hatched, moving back to coastal areas around May (Tonk & Rozemeijer, 2019).

EUROPEAN LOBSTER

3.4.7. A total of 1,168 tonnes of European lobster, worth £17.7 million was caught from Scottish vessel in 2022 (Scottish Fisheries Statistics, 2022). The stock assessment of lobsters in 2019, as reported by Cefas, highlighted a concerning trend of high exploitation rates in various regions. Lobster stocks in the North Sea, East of Scotland, Orkney, and some areas on the west coast of Scotland were identified as experiencing significant exploitation pressures. Anecdotal evidence suggested a recent increase in fishing activity, both in terms of the number of pots used and the expanded distribution of fishing efforts.

3.4.8. European lobster inhabits similar habitats to those described for brown crab above. The European lobster has a wide distribution, extending from Scandinavia to the Iberian Peninsula, and is recognised for its extensive migrations, particularly related to reproductive behaviour and finding suitable habitats.

SCALLOP

3.4.9. Regionally, key scallop grounds are located to the south of the study area in the central North Sea (Marine Scotland, 2016). The Scottish Fisheries Statistics (2022) show that 16,675 tonnes of scallops were landed in 2022, worth £31,742 million. Scallops typically inhabit shallow depressions in the seabed, preferring areas of clean firm sand and fine or sandy gravel and are occasionally observed on muddy sands (Marshall & Wilson, 2008). Scallops undertake limited swimming, with swimming behaviours likely to be at a high energy cost, and generally associated with escape scenarios. Consequently, this species is not expected to travel large distances (Marshall & Wilson, 2008).

PELAGIC SPECIES

HERRING

3.4.10. Herring is one of the most economically important pelagic fisheries in the North Sea. In 2021, 72,837 tonnes of herring landed by Scottish vessels worth £49.8 million (Scottish Fisheries Statistics, 2022). They have a wide-ranging spatial distribution across the North Sea; however, most adults are fond on the continental shelfs, they form large shoals and have diurnal vertical migration patterns (ICES, 2023d). They lay their eggs on gravel substratum, making them particularly susceptible to anthropogenic activity. Due to overexploitation and poor recruitment, the North Sea herring spawning stock declined in the 1970s, leading to fishery closure in 1977. Given the unique sedimentary requirement for herring spawning

grounds and the stock's vulnerability to overfishing, herring spawning grounds may be subject to protection if found.

MACKEREL

3.4.11. Mackerel is the most valuable pelagic fishery in the North Sea, with 213,306 tonnes landed by Scottish vessels in 2022, worth £173,569 million (Scottish Fisheries Statistics, 2022). They have a wide-ranging distribution but predominantly inhabit waters on the continental shelf. Mackerel migrate annually, likely in response to oceanographic temperatures and the availability of food. Mackerel typically spawn between May and July.

3.4.12. During winter, both immature and mature mackerel are more abundant along the edges of the continental shelf and Norwegian Deeps, with densities increasing in summer as they enter the Southern Bight through the Channel and the northern North Sea around Scotland (Jansen *et al.*, 2012). The North Sea mackerel stock has faced challenges due to overexploitation and poor recruitment, leading to unsustainable harvesting levels.

3.4.13. The North Sea mackerel stock's protection and management involves various measures, including fishing prohibitions in specific areas and times. After spawning, the North Sea stock mixes with immigrants of the western stock on feeding grounds in the southern Norwegian Sea before returning to over-wintering areas. Most mackerel landings are concentrated around the Shetland and Orkney Isles, extending into the central North Sea. Fisheries exploit mackerel throughout the year, with peak landings typically occurring in the 3rd quarter (July to September) (ICES, 2024).

DEMERSAL SPECIES

SANDEEL

3.4.14. Prior to the recent ban on commercial sandeel fishing in UK waters, sandeels were an important target species for Scottish fishing vessels. Sandeel landings by Scottish vessels fluctuated significantly, but often exceeded 100,000 tonnes per year in the early 2000s, peaking at over 150,000 tonnes in 2002 (Marine Scotland, 2023). However, landings declined in the late 2000s and 2010s, falling to around 50,000-70,000 tonnes per year on average. Sandeels are a vital component of the Scottish marine ecosystem, serving as a crucial food source for seabirds, marine mammals, and predatory fish. The decline in sandeel populations in recent years has had significant impacts on these dependent species, contributing to declines in seabird populations and affecting the overall health of the marine ecosystem.

3.4.15. A recent change in legislation involves the banning of commercial sandeel (lesser & Raitt's sandeel) fishing in UK waters, including Scottish waters. This ban was announced by the UK Government in January 2024 and confirmed in February 2024, with the aim of benefiting seabirds and other wildlife that depend on sandeels as a crucial part of their diet (Scottish Government, 2023). The ban is a response to the decline in sandeel populations, which are an important food source for many species, including marine mammals, seabirds, and predatory fish. The ban is intended to support the wider marine ecosystem and provide greater resilience to vulnerable species, particularly in the face of climate change and the impact of warming seas (Coull *et al.*, 1988). The ban on sandeel fishing proposed by the Scottish Government is set to be in effect from April 2024. This closure will complement the existing sandeel management measures, such as the closure in sandeel management area 4 that has been in place since 2000 to avoid bycatch of cod and haddock and negative impacts on seabird food supply.

HADDOCK

3.4.16. Haddock are widespread across deeper waters in the North Atlantic, with a significant presence in the North Sea. Haddock typically spawn between March to May; however, spawning stock is strongly influenced by recruitment from the previous year. A total of 26,851 tonnes was landed by Scottish vessels in 2022, worth £34 million (Scottish Fisheries Statistics, 2022). More recent data from the MMO (2022) reported landing of 45,770 tonnes.

3.5. DIADROMOUS SPECIES

3.5.1. Migratory fish are species that spend part of their life cycle in freshwater and part in seawater; such species are termed diadromous (migrate between freshwater and saltwater) and anadromous (migrating up rivers from the sea to spawn). Several migratory fish species have the potential to transit the fish and shellfish study area, migrating between the North Sea and rivers. The rivers of particular importance and focus in this Chapter are outlined in Figure 3-17.

3.5.2. Migratory fish species that have the potential to occur in the nearby rivers and estuaries near the Proposed Development include Atlantic salmon, sea trout, European eel, smelt (*Osmerus eperlanus*), twaite shad (*Alosa fallax*), allis shad (*Alosa alosa*), river lampreys and sea lampreys. Several species of fish living in Scottish rivers migrate between the sea and the upper reaches of rivers during their life cycle. Atlantic salmon, sea trout and lampreys spend most of their adult lives in the oceans but return to freshwater to reproduce. European eel are also migratory diadromous fish, but their lifestyle differs from anadromous fish; adult eels migrate out to sea to spawn and their larvae make the return journey (termed catadromous).

3.5.3. Grade 3 rivers are characterised by a probability of less than 60% to achieve their conservation limit, leading to the enforcement of mandatory catch and release regulations as a measure to support conservation objectives within these river systems (Scottish Government, 2023). The nearest grade 3 rivers to the Proposed Development are the River Deveron, River Ugie, and River Ythan, River Don, Cowie Don and Carron Water (see Figure 3-17).

3.5.4. Some diadromous species may transit the study area as part of their migration or during foraging activity. Atlantic salmon are present in the River Ugie, located to the north of the Proposed Development's cable landfall area (Gilbey *et al.*, 2021; Statoil, 2015). The rivers Dee, South Esk and Spey (30 km, 86 km, and 72.3 km from the Proposed Development, respectively) are the closest Special Areas of Conservation (SACs) with a qualifying interest of diadromous species (all Atlantic salmon), whose dominant migratory routes have the potential to pass through the Muir Mhòr Array Area and offshore ECC (Gilbey *et al.*, 2021; Statoil, 2015).

ATLANTIC SALMON

3.5.5. Atlantic salmon are designated under Annex III of the Bern Convention and freshwater populations on The Conservation of Habitats and Species Regulations (UK Government, 2017). Atlantic salmon are also a fish species which are considered under the Scottish Biodiversity List. Additionally, Atlantic salmon have been reclassified by the IUCN as "Endangered" in the UK with a projected population decline from 50-80% between 2010 and 2025 and listed as "Near threatened" internationally (IUCN, 2023).

3.5.6. Atlantic salmon are anadromous fish, spawning in freshwater and feeding at sea. Salmon spawn in the upper reaches of rivers, where they live for one to three years before migrating to sea as smolts. At sea, salmon grow rapidly and after one to four years return to their natal river to spawn (Vladić & Petersson, 2015). A study by (Newton *et al.*, 2017) investigated the

movements of Atlantic salmon smolt in the Cromarty and Moray Firths; the study observed relatively rapid downstream migration, with the fish taking an average of eight days to travel approximately 62 km. An eastern movement of smolt was observed from the Cromarty Firth, with observations made up to 30 km from shore in the marine environment, and >60 km from the river mouth. This is supported by Thorstad *et al.* (2004) and Finstad *et al.* (2005) who noted that smolts undergo rapid migrations towards open marine areas, away from their river of origin, and in general do not follow nearby shores. However, contradictory evidence from Malcolm *et al.* (2010), suggests that smolt utilise nearshore areas at the commencement of their marine migration. A study investigating the migratory routes of adult Atlantic salmon in Scotland observed a general migratory pattern, whereby salmon migrate through the North Sea, travel along the coast back to their home river for spawning, and then return to the sea for feeding and growth (Malcolm *et al.*, 2010). This behaviour suggests the potential for Atlantic salmon to transit the fish and shellfish study area during migration.

3.5.7. Assessment of the juvenile salmon stocks in the River Dee (shown in Figure 3-17) through the National Electrofishing Programme for Scotland (NEPS) has evaluated juvenile stocks in the Dee as Grade 2, suggesting that there are significant issues with recruitment and survival within the catchment (Malcolm *et al* 2020).

3.5.8. According to the Scottish Fisheries Statistics (2022), the total reported rod catch of Atlantic salmon for 2022 is 42,204, the fourth lowest since 1952. This is an increase of 16% compared to 2021 and 96% of the previous five-year average. Catch and release in 2022 accounted for 97% of the total rod catch and 99% of the rod caught spring multi sea-winter fish (taken before 1 May). The reported retained catch for the net fisheries was among the lowest recorded since 1952. Released net caught fish were reported for the first time in 2021, with a total of 17 fish reported as being of farmed origin, representing 0.04% of the total Scottish catch, by all methods, in 2022.

3.5.9. Despite this species not being detected in the site-specific eDNA surveys, the literature suggests that salmon are likely to be migrating to and from some of the inland rivers situated relatively close to the Proposed Development, including the River Ugie, River Ythan, River Tay and River Urie (shown in Figure 3-17) with the possibility of this species traversing the Proposed Development.

BROWN TROUT (SEA TROUT)

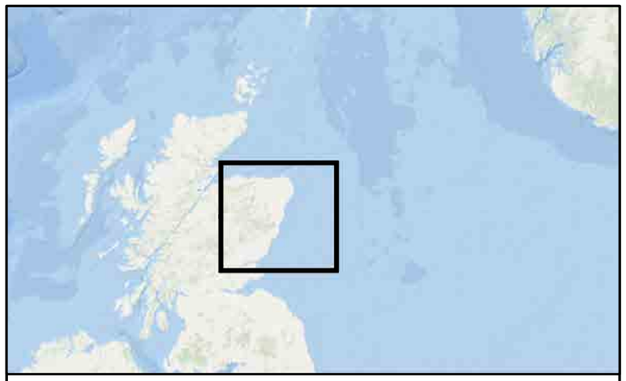
3.5.10. Similar to Atlantic salmon, brown trout also spend a number of years in fresh water before migrating to sea, however in contrast to Atlantic salmon, the species often return to fresh water to overwinter. Netting and tracking data for post-smolt brown trout suggest that the species typically remain close to the coast for the first couple of months before moving further offshore (Finstad *et al.* 2005 as cited in Malcolm *et al.* 2010). There is little consistency in observed migratory patterns of adult brown trout, with studies on the west coast of Scotland suggesting locally constrained areas, and contrasting studies suggesting wide-range migrations, supported by offshore fishing vessel catches of the species suggesting offshore movement and migrations (Malcolm *et al.*, 2010). As detailed in Section 3.2, brown trout were recorded in water column eDNA samples from the Array Area.

3.5.11. According to the Scottish Fisheries Statistics (2022), The total reported rod catch of sea trout for 2022 is 14,509, the fourth lowest since 1952. This is an increase of 11% compared to 2021 and 95% of the previous five-year average. Catches of sea trout have been collected since 2004; the total reported rod catch for 2022 is 8,202. This is an increase of 25% compared to 2021 and 110% of the previous five-year average. Catch and release in 2022 accounted for 91% of the total sea trout rod catch. This is the highest percentage of released rod caught fish since records began in 1994. Reported retained catch and effort for the net fisheries were

among the lowest recorded since records began. Released net caught fish were reported for the first time in 2021.

500000
550000
600000
6400000
6350000
6300000
6250000

River Isla
River Deveron
North Ugie Water
South Ugie Water
River Ugie
River Spey
River Bogie
River Urie
River Ythan
River Don
River Dee
Cowie Water
Carron Water
River North Esk
West Water
River Isla
River South Esk
River Tay



Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Salmon Present (Scottish Government, 2008)
- Salmon Likely Present (Scottish Government, 2008)
- Watercourses

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Rivers of Importance for Migrating Salmon in Relation to the Fish and Shellfish Ecology Study Area

Figure: 3.17	Drawing No: GoBe-0120		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:650,000 @ A3

0 10 20 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM
A joint venture between Fred. Olsen Seawind & Vattenfall

EUROPEAN EEL

3.5.12. European Eel are listed as critically endangered on the IUCN Red List and are UK Biodiversity Action Plan (BAP) priority fish species. In addition, the Scottish Eel Management Plan was established in 2010 in response to the Eel Recovery Plan (formed under European Commission Council Regulation No 1100/2007) with the aim of improving the European eel stocks (Defra, 2010). European eel are catadromous, feeding in freshwater and spawning at sea. The movements of juveniles migrating from the spawning grounds in the Sargasso Sea are thought to be primarily dictated by the course of prevailing currents, and there is a general assumption that proximity to Atlantic currents is associated with high eel numbers (Malcolm *et al.*, 2010), and due to the location and direction of the North Atlantic Drift current, the migratory movements of juvenile European eel are assumed to follow a southern movement along the coast. In contrast to this, the migration routes of adult eels do not appear to hug the UK coastline, however, data on the understanding of European eel movements are scarce (Malcolm *et al.*, 2010). This species was not detected in any of the regional survey datasets or in the Proposed Development site-specific eDNA surveys, so is considered unlikely to be found in significant numbers within the fish and shellfish ecology study areas, however it is still considered to ensure a precautionary approach.

RIVER LAMPREY AND SEA LAMPREY

3.5.13. River lamprey and sea lamprey are designated under Appendix III of the Bern Convention, The Conservation of Habitats and Species Regulations (2017), Schedule 5 of the Wildlife and Countryside Act and are on the Scottish Biodiversity List. River lamprey are widespread in the UK, typically occurring close to the coast (Barnes, 2008a). River lamprey are an anadromous species which grow to maturity in estuaries around Britain and then move into fresh water to spawn in clean rivers and streams. The larvae spend several years in silt beds before metamorphosing and migrating downstream to estuaries (Maitland, 2003). River lamprey have been recorded in the River Ugie (shown in Figure 3-17) at various locations during the National Lamprey Survey of Scotland from 2003-2005 (NBN, 2020).

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

3.5.15. These lamprey species were not detected in any of the regional survey data or the site-specific eDNA surveys, however they have been recorded in the River Ugie, which suggests that they have the potential to migrate through the fish and shellfish ecology study areas.

ALLIS SHAD AND TWAITE SHAD

3.5.16. The allis shad and the twaite shad are both anadromous fish species found in the northeast Atlantic Ocean, including the North Sea and coastal waters of Scotland. The habitat requirements of twaite shad are not fully understood, but they are known to spawn at night in shallow areas near deeper pools, with their eggs sinking into the spaces between coarse gravel and cobble substrates (JNCC, 2021c). Allis shad also have poorly understood habitat needs, spending most of their adult lives in coastal waters and estuaries before migrating into rivers to spawn, sometimes traveling up to 800 km upstream in continental Europe. Allis shad spawn at night, releasing their eggs into the current where they settle among gaps in gravelly substrates, with shallow, gravelly areas adjacent to deep pools thought to represent optimal spawning habitat (JNCC, 2021d). These species were not detected in any of the regional

survey datasets or in the site-specific eDNA surveys, so are considered unlikely to be found in significant numbers within the fish and shellfish ecology study areas, however they are considered to ensure a precautionary approach.

SMELT

3.5.17. The smelt primarily inhabit estuaries and large lakes, spending the majority of their life in the estuarine zone with only brief excursions into the littoral zone (Arula *et al.,* 2017). When it comes time to spawn, the sparling will enter rivers, typically depositing their eggs on sandy or gravelly bottoms in the fast-flowing waters of lake tributaries or the shallow shores of lakes and rivers. Given their strong preference for estuarine environments, it is unlikely that sparling would be found within the fish and shellfish ecology study areas, as they typically avoid venturing too far into the marine environment. In addition, this species was not detected in any of the regional survey datasets or in the site-specific eDNA surveys.

3.6. ELASMOBRANCHS

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

3.6.2. Elasmobranchs (sharks and rays) are a particularly sensitive species group due to their slow growth rates and low fecundity (Salvador *et al.*, 2022). Many of the sharks and rays living in Scottish waters are included in the OSPAR list of threatened and/ or declined species, these include tope, common smoothhound, starry smoothhound, thornback ray, blonde ray, spotted ray, spurdog and small-spotted catshark (OSPAR, 2024). There are low intensity nursery grounds for common skate, spotted ray, spurdog and tope shark that interact with the fish and shellfish study area, shown in Figure 3-7 and Figure 3-8 (Coull *et al.*, 1988; Ellis *et al.*, 2012). The site-specific eDNA surveys detected porbeagle and starry smoothhound in the offshore ECC.

BASKING SHARK

3.6.3. Basking sharks are the largest fish in the North Atlantic, reaching up to 12 m in length. Basking sharks are obligate ram feeders, meaning that they use their gill rakers to filter zooplankton from the water as they swim along (Wilson *et al.*, 2020). They are long-lived species, with some individuals reaching up to 100 years old. Defining characteristics of basking shark include slow growth, delayed maturation, long gestation periods, production of few young. Males are believed to reach sexual maturity between 12-16 years and females in the region of 16-20 years (Wilson *et al.*, 2020).They are thought to breed at the start of summer and offspring gestation takes between one to three and a half years (Wilson *et al.*, 2020).

3.6.4. Basking sharks are currently listed as Endangered on the IUCN Red List (IUCN, 2023b) and are protected under Schedule 5 of the Wildlife and Countryside Act (1981), Countryside Rights of Way Act (2000) and the Nature Conservation (Scotland) Act (2004).

3.6.5. Basking sharks are often found along ocean fronts, potentially due to the availability of food and migrate from the western English Channel in spring to western Scottish waters, where they spend the summer and early autumn before moving offshore in winter. However, it is important to note that the migration of basking sharks is not fully understood and remains rather ambiguous in waters around the UK (Wilson *et al.*, 2020).

3.6.6. A study carried out by Austin *et al.*, (2019) indicates that the northern North Sea, located on the east coast of Scotland, has not been previously recognised as a significant gathering area for basking sharks. Nevertheless, historical sightings have been documented in this region. There have been reports of exceptionally high numbers of basking sharks on the north-east coast of Scotland recently (Wilson *et al.*, 2020). According to Austin *et al.*, (2019), historical data indicates that the north-east coast of Scotland has been frequented by basking sharks, albeit in limited numbers. This region presents potential for future population growth as the basking shark population in the north-east Atlantic continues to recover from past exploitation.

COMMON SKATE

3.6.7. The common skate was historically abundant in the northeast Atlantic, including the northern North Sea, but its population has drastically declined due to overfishing and bycatch. It is now considered critically endangered globally and in European waters. The common skate is a bottom-dwelling species found at depths of 100-200 m, feeding on a variety of prey including crustaceans, molluscs, and small to medium-sized fish (Neal & Pizzolla, 2006). While the species has been extirpated from parts of its former range, it is believed to still have some strongholds off western Scotland and in the Celtic Sea. Recent studies indicate the species is now rare in the northern North Sea, and it was not detected in site-specific eDNA samples. However, the fish and shellfish ecology study areas overlap with low-intensity nursery grounds for the common skate.

SPOTTED RAY

3.6.8. The spotted ray, also known as the spotted skate, was historically found in the northern North Sea. However, its population has declined significantly due to overfishing and bycatch. The spotted ray is a small, bottom-dwelling ray species that feeds on a variety of prey, including small fish, crustaceans, and molluscs (Gibson-Hall, 2018). Recent studies indicate the spotted ray is now rare in the northern North Sea, however it does have known nursery grounds within the footprint of the Proposed Development.

SPURDOG

3.6.9. The spurdog, also known as the spiny dogfish, was historically widespread in the northeast Atlantic, including the northern North Sea. However, its population has declined significantly due to overfishing and bycatch. The spurdog is a small, bottom-dwelling shark species that feeds on a variety of prey, including small fish, crustaceans, and molluscs (Barnes, 2008). While the species has been extirpated from parts of its former range, it is believed to still have some remnant populations in the region. Recent studies indicate the spurdog is now rare in the northern North Sea, and it was not detected in site-specific eDNA samples. However, the study areas overlap with known nursery grounds for the spurdog.

TOPE SHARK

3.6.10. The tope shark, also known as the school shark or oil shark, was historically widespread in the northeast Atlantic, including the northern North Sea. However, its population has declined significantly due to overfishing and bycatch. The tope shark is a medium-sized, bottom-dwelling shark species that feeds on a variety of prey, including small fish, crustaceans, and molluscs (Barnes, 2008). Recent studies indicate the tope shark is now rare in the northern North Sea, but it does have known nursery grounds within the footprint of the Proposed Development.

STARRY SMOOTHHOUND

3.6.11. The starry smoothhound was historically widespread around the British Isles, including the northern North Sea. It is a shallow-water shark species that favours sandy, shingle, and light broken ground, and tends to stay clear of heavy, rocky areas. Recent studies indicate the starry smoothhound is now rare in the northern North Sea. A survey of over 400 smoothhounds around the UK found that every single one was a starry smoothhound, with no records made of common smoothhound (*Mustelus mustelus)* (Farrell *et al.,* 2009). This, however, was likely due to misidentifications, as the two species are very similar in appearance. Overall, the starry smoothhound seems to have declined in the northern North Sea, but may still be present in certain areas, especially along the southern and western coasts of the UK. More research is needed to fully understand its current distribution and population status in this region.

PORBEAGLE

3.6.12. The porbeagle shark (*Lamna nasus*) was historically found throughout the northeast Atlantic, including the northern North Sea, but its population has declined significantly in this region in recent decades. Studies indicate the porbeagle is now rare or absent from the northern North Sea, likely due to historical overfishing, as the species was heavily targeted for its meat, fins, and liver oil (Barnes, 2008). While porbeagles were once common in the North Sea, their range has contracted, and they are now considered endangered throughout much of the northeast Atlantic, with some residual populations potentially remaining in the western English Channel and Celtic Sea. Continued conservation efforts will be crucial to prevent further declines and potential local extinctions of the porbeagle shark in the northern North Sea.

3.7. SPECIES OF CONSERVATION IMPORTANCE

3.7.1. Within the northern North Sea region, there are records of several marine and estuarine species protected under national and international legislation. Species of conservation importance that have the potential to be present within the fish and shellfish ecology study area are listed below in Table 3-4, along with their associated designations.

3.7.2. On account of the conservation importance of these species to the region, all species are considered sensitive receptors to impacts from the Proposed Development and, therefore, the LSE on these species from the Proposed Development will be taken into consideration in the fish and shellfish ecology assessment.

Table 3-4 Fish and shellfish species that are protected or considered threatened/declining, which are potentially present within the fish and shellfish study areas and wider northern North Sea biogeographic region.

Fish and shellfish species	
OSPAR List of threatened and/or declining species	
Allis shad	Greenland halibut (*Reinhardtius hippoglossoides*)
Atlantic salmon	Sea lamprey
Cod	Gulper Shark (*Centrophorus granulosus*)
European eel	Leafscale gulper shark (*Centrophorus squamosus)*
Basking shark	Porbeagle

Spurdog	Portuguese dogfish *(Centroscymnus coelolepi*)
Spotted ray	Common skate
Thornback ray	White skate (*Dipturus alba*)
Ocean quahog	Dog whelk (*Nucella lapillus*)
Flat oyster (*Ostrea edulis*)	
UK Post-2010 Biodiversity Framework Priority Species	
Allis shad	Ling
Anglerfish	Mackerel
Atlantic halibut (*Hippoglossus hippoglossus*)	Plaice
Basking shark	Porbeagle
Blue ling (*Molva dipterygia*)	Portuguese dogfish
Blue shark (Prionace glauca)	Sandy ray (*Leucoraja circularis*)
Cod	Sea trout
Common skate	Smelt
European eel	Spurdog
Greenland halibut	Tope
Gulper Shark	Twaite shad
Hake	White skate
Horse mackerel (*Trachurus trachurus*)	Whiting
Leafscale gulper shark	*Nephrops*
Lesser sandeel	Brown crab
European lobster	Shore crab (*Carcinus maenas*)
Velvet crab (*Necora puber*)	Blue Mussel (*Mytilus edulis*)
King scallop (*Pecten maximus*)	Raitt's sandeel
Dog whelk (*Nucella lapillus*)	
Scottish Marine Priority Feature	
Anglerfish	Atlantic Mackerel
Ling	Cod
Norway pout	Herring
Lesser sandeel	Saithe (juveniles)

Whiting (juveniles)	Raitt's sandeel
Common skate	Basking shark
European lobster	Spurdog
Velvet crab	Edible crab
King scallop	Shore crab
Dog whelk	Blue Mussel
Nature Conservation (Scotland) Act 2004	
Basking Shark	
IUCN Red List	
Atlantic salmon (Vulnerable)	Atlantic halibut (Vulnerable)
Cod (Vulnerable)	Greenland halibut (Near threatened)
European eel (Critically endangered)	Gulper shark (Vulnerable)
Basking shark (Endangered)	Leafscale gulper shark (Endangered)
Blue shark (Near Threatened)	Porbeagle (Critically Endangered)
Spurdog (Vulnerable)	Portuguese dogfish (Near Threatened)
Tope (Vulnerable)	Common skate (Critically Endangered)
Sandy ray (Vulnerable)	White skate (Endangered)
Thornback ray (Near Threatened)	
Annex II Fish Species EU Habitats Directive (92/43/EEC)	
Allis shad	River lamprey
Atlantic salmon	Sea lamprey
European eel	Twaite shad

3.8. DESIGNATED SITES

3.8.1. All designated sites that have qualifying features or conservation objectives related to fish and shellfish ecology, have been listed in Table 3-5 and illustrated in Figure 3-18.

3.8.2. The southeastern edge of the offshore ECC and eastern edge of the Array Area intersects with the Turbot Bank Nature Conservation Marine Protected Area (NCMPA), which has been designated for the protection of sandeels. The four river SAC shown in Figure 3.19 - the River Dee, River Spey, River Tay, and River South Esk - all contain diadromous fish designated features as well as protection status for freshwater pearl mussels (*Margaritifera margaritifera*). None of the river SACs overlap with the fish and shellfish study areas, however, as these sites contain designated migratory species which have the potential to transit the Proposed Development during migration, these sites have therefore been given due consideration.

3.8.3. The Southern Trench NCMPA intersects the offshore ECC and has been designated for the minke whale (*Balaenoptera acutorostrata*) and burrowed mud as well as two geodiversity features (Quaternary of Scotland, Submarine Mass Movement). The MPA has a conservation objective to maintain productivity and feeding conditions for local mobile prey species associated with mike whale. Juvenile and adult minke whale are regularly observed feeding on non-spiny fish such as sandeel, herring, whiting and cod, squid, and sprat in the MPA.

3.8.4. The Moray Firth SAC is designated for the Annex II species bottlenose dolphin (*Tursiops truncates*). The SAC has a conservation objective to maintain the availability of prey species for bottlenose dolphin.

Table 3-5 designated sites in relation to the fish and shellfish ecology study areas

Site	Location (relative to the Proposed Development)	Fish and Shellfish Qualifying Feature
Turbot Bank Nature Conservation MPA	Overlap with offshore ECC, 0.03 km from the Array Area	Sandeel
Southern Trench Nature Conservation MPA	Overlap with offshore ECC, 40.4 km from the Array Area	Included for presence of herring, mackerel, and cod as prey species for minke whales
Moray Firth SAC	115.3 km from the Array Area, 89.2 km from the offshore ECC	Included for presence of herring and mackerel as prey species for bottlenose dolphins
River Spey SAC	140.8 km to the Array Area, 72.3 km to offshore ECC	Atlantic salmon, sea lamprey and freshwater pearl mussel
River Dee SAC	86.9 km to the Array Area, 30 km to offshore ECC	Atlantic salmon and freshwater pearl mussel
River South Esk SAC	135.4 km to the Array Area, 86 km to offshore ECC	Atlantic salmon and freshwater pearl mussel
River Tay SAC	171.4 km to the Array Area, 148.5 km to offshore ECC.	Atlantic salmon, sea lamprey and freshwater pearl mussel

475000 550000 625000 700000

6475000 6400000 6325000 6250000

Berriedale and Langwell Waters

Moray Firth

Southern Trench

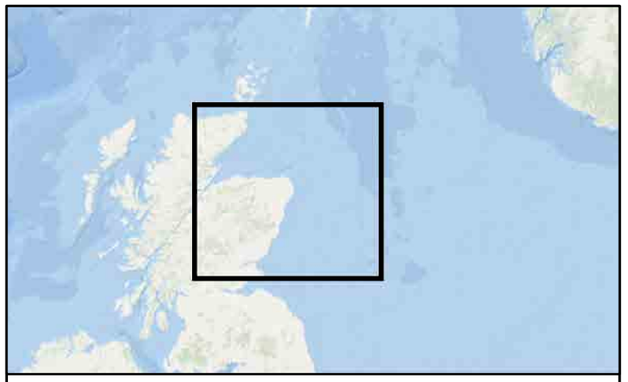
River Spey

Turbot Bank

River Dee

River South Esk

River Tay



Legend:

- Array Area
- Offshore Export Cable Corridor
- Secondary Zone of Influence
- Underwater Noise Zone of Influence
- Marine Protected Areas
- Special Areas of Conservation

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Designated Protected Areas in Relation to the Fish and Shellfish Ecology Study Area

Figure: 3.18	Drawing No: GoBe-0121		
Revision:	Date:	Drawn:	Checked:
01	17/06/24	EV	BPHB

Map scale 1:1,050,000 @ A3

0 10 20 30 40 km

N

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

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4. SUMMARY

4.1.1. The following Sections provide a summary of the fish and shellfish ecology baseline characterisation and set out the detail the VERs to be considered in the fish and shellfish assessment presented in Volume 2, Chapter 10 (Fish and Shellfish Ecology), as informed by the baseline.

4.1. BASELINE

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

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

4.1.3. The fish assemblage within the fish and shellfish ecology study areas is typical of the northern North Sea, with a mix of demersal and pelagic species. There are known spawning grounds for nine species (herring, sandeel, cod, plaice, whiting, Norway pout, lemon sole, *Nephrops*, and sprat) and nursery grounds for nineteen species (herring, sandeel, cod, plaice, whiting, Norway pout, lemon sole, *Nephrops*, sprat, haddock, tope, spurdog, spotted ray, anglerfish, blue whiting, saithe, ling, mackerel, and hake). The Proposed Development overlaps with the Buchan/Shetland herring stock and high-intensity grounds for sandeel, with the majority covered by "Preferred" habitat spawning sediments for sandeel. Eight diadromous fish species, including Atlantic salmon, sea trout, European eel, river lamprey, sea lamprey, allis shad, twaite shad, and smelt, have the potential to be present in the vicinity of the Proposed Development. Seven elasmobranch fish species, including basking shark, porbeagle, spurdog, tope, spotted ray, common skate, and thornback ray, have the potential to be present within the footprint of the Proposed Development. Several protected sites, including the Turbot Bank NCMPA, Southern Trench NCMPA the River South Esk SAC, the River Dee SAC, the River Tay SAC and the River Spey SAC, are located near the Proposed Development. The shellfish community includes *Nephrops*, European lobster, brown crab, ocean quahog, and scallop, most of which are fished commercially in the locality.

4.2. VALUED ECOLOGICAL RECEPTORS

4.2.1. The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (Chartered Institute of Ecology and Environment Management, 2018). The most straightforward context for assessing ecological value is to identify those species and habitats that have specific biodiversity importance recognised through international or national legislation or local, regional or national conservation plans (e.g., species listed on The Conservation of Habitats and Species Regulations (2017), Scottish Biodiversity List species or species of principal importance listed under the Natural Environment and Rural Communities (NERC) Act 2006, and species listed as features of existing or recommended Nature Conservation MPAs. Evaluation has also assessed the receptor value in accordance with the functional role of the habitat or species. The criteria used to inform this assessment are listed in Table 4-1.

Table 4-1 Criteria used to inform the valuation of ecological receptors in the fish and shellfish study areas (derived from guidance published by Chartered Institute of Ecology and Environmental Management (CIEEM) (2018)).

VER value	VER criteria used to define value
International	Internationally designated sites, or species designated under international law (i.e., species designated under the OSPAR List of Threatened and/or Declining Species, or species listed as Critically Endangered, Endangered or Vulnerable on the IUCN Red List)
National	Species protected under national law (i.e., Annex II species listed as features of SACs) within the National Site Network. Annex II species which are not listed as features of SACs in the fish and shellfish study areas. Species protected under national legislation, including The Conservation of Salmon (Scotland) Regulations 2016 (as amended) and the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. Species protected under the Scottish Eel Management Plan (2010). Species protected under national policy, including the Scottish Wild Salmon Strategy (Scottish Government, 2022), and the Eel Management plans for the United Kingdom: Scotland River Basin District (Defra, 2010). Species listed as a PMF: Scotland adopted a list of 81 PMFs in 2014, representing species and habitats on existing conservation lists that were assessed against a set of criteria, including the abundance of the feature in Scottish seas, the conservation status and the functional role played by the feature. Scottish Biodiversity List species that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, species classified as features of conservation importance that have regionally important populations within the fish and shellfish study areas (are locally widespread and/or abundant). Nature Conservation MPA features, including species classified as features of conservation importance and broad-scale habitats. Species that have spawning or nursery areas within the fish and shellfish study areas that are important nationally (e.g., may be primary spawning/nursery area for that species).
Regional	Scottish Biodiversity List species that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, species classified as features of conservation importance that have regionally important populations within the fish and shellfish study areas (are locally widespread and/or abundant). Nature Conservation MPA features, including species classified as features of conservation importance and broad-scale habitats. Species of commercial importance, to fisheries in the area. Species of ecological importance (i.e., are an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages in the fish and shellfish study areas. Species that have spawning or nursery areas within the study area that are important regionally.
Local	Species of commercial importance, but do not form a key component of the fish assemblages within the fish and shellfish study areas. The spawning/nursery area for the species is located outside of the study areas. The species is common throughout the UK but forms a component of the fish assemblages in the study areas.

4.2.2. With consideration of each receptor's distribution and abundance, spawning and nursery activity, as well as their commercial, conservation and ecological importance, an assessment of the value of each of these receptors within the defined fish and shellfish study areas has been provided in Table 4-2.

Table 4-2 Summary of fish and shellfish VERs and their value/importance within the fish and shellfish study areas.

Species	Source	Valuation	Justification
Fish VERs			
Atlantic salmon	Beatrice OWF salmon survey; Marine Scotland Survey (2017); nearby designated sites and literature review (various sources).	International	• OSPAR list of threatened and/or declining species and habitats; • 'Vulnerable' on the IUCN Red List of threatened species; • Protected under the Convention on the Conservation of European Wildlife and Natural Habitats ('BERN') convention; • Protected under the Salmon Act; • PMF (Scotland); • Scottish Biodiversity list; • Nearby River Spey SAC, River Dee SAC, River Tay and River South Esk SAC designated for Atlantic salmon; and • Potential to transit through the study areas.
Basking shark	Literature review (various sources).	International	• OSPAR list of threatened and/or declining species and habitats; • 'Endangered' on the IUCN Red List of threatened species; • PMF (Scotland); • Scottish Biodiversity list; and • Protected under the Nature Conservation (Scotland) Act 2004.
Cod	North Sea bottom trawl data; Hywind OWF trawl survey and Beatrice OWF otter trawl survey.	International	• OSPAR list of threatened and/or declining species; • 'Vulnerable' on the IUCN red list of threatened species; • PMF (Scotland); • Scottish Biodiversity list; • Important prey species for minke whale, a designated feature of the nearby Southern Trench Nature Conservation MPA; and • Study areas overlap with low intensity spawning and nursery grounds.
Starry Smooth hound	Site specific eDNA survey (offshore ECC).	International	• 'Near Threatened' on the IUCN Red List of threatened species
European hake	Site specific eDNA survey (Array Area and offshore ECC) and literature review (various sources).	National	• Scottish Biodiversity list; and • Study areas overlap with low intensity nursery grounds.
European eel	Literature review	International	• OSPAR list of threatened and/or

Species	Source	Valuation	Justification
	(various sources).		declining species and habitats; • 'Critically endangered' on the IUCN Red List of threatened species; • Protected under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and Scottish Eel Management Plan (2010); • PMF (Scotland); • Scottish Biodiversity list; and • Potential to transit through the study areas.
Sea lamprey	Literature review (various sources).	International	• OSPAR list of threatened and/or declining species and habitats; • Protected under the BERN convention; • Protected under the Salmon Act; • PMF (Scotland); • Scottish Biodiversity list; and • Potential to transit through the study areas.
Raitt's sandeel	North Sea bottom trawl data; Hywind OWF trawl survey; Beatrice OWF sand eel survey and nearby designated sites.	National	• PMF (Scotland); • Scottish Biodiversity list; • Nearby Turbot Bank Nature Conservation MPA designated for sandeel; and • Study areas overlap with high intensity spawning grounds and low intensity nursery grounds.
Lesser sandeel	Site-specific camera and video transects; Hywind OWF trawl survey; Moray West OWF epibenthic beam trawl surveys and nearby designated sites.	National	• PMF (Scotland); • Scottish Biodiversity list; • Nearby Turbot Bank Nature Conservation MPA designated for sandeel; and • Study areas overlap with high intensity spawning grounds and low intensity nursery grounds.
Atlantic herring	Site specific eDNA survey (ECC area most abundant species); North Sea bottom trawl data and Hywind OWF trawl survey.	National	• PMF (Scotland); • Scottish Biodiversity list; • Commercially important species in the region; • Important prey species for minke whale, a designated feature of the nearby Southern Trench Nature Conservation MPA. Also, an important prey species for bottlenose dolphin in the nearby Moray Firth SAC; and • Study areas overlap with

Species	Source	Valuation	Justification
			spawning grounds (undetermined intensity), with high intensity nursery grounds within the offshore ECC.
Atlantic mackerel	Site specific eDNA survey (offshore ECC & Array Area); MMO landing statistics and North Sea bottom trawls.	National	• PMF (Scotland); • Scottish Biodiversity list; • Commercially important species in the region; • Important prey species for minke whale, a designated features of the nearby Southern Trench Nature Conservation MPA. Also, an important prey species for bottlenose dolphin in the nearby Moray Firth SAC; and • Study areas overlap with low intensity nursery grounds.
River lamprey	Literature review (various sources)	National	• PMF (Scotland); and • Scottish Biodiversity list.
Twaite shad	Literature review (various sources)	National	• Scottish Biodiversity list.
Allis shad	Literature review (various sources)	International	• OSPAR list of threatened and/or declining species and habitats; • Scottish Biodiversity list.
Whiting	eDNA survey (Array Area most abundant species); North Sea bottom trawl data; Hywind OWF trawl survey and Beatrice OWF otter trawl survey.	National	• PMF (Scotland); • Scottish Biodiversity list; and • Study areas overlap with low intensity spawning grounds and high intensity nursery grounds within the offshore ECC.
Blue whiting	MMO landing statistics and literature review (various sources)	National	• PMF (Scotland); • Scottish Biodiversity list; and • Study areas overlap with low intensity nursery grounds.
Plaice	Site-specific camera & video transects; North Sea bottom trawl; Hywind OWF trawl survey and Moray West OWF epibenthic beam trawl surveys.	National	• Scottish Biodiversity list; and • Study areas overlap with low intensity spawning and nursery grounds.
Anglerfish	North Sea bottom trawl data and Hywind trawl OWF survey.	National	• PMF (Scotland); • Scottish Biodiversity list; • Commercially important species in the region; and • Study areas overlap with low intensity nursery grounds.
Ling	Hywind OWF trawl	National	• PMF (Scotland);

Species	Source	Valuation	Justification
	survey and literature review (various sources).		• Scottish Biodiversity list; and • Study areas overlap with low intensity nursery grounds.
Saithe	Hywind OWF trawl survey and literature review (various sources).	National	• PMF (Scotland); and • Study areas overlap with low intensity nursery grounds.
Norway pout	Site specific eDNA survey (offshore ECC); North Sea bottom trawl data and Hywind OWF trawl survey.	National	• PMF (Scotland); • Scottish Biodiversity list; and • Study areas overlap with low intensity spawning and nursery grounds.
Brown trout (Sea trout)	Site specific eDNA survey (offshore ECC) and literature review (various sources).	National	• PMF (Scotland); • Scottish Biodiversity list; • Protected under the Salmon Act; and • Evidence of transit through the study areas.
Haddock	North Sea bottom trawl; Hywind OWF trawl survey and Beatrice OWF otter trawl survey.	Regional	• Commercially important species in the region; and • Study areas overlap with nursery grounds (unspecified intensity).
Lemon sole	Hywind OWF trawl survey and Moray West OWF epibenthic beam trawl surveys.	Regional	• Study areas overlap with low intensity spawning and nursery grounds.
Sprat	Hywind OWF trawl survey.	Regional	• Study areas overlap with low intensity spawning and nursery grounds.
Porbeagle	Site specific eDNA survey (offshore ECC).	International	• OSPAR list of threatened and/or declining species and habitats; • 'Critically endangered' on the IUCN Red List of threatened species; • FOCI; • PMF (Scotland); • Scottish Biodiversity list; and • Evidence of transit through the study areas.
Spurdog	Hywind OWF trawl survey and Scottish government fishing statistics data	International	• OSPAR list of threatened and/or declining species and habitats; • 'Vulnerable' on the IUCN Red List of threatened species; • PMF (Scotland); • Scottish Biodiversity list; and • Study areas overlap with low intensity nursery grounds.
Tope	Hywind OWF trawl	International	• 'Vulnerable' on the IUCN Red List

Species	Source	Valuation	Justification
	survey.		of threatened species; • PMF (Scotland); • Scottish Biodiversity list; and • Study areas overlap with low intensity nursery grounds.
Spotted ray	Hywind OWF trawl survey.	International	• PMF (Scotland); • OSPAR list of threatened and/or declining species and habitats; and • Study areas overlap with low intensity nursery grounds.
Common skate	Hywind OWF trawl survey.	International	• OSPAR list of threatened and/or declining species and habitats; • 'Critically Endangered' on the IUCN Red List of threatened species; • PMF (Scotland); • Scottish Biodiversity list; and • Study areas overlap with low intensity nursery grounds.
Thornback ray	Site-specific camera and video transects and Scottish government fishing statistics data	International	• OSPAR list of threatened and/or declining species and habitats; • 'Near Threatened' on the IUCN Red List of threatened species; • Scottish Biodiversity list; and • Evidence of presence in the study areas.
Shellfish VERs			
Freshwater pearl mussel	Nearby designated sites	International	• 'Endangered' on the IUCN Red List of threatened species; and • Nearby River Spey SAC, River Dee SAC, River Tay and River South Esk SAC designated for freshwater pearl mussel.
Ocean quahog	Site specific Grab samples and video transects (Array Area and ECC) and Hywind OWF benthic sampling survey	International	• OSPAR list of threatened and/or declining species and habitats; • PMF (Scotland); and • Evidence of presence in the study areas.
Brown crab	Hywind OWF surveys.	Regional	• Commercially important species in the region; and • Potential to be present in the study areas.
Scallop	Hywind OWF surveys.	Regional	• Commercially important species in the region; and • Potential to be present in the study areas.
Norway lobster	Hywind OWF surveys.	Regional	• Commercially important species

Species	Source	Valuation	Justification
(*Nephrops*)			in the region; • Potential to be present in the study area; and • Study areas overlap with nursery grounds (unspecified intensity).
European lobster	Hywind OWF surveys and literature review (various sources).	Regional	• Commercially important species in the region; and • Potential to be present in the study areas.

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