CALEDONIA
Offshore Wind Farm

Code: UKCAL-CWF-CON-EIA-RPT-00007-7B13

Volume 7B Proposed Development (Offshore) Appendices

Appendix 5-1 Fish and Shellfish Ecology Technical Baseline Report

Caledonia Offshore Wind Farm Ltd

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Volume 7B Appendix 5-1 Fish and Shellfish Ecology Technical Baseline Report

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Acronyms and Abbreviations

BAP	Biodiversity Action Plan
BGS	British Geological Survey
Cefas	Centre for Environment, Fisheries and Aquaculture
CIEEM	Chartered Institute of Ecology and Environmental Management
DDV	Drop Down Video
eDNA	Environmental DNA
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electromagnetic Fields
ESFJC	Eastern Sea Fisheries Joint Committee
EU	European Union
FeAST	The Feature Activity Sensitivity Tool
FU	Functional Units
G	Gravel
gS	Gravelly sand
GIS	Geographic Information System
GPS	Global Positioning System
IBTS	International Bottom Trawl Survey
ICES	The International Council for the Exploration of the Sea
IEF	Important Ecological Feature
IFCA	Inshore Fisheries and Conservation Authority

IHLS	International Herring Larval Survey
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MBES	Multi-Beam Echo Sounder
MCZ	Marine Conservation Zone
MDS	Maximum Design Scenario
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MPA	Marine Protected Area
MWS	Multi-winter Salmon
NBN	National Biodiversity Network
NCMPA	Nature Conservation Marine Protected Area
NERC	Natural Environment and Rural Communities
NIMF	Nationally Important Marine Features
NMPi	National Marine Plan Interactive
OECC	Offshore Export Cable Corridor
ORJIP	Offshore Renewable Joint Industry Project
OSPAR	Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic)
OWF	Offshore Windfarm
OTUs	Operational Taxonomic Units
PMF	Priority Marine Features
PSA	Particle Size Analysis
rMCZ	Recommended MCZ
SAC	Special Area of Conservation

SBP	Sub-Bottom Profiler
SPA	Special Protection Areas
SSC	Suspended Sediment Concentration
SSS	Side Scan Sonar
SWS	Single-Winter Salmon
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 Proposed Development (Offshore)

1.1.1.1 This technical report has been prepared as an appendix of the Caledonia Offshore Wind Farm (OWF) Environmental Impact Assessment Report (EIAR) in relation to fish and shellfish ecology. It details the ecological baseline for fish (both pelagic and demersal, including elasmobranch species) and shellfish (molluscs and crustaceans) communities associated with the study area.

1.1.1.2 It should be noted that the Proposed Development (Offshore) includes all offshore infrastructure within Caledonia OWF (including the Array Areas for Caledonia North and Caledonia South, referred to as the Caledonia North Site and Caledonia South Site respectively) and the Caledonia Offshore Export Cable Corridor (OECC) (which includes the Caledonia North OECC and Caledonia South OECC), seaward of Mean High-Water Springs (MHWS). The information within this report provides the fish and shellfish baseline for the whole Caledonia OWF and Caledonia OECC.

1.1.1.3 This technical report has been prepared to inform the Environmental Impact Assessment (EIA) within Volumes 2, 3 and 4, Chapter 5: Fish and Shellfish Ecology.

1.2 Document Purpose and Structure

1.2.1.1 The purpose of this technical report is to provide a contemporary and comprehensive analysis of site-specific surveys within Caledonia OWF (Caledonia North Site and Caledonia South Site) and Caledonia OECC and regional fish and shellfish ecology data within the fish and shellfish ecology study area defined for the Proposed Development (Offshore), providing an overview of the baseline conditions across the study area.

1.2.1.2 This document is broadly structured as follows:

- Definition of the proposed fish and shellfish ecology study area;
- Details of the scope and methodology;
- Outline of data sources used to inform the characterisation;
- A review of the baseline (existing) conditions of the study area;
- Identification of fish and shellfish Valued Ecological Receptors (VERs) for the study area; and
- Conclusion.

1.2.1.3 It is important to note that this document accompanies Volumes 2, 3 and 4, Chapter 5: Fish and Shellfish Ecology and should also be read alongside the following EIAR chapters and technical appendices:

- Volumes 2, 3 and 4, Chapter 2: Marine and Coastal Processes;
- Volumes 2, 3 and 4, Chapter 3: Marine Water and Sediment Quality;
- Volumes 2, 3 and 4, Chapter 4: Benthic Subtidal and Intertidal Ecology;
- Volumes 2, 3 and 4, Chapter 7: Marine Mammals;
- Volumes 2, 3 and 4, Chapter 8: Commercial Fisheries; and
- Volume 7, Appendix 6: Underwater Noise Assessment.

2 Scope and Methodology

2.1 Overview

2.1.1.1 This technical report presents a baseline characterisation of the current fish and shellfish environment. It encompasses the results of a desktop study that compiles site-specific data from the study area, regional datasets, and industry-specific monitoring conducted for several regional OWFs. This technical report accompanies Volumes 2, 3 and 4, Chapter 5: Fish and Shellfish Ecology.

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

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

2.2 Fish and Shellfish Ecology Study Area

2.2.1.1 For the purposes of this report, the fish and shellfish study area (hereafter referred to as the study area) is defined as three spatial scales and is presented in Figure 2-1. The individual scales are detailed below:

- For direct (primary) impacts on fish and shellfish receptors, the study area includes the Proposed Development (Offshore) up to and including the intertidal zone, up to mean high water springs (MHWS). The term "primary impacts" refers to the direct effects on fish and shellfish species within the Caledonia OWF and Caledonia OECC boundaries including factors such as 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 is expected to travel following disturbance as a result of the Proposed Development (Offshore) 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 distance surrounding the Proposed Development (Offshore) is up to 10km. The secondary ZoI is shown in Figure 2-1.

- The largest (primary) ZoI relates to underwater noise (UWN) from piling in the Caledonia OWF. A precautionary 70km ZoI has been defined for underwater noise impacts on fish and shellfish receptors, which fully encompasses subsea noise impact ranges predicted for recent offshore windfarm applications in the northern North Sea region. Fish responses to underwater noise stimuli can vary significantly between species, with some species exhibiting fleeing behavior while others may remain relatively stationary depending on noise thresholds (Popper and Hastings, 2009[1]; Hawkins *et al*., 2015[2]). To account for this variation, the assessment has considered both fleeing and stationary receptor modelling approaches thus ensuring a comprehensive evaluation of the potential impacts of underwater noise on different fish species and life stages within the project's ZoI. The maximum impact ranges for both stationary (e.g., spawning Atlantic herring (*Clupea harengus*) or spawning (*Ammodytes spp*.)) and fleeing receptors (e.g., Atlantic Salmon), as informed by underwater noise modelling for recent OWF projects (detailed in Volume 7, Appendix 6: Underwater Noise Assessment) have been used to inform the 70km ZoI for UWN impacts, which is considered suitably precautionary for the Proposed Development (Offshore).
- The exact extents over which noise effect thresholds will be reached has been determined through detailed underwater noise modelling, based on the maximum design scenario (MDS) and relates to the greatest spatial temporal effects. For fish and shellfish, the largest spatial UWN contour is represented by pile driving for the sequential installation of up to four pin piles in a 24-hour period within the Caledonia OWF. Temporary Threshold Shift (TTS) ranges occur at 186 decibels (dB) Sound Exposure Level Cumulative (SELcum) and are predicted to be 64km for a stationary receptor, reducing to 45km when considering a fleeing receptor. This reduces dramatically at Recoverable Injury threshold at 203dB SEL_{cum} and is predicted to be 10km for a stationary receptor, reducing to 400m when considering a fleeing receptor. Refer to Volumes 2, 3 and 4, Chapter 5: Fish and Shellfish Ecology and Volume 7, Appendix 6: Underwater Noise Assessment for further detail. Based on these worst case UWN impacts ranges and the non-lethal impacts from TTS, the 70km ZoI for UWN is considered suitable.

2.2.1.2 The variations in these impact ranges arise from differences in bathymetry around the different parts of the Proposed Development (Offshore) and the specific piling parameters.

2.2.1.3 Additionally, impact ranges for recent United Kingdon (UK) OWF applications have been used to assist the determination of the study area for UWN. The maximum impact ranges for both stationary (e.g., spawning Atlantic herring) and fleeing receptors (e.g., Atlantic salmon) from recent OWF applications

have been presented in Table 2-1 below. It is crucial to ensure that modelling for impact ranges for fleeing and stationary receptors to account for variation between species life history and developmental stages groups and to account for the limited data on fish reactions to noise stimulus over large distances. Taking the maximum impact ranges as informed by underwater noise modelling for recent offshore windfarm projects, a 70km ZoI for underwater noise impacts is deemed suitable.

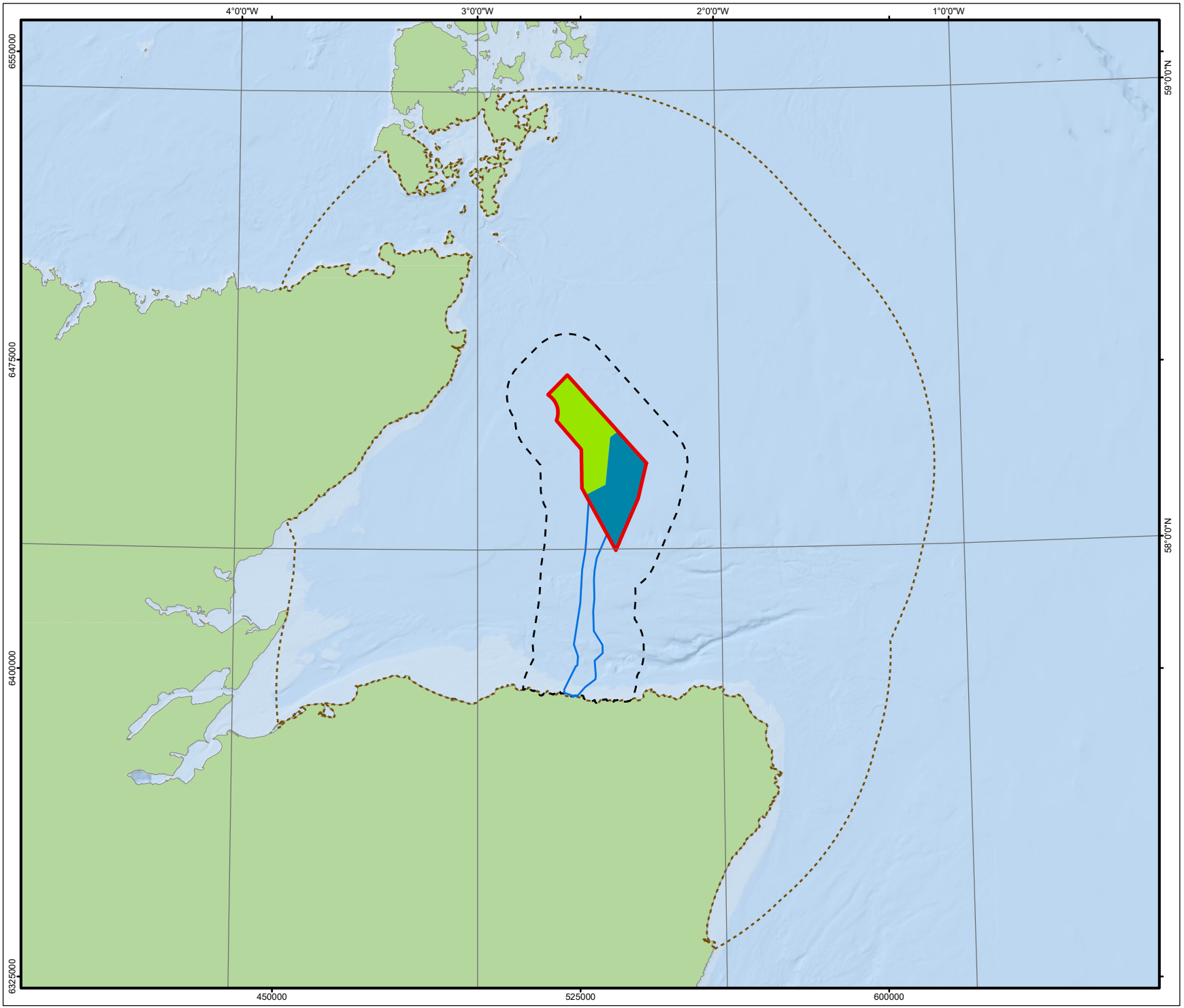
Table 2-1: Maximum modelled impact ranges for fleeing and stationary receptors from recent OWF applications.

Project	Maximum Impact Range for a Fleeing Receptor	Maximum Impact Range for a Stationary Receptor
Awel y Mor OWF	17km	36km
Sheringham and Shoal and Dudgeon OWF Extension Projects	10km	19km
Hornsea Four OWF	26km	38km
Norfolk Boreas OWF	6.5km	18km

2.2.1.4 The underwater noise (primary) ZoI, represents the largest ZoI, and encompasses both the primary and secondary ZoIs. For the purposes of characterising the fish and shellfish ecology baseline for the Proposed Development (Offshore), the largest ZoI will be used, and hereafter will be referred to as the 'study area'. Where interactions of features (such as rivers of importance for migratory species) interact with a specific ZoI, reference will be made to an individual ZoI as appropriate.

2.2.1.5 Figure 2-1 indicates the location of the Proposed Development (Offshore) and the primary underwater noise ZoI (70km) and secondary ZoI (10km).

2.2.1.6 The study area overlaps with the International Council for the Exploration of the Sea (ICES) rectangles 44E7 and 45E7 (see Volumes 2, 3 and 4, Chapter 8: Commercial Fisheries), providing a regional context on fish and shellfish ecology.



- Caledonia OWF
- Caledonia North Site
- Caledonia South Site
- Offshore Export Cable Corridor
- 70km Primary Underwater Noise Zone of influence
- 10km Secondary Zone of Influence

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0 10 20 30 40 km

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CALEDONIA Offshore Wind Farm

GoBe APEM Group

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Figure 2-1: Study Area Relative to the Proposed Development (Offshore)

STATUS: Approved
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2.3 Data Sources

2.3.1 Overview

2.3.1.1 A detailed desktop review was carried out to establish the baseline of information available on fish and shellfish populations in the study area. This includes information on fish and shellfish ecological communities in the Moray Firth region as well as details on spawning and nursery behaviour and habitats for key species, migratory species and species of conservation importance. Species of commercial importance were identified, and the individual species accounts presented herein detail whether or not the species assessed are considered to be of commercial importance (Volumes 2, 3 and 4, Chapter 8: Commercial Fisheries).

2.3.1.2 Data to support the baseline characterisation of the study area 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 in relation to the study area.

2.3.1.3 Environmental baseline surveys were completed across the Caledonia OWF and Caledonia OECC by Gardline in 2023. These assessments are presented in Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor). 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, and environmental sampling (e.g., environmental DNA (eDNA), grab sampling, sediment contaminant and particle sizes analyses and video and still photography). The survey results are used to support the baseline characterisation in this report.

Table 2-2: Key sources of fish and shellfish data

Title	Data utilisation	Author	Year
Publicly available datasets			
Fisheries datasets available from the Marine Scotland MAPS National Marine Plan Interactive (NMPi), including ScotMap data	An interactive map providing a data overview of the Scottish marine environment.	Marine Scotland[3]	2024
ICES International Herring Larval Survey (IHLS data from 2011/2012 – 2023/2024)	Time-series trawl data on herring larvae distribution used to characterise areas of actively spawning herring in relation to the study area.	ICES IHLS Data[4]	2023
UK sea fisheries annual statistics report	Commercial fisheries specific data (national and regional coverage). Used to provide data related to fisheries landings within the area.	Marine Management Organization (MMO)[5]	2022
EUSeaMap broadscale marine habitat data	Broadscale marine habitat data presented to provide an indication of the location of suitable habitat and spawning grounds for sandeel and herring.	EUSeaMap[6]	2021
A verified distribution model for the lesser sandeel, (*Ammodytes marinus)*	The model focuses on the distribution patterns of this specific species, providing valuable insights into its habitat and ecological preferences	Langton *et al*.[7]	2021
Scottish Sea Fisheries Statistics, Data from 2016-2020	Commercial fisheries specific data (national and regional coverage). Used to provide data related to fisheries landings within the area.	Scottish Government[8]	2020
Feature Activity Sensitivity Tool (FeAST)	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	NatureScot[9]	2020

Title	Data utilisation	Author	Year
	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).		
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. The methodology defined within this study was used to undertake a spatial analysis of the IHLS data to identify areas of active spawning herring grounds with overlap with the study area.	Boyle and New, ORJIP[10]	2018
Spawning grounds of whiting (*Merlangius merlangus*)	Definition of areas of likely spawning activity for whiting in the North Sea.	González-Irusta and Wright[11]	2017
Spawning grounds of Atlantic cod (*Gadus morhua*) in the North Sea	Definition of areas of likely spawning activity for Atlantic cod in the North Sea.	Gonzalez-Irusta and Wright[12]	2016
British Geological Survey (BGS) Marine Sediment Particle Size Analysis (PSA) dataset sourced from the BGS GeoIndex Offshore portal	National PSA dataset	BGS[13]	2015
Updating Fisheries Sensitivity Maps in British Waters	Fish sensitivity maps showing aggregates of 0 group fish and/or larvae of key commercial fisheries (0 group fish are defined as fish in the first year of their lives)	Aries *et al*.[14]	2014
Screening spatial interactions between marine aggregate application areas and sandeel habitat	Methodology used to identify spawning habitats of sandeel within the study area.	Latto *et al*.[15]	2013

Title	Data utilisation	Author	Year
Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas	Methodologies used to identify spawning habitats of herring within the study area.	Reach *et al*.[16]	2013
ICES North Sea International Bottom Trawl Survey (IBTS)	Time-series groundfish survey data collected throughout European seas used to characterise the fish assemblages across the study area.	ICES[17]	2012-2023
ICES Beam Trawl Surveys	Time-series groundfish survey data collected throughout European seas used to characterise the fish assemblages across the study area.	ICES[18]	2012-2023
Spawning and Nursery Grounds of Selected Fish Species in UK	Used to provide information on fish spawning and nursery grounds.	Ellis *et al*.[19]	2012
ICES Scottish Rockall Survey	Time-series groundfish survey data collected along the west coast of Scotland.	ICES[20]	2011-2012
Fisheries Sensitivity Maps in British Waters	Used to provide information on likely spawning or nursery areas for commercial species	Coull *et al*.[21]	1998
OWF Development Survey Data			
Beatrice OWF Farm Post-Construction Baseline Sandeel Survey – Technical Report	Post-construction monitoring reports describing the sandeel distributions within the Beatrice OWF area, through data collection (modified shellfish dredge).	Beatrice Offshore Windfarm Limited (BOWL)[22]	2021
Beatrice OWF – Post-Construction Cod (*G. Morhua*) Spawning Survey – Technical Report	Post-construction monitoring reports describing the degree of cod spawning activity throughout the Beatrice OWF area.	BOWL[23]	2021
Moray West OWF EIAR – Chapter 8: Fish and Shellfish Ecology)	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	Moray OWF (West) Limited[24]	2018

Title	Data utilisation	Author	Year
Beatrice OWF – Atlantic Salmon Salmo Salar smolt movements survey	Survey on Atlantic salmon (*S. Salar*) smolt movements in the Cromarty and Moray Firths.	BOWL[25]	2017
Beatrice OWF Pre-Construction Baseline Herring Larval Surveys Summary Technical Report	Pre-construction monitoring report to form a baseline dataset of herring larvae density within the Beatrice OWF area during spawning.	BOWL[26]	2016
Hywind Scotland Pilot Park: Environmental Statement	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	Statoil[27]	2015
Beatrice OWF – Pre-Construction Cod (*Gadus morhua*) Spawning Survey – Technical Report	Pre-construction monitoring reports describing the degree of cod spawning activity throughout the Beatrice OWF area.	BOWL[28]	2015
Beatrice OWF Farm Pre-Construction Baseline Sandeel Survey – Technical Report	Pre-construction monitoring reports describing the sandeel distributions within the Beatrice OWF area, through data collection (modified shellfish dredge).	BOWL[29]	2014
Hywind Scotland Pilot OWF Benthic and Geophysical Survey Report	Site-specific survey report characterising the benthic and geophysical environment of the Hywind Scotland Pilot OWF study area.	Statoil[30]	2013
Moray East OWF EIAR Technical Appendices – Sandeel Survey Report	Site-specific survey report investigating and detailing the distribution of sandeel within the Moray East OWF area.	Moray Offshore Renewables Limited[31]	2012
Beatrice OWF EIAR – Annex 11A: Fish and Shellfish Ecology Technical Report	Details the fish and shellfish ecology baseline for the Beatrice OWF development.	BOWL[32]	2012
Beatrice OWF EIAR – Chapter 11: Fish and Shellfish Ecology	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	BOWL[33]	2012

Title	Data utilisation	Author	Year
Moray East OWF EIAR Technical Appendices – Fish and Shellfish Ecology Technical Report	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	Moray Offshore Renewables Limited[34]	2011
Moray East OWF EIAR – Chapters 7.2 and 10.2: Fish and Shellfish Ecology	Provides an analysis of data collected across the wider northern North Sea biogeographic region.	Moray Offshore Renewables Limited[35]	2011
Site-specific survey data			
Site-specific Benthic Ecology Baseline Characterisation Surveys	Site-specific survey data from the Caledonia OWF and the Caledonia OECC inclusive of benthic grabs; Drop Down Video (DDV); epibenthic trawls; PSA; sediment total carbon content; sediment contaminant analysis; and lab work, data analysis and reporting	See Volume 7B, Appendix 4-1 and Volume 7B, Appendix 4-2	2023
Site-specific Geophysical Survey	Includes shallow geophysical, ultra-high resolution seismic (UHRS), side scan sonar (SSS), multi-Beam Echo Sounder (MBES), magnetometer, high frequency sub-bottom profiler (SBP) and vibrocore collection.	See Volume 7B, Appendix 4-1 and Volume 7B, Appendix 4-2	2023
Site-specific Environmental DNA (eDNA) Survey	Two samples for sediment eDNA and four for water eDNA (two near surface and two near seabed) were collected at each of the sampling locations alongside the geophysical surveys, used to provide a snapshot of fish and shellfish species presence (from approximately the past 24 hours) at each sample location within the Caledonia OWF (10 sample locations) and Caledonia OECC (8 sample locations).	See Volume 7B, Appendix 4-1 and Volume 7B, Appendix 4-2	2023

2.4 Methodology

2.4.1 Site-specific Data

2.4.1.1 Site specific baseline characterisation surveys, inclusive of grab sampling, camera transects and eDNA sampling were undertaken within the Caledonia OWF (Figure 2-2) and the Caledonia OECC (Figure 2-3). The surveys were conducted by Gardline on behalf of Caledonia Offshore Wind Farm Ltd (the Applicant) between 14 and 22 April 2023 (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Survey Report (Offshore Export Cable Corridor)), to inform the baseline for fish and shellfish ecology.

Grab Sampling and Camera Transects

2.4.1.2 Seabed imagery was recorded from seven camera stations, and grab samples collected at 35 locations across Caledonia OWF and Caledonia OECC. The grab samples, complemented by the seabed imager, were used to classify the sediment composition, and benthic habitats present across the Caledonia OWF and Caledonia OECC. The survey locations across the Caledonia OWF and Caledonia OECC are presented in Figure 2-2 and Figure 2-3.

2.4.1.3 Sediment composition was characterised as primarily sand, with occasional gravel and shell fragments. Observed fauna was generally sparse, with 34% of images containing no visible fauna (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)).

2.4.1.4 Particle size analysis (PSA) supported the seabed imagery with sediment across the Caledonia OWF and Caledonia OECC classified as muddy sand to sandy gravel under modified Folk (1954[36]). Generally, across the Caledonia OWF, sand was the dominant fraction accounting for between 49.0% and 97.1% of the sediment, with the exception of Station ENV13 in the Northeast where gravel was the dominant fraction accounting for 50.2% of the sediment (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area)).

2.4.1.5 Sediment samples within the Caledonia OWF were dominated by the sand fraction. Sediments were described as very poorly to moderately well sorted coarse silt to granule (Folk, 1954[36]; Volume 7B, Appendix 4-1: Environmental Baseline Survey Report (Array Area)).

Environmental DNA

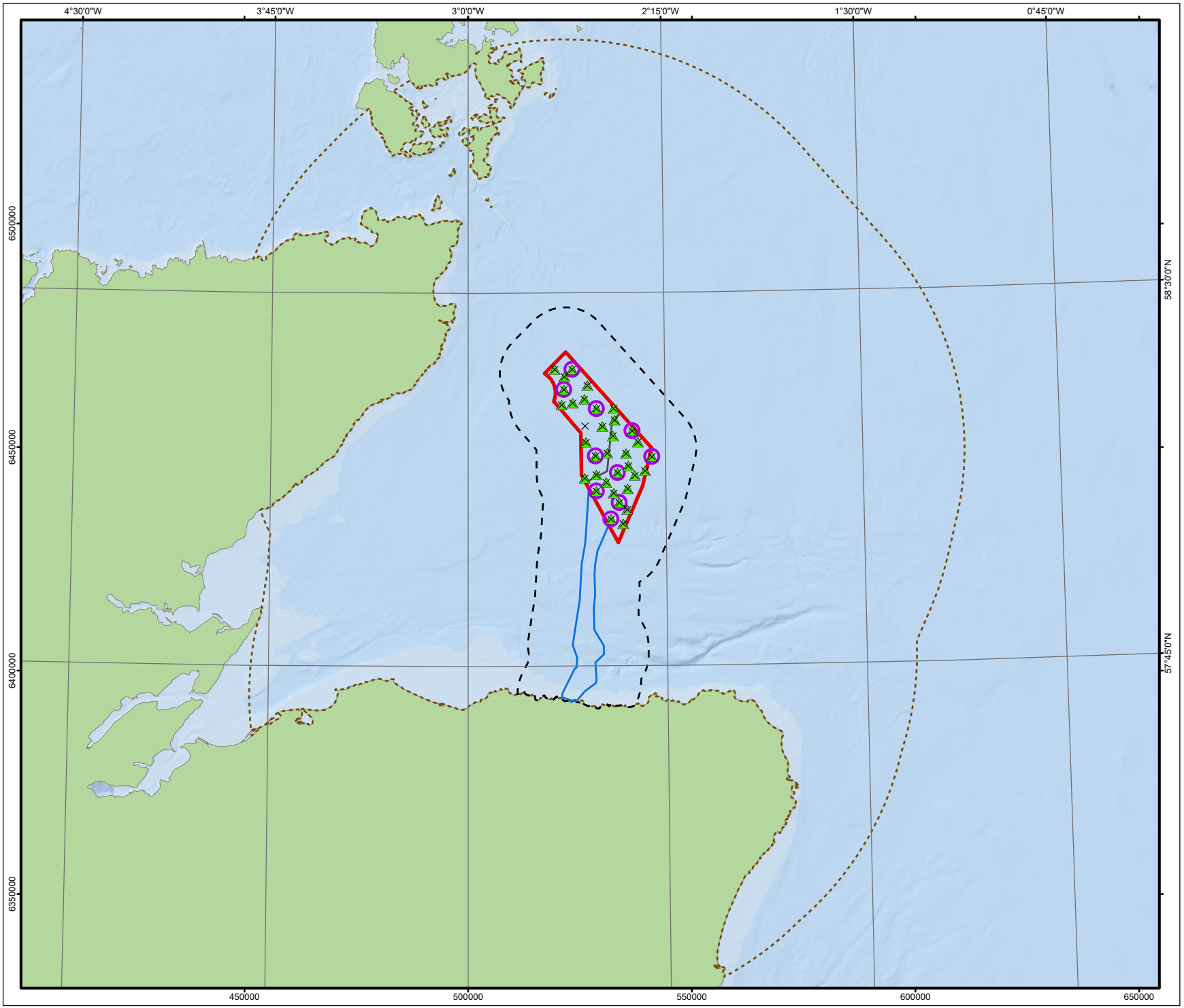
2.4.1.6 Site-specific environmental DNA (eDNA) surveys were also conducted across the Caledonia OWF and Caledonia OECC to provide a supplementary snapshot of fish and shellfish species presence (from approximately the preceding 24-hours) at each sample location. The sampling locations across the Caledonia

OWF and Caledonia OECC are presented in Figure 2-2 and Figure 2-3. An eDNA survey is a non-intrusive sampling technique utilised to detect species presence by analysing the DNA present in water samples. This method entails collecting environmental DNA present in the water column (e.g., from excretions or secretions) rather than directly sampling the organism itself.

2.4.1.7 In eDNA sampling, "reads" indicate the frequency of detecting a specific DNA sequence in a sample, revealing the presence and abundance of various species. The survey reports (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)) represented fish as Operational Taxonomic Units (OTUs) and grouped them by class (Denzer and Kaiser, 2023[37]).

2.4.1.8 The fish eDNA dataset within the Caledonia OWF identified 69 OTUs from 20 classes, based on family with the proportional contribution of these taxonomic families to the overall structure, which are further detailed in Section 2.5.1.10.

2.4.1.9 The fish eDNA dataset within the Caledonia OECC identified 68 OTUs from 26 classes, based on family with the proportional contribution of these taxonomic families to the overall structure, which are further detailed in Section 2.5.1.10.



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

eDNA Samples

Camera Transects and Grab Samples

PSA Locations

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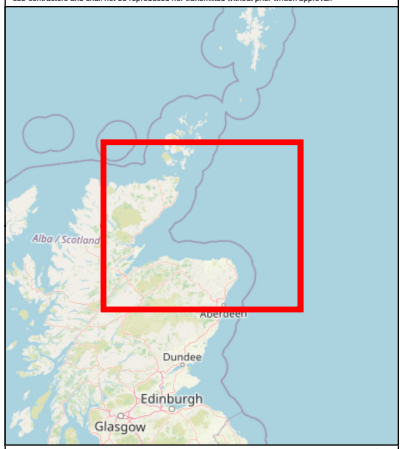

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CALEDONIA Offshore Wind Farm

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CONTRACTOR REV: 01

GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)

DRAWING TITLE

Figure 2-2: Site-Specific Survey Locations Within Caledonia OWF

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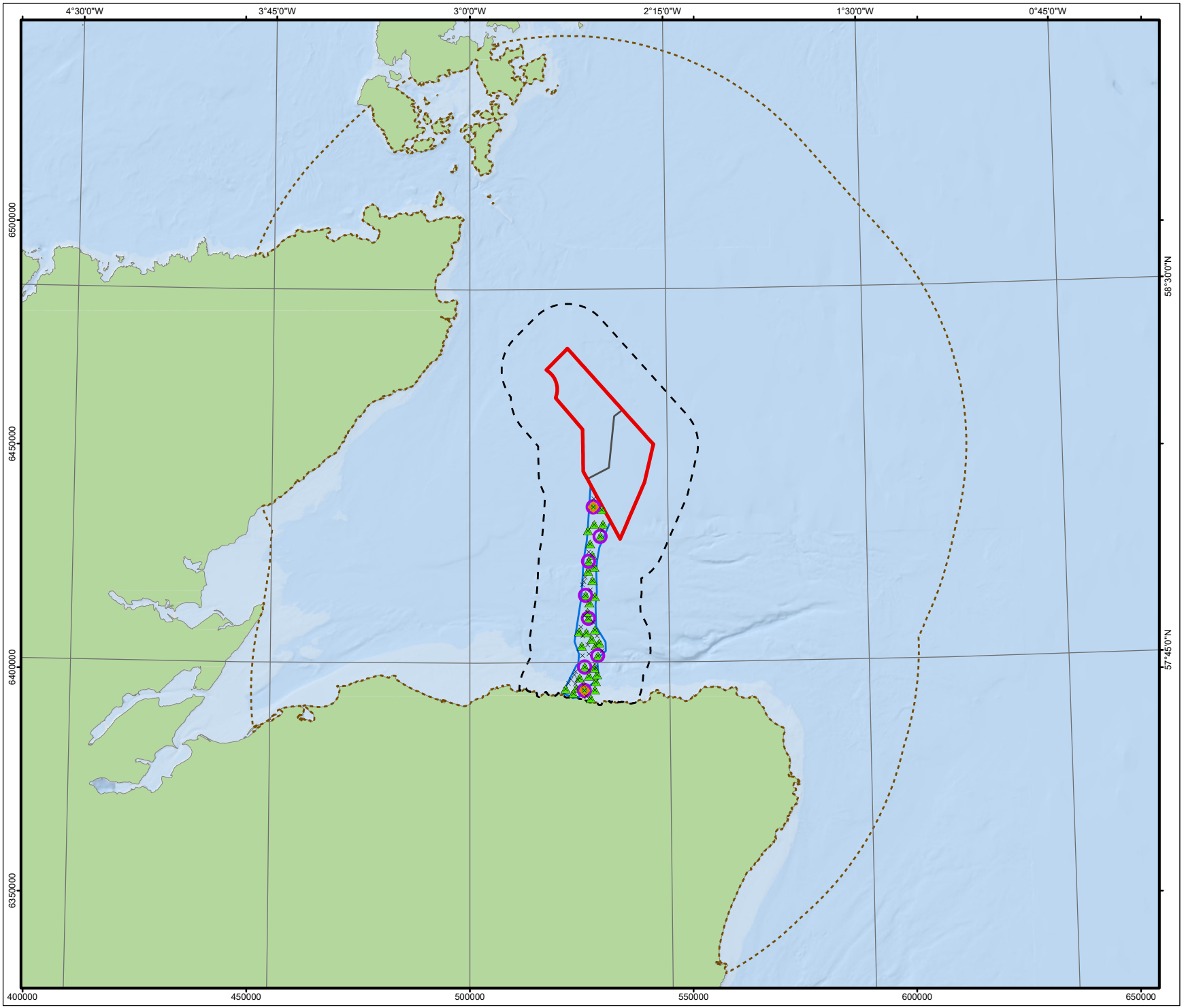

- Caledonia OWF
- Caledonia North Site and Caledonia South Site Division Line
- Offshore Export Cable Corridor
- 70km Primary Underwater Noise Zone of Influence
- 10km Secondary Zone of Influence
- eDNA Samples
- Grab Samples
- Camera Transects
- PSA Locations

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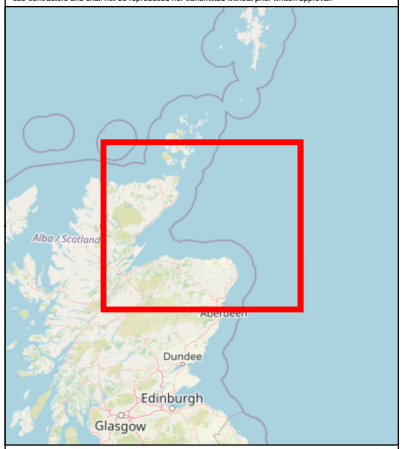

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CONTRACTOR DRAWING NO: UKCAL1_GO_WNF_FAS_MAP_00088	CONTRACTOR REV: 01
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 2-3: Site-Specific Survey Locations Within the OECC

STATUS: Approved	SCALE: 1:1,150,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

2.4.2 Publicly Available Datasets

2.4.2.1 The desktop study revealed numerous data sources from across the Moray Firth Region as well as specific surveys carried out by other OWFs in the region, these are detailed in Table 2-2.

International Herring Larval Survey Data

2.4.2.2 International Herring Larval Survey (IHLS) data was downloaded from the ICES Eggs and Larvae data pages for the last ten available years (2011/2012 to 2023/2024 data[4]) for all larval size classes, 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 2-3), 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 dataset (with trawl replicates removed).

2.4.2.3 The query outputs were separate annual spawning season datasets, and a dataset for the full period (2011/2012 – 2023/2024) 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 50km was used to allow sufficient overlap between the data points, so that the extrapolation of the heat maps covers the full IHLS survey area.

2.4.2.4 Rasters[i] produced from this data were then categorised in ArcGIS, using the methodology summarised in Figure 2-4.

[i] A matrix of cells (or pixels) organised into rows and columns (or a grid) where each cell contains a value representing abundance information.

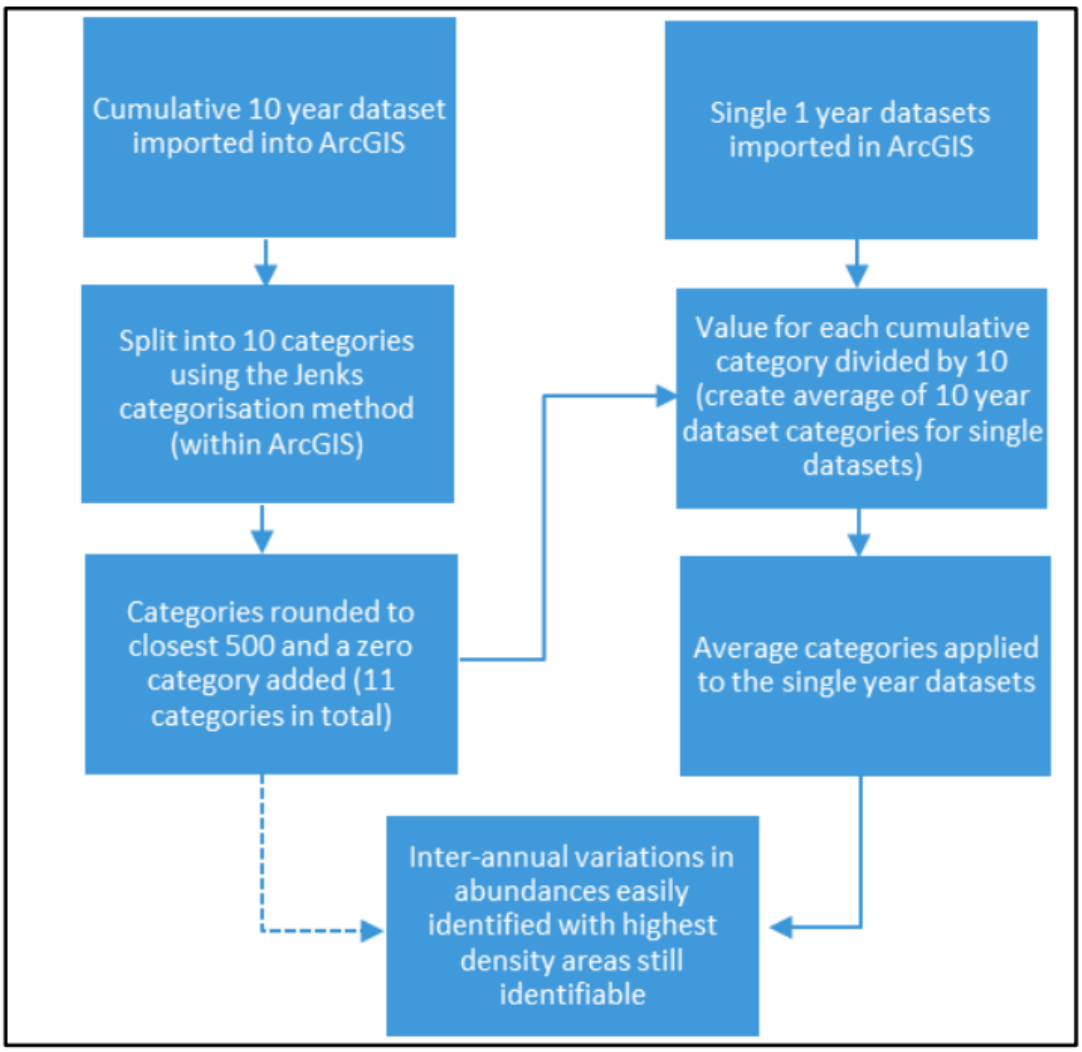


Figure 2-4: Data Categorisation Methodology (reproduced from Boyle and New, 2018[38]).

2.4.2.5 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.

2.4.2.6 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[21]) fish sensitivity maps, that show historic and potential spawning sites and nursery areas. The results of this analysis are shown in Figure 3-9 and Figure 3-12.

Spawning Habitat Suitability Heatmaps

2.4.2.7 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 area.

Herring

2.4.2.8 Areas of potential herring spawning habitat have been identified using site-specific PSA data collected as part of benthic characterisation surveys (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)) and EMODnet 1:250,000 sediment maps (EMODnet, 2023[6]), which show the distribution of sediment classes. These data have been classified in accordance with MarineSpace *et al*. (2013a[39]; adapted from Reach *et al*., 2013[16]) 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 Caledonia OWF and Caledonia OECC.

Table 2-3: Herring habitat sediment classifications (Sources from MarineSpace *et al*. (2013a[39]; adapted from Reach *et al*., 2013[16])

Folk Class (Folk, 1954[41])	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

2.4.2.9 Following the MarineSpace *et al*. (2013a[39]) 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 3-7; 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

2.4.2.10 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 sediment maps[6]	Preferred sediment	Preferred sediment consists of Gravel and sandy gravel	3	As detailed in Reach *et al.* (2013[16]), herring are known to prefer G and sG substrates for 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[39]).
	Marginal sediment	Marginal sediment consists of Gravelly sand	2	
IHLS (ICES, 2011-2024[4])	High number of small larvae (per m^2)	0-11mm length of larva*. The highest number recorded over period 2007-2020 for each survey station. Score applied within contoured area with >600 larvae per m^2.	5	Highest score assigned as it is a direct indicator of presence/absence of larvae at the surface of the spawning habitat.
Identified historic spawning grounds (Coull *et al.*, 1998[21])	Identified herring spawning grounds	Historic herring spawning grounds	3	Whilst the Coull *et al.* (1998[21]) 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.
Eastern Sea Fisheries Joint Committee (ESFJC)	Identified fishing grounds	Dataset specifically provides boundaries of Atlantic Herring, Sprat, and sandeel regions, together	3	As the ESFJC datasets are specifically for herring, sprat and sandeel they are

Data Source	Data Theme	Data Notes	Confidence Score	Justification of Confidence Score
identified fishing grounds		with month and season present, fishing gear used, and importance of any area to the fishers		very relevant to inform spawning grounds.
Vessel monitoring system (VMS) data		VMS data, showing the position, time at a position, and course and speed of fishing vessels. Use of pelagic gears are an indicator of herring spawning areas; and demersal gears are an indicator of sandeel habitat.	2	VMS data only provide differentiation between fishing locations by gear types, and therefore it is the gear types that have been used to inform spawning areas. As one gear type will target a number of species and not just herring or sandeel, the probability of it informing spawning grounds or habitat is very low.
The outputs of this heatmapping exercise are presented in Figure 3-9. * 0-11mm larval length. Herring larvae of <10mm size generally with yolk-sac still attached and associated with the benthos; or just post yolk-sac and liberating into the plankton.				

Sandeel

2.4.2.11 Areas of potential sandeel spawning habitat have been identified using site-specific PSA data collected as part of benthic characterisation surveys (Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Report (Offshore Export Cable Corridor)) and EMODnet 1:250,000 sediment maps, which show the distribution of sediment classes. These data have been classified in accordance with the MarineSpace *et al*. (2013b[40]) classifications (adapted from Latto *et al*., 2013[15]) 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 Caledonia OWF and Caledonia OECC (Figure 3-10).

Table 2-5: Sandeel potential habitat sediment classifications (MarineSpace *et al*., 2013b[40]; adapted from Latto *et al*., 2013[15]).

Folk Class (Folk 1954[41])	Fractional Composition	Habitat Sediment Preference	Habitat Sediment Classification
Part sand, part slightly gravelly sand and part gravelly sand	<1% muds, >85% sand	Prime	Preferred
Part sandy gravel and part gravelly sand	<4% muds, >70% sand	Sub-prime	Preferred
Part gravelly sand and part sandy gravel	<10% muds, >50% sand	Suitable	Marginal
Everything excluding gravel, part sandy gravel and part gravelly sand	>10% muds, <50% sand	Unsuitable	Unsuitable

2.4.2.12 Following the method similar to that described by MarineSpace Ltd *et al*. (2013b[40]), 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 sandeel 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[6]	Preferred sediment	Preferred sediment consists of Sand (S) and gS.	3	As detailed in Latto *et al.* (2013[15]), 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[40]).
	Marginal sediment	Marginal sediment consists of sG.	2	

Data Source	Data Theme	Data Notes	Confidence Score	Justification of Confidence Score
Sandeel fishing grounds (Jensen *et al.*, 2011[42])	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.
Eastern Sea Fisheries Joint Committee (ESFJC) identified fishing grounds	Identified fishing grounds	Dataset specifically provides boundaries of Atlantic Herring, Sprat, and sandeel regions, together with month and season present, fishing gear used, and importance of any area to the fishers	3	As the ESFJC datasets are specifically for herring, sprat and sandeel they are very relevant to inform spawning grounds.
Vessel monitoring system (VMS) data		VMS data, showing the position, time at a position, and course and speed of fishing vessels. Use of pelagic gears are an indicator of herring spawning areas; and demersal gears are an indicator of sandeel habitat.	2	VMS data only provide differentiation between fishing locations by gear types, and therefore it is the gear types that have been used to inform spawning areas. As one gear type will target a number of species and not just herring or sandeel, the probability of it informing spawning grounds or habitat is very low.
Identified historic spawning grounds (Coull *et al.*, 1998[21])	Identified sandeel spawning grounds	Historic sandeel spawning grounds.	3	Whilst the Coull *et al.* (1998[21]) 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.
The outputs of this heatmapping exercise are presented in Figure 3-12.				

2.5 Limitations

2.5.1.1 Mobile species, such as fish, exhibit varying spatial and temporal patterns. Surveys across the study area were conducted to provide a semi-seasonal description of the fish and shellfish assemblages. The data collected during these site-specific 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 regional surveys, they should still be included in the baseline characterisation. Therefore, this baseline characterisation draws upon wider scientific literature and available information to ensure a more comprehensive and precautionary baseline, identifying all likely present species within the study area.

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

2.5.1.3 Coull *et al*. (1988[43]) and Ellis *et al*. (2012[19]) 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[43]) 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[19]) is also limited by the wide scale distribution of sampling sites used for the annual international larval survey data used, consequently resulting in broadscale grids of spawning and nursery grounds. The spatial extent of the spawning grounds and the duration of spawning periods indicated in these studies are therefore considered likely to represent the maximum theoretical extent of the areas and periods within which spawning will occur. Spawning grounds may therefore be smaller in extent and display shorter spawning periods and, in some cases, spawning grounds indicated by these sources may no longer be active. Where available, additional research publications and data have been reviewed to provide the best, most contemporary and site-specific information. When considering demersal spawners which display substrate dependency (e.g., herring and sandeel), site-specific PSA and geophysical data have been used to ground truth the Coull *et al*. (1988[43]) and Ellis *et al*. (2012[19]) datasets.

2.5.1.4 The EMODnet (2023[6]) broadscale marine habitat data have also been used to identify preferred sandeel and herring spawning habitats. It should be

acknowledged that this dataset is somewhat limited by the broadscale nature of the data, as it does not account for small-scale, localised differences in seabed sediments, unlike the data obtained from site-specific grab sampling. In this case it is important to review all the datasets presented to develop a clear overview of preferred sandeel and herring habitat.

2.5.1.5 The site-specific PSA data have been used to check the validity of the broadscale marine habitat data from Coull *et al*. (1988[21]) and EMODnet, (2023[6]). These PSA data have also been classified in accordance with the Latto *et al*. (2013[15]) and Reach *et al*. (2013[16]) classifications to identify areas of preferred spawning habitat for sandeel and herring, respectively, and to identify potential spawning grounds for herring and sandeel as defined by Coull *et al*. (1998[21]) and Ellis *et al.* (2012[19]). The use of PSA data and broadscale habitat mapping is intended to provide a proxy for the presence of sandeel and herring spawning habitat in these locations (based on suitability of habitats, i.e., the potential for spawning rather than actual contemporary spawning activity).

2.5.1.6 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 have therefore interpreted in combination with site specific geophysical data collected across the site and additional data, sourced from the British Geological Survey (BGS, 2024[44]) and EMODnet Broadscale Habitat Map (EMODnet, 2023[6]) to provide the most comprehensive cover of the study area. It is important to note, that 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 therefore presented represents a long-term dataset. This allows for a detailed overview of the characteristic fish and shellfish species in the study area. The diversity and abundance of many species, particularly demersal fish species, is linked to habitat types, which have remained relatively constant in the study area, indicating no major shift in the fish and shellfish communities over the time-period of the data used in this technical report.

2.5.1.7 eDNA data have also been collected alongside the geophysical surveys to provide a snapshot of fish and shellfish species presence (from approximately the preceding 24-hours) at each sample location. As eDNA is a relatively new way of supplementing baseline characterisation in OWF 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[45]). 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[45]). 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[45]). 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[45]).

2.5.1.8 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[46]). Therefore, eDNA methods may not fully capture the diversity of elasmobranch species, leading to the underestimation of their presence (Ip *et al*., 2021[47]; Merten Cruz *et al*., 2023[46]). 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. While eDNA is a powerful tool for understanding and characterising the elasmobranch populations in the study area, its limitations in detecting species with minimal presence in the water are considered and supplemented with information from previous OWF surveys in the vicinity along with an extensive literature review.

2.5.1.9 Despite the data limitations detailed within this section of the technical report, the baseline data is considered a robust and sufficient evidence base to inform the fish and shellfish baseline characterisation and underpin the assessment process.

2.5.1.10 This characterisation of the species found within the study area has been completed by drawing upon work that was undertaken in support of various OWF projects in the vicinity of the Proposed Development (Offshore) as well as wider information from publicly available sources in Table 2-2. Data from other OWFs have been drawn upon to inform this appendix, as the species and habitats found within these areas will be broadly similar.

3 Baseline Conditions

3.1 Overview

3.1.1.1 The following section describes the fish and shellfish communities present within the study area (Figure 2-1). The baseline description of the study area draws on site-specific data collected within the spatial extent of the Caledonia OWF and Caledonia OECC, regional datasets and industry specific accounts, and monitoring studies undertaken for a number of 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.

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

3.2 Fish and Shellfish Ecology Assemblage

3.2.1 Site-specific Surveys

3.2.1.1 The characterisation of the species found within the study area has been completed by drawing upon site specific surveys, work that was undertaken in support of various OWFs in the vicinity of the Proposed Development (Offshore) as well as wider information from publicly available sources (Table 2-2). The spatial distribution of fish and shellfish in the Moray Firth region is seasonal, with many species using the Moray Firth for overwintering, feeding, breeding, and nursery purposes.

3.2.1.2 From eDNA samples taken across the Caledonia OWF (Figure 2-2), a total of 69 OTUs from 20 classes were detected as detailed in Table 3-1. The Cods (Gadidae) (15%) and Dabs (Pleuronectidae) (15%) where the most prevalent, with relatively high proportions of Sandlance (Ammodytidae) (10%), Herring (Clupeidae) (5%), Dragonet (Callionymidae) (5%), Cottids (Cottidae) (5%) and Flatfish (Scophthalmidae) (5%). Two OTUs of native Salmonids (Salmonidae) were recorded across Caledonia OWF with one additional count

of the invasive Pink Salmon (*Oncorhynchus gorbuscha*) recorded in one surface water sample.

3.2.1.3 Results taken from eDNA samples across the Caledonia OECC (Figure 2-3) found a total of 68 fish OTUs from 26 classes (Table 3-1). eDNA samples from the Caledonia OECC contained broadly the same classes as found in the Caledonia OWF, with the Cods (13%) and Dabs (13%) being the most prevalent, with relatively high proportions of Herring (4%), Dragonet (5%) and Cottids (7%). Additionally, 2 OTUs of native Salmonids were recorded.

Table 3-1: Fish OTUs derived from eDNA data across the Caledonia OWF and Caledonia OECC.

Caledonia OWF			Caledonia OECC		
Class	OTU	Proportional Contribution (%)	Class	OTU	Proportional Contribution (%)
Cods (Gadidae)	11	15.94	Cods (Gadidae)	9	13.24
Dabs (Pleuronectidae)	11	15.94	Dabs (Pleuronectidae)	9	13.24
Sandlance (Ammodytidae)	7	10.14	Cottids (Cottidae)	5	7.35
Cottids (Cottidae)	4	5.8	Dragonet (Callionymidae)	4	5.88
Dragonet (Callionymidae)	4	5.8	Sandlance (Ammodytidae)	3	4.41
Herring (Clupeidae)	4	5.8	Herring (Clupeidae)	3	4.41
Flatfish (Scophthalmidae)	4	5.8	Gobies (Gobiidae)	3	4.41
Gobies (Gobiidae)	4	5.8	Poacher (Agonidae)	3	4.41
Sea robins (Triglidae)	3	4.35	Smelts (Argentinidae)	2	2.94
Smelts (Argentinidae)	2	2.9	Blenny (Blenniidae)	2	2.94
Lump fish (Cyclopteridae)	2	2.9	Gunnels (Pholidae)	2	2.94
Gunnels (Pholidae)	2	2.9	Mackerels (Scombridae)	2	2.94
Salmonids (Salmonidae)	2	2.9	Snail Fish (Liparidae)	2	2.94

Caledonia OWF			Caledonia OECC		
Class	OTU	Proportional Contribution (%)	Class	OTU	Proportional Contribution (%)
Mackerels (Scombridae)	2	2.9	Lings (Lotidae)	2	2.94
Pricklebacks (Stichaeidae)	2	2.9	Salmonids (Salmonidae)	2	2.94
Wrasses (Labridae)	1	1.45	Lump fish (Cyclopteridae)	2	2.94
Soles (Soleidae)	1	1.45	Flatfish (Scophthalmidae)	2	2.94
Poacher (Agonidae)	1	1.45	Pipe Fish (Syngnathidae)	2	2.94
Stickle Backs (Gasterosteidae)	1	1.45	Sea robins (Triglidae)	2	2.94
Lings (Lotidae)	1	1.45	Wrasses (Labridae)	1	1.47
			Shads (Alosidae)	1	1.47
			Cyprinidae	1	1.47
			Stickle Backs (Gasterosteidae)	1	1.47
			Soles (Soleidae)	1	1.47
			Pricklebacks (Stichaeidae)	1	1.47
Total	**69**	**100%**	**Total**	**68**	**100%**

3.2.1.4 The overall fish eDNA dataset within the Caledonia OWF and Caledonia OECC recorded 26 Classes of fish and a combined 137 OTUs. In addition to the classification of 26 classes, several key species were also identified from the eDNA dataset including Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), Norway pout (*Trisopterus esmarkii*), Atlantic mackerel (*Scomber scombrus*) and right eyed flounder (Pleuronectidae). The invasive species Pacific pink salmon was also recorded. Additionally, eDNA surveys carried out in the Caledonia OECC recorded, Atlantic cod, herring, whiting (*Merlangius merlangus*), Norway pout and mackerel.

OWF Development Surveys

3.2.1.5 The characterisation of the species assemblages found within the study area and in the wider region has been completed by drawing upon work that was undertaken in support of various OWF projects in the vicinity of the Proposed Development (Offshore) 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.

3.2.1.6 The Hywind Scotland Pilot OWF lies just outside the study area, however the fish and shellfish community data has still been utilised in the report due to the proximity of Hywind Scotland Pilot OWF to the Southern Trench Nature Conservation Marine Protected Areas (NCMPA; JNCC, 2022[48]) and due to highlighting the presence of species which are distributed through the Moray Firth and North Sea as well as identifying migratory species such as Atlantic Salmon (*Salmo salar*) which are Priority Marine Features (PMF) in Scottish waters.

3.2.1.7 Data collected by the Hywind Scotland Pilot OWF EIAR (Statoil, 2015[27]) to described fish 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[27]).

3.2.1.8 As part of the Hywind Scotland Pilot OWF benthic survey (MMT, 2013[30]), 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.

3.2.1.9 The Hywind Scotland Pilot OWF EIAR (Statoil, 2015[27]) also described the following diadromous migratory species as having the potential to transit through the Hywind project area and surrounding area: Atlantic salmon, sea trout (*Salmo trutta*), European eel (*Anguilla anguilla*), river lamprey (*Lampetra fluviatillis*) and sea lamprey (*Petromyzon marinus*), all of which are PMF. eDNA metabarcoding surveys using the MiFish primer set identified Atlantic salmon within the Hywind Scotland Pilot OWF study area.

3.2.1.10 In terms of elasmobranchs, the Hywind Scotland Pilot OWF EIAR (Statoil, 2015[27]) described the presence of spotted ray, common skate (*Dipturus batis*), spurdog (*Squalus acanthias*) 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.

3.2.1.11 Epibenthic beam trawl surveys conducted in the neighbouring (west) Moray West OWF site between May and June 2017 (Moray Offshore Windfarm (West) Limited, 2018[24]) revealed a species assemblage typical of this area of the North Sea. The fish community was largely characterised by demersal species recorded in abundance during surveys, including dragonet (*Callionymus lyra*), dab (*Limanda limanda*) and plaice (*Pleuronectes platessa*). Less abundant species included lemon sole (*Microstomus kitt*), pogge (*Agonus cataphractus*) and grey gurnard (*Eutrigla gurnardus*). Typically, areas with higher diversity tended to be recorded in more heterogenous seabed habitats present in these areas, which include patches of coarser mixed sediment, gravels and stones/cobble; a similar trend was evident at both the Moray East and Beatrice OWF surveys (Moray Offshore Renewables Limited, 2011a[34]; 2011b[35]; BOWL, 2012[32]. Less abundant fish species included monkfish (*Lophius* spp.), Norwegian topknot (*Phrynorhombus norvegicus*), sandeel (Ammodytidae, *Ammodytes* spp.) and elasmobranchs such as the cuckoo ray (*Leucoraja naevus*) and lesser spotted dogfish (*Scyliorhinus canicular*), but generally in low abundances (Moray Offshore Windfarm (West) Limited, 2018[24]).

3.2.1.12 Otter trawl surveys conducted in March 2021 to identify cod distributions across the Beatrice OWF site revealed that cod abundance was relatively low, while haddock was the most abundant species accounting for the majority of the total by-catch, followed by whiting and squid (*Loligo forbesi*), (BOWL, 2021a[22]; 2021b[23]).

3.2.1.13 Between January and March 2012, dredge tow surveys were conducted across the Moray East OWF and western Moray Firth area to identify sandeel distributions (Moray Offshore Renewables Limited, 2011a[34]; 2011b[35]) Raitt's sandeel, smooth sandeel (*Gymnammodytes semisquamatus*) and greater sandeel (*Hyperoplus lanceolatus*) were identified, with Raitt's sandeel being the most abundant. Overall, the distribution of sandeel was patchy and abundance was low, with the majority captured in areas characterised with sandy substrate (sand, sandy gravel, gravelly sand, sandy gravel).

3.2.1.14 Sandeel surveys undertaken by Beatrice OWF in 2014 reported similar findings, indicating patchy sandeel distribution across the sites, with sandeel recorded in relatively low numbers (BOWL, 2014[29]). Post-construction monitoring at Beatrice OWF undertaken in 2021 reported significant increases in sandeel numbers, when compared to the 2014 pre-construction surveys (BOWL, 2014[29]; 2021a[2222]; 2021b[23])'. Similarly, results from sandeel surveys across the Beatrice OWF site in December 2020 indicated patchy distribution with low abundance, with Raitt's sandeel being the most prevalent (BOWL, 2021a[22]; 2021b[23]). This increase in sandeel abundance indicates that the construction of the Beatrice OWF resulted in no negative impacts on the local sandeel population (BOWL, 2014[29]; 2021a[22]; 2021b[23]).

3.2.1.15 Pre-construction herring larvae surveys were undertaken by Beatrice OWF Limited in 2014 and 2016 (BOWL, 2014[29]; 2016[26]), as well as for the Moray

East OWF (Moray East OWF, 2018[49]). 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, 2011a[34]; 2011b[35]).

3.2.1.16 Several shellfish species are known to be abundant within the study area, including Nephrops (particularly significant for commercial fisheries within the region), squid (*Loligo* spp.), and king scallop (*Pecten maximus*) (Scottish Government, 2020[50]; ICES, 2022[51]). Moray West OWF site epibenthic trawls recorded hermit crabs (*Pagurus prideaux* and *Pagurus bernhardus*), toad crab (*Hyas coarctatus*), long legged crab (*Macropodia rostrata*), squat lobster (*Galathea intermedia*) and saddle oyster (*Anomia ephippium*). Additionally, prawn (*Pandalina brevirostris*) and pink shrimp (*Pandalus montagui*) were present but generally in low abundances (Moray Offshore Windfarm (West) Limited, 2018[24]).

Regional Surveys

3.2.1.17 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, 2023[52]). The trawl surveys identified assemblages consisting of haddock, whiting, herring, Norway pout (*Trisopterus esmarkii*), cod, Atlantic mackerel, plaice, anglerfish (Lophiiformes) and Raitt's sandeel.

3.2.1.18 Elasmobranch species are also known to be present in the Moray Firth area although with low percentage of total landings in the study area (Scotland Marine Atlas, 2011[53] ; ICES, 2022[17]). An extensive literature review by Ellis *et al*. (2005[54]) 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 (*Raja clavata*) and spotted ray (*Raja montagui*).

3.2.1.19 In addition to the species mentioned above, basking shark (*Cetorhinus maximus*) migrate from the western English Channel in spring to west Scottish waters, where they spend the summer and early autumn before moving offshore in winter. Basking shark sightings have occurred infrequently in the study area and across the Moray Firth (Scottish Government, 2022[55]).

3.2.1.20 Details of those species recorded and other species that are known to be present in the study area are detailed in Table 3-2.

Table 3-2: Species recorded in both site-specific and regional surveys within the study area.

eDNA	Beam Trawl	Otter Trawl	Dredge Tow	Shellfish	Elasmobranchs	Spawning	Nursery
▪ Atlantic Mackerel ▪ Cod ▪ Haddock ▪ Herring ▪ Norway Pout ▪ Ocean Quahog ▪ Pink Salmon	▪ Cuckoo Ray ▪ Dab ▪ Dragonet ▪ Grey gurnard ▪ Lemon sole ▪ Monkfish ▪ Plaice ▪ Pogge ▪ Sandeel ▪ Spotted dogfish ▪ Topknot	▪ Cod ▪ Haddock ▪ Squid ▪ Whiting	▪ Greater sandeel ▪ Raitt's sandeel ▪ Smooth sandeel	▪ Hermit crab ▪ King scallop ▪ Long-legged crab ▪ Nephrops ▪ Pink shrimp ▪ Prawn ▪ Saddle oyster ▪ Squat lobster ▪ Squid	▪ Basking shark ▪ Spotted ray ▪ Spurdog ▪ Whiting ▪ Sandeel ▪ Nephrops	▪ Anglerfish ▪ Cod ▪ Haddock ▪ Hake ▪ Herring ▪ Lemon sole ▪ Ling ▪ Mackerel ▪ Nephrops ▪ Plaice ▪ Sandeel ▪ Spotted ray ▪ Sprat ▪ Spurdog ▪ Thornback ray ▪ Whiting	▪ Anglerfish ▪ Blue whiting ▪ Haddock ▪ European Hake ▪ Herring ▪ Lemon sole ▪ Ling ▪ Mackerel ▪ Nephrops ▪ Plaice ▪ Sandeel ▪ Spotted ray ▪ Sprat ▪ Spurdog ▪ Thornback ray ▪ Tope Shark ▪ Whiting
Source: See Volume 7B, Appendix 4-1; Volume 7B, Appendix 4-2	Source: Moray Offshore Windfarm (West) Limited (2018[24])	Source: BOWL (2021a[22]; 2021b[23])	Source: Moray Offshore Renewables Limited (2011a[34]; 2011b[35]); BOWL (2014[29]; 2021a[23]; 2021b[16])	Source: Moray Offshore Windfarm (West) Limited (2018[24]); Scottish Government (2020[50]); ICES (2022[1751])	Source: Ellis *et al*. (2004[54]); Scottish Government (2020[50]); ICES (2022[17])	Source: Coull *et al*. (1998[21]); Ellis *et al*. (2010[56]; 2012[19])	Source: Coull *et al*. (1998[21]); Ellis *et al*. (2010[56]; 2012[19])

3.3 Spawning and Nursery Grounds

3.3.1 Overview

3.3.1.1 The spawning and nursery grounds of several fish species are known to be located within or in close proximity to the study area based on available information on spawning and nursery areas for fish species (Coull *et al*., 1998[21]; supported by data sources from Ellis *et al*., 2010[56]; 2012[19]).

3.3.1.2 Further information is provided in Aires *et al*. (2014[14]). The study assessed evidence of aggregations of '0 group fish' (fish in the first year of their lives) around the UK coastline. These data were ascertained from species distribution modelling combining observations of species occurrence or abundance with environmental data (Aires *et al*., 2014[14]). The outputs of this process have been used as a guide for the most likely locations of aggregations of 0 group fish. It should be acknowledged that these data do not represent nursery areas as described in Coull *et al*. (1998[21]) but however do provide an indication of important areas for fish population. Nursery areas can comprise a larger spread of ages and sizes (Aires *et al*., 2014[14]).

3.3.1.3 In addition, information has been sourced by Gonzalez-Irusta and Wright (2016[12]; 2017[11]), which defines areas of likely spawning activity for key commercial species in the North Sea. These data have been used in this report to supplement the findings of Coull *et al*. (1998[21]) and Ellis *et al*. (2012[19]).

3.3.1.4 Spawning grounds for cod, herring, plaice, sprat, whiting and sandeel overlap with the study area as well as extending over much of the Moray Firth and northern North Sea (Figure 3-1, Figure 3-2 and Figure 3-3) (Coull *et al*., 1998[21]; Ellis *et al*., 2010[56]; 2012[19]) Gonzalez-Irusta and Wright (2016[12]) defined areas of 'occasional grounds for spawning cod' along the Moray First coast, interacting with the nearshore portion of the study area. However, the Caledonia OWF within the study area is classified as 'unfavourable grounds for spawning'. In contrasts to the findings of Coull *et al*. (1998[21]) and Ellis *et al*. (2010[56]; 2012[19]), the Moray Firth is largely classified by Gonzalez-Irusta and Wright (2016[12]) as being 'unsuitable for spawning whiting', with 'grounds more important for spawning herring' being distributed in the southern North Sea.

3.3.1.5 Spawning grounds for Nephrops and scallops are also present within the Moray Firth (Figure 3-1). The distribution of Nephrops is largely dependent on the presence of seabed habitats comprising muddy substrates. Scallop spawning grounds have been identified in the northern area of the Moray Firth, correlating with areas of fine or sandy gravel substrates (Keltz and Bailey, 2010[57]).

3.3.1.6 The study area also coincides with high intensity herring, cod and anglerfish (*Lophius piscatorius*) nursery grounds (Figure 3-3), and many low intensity nursery grounds including lemon sole, haddock, sprat, whiting, Nephrops, hake, ling, mackerel, plaice, sandeel, spotted ray, spurdog and thornback ray (Figure 3-4, Figure 3-5, Figure 3-6 and Figure 3-7).

3.3.1.7 The modelled probability of the presence of 0 group herring aggregations within the study area shows a probability of presence of 0.16 to 0.33 along the Moray Firth coast, and a lower probability of presence of 0 to 0.16 further offshore, within the study area (Aires *et al*., 2014[14]).

3.3.1.8 The probability of the presence of 0 group cod aggregations within the study area shows a patchy distribution, with discrete areas of 0.32 probability of cod presence along the Moray Firth coast, and further offshore within the study area. Similar observations are evident for group 0 anglerfish, with patchy distributions of 0.29 probability modelled across the Moray Firth (Aires *et al*., 2014[14]).

3.3.1.9 Conversely, higher probabilities were modelled for the presence of 0 group haddock across the Moray Firth, ranging from 0.32 to 0.65, and peaking at 0.99 (in discrete areas) within the nearshore portion of the study area, overlapping the Caledonia OECC. A similar distribution pattern was evident for whiting, with probabilities of 0 group whiting presence ranging from 0.28 to 0.08 in the nearshore, across the Caledonia OECC, with lower probabilities of presence in patchy distribution further offshore, in the Caledonia OWF and study area (Aires *et al*., 2014[14]).

3.3.1.10 Modelled probability of 0 group plaice presence, showed probabilities ranging from 0.18 to 0.36 along the Moray Firth coast, within the nearshore portion of the study area (Aires *et al*., 2014[14]).

3.3.1.11 The modelled probability of the presence of 0 group mackerel, hake and sprat aggregations in the study area all showed discrete areas of 0.24, 0.26 and 0.28 probability respectively of presence in the nearshore (Aires *et al*., 2014[14]).

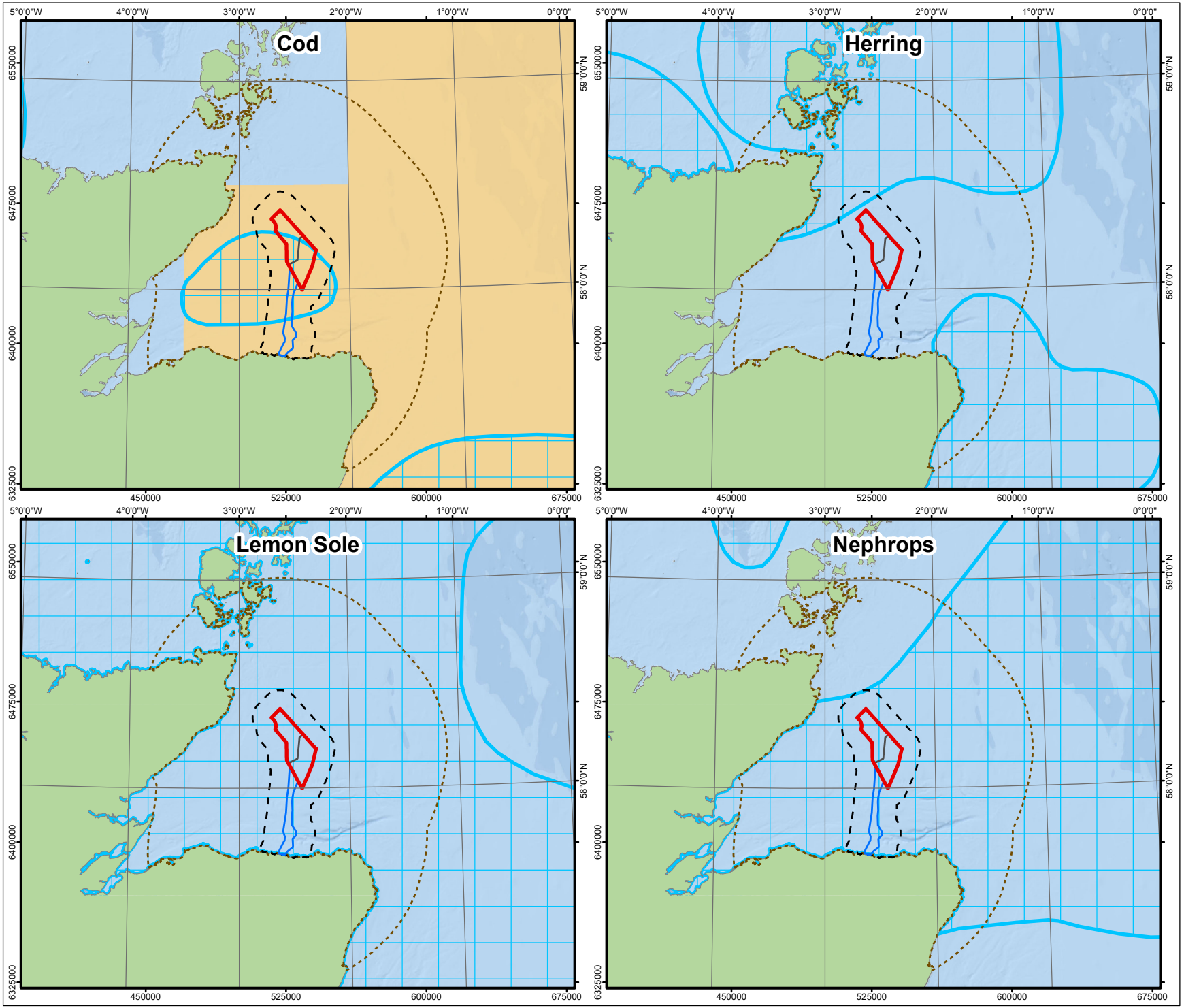
3.3.1.12 No 0 group probabilities were modelled for lemon sole. Nephrops, ling, sandeel, spotted ray, spurdog and thornback ray, all of which have low intensity spawning grounds in the study area (Aires *et al*., 2014[14]).

3.3.1.13 It should be noted that in a broader context, the study area has a spatially limited interaction with a small portion of the overall spawning sites and nursery grounds for the species discussed above. The spawning and nursery grounds of these species in the study area form part of far greater spawning and nursery grounds within the northern North Sea system and, therefore, impacts from the Proposed Development (Offshore) are expected to be of smaller significance.

3.3.1.14 Due to their prevalence and importance as Valued Ecological Receptors (VER's) and their demersal spawning natures, cod, herring and sandeel spawning grounds have been assessed in more detail below in Sections 3.3.2, 3.3.3 and 3.3.4 respectively.

Table 3-3: Summary of spawning timings (Coull *et al*., 1998[21]) in the northern North Sea for fish species known to have spawning habitats in the study area (Blue cells indicate spawning period with dark blue indicating 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)												
Sprat												
Nephrops												



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

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

Higher

Lower

Undetermined

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

Higher

Lower

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0 10 20 30 40 50 60 km

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Figure 3-1: Spawning Grounds Within the Study Area (Coull et al., 1998; Ellis et al., 2012)

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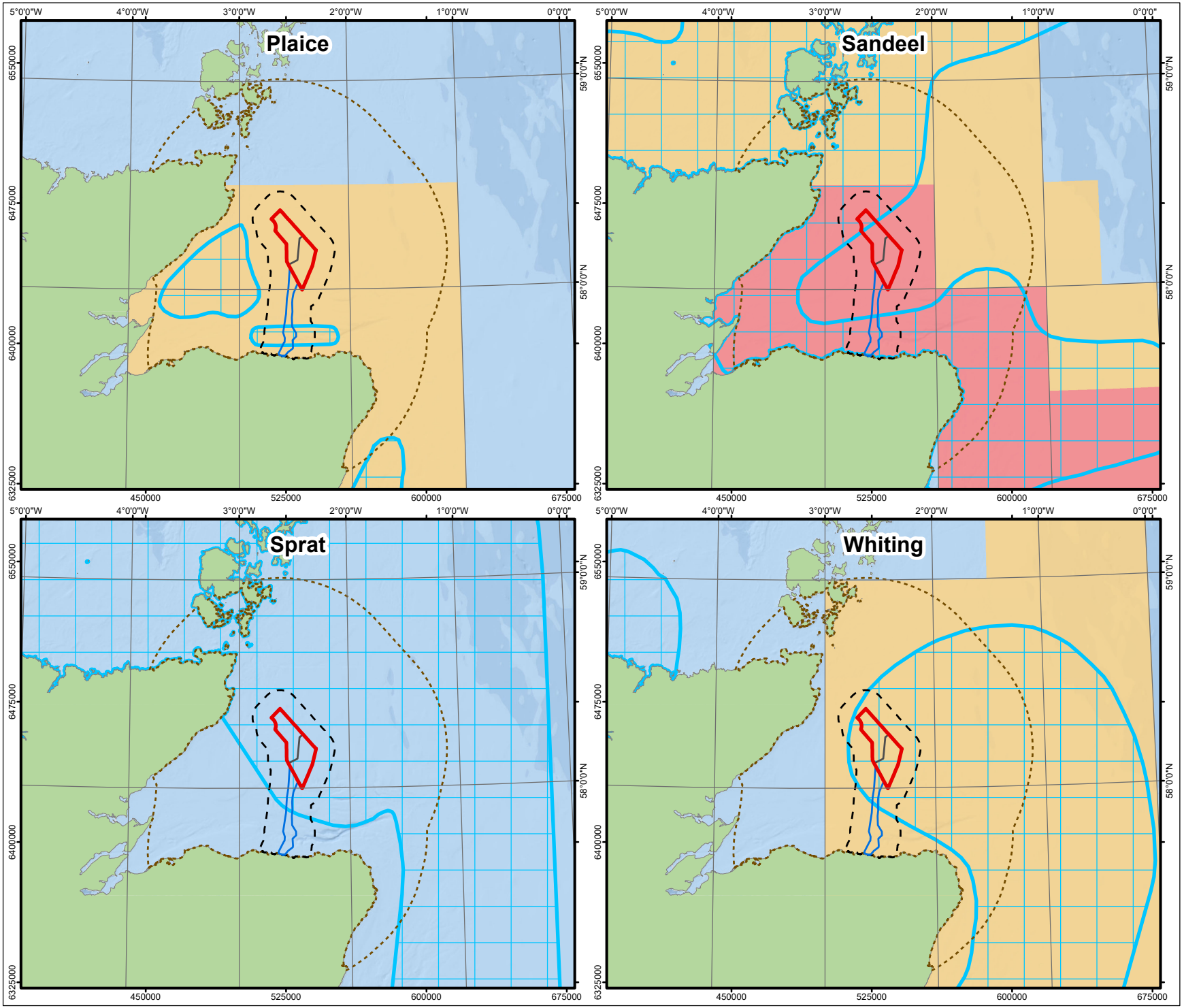

Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

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

Higher

Lower

Undetermined

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

Higher

Lower

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0 10 20 30 40 50 60 km

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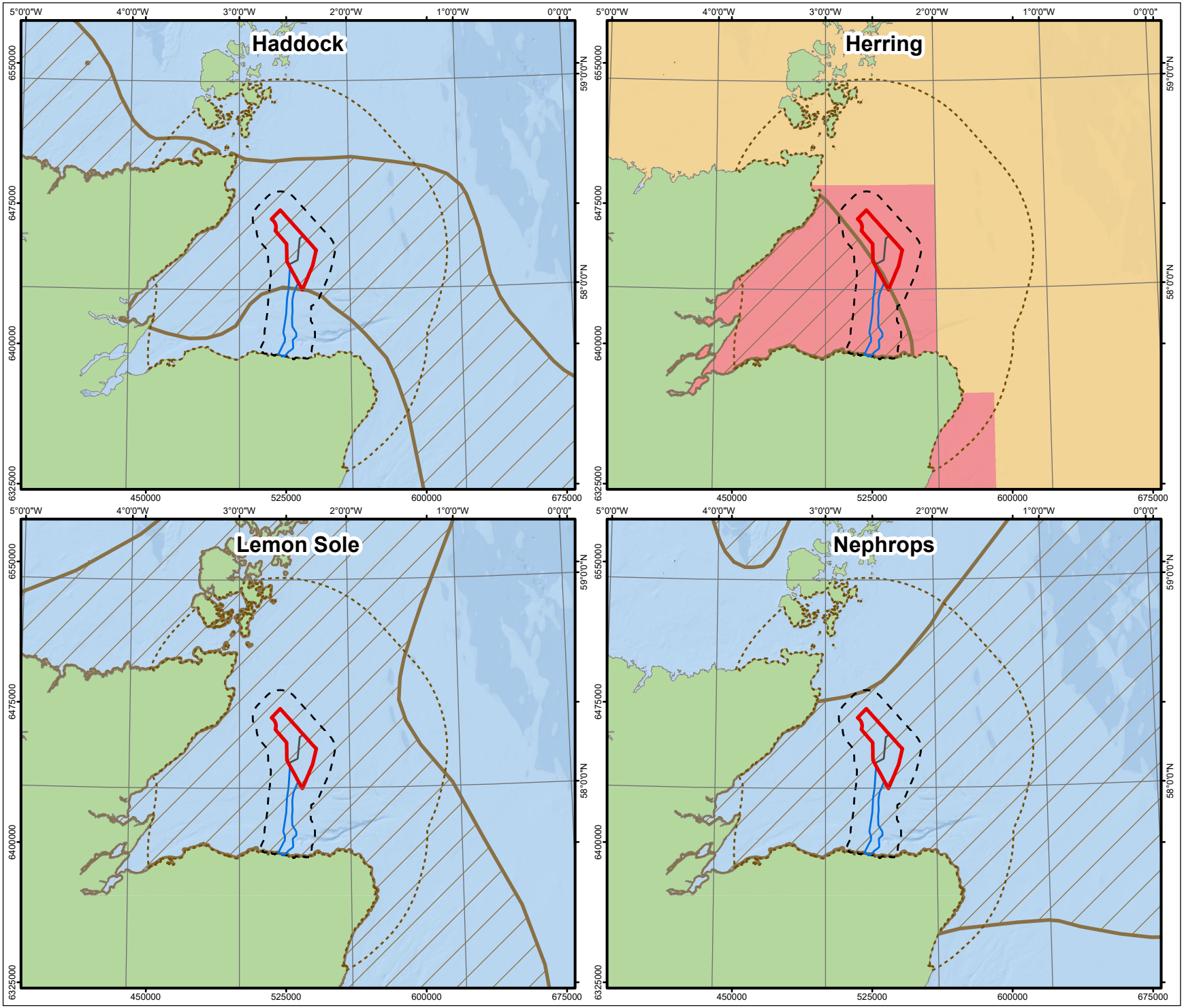
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-2: Spawning Grounds Within the Study Area (Coull et al., 1998; Ellis et al., 2012)

STATUS: Approved	SCALE: 1:2,750,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Nursery Grounds (Coull *et al.*, 1998)

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

Higher

Lower

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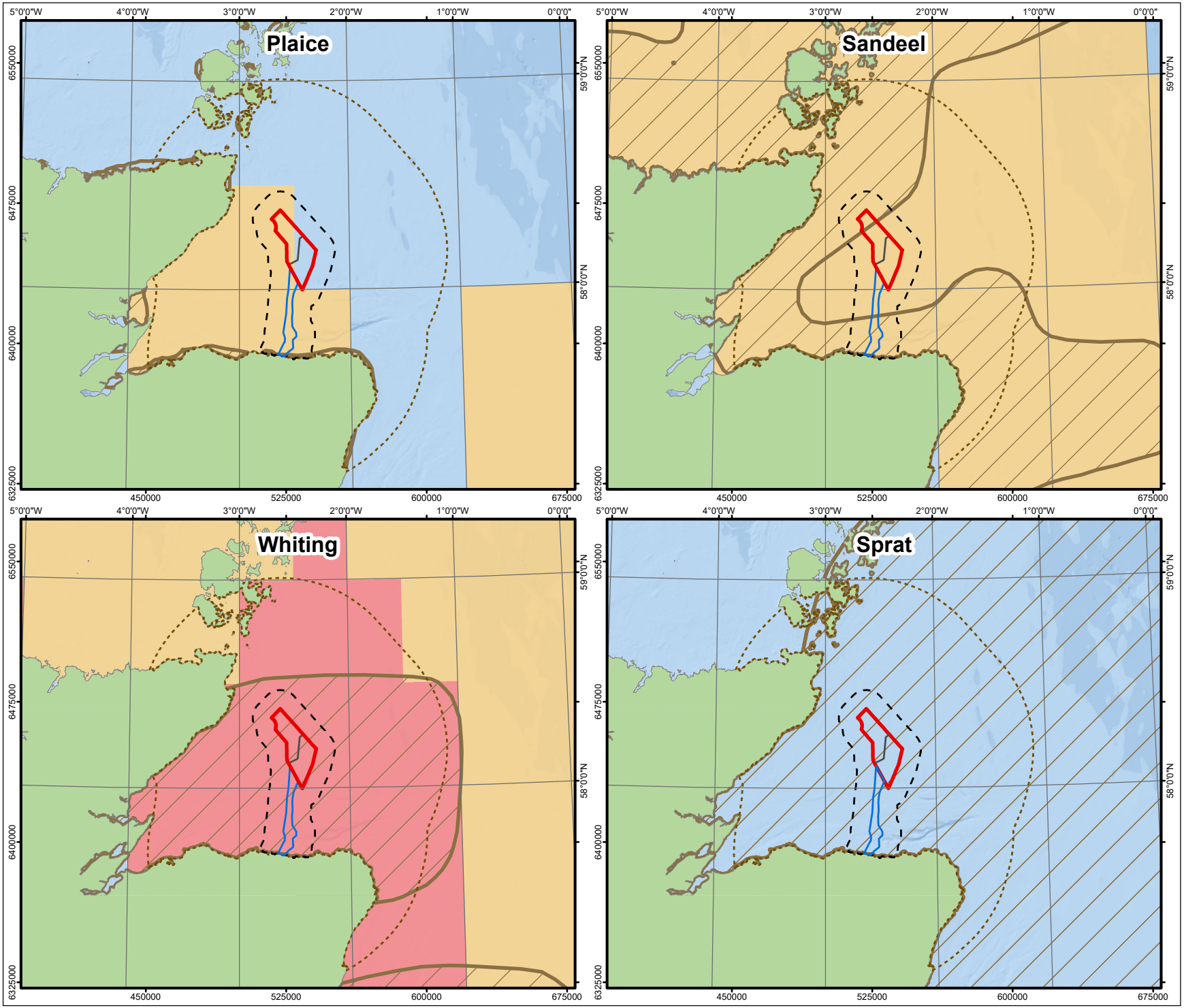
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-3: Nursery Grounds Within the Study Area (Coull et al., 1998; Ellis et al., 2012)

STATUS: Approved	SCALE: 1:2,750,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Nursery Grounds (Coull *et al.*, 1998)

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

Higher

Lower

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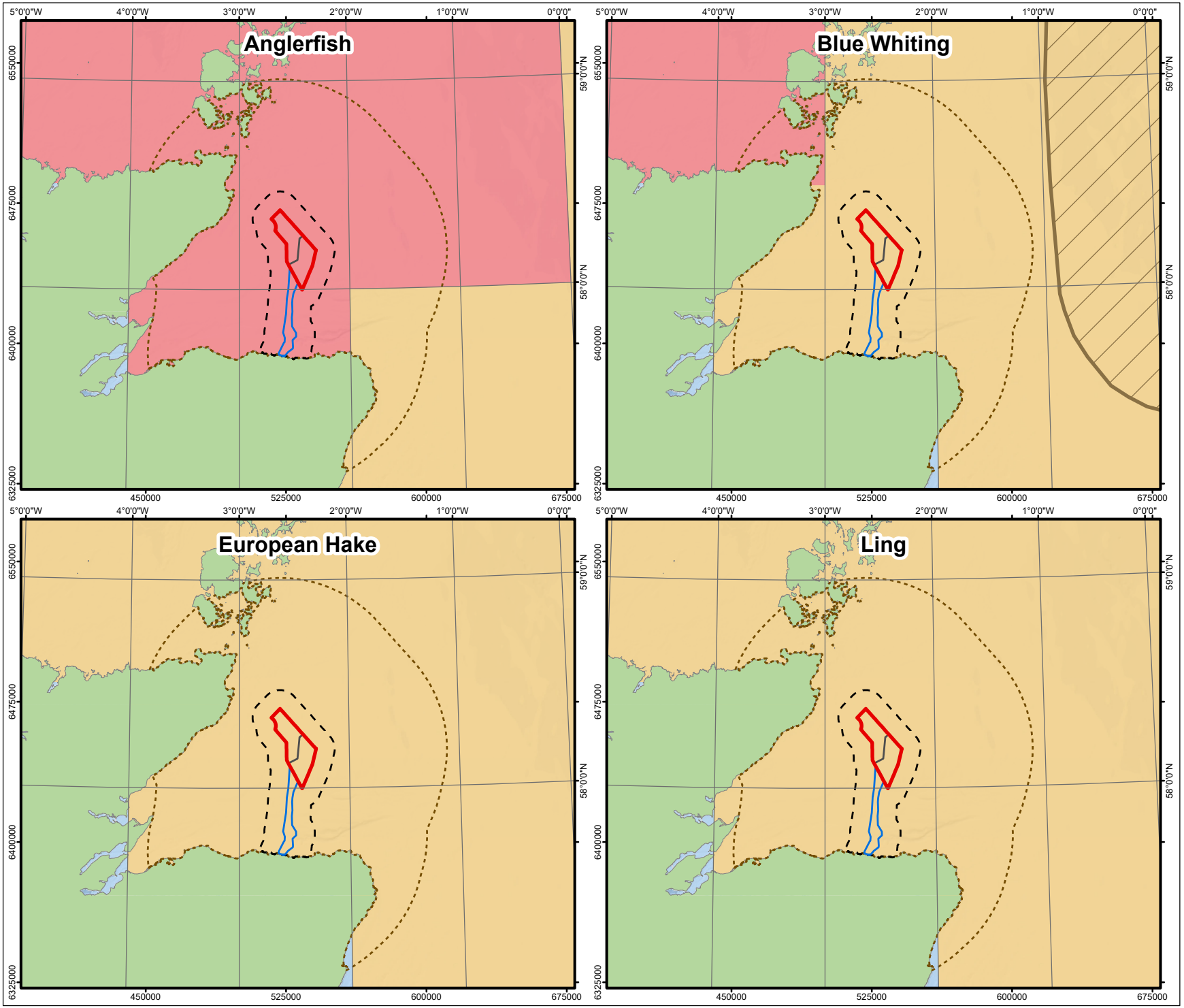
DRAWING TITLE

Figure 3-4: Nursery Grounds Within the Study Area (Coull et al., 1998; Ellis et al., 2012)

STATUS: Approved	SCALE: 1:2,750,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Nursery Grounds (Coull *et al.*, 1998)

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

Higher

Lower

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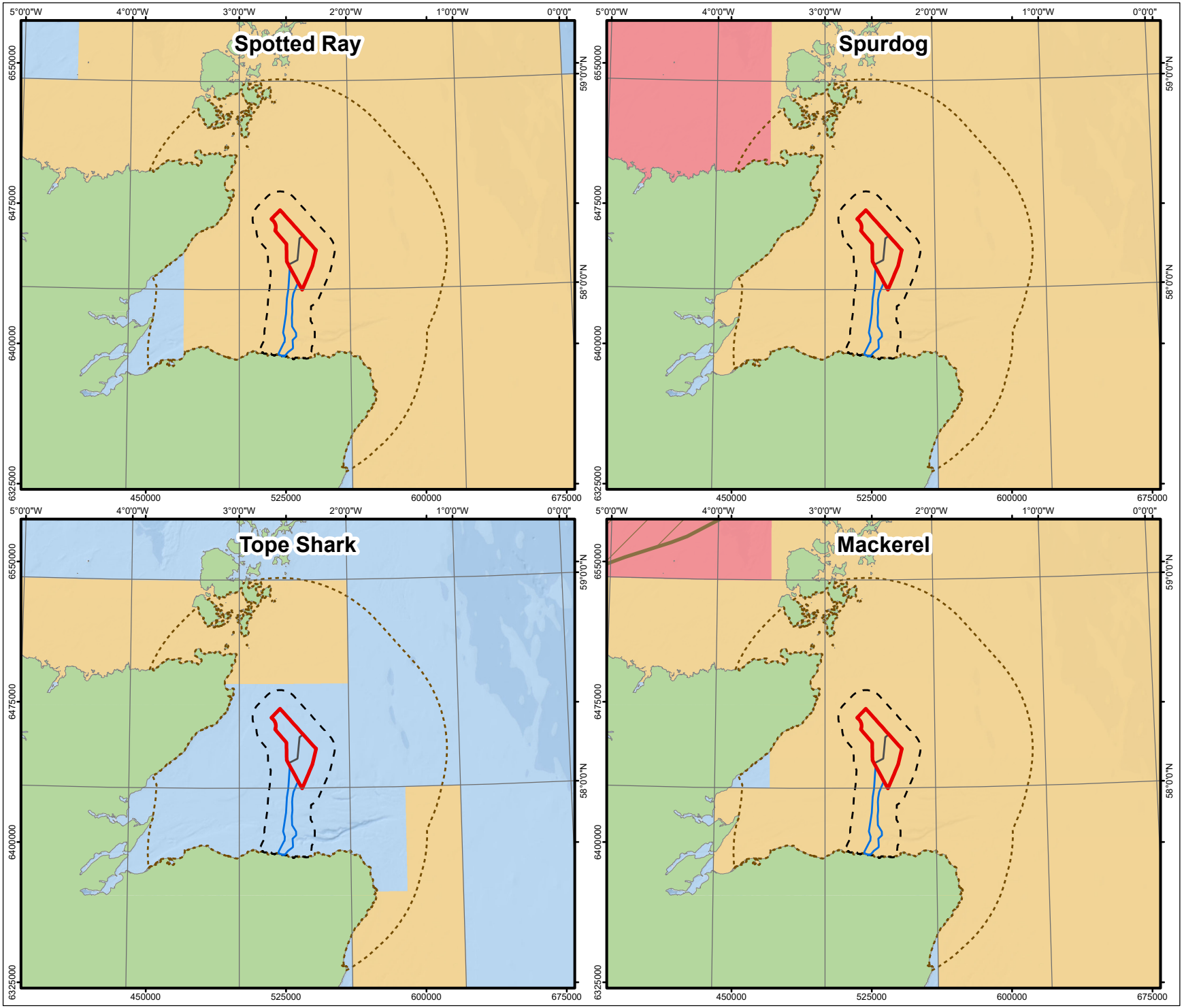
DRAWING TITLE

Figure 3-5: Nursery Grounds Within the Study Area (Coull et al., 1998; Ellis et al., 2012)

STATUS: Approved	SCALE: 1:2,750,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Nursery Grounds (Coull *et al.*, 1998)

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

Higher

Lower

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GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-6: Nursery Grounds Within the Study Area (Coull et al., 1998; Ellis et al., 2012)

STATUS: Approved	SCALE: 1:2,750,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

3.3.2 Cod Spawning Grounds

3.3.2.1 Cod spawn throughout much of the northern North Sea; however, there is evidence of substock structuring (Fox *et al*., 2008[58]; ICES, 2007[59]). In the Moray Firth, the cod population has been found to be genetically distinct from other North Sea cod (Hutchinson *et al*., 2001[60]).

3.3.2.2 The Moray Firth is renowned for having high intensity cod spawning and nursery grounds; the study area overlaps with both a low intensity cod spawning area (with spawning occurring in winter) (Figure 3-1) and a high intensity nursery ground (Coull *et al*., 1998[21]; Ellis *et al*., 2010[56]; 2012[19]) .

3.3.2.3 Cod are broadcast spawners with pelagic eggs which hatch over a period of two to three weeks, depending on water temperature (Wright *et al*., 2003[61]). Sediment type can be an important factor in mate selection as male cod create structures called leks and exhibit a preference for coarse sands. Once males have created their leks within areas of suitable substrates, they subsequently defend these from other males (González-Irusta and Wright, 2016[12]; Grabowski *et al*., 2009[62]; Nordeide and Folstad, 2000[63]).

3.3.2.4 Cod spawning surveys were conducted across the Moray East OWF in 2013 (Brown and May Marine, 2013[64]) and more recently otter trawl surveys were conducted for pre- and post-construction monitoring of the Beatrice OWF (BOWL, 2015[28]; 2021a[22]; 2021b[23]). Results from these surveys showed that, based on catch rates, areas could be classified as a "spawning area" for cod despite showing a patchy distribution, with more likely spawning grounds to the north (BOWL, 2015[28]; 2021a[22]; 2021b[23]). Based on the combination of site specific eDNA data and literature it can be assumed with high confidence that cod will be present across the study area.

3.3.3 Herring Spawning Grounds

3.3.3.1 There are two large herring stock spawning grounds that run along much of the east coast of Scotland and extend offshore. The Buchan stock overlaps with the south of the study area and the Orkney/Shetland herring spawning ground overlaps with the north of the study area areas as indicated by Coull *et al*. (1998[21]) (Figure 3-8). The main spawning time for both of these stocks is in the autumn, typically between August to October. The IHLS data indicates that the main spawning is located to the south of the Caledonia North at the Buchan spawning grounds (based on distribution and density of larvae) and then to the north with the Orkney/Shetland herring spawning grounds.

3.3.3.2 Herring are demersal spawners, that lay their eggs onto or into seabed sediments. They also exhibit substrate dependency and show a high preference for coarse grounds and high energy environments when selecting spawning grounds (Keltz and Bailey, 2010[57]; De Groot, 1980[65]; Maucorps, 1969[66]; Munro *et al*., 1998[67]; Parrish *et al*., 1959[68]; Blaxter, 1985[69]). Females

deposit sticky eggs in single batches directly on to the seabed on a substrate of coarse sand, gravel, small stones or rocks (Keltz and Bailey, 2010[57]; Munro *et al*., 1998[67]; Hodgson, 1957[70]). Spawning of the Shetland-Orkney sub-stock occurs between August and September (Table 3-3) and shoals of herring arrive at traditional spawning grounds in a series of waves, where they congregate (Lambert, 1987[71]; Coull *et al*., 1998[21])'.

3.3.3.3 It has been suggested that herring are able to discriminate sources of sound emitted by various sediment types, each being characterised by its own specific noise spectrum. Herring would in this way be able to use the sound characteristics of the seabed as a clue to recognise their spawning sites in addition to homing (Enger, 1967[72]). Herring larvae hatch in approximately three weeks, depending on the sea temperature (Keltz and Bailey, 2010[57]; Maucorps, 1969[66]; Munro *et al*., 1998[67], Hodgson, 1957[70]). Hatched larvae measure between 6 and 10mm and depend on their yolk-sac until first feeding (Hodgson, 1957[70]). Once the yolk-sac has been absorbed, larvae become pelagic and feed on plankton. They are then passively carried by prevailing currents before arriving at the nursery grounds (Keltz and Bailey, 2010[5757]; Maucorps, 1969[66]; Munro *et al*., 1998[67]; Hodgson, 1957[70]). Herring larvae from the Orkney/Shetland stock drift south into nursery grounds in the Moray Firth and east to nursery grounds in the Skagerrak and Kattegat. Herring larvae of the Buchan stock drift south into nursery grounds in the Firth of Forth and east to Skagerrak and Kattegat nursery grounds. Heath *et al*. (1989[73]) found that herring larvae from a spawning site at Clythness in the Moray Firth drifted from the spawning grounds at a rate of 1-2km/day.

3.3.3.4 Pre-construction herring larvae surveys were undertaken by BOWL in 2014 and 2015 (BOWL, 2014[29]; 2016[26]). Data collected across Beatrice OWF identified larvae to the north of the Caledonia OWF which originated from well-established spawning grounds located around Orkney and Shetland, before being 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 Firth 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. Generally, the smallest larvae were found to the south of the array and the largest were found to the north (Figure 3-8).

3.3.3.5 Adult herring migrate considerable distances in large shoals to feeding and spawning grounds (Munro *et al*., 1998[67]). Juvenile fish remain in nursery areas for up to two years before joining adult fish on their migration. Herring's migration is divided into three phases: The over-wintering phase, the feeding phase and the reproduction/spawning phase. North Sea herring spawn off the Scottish and English east coast, migrate east to the Skagerrak and Kattegat where they overwinter and then move to the feeding grounds in the Fladen Grounds and Viking Bank before returning to the spawning grounds. In the

Moray Firth, juveniles are present throughout the year, whilst adults are more prevalent during the spawning season.

3.3.3.6 Herring are important as a prey species for other fish, marine mammals and birds within the wider North Sea food-web. Herring are particularly sensitive to noise impacts as they have swim bladders that are involved in hearing.

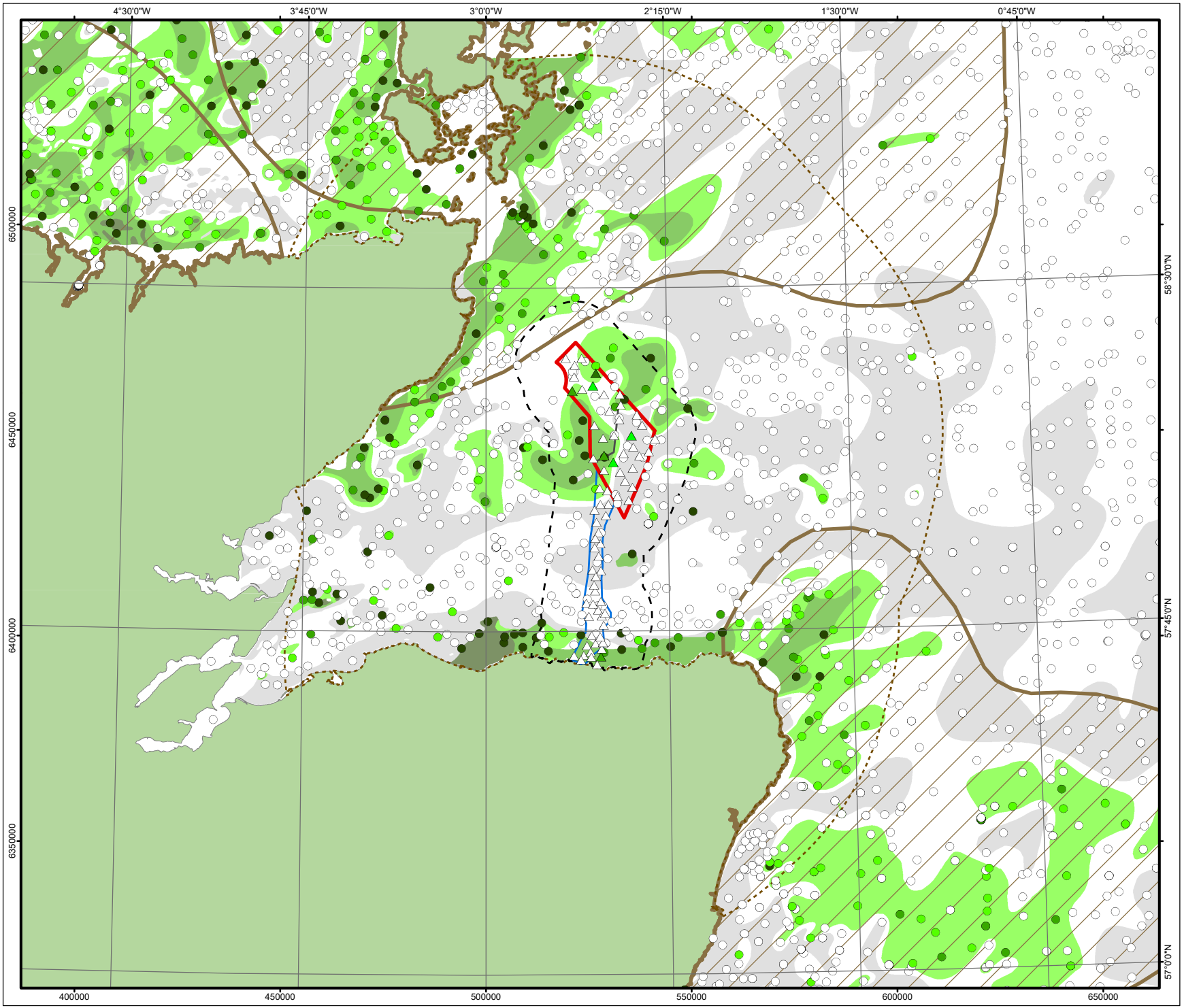
3.3.3.7 Analysis of particle size distribution at stations within the Caledonia OWF classified the majority of the area to be 'Unsuitable' for spawning, suggesting a very low likelihood of herring spawning (Figure 3-7). This is attributed to the presence of >5% mud or <10% gravel at these grab sampling stations. Discrete areas to the East and West of the Caledonia OWF (within the secondary ZoI) have been classified as ''Marginal' or 'Preferred', corresponding with habitats categorised as 'Coarse Substrates' (EMODnet, 2023[6]). Areas of 'Marginal' and 'Preferred' sediment are also located to the North of the Caledonia OWF (within the underwater noise ZoI) between Duncansby Head and the Orkney Islands, corresponding to areas of 'Coarse Substrates' (EMODnet, 2023[6]).

3.3.3.8 Particle size distribution at stations within the Caledonia OECC, indicated that most sites were categorised as 'Unsuitable', with the majority having a <10% gravel or >5% mud content. However, areas in the nearshore within the secondary ZoI and the underwater ZoI, showed a higher likelihood of herring spawning due to a higher gravel content and lower fines content; with sediments classified as 'Marginal' and 'Preferred' sediment, corresponding to areas of 'Coarse Substrates' (EMODnet, 2023[6]). At the south east limit of the area, there is an overlap with the Buchan Herring spawning grounds and area of intermediate larva abundance (12,500 – 18,500 per m^2) (Figure 3-8) and areas of "High" spawning potential (Figure 3-9). At the Northern extent of the study area there is a slight overlap with the Orkney/Shetland herring spawning grounds and areas of intermediate larva abundance (12,500 – 18,500 per m^2)(Figure 3-8) and areas of "High" spawning potential (Figure 3-9).

3.3.3.9 It should be noted that MarineSpace *et al*. (2013a[39]) 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[39]).

3.3.3.10 In summary, the study area intersects the Buchan stock spawning grounds to the south and the Orkney/Shetland stock spawning grounds to the north (Coull *et al*., 1988[21]). Although the Caledonia OWF and Caledonia OECC does not have a direct overlap with either of the spawning grounds they do overlap with the study area. However, areas of highest herring larvae abundances are

situated far to the south outside of the study area (Figure 3-8 and Figure 3-9). Across the Caledonia OWF and Caledonia OECC, most stations were deemed 'Unsuitable' for herring spawning due to high mud content or low gravel content, indicating a low likelihood of spawning (Figure 3-7). However, locations of more favourable sediments for herring spawning are evident to the East and West of the Caledonia OWF (within the secondary ZoI), and to the North of the Caledonia OWF (within the underwater noise ZoI). Favourable sediments for herring spawning are also located along the southern coast of the Moray Firth (outside of the Caledonia OECC, and within the secondary ZoI and underwater noise ZoI), with classifications ranging from 'Marginal' to 'Preferred' based on gravel content (Figure 3-7).



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Herring Spawning Grounds (Coull et al., 1998)

Herring Habitat Suitability (Reach *et al.*, 2013) (Gardline Limited and Titan Environmental Surveys, 2023)

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

Herring Habitat Suitability (Reach *et al.*, 2013) (BGS, 2015)

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

Seabed Substrate (EMODnet) Herring Habitat Suitability (Reach *et al.*, 2013)

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

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Figure 3-7: Herring Spawning Substrates Relative to the Study Area

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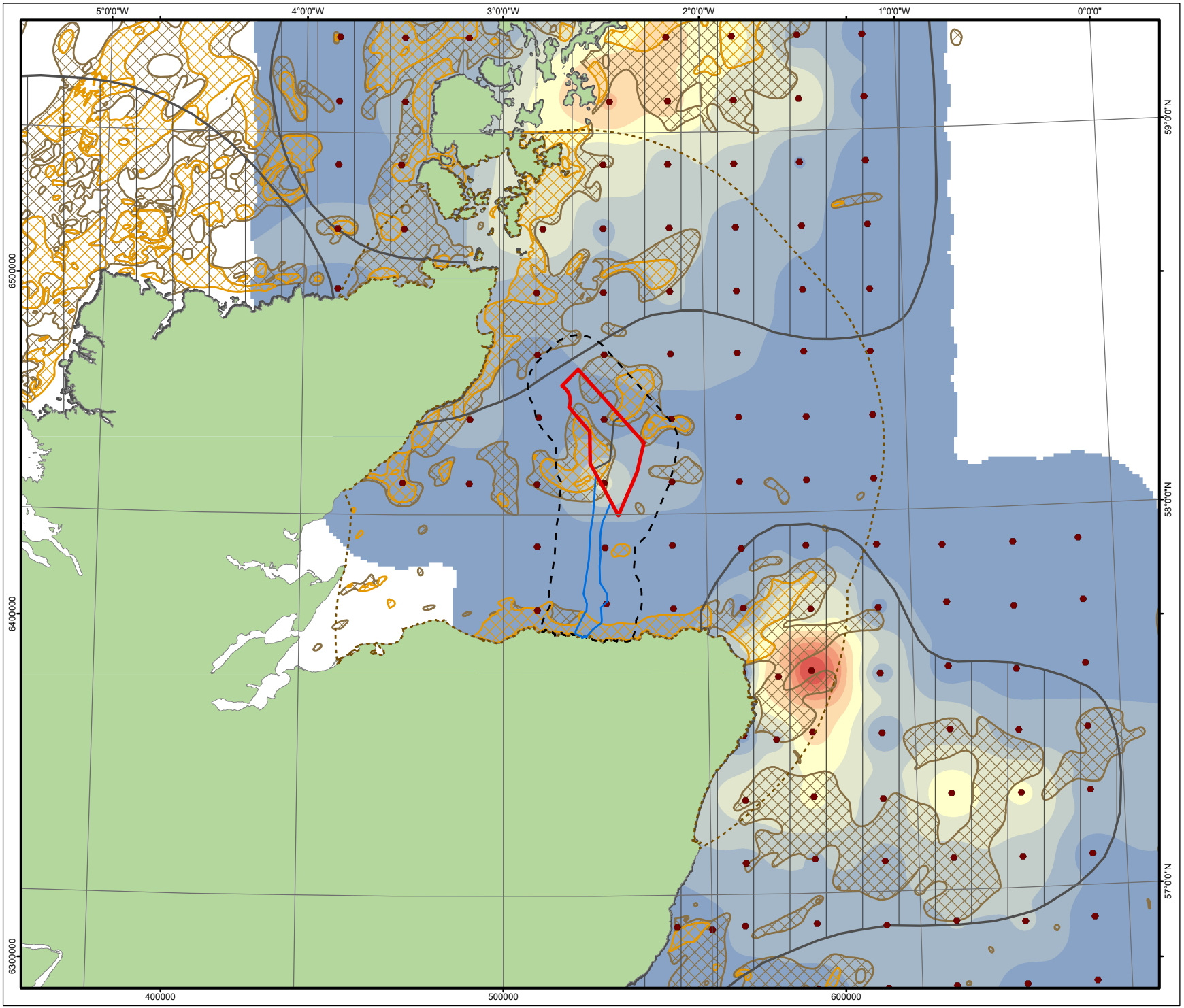

Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Herring Spawning Grounds (Coull et al., 1998)

EMODnet Sediment Class Herring Habitat Suitability

Marginal Sediment

Preferred Sediment

International Herring Larvae Survey

Sample Location (2011 - 2024)

IHLS Season 2011-12 to Season 2023-24 - Larval abundance per m²

0

0.1 - 1,500

1,500.1 - 3,500

3,500.1 - 5,500

5,500.1 - 9,500

9,500.1 - 14,500

14,500.1 - 20,000

20,000.1 - 26,000

26,000.1 - 35,000

35,000.1 - 45,000

45,000.1 - 59,000

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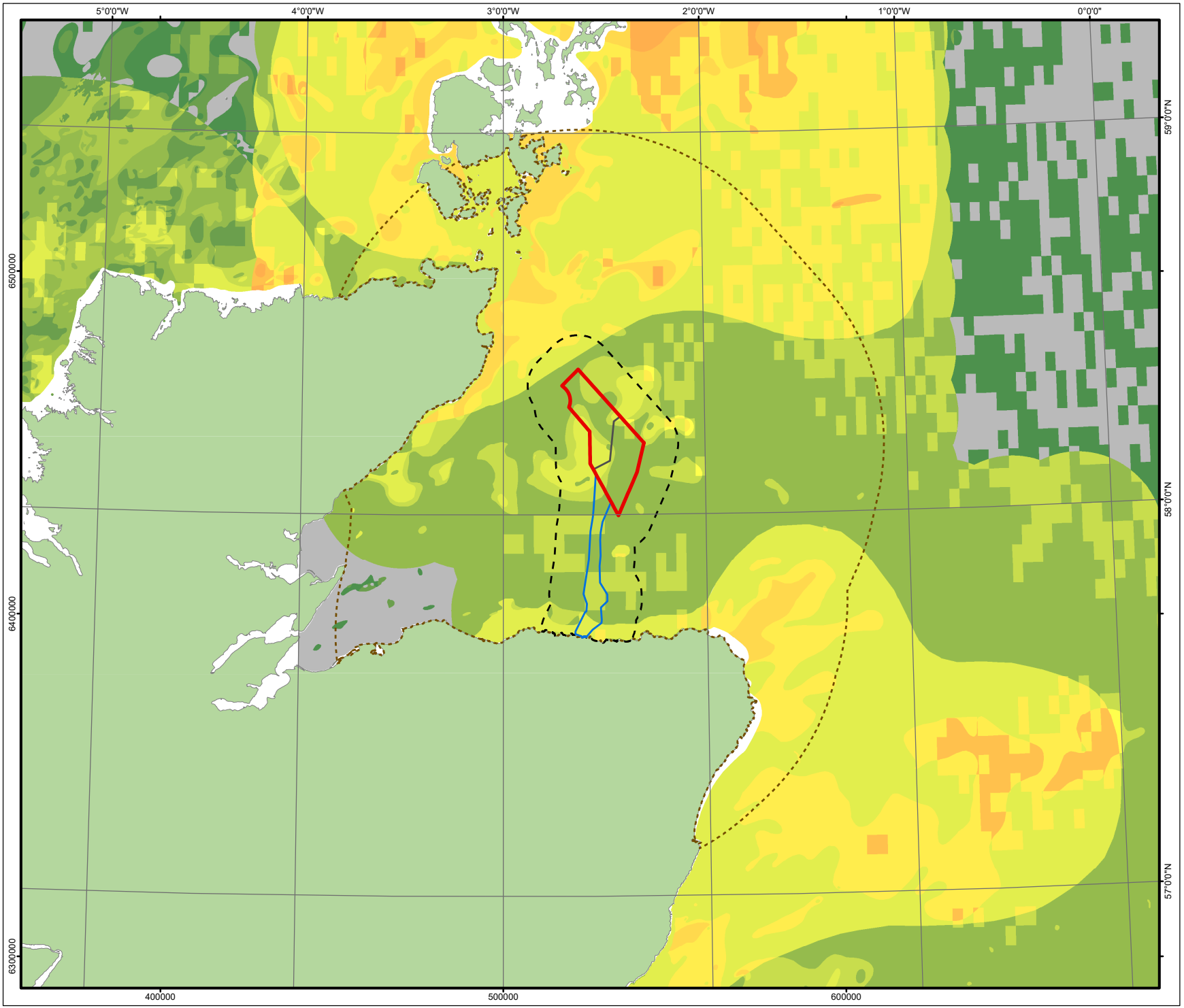
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-8: Indicative Herring Spawning Data Relative to the Study Area (IHLS, 2011-2024)

STATUS: Approved	SCALE: 1:1,500,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Herring 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)

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DRAWING TITLE

Figure 3-9: Herring Spawning Potential Heat Map Relative to the Study Area

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DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

3.3.4 Sandeel Spawning Grounds

3.3.4.1 The North Sea sandeel stock has been divided into seven sub populations which are reproductively isolated from each other (ICES, 2009[74]). The sandeel population of the Moray Firth is part of the Central Western North Sea sandeel stock (ICES, 2009[74]; ICES 2022b[75]).

3.3.4.2 Sandeel 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 sandeel, coupled with their vulnerability to changes in habitat, they are of increasing conservation interest and listed as a species of principal importance in the UK, designated as a nationally important marine feature (Hirst *et al*., 2012[76]) and a Scottish PMF.

3.3.4.3 The study area and inshore area of the Moray Firth is identified as a high intensity spawning ground for sandeel with low intensity spawning grounds to the west and in the northern North Sea (Figure 3-2 and Figure 3-4) (Coull *et al*., 1998[21]; Ellis *et al*., 2010[56]; 2012[19]). Sandeel are of relevance when considering impacts to spawning areas, as they are demersal spawners that lay their eggs onto or into seabed sediments (Figure 3-10 and Figure 3-11). Sandeel also exhibit substrate dependency, preferring sandy substrates on which to spawn, as identified in the baseline data (Table 2-2).

3.3.4.4 The north of the Caledonia OWF overlaps with and are classed as having "High" potential for sandeel spawning to occur, with the rest of Caledonia OWF and Caledonia OECC being classified as either "medium" or "low" (Figure 3-12). Throughout the study area there is high variability and patchy distribution in areas of "Low", "Medium" and "High" potential for sandeel spawning.

3.3.4.5 Sandeel are a group of shoaling fish which spend most of the year buried in the seabed and only emerge into the water column briefly in winter for spawning and for an extended feeding period in spring and summer (Van der Kooij *et al*., 2008[77]). Spawning principally takes place in December and January (Gauld and Hutcheon, 1990[78]; Bergstad *et al*., 2001[79]; Winslade 1974[80]). Females lay demersal eggs and after several weeks planktonic larvae hatch, usually in February-March (Macer, 1965[81]; Langham, 1971[82]; Wright and Bailey, 1996[83]). After spawning, the fish remain buried in sand until April (Winslade, 1974[80]).

3.3.4.6 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. Much of Caledonia OWF and Caledonia OECC are classed as having "Preferred Sediment" for sandeel spawning (Figure 3-11). Sandeel are highly substrate specific (Wright *et al*., 2000[84]); after an initial larval dispersal

period, sandeel display a degree of site fidelity (Jensen *et al*., 2011[42]) so their settled distribution reflects the distribution of preferred habitat (Figure 3-10).

3.3.4.7 Studies undertaken in the natural environment (Holland *et al*., 2005[85]) and in the laboratory (Wright *et al*., 2000[84]) have investigated the preferable sediment characteristics for spawning sandeel; both studies provided similar results, indicating a preference for sediments with a high percentage of medium to coarse grained sands (particle size 0.25mm to 2mm) while sediments with high percentages of fine sand, coarse silt, medium silt and fine silt (particles <0.25mm in diameter) were avoided.

3.3.4.8 A study by Greenstreet *et al*. (2010[86]) draws on the research by Holland *et al*. (2005[85]), defining four substrate preference categories, as defined based on the relationship between the percentages of silt and fine sand and of coarse sand in the sediment and the proportion of samples with sandeel recorded present. Latto *et al*. (2013[15]) used this research to produce four sandeel sediment preference categories, which were defined as; Prime, Sub Prime, Suitable and Unsuitable. To inform this baseline characterisation, PSA data sourced from site specific surveys (Gardline (2023) Volume 7B, Appendix 4-1: Environmental Baseline Report (Array Area) and Volume 7B, Appendix 4-2: Environmental Baseline Survey Report (Offshore Export Cable Corridor)), and BGS (2015[13]) have been classified in accordance with MarineSpace Ltd *et al*. (2013b[40]) as adapted from Latto *et al*. (2013[15]).

3.3.4.9 Particle size distribution at stations within the Caledonia OWF, indicated that most sites were classified as 'Marginal' and 'Preferred' habitats for sandeel spawning, using the method outlined by MarineSpace Ltd *et al*. (2013b[40]), corresponding to areas of 'Coarse Substrates' and 'Sand' (EMODnet, 2023[6]).

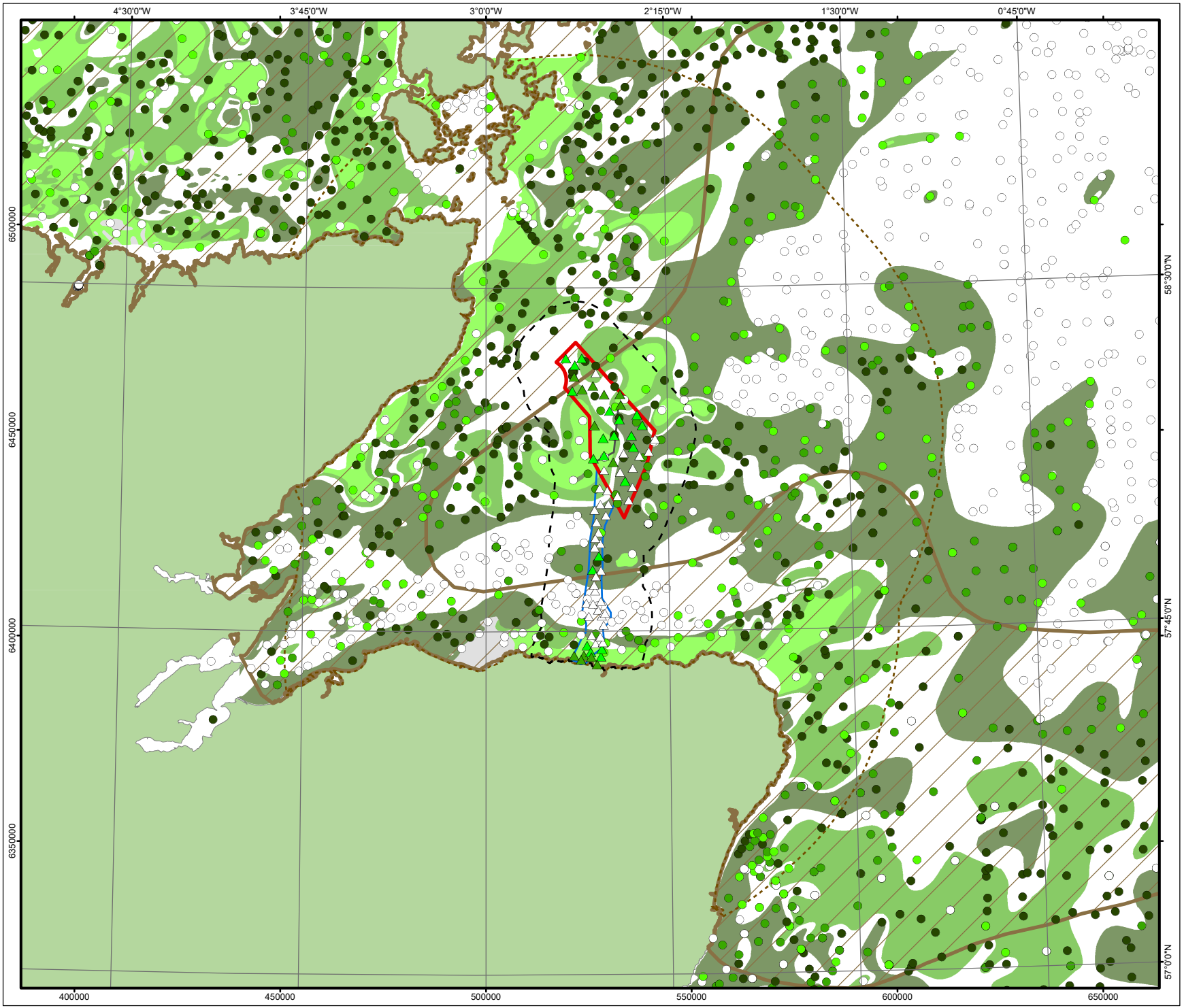
3.3.4.10 Areas to the East, West and North of the Caledonia OWF within the study area, were also classified as 'Marginal' and 'Preferred' spawning habitats. The Langton *et al*. (2021[7]) species distribution model for lesser sandeel predicts that the probability of finding buried sandeel within the Caledonia OWF, is approximately 50%, with discrete areas of 75% probability in the northern portion of the Caledonia OWF. The model also estimates that the density of sandeel in this area would be from 0 to 30 individuals per m^2 across the Caledonia OWF, with discrete areas of up to 60 individuals in the northern portion of the Caledonia OWF. This indicates that there is a moderate likelihood of encountering buried sandeel at low to medium densities within the Caledonia OWF based on the verified distribution model. The Langton *et al*. (2021[7]) species distribution model, however, identifies areas of 0.5 (50%) to 1 (100%) probability that spawning sandeel are present to the West of the Caledonia OWF (within study area; secondary ZoI and underwater noise ZoI). Densities of 90 to 120 or greater individuals per m^2 are predicted in this area of the Moray Firth.

3.3.4.11 The majority of the Caledonia OECC is classified as 'Unsuitable' habitats for spawning sandeel, with areas to the East and West of the Caledonia OECC also being classified as 'Unsuitable' (Figure 3-10). This corresponds with a

band of 'Muddy Sand' which stretches across the mid portion of the Caledonia OECC and study area. This is supported by the Langton *et al*. (2021[7]) species distribution model for lesser sandeel, which predicts the probability of finding buried sandeel within the Caledonia OECC as zero.

3.3.4.12 The nearshore portion of the Caledonia OECC and study area, is classified as being of 'Marginal' to 'Preferred' substrate for sandeel spawning, corresponding with a stretch of 'Coarse Substrate' across the southern coast of the Moray Firth. This is further supported by the Langton *et al*. (2021[7]) species distribution model, which predicts the probability of finding buried sandeel within the nearshore portion of the Caledonia OECC as 50% to 75%. The model also estimates that the density of buried sandeel to the west of Caledonia OWF would be between 30 and 90 individuals per m^2 (Figure 3-13). This indicates that there is a moderate likelihood of encountering buried sandeel within the Caledonia OWF based on the verified distribution model. Predicted density of sandeel in North Sea are shown in Figure 3-13 (Langton *et al*., 2021[7]).

3.3.4.13 In summary, the likelihood of sandeel spawning in the study area is moderate, with areas of high likelihood of spawning sandeel apparent further inshore, to the west of the Caledonia OWF.



Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Sandeel Spawning Grounds (Coull et al., 1998)

Sandeel Habitat Suitability (Latto et al., 2013) (Gardline Limited and Titan Environmental Surveys, 2023)

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

Sandeel Habitat Suitability (Latto et al., 2013) (BGS, 2015)

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

Seabed Substrate (EMODnet) Sandeel Habitat Suitability (Latto *et al.*, 2013)

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

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DRAWING TITLE

Figure 3-10: Sandeel Spawning Substrates Relative to the Study Area

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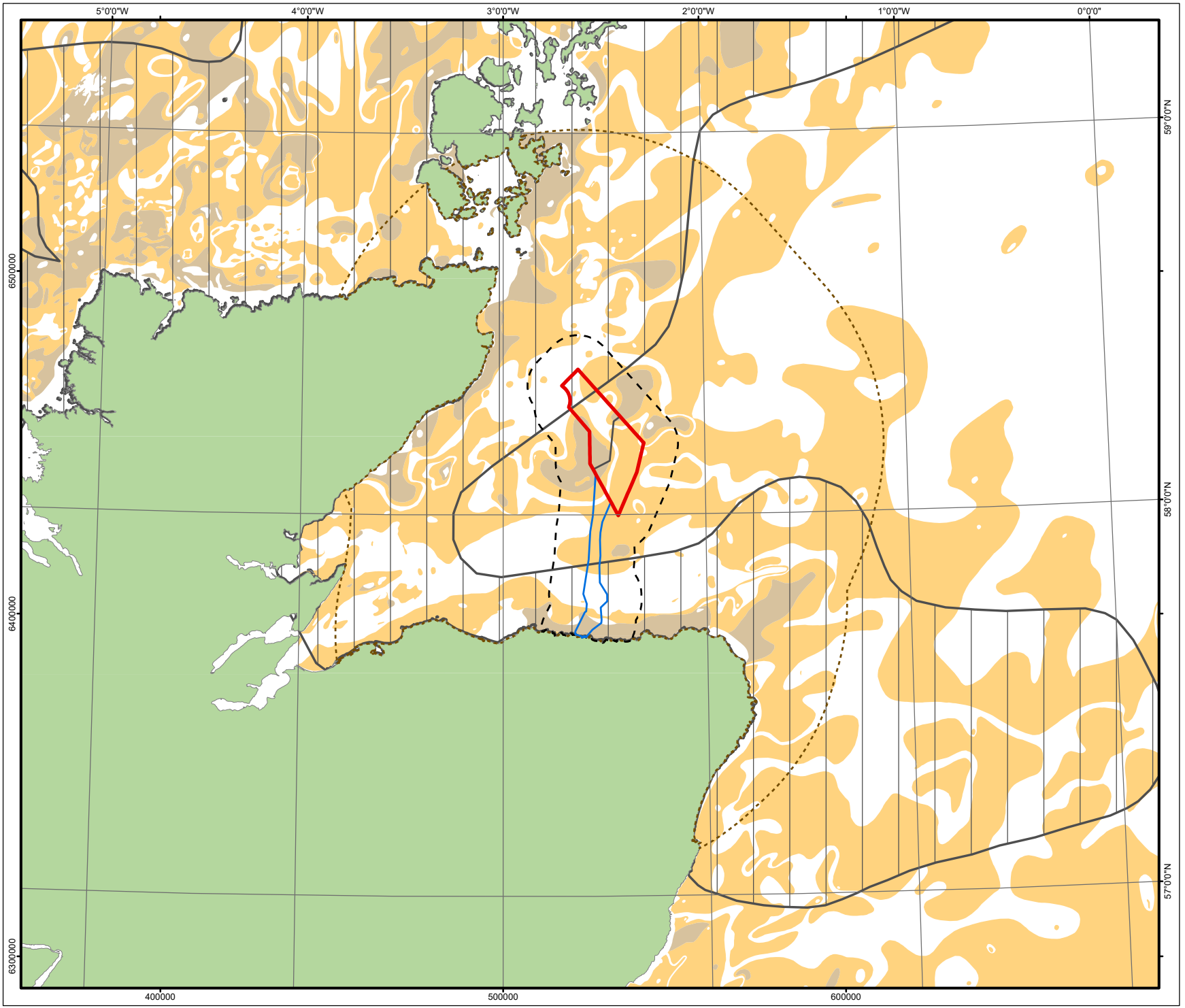

Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Sandeel Spawning Grounds (Coull et al., 1998)

Sandeel Habitat Suitability

Marginal Sediment

Preferred Sediment

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GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-11: Indicative Sandeel Spawning Data Relative to the Study Area (Coull et al., 1998)

STATUS: Approved	SCALE: 1:1,500,000	
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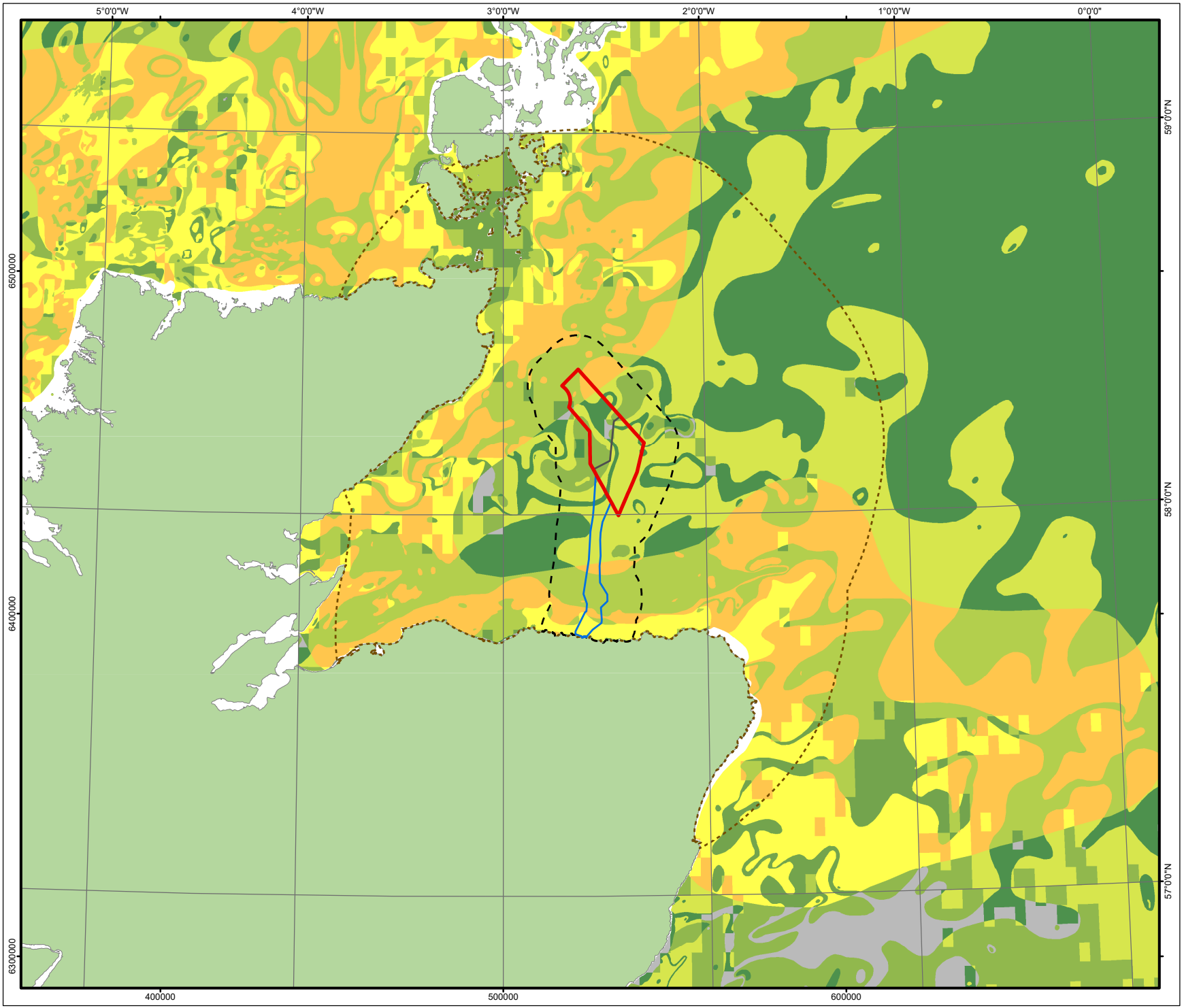

Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Sandeel 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)

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GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-12: Sandeel Spawning Potential Heat Map Relative to the Study Area

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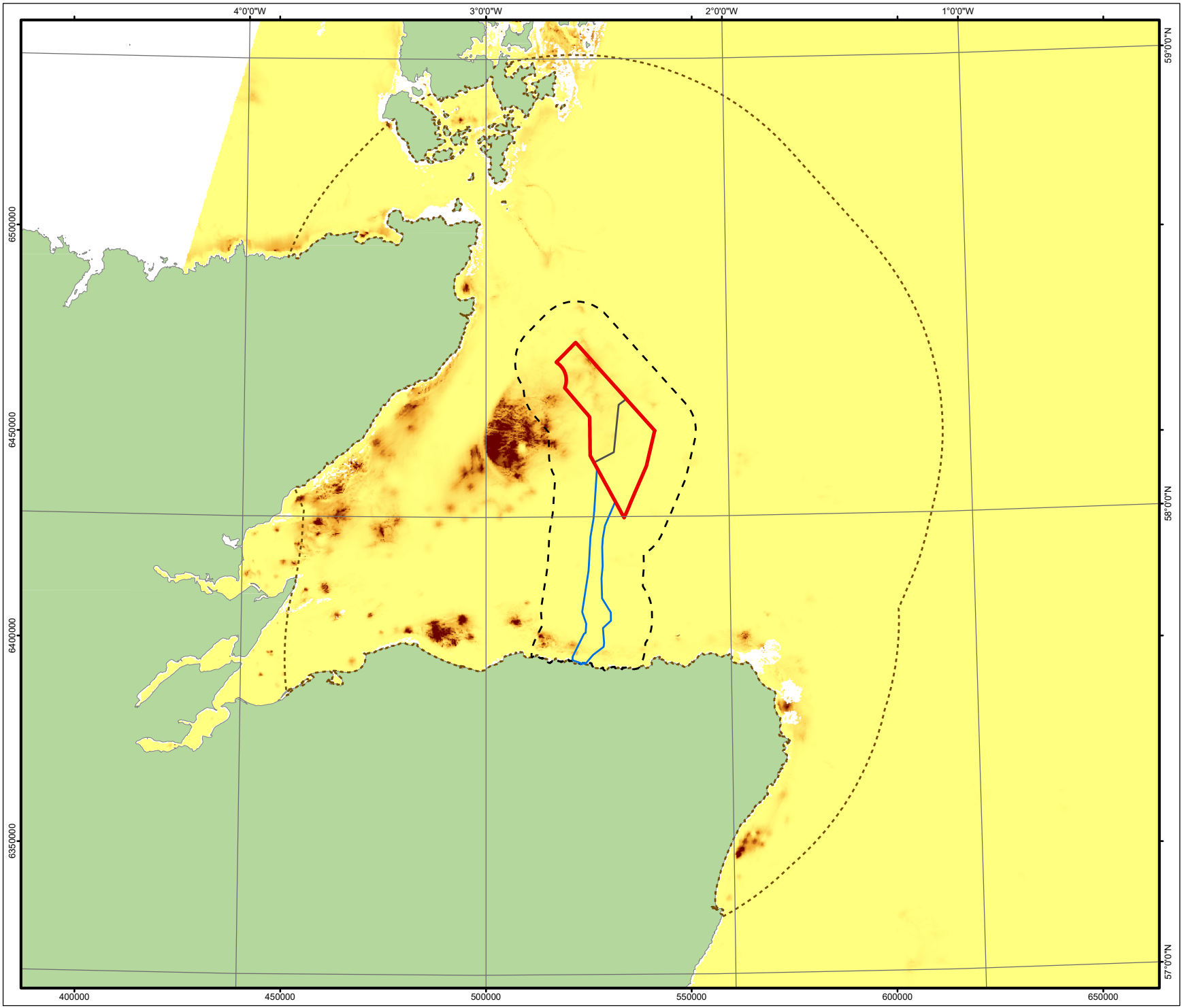

Caledonia OWF

Caledonia North Site and Caledonia South Site Division Line

Offshore Export Cable Corridor

70km Primary Underwater Noise Zone of Influence

10km Secondary Zone of Influence

Predicted Density of Buried Sandeel (Number per m2)

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

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0 10 20 30 40 km

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GoBe APEM Group

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GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-13: Predicted Density of Buried Sandeel Relative to the Study Area (Langton et al., 2021)

STATUS: Approved	SCALE: 1:1,250,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

3.4 Species of Commercial Importance

3.4.1.1 The Moray Firth is an important location for several commercial fisheries. The study area used for the assessment of the Fish and Shellfish Ecology receptors (Figure 2-1) is located in ICES rectangles 44E7 and 45E7. As detailed in Volumes 2, 3 and 4, Chapter 8: Commercial Fisheries, landings from these areas from 2016 to 2022 were dominated by long-finned squid, Nephrops, haddock, king scallop and brown crab (MMO, 2022[87]). Peaks in landings of mackerel were observed in 2019 and such patterns in landings by ICES rectangles are typical for pelagic species that swim in fast moving shoals and may not be specifically linked to areas or habitats when caught in the water column (MMO, 2022[55]). ICES rectangles 44E7 and 45E7 support local fishing fleets which target brown crab.

3.4.2 Shellfish

3.4.2.1 Shellfish are considered to be potentially sensitive to the construction, maintenance and decommissioning activities of the Proposed Development (Offshore) based on their limited mobility, and therefore are considered less able to avoid potential disturbances than more mobile species.

Nephrops

3.4.2.2 Nephrops have a wide distribution across the Eastern Atlantic and North Sea. They are present at depths between 20 and 800 meters in soft, sublittoral sediment. Nephrops are the most valuable shellfish fishery in the Scottish North Sea, and in 2022, 1,415 tonnes of creeled Nephrops were landed by Scottish vessels with a total value of £16 million. 18,000 tonnes of trawled Nephrops were landed by Scottish vessels with a total value of £67 million (Scottish Fisheries Statistics, 2022[88]).

3.4.2.3 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. They leave their burrows at dawn and dusk to forage, exhibiting diel feeding patterns[ii]. They do not reach sexual maturity until two to three years old and have an annual reproductive cycle. During this cycle, sexually mature individuals moult towards the end of spring, and mating takes place before the females' exoskeleton has hardened. Fertilised eggs are then carried on the female's abdomen for eight to nine months. Females tend to remain within their burrows during this time. 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

[ii] Diel behaviour pattern is one which involves a cycle occurring over a 24 hour period - Nephrops emerge from their burrows at dawn and dusk to forage returning to their burrows for much of the intervening period to shelter from potential predators.

potential and adults show no evidence of migration (Hill and Sabatini, 2008[89]).

3.4.2.4 For the purposes of management, to map inferred fishing distribution, Nephrops are split into a number of stocks or ICES 'functional units' (FU) based on the distribution of discrete patches of mud which they inhibit. The study area is located within the FU9 which encompasses the Moray Firth. Suitable Nephrops habitat within FU9, is located to the south of the Caledonia OWF, stretching across the majority of the Caledonia OECC (Marine Scotland National Marine Plan interactive, 2022[90]).

3.4.2.5 Nephrops burrow density surveys undertaken by Marine Scotland from 2007-2016 indicated that the burrowed mud habitat is extensively distributed along the south of the Moray Firth, broadly reflecting the known distribution of burrowed mud biotopes (Marine Scotland, 2021[91]).

3.4.2.6 As detailed in Section 3.3, a Nephrops ground lies within the study area. Nephrops have also been recorded in other OWF development surveys in the study area. Therefore, it can be assumed with confidence that Nephrops will be present within the study area.

Brown Crab

3.4.2.7 Brown crab (also known as the edible crab) is one of the most economically important crab species in UK waters. The Scottish Fisheries Statistics (2022[88]) show that 7,670 tonnes of brown crab were landed in 2022, worth £19.1 million. A brown crab stock status assessment undertaken in 2019 by Centre for Environment, Fisheries and Aquaculture (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[92]). These findings are supported by the Scotland Marine Assessment, undertaken in 2020 (Moffat *et al*., 2020[93]).

3.4.2.8 Brown crab inhabit a range of intertidal and subtidal habitats, including bedrock, under boulders, mixed coarse grounds, and offshore muddy sands, being found at depths of up to 100m (Bennett and Brown, 1983[94]). Brown crab populations have a wide range, extending from Scandinavia to Portugal (Bridges, 2018[95]), with adult crabs known to undertake extensive migrations to offshore overwintering grounds where eggs are hatched, moving back to coastal areas around May (Tonk and Rozemeijer, 2019[96]).

3.4.2.9 A study by Mequita *et al*. (2020[97]) investigated the spatial distribution of brown crab around Scotland, based on catch rates of dredge and trawl surveys off the east coast of Scotland. The results showed high predicted catch rates in coastal areas of the Moray Firth, and further offshore in the Firths of Forth and Tay. The spatial distribution of males and females was observed to be quite similar, although there was some evidence of higher catch rates of females in the inshore waters south of Orkney and further

offshore. Tagging studies have evidenced female crabs moving more frequently and further than male crabs (Edwards, 1979[98]; Bennet and Brown, 1983[99]; Hunter *et al*., 2013[100]; Jones *et al*., 2010[101]; Coleman and Rodrigues, 2016[102]). As evidenced by Mequita *et al*. (2020[97]), juveniles showed a clear inshore distribution up to approximately 20km from the coast. This is supported by Bennett (1974[103]; 1995[104]) and Robinson and Tully, (2000[105]) which described juvenile brown crabs as typically inhabiting shallow inshore waters.

3.4.2.10 Brown crab were not recorded in site specific eDNA surveys, although they were recorded in other OWF development surveys as detailed in Section 3.2 of this report. Based on the regional commercial importance of brown crab and evidence in the supporting literature, the presence of brown crab in the study area can be assumed with confidence.

European Lobster

3.4.2.11 A total of 1,168 tonnes of European lobster, worth £17.7 million was caught from Scottish vessels in 2022 (Scottish Fisheries Statistics, 2022[88]). 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.

3.4.2.12 European lobster are found from the lower shore to water depths of 60m and inhabit hard rocky substrates or compressed mud. They are nocturnal and territorial, usually living in holes, burrows or crevices. 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.

3.4.2.13 Lobster were not recorded in site specific eDNA surveys, although were recorded in other OWF development surveys as detailed in Section 3.2 of this report. Based on the regional commercial importance of lobster, and evidence in the supporting literature, the presence of lobster in the study area can be assumed with confidence.

Scallop

3.4.2.14 Regionally, key scallop grounds are located to the south of the study area in the central North Sea (Marine Scotland, 2016[106]). In 2022, 16,675 tonnes of scallop were landed by Scottish vessels (Scottish Fisheries Statistics, 2022[88]). Scotland's Marine Assessment (2020[107]) reported declining scallop stocks of the east of Scotland, due to an increase in exploitation (Moffat *et al*., 2020[93]).

3.4.2.15 Scallop typically inhabit shallow depressions in the seabed, preferring areas of clean firm sand, fine or sandy gravel, and are occasionally observed on muddy sands (Marshall and Wilson, 2008[108]). Scallop undertake limited swimming, with swimming behaviours likely to be at a high energy cost, and generally associated with escape scenarios. Consequently, this species is not expected to travel large distances (Marshall and Wilson, 2008[108]).

3.4.2.16 King scallop (*Pecten maximus*) were not recorded in site specific eDNA surveys, although were recorded in other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report. Based on the regional commercial importance of king scallop, the presence of scallop in the study area can be assumed with confidence.

Squid

3.4.2.17 A substantial proportion of Scottish squid landings come from the Moray Firth (Young *et al*., 2006[109]; Beatrice OWF, 2011[110]). The species is typically found on the continental shelf and offshore banks.

3.4.2.18 Although spawning grounds have not been defined, it is very likely that the Moray Firth includes spawning grounds for this species (Young *et al*., 2006[109]). Fishermen have reported finding squid eggs off Burghead and Buckie on the Moray Firth coast in May and June in waters, between five and six metres deep. Eggs have also been encountered on lobster creels shot on hard ground in the Moray Firth (Young *et al*., 2006[109]).

3.4.2.19 In Scottish waters, spawning occurs over an extended period from December to June, with peak spawning having been reported from December to March (Lum-Kong *et al*., 1992[111]; Pierce *et al*., 1994[112], Boyle, 1995[113],; Collins *et al*., 1997[114]). The winter breeding cohort appears to spawn in inshore waters, and some evidence suggests that the spawning grounds of the summer breeders are also inshore (Viana *et al*., 2009[115]). All individuals are semelparous and die after spawning (Rocha *et al*., 2001[116]) Recruitment of juvenile squid to the adult population has been reported to peak in spring (April) and in autumn (July to October), the latter being the main recruitment period (Boyle, 1995[113], Viana *et al*., 2009[115], Pierce *et al*., 1994[112]).

3.4.2.20 The main Scottish fishery for squid occurs in coastal waters and usually exhibits a marked seasonal peak around October and November, corresponding to the occurrence of pre-breeding squid. In the Moray Firth, a directed fishery for squid has developed in late summer and autumn in coastal waters between Troup Head and Spey Bay in the south of the Moray Firth, with additional activity recorded on parts of the Smith Bank and along the north coast (Young *et al*., 2006[109]; Campbell and McLay, 2007[117]).

3.4.2.21 Squid were not recorded in site specific eDNA surveys, although were recorded in other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report. Based on the regional commercial importance of

squid and presence in OWF surveys, their presence in the study area can be assumed with confidence.

3.4.3 Pelagic Fish

Herring

3.4.3.1 Herring are one of the most economically important pelagic fisheries in the North Sea. In 2022, 72,837 tonnes of herring were landed by Scottish vessels (Scottish Fisheries Statistics, 2022[88]). Herring have a wide-ranging spatial distribution across the North Sea; however, most adults are found on the continental shelfs where they form large shoals and have a diurnal vertical migration pattern (ICES, 2023[52]) They lay their eggs on gravel substratum, making them particularly susceptible to anthropogenic activity. The presence of herring was recorded in site specific eDNA surveys, other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report.Herring Spawning Grounds Based on the recorded presence of herring in eDNA surveys within the study area, and the commercial importance of the species to the region, the presence of herring in the study area can be assumed with high confidence.

Mackerel

3.4.3.2 Mackerel are the most valuable pelagic fishery in the North Sea, accounting for up to 35% of the total value of Scottish vessels' landings in 2022 worth £213 million (Scottish Fisheries Statistics, 2022[88]). They have a wide-ranging distribution but predominantly inhabit waters on the continental shelf. Mackerel migrate annually, which is likely in response to oceanographic temperatures and the availability of food. Mackerel typically spawn between May and July (Coull *et al*., 1988[43]).

3.4.3.3 The presence of mackerel was recorded in site specific eDNA surveys, other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report. Nursery and spawning grounds for mackerel are also located within the study area. Based on the recorded presence of mackerel in eDNA surveys within the study area, and the commercial importance of the species to the region, the presence of mackerel in the study area can be assumed with confidence.

3.4.4 Demersal Species

Sandeel

3.4.4.1 A recent change in legislation involves the banning of commercial sandeel fishing in UK waters, including Scottish waters. This ban was announced by the UK Government, with the aim of benefiting seabirds and other wildlife that depend on sandeel as a crucial part of their diet (Scottish Government,

2023[118]). 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[43]). The Sandeel (Prohibition of Fishing) (Scotland) Order 2024 was laid in the Scottish Parliament on 5 February 2024 and came into force on 26 March 2024 (Scottish Government, 2024[119]). The Order covers all Scottish waters including the section of the UK's Exclusive Economic Zone (EEZ) adjacent to Scotland and applies to all vessels fishing in these waters. It should be acknowledged however, that the Order has been challenged by the EU, with the EU stating that the closure of the UK's sandeel fishery deprives EU vessels of important fishing opportunities and impinges the UK's basic commitments under the Trade and Cooperation Agreement.

3.4.4.2 Evidence establishing the effect of sandeel fishery closures is limited. Studies led by the Marine Directorate compared measures of sandeel abundances before and during the closure of a sandeel fishery in the Firth of Forth (Rattray Head to St Abbs) in 2000 (Greenstreet *et al*., 2010[120]). High levels of recruitment, combined with a lack of significant fishing activity led to an immediate and substantial increase in sandeel biomass. However, from 2001 to 2007, a consistent decline in biomass was evident, reaching levels consistent with those observed when the fishery was active. This is considered a result of poor recruitment, predation and other causes of natural mortality, which exceed growth production in the population. Guillemot, razorbills, puffins and kittiwakes recorded in the area reflected the sandeel biomass trends, with an apparent increase following the fishery closure, followed by a subsequent decline as local sandeel abundance declined. Therefore, as evidenced by Greenstreet *et al.* (2010[121]), the closure of the area to fishing activity, was not sufficient to ensure high abundances of sandeel in the area.

3.4.4.3 The presence of sandeel was not recorded in site specific eDNA surveys, although sandeel were recorded in other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report. Nursery and spawning grounds for sandeel are also located within the study area (see section 3.3.4). Based on the recorded presence of sandeel in the site specific data, additional data sources and the commercial importance of the species to the region, the presence of sandeel in the study area can be assumed with high confidence.

Haddock

3.4.4.4 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 (Coull *et al*., 1988[43]); however, spawning stock is strongly influenced by recruitment from the previous year. Over 26,851 tonnes of haddock was landed by Scottish vessels in 2022 (Scottish Fisheries Statistics, 2022[88]).

3.4.4.5 The presence of haddock was recorded in site specific eDNA surveys, other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report. Nursery grounds for haddock are also located within the study area. Based on the recorded presence of haddock in the study area, and the commercial importance of the species to the region, the presence of haddock in the study area can be assumed with confidence.

Cod

3.4.4.6 Cod were historically commercially targeted in the Moray Firth. A series of quota reductions in the 1980s restricted the fishermen's ability to legally land cod, rendering the fishery presently unviable in the Moray Firth (Commercial Fisheries Report BMM, 2011[122]). Landings weights for this species are therefore relatively low within the Moray Firth, representing 2.9% of total fish landings weights and 1.1% of the total within ICES rectangle 45E7. In 2022, 6,863 tonnes of cod where landed by Scottish vessels, a 17% increase compared to 2021 (Scottish Fisheries Statistics, 2022[88]).

3.4.4.7 Cod are found from shallow coastal waters to the shelf edge (200m depth) and beyond with catches reported from 600m depths (ICES, 2011b[123], Hedger *et al*., 2004[124]). Hedger *et al*. (2004[124]) found the greatest abundances of mature cod in depths less than 50m or greater than 150m (along the Norwegian Trench) over the entire temperature and salinity range of the North Sea. Cod in the Moray Firth are believed to be a sedentary residential population that provides year-round site fidelity (Wright *et al*., 2007[125]).

3.4.4.8 The presence of cod was recorded in site specific eDNA surveys, other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report. Spawning grounds for cod are also located within the study area. Based on the recorded presence of cod in eDNA samples within the study area, and the commercial importance of the species to the region, the presence of cod in the study area can be assumed with high confidence.

Whiting

3.4.4.9 Whiting have a wide distribution across the North Sea and spatial patterns to sea surface temperature appear to influence their distribution (Zheng *et al*., 2002[126]). Movements of whiting around the North Sea occur predominantly along Scotland's east coast. In 2022, 8,879 tonnes were landed by Scottish vessels (Scottish Fisheries Statistics, 2022[88]).

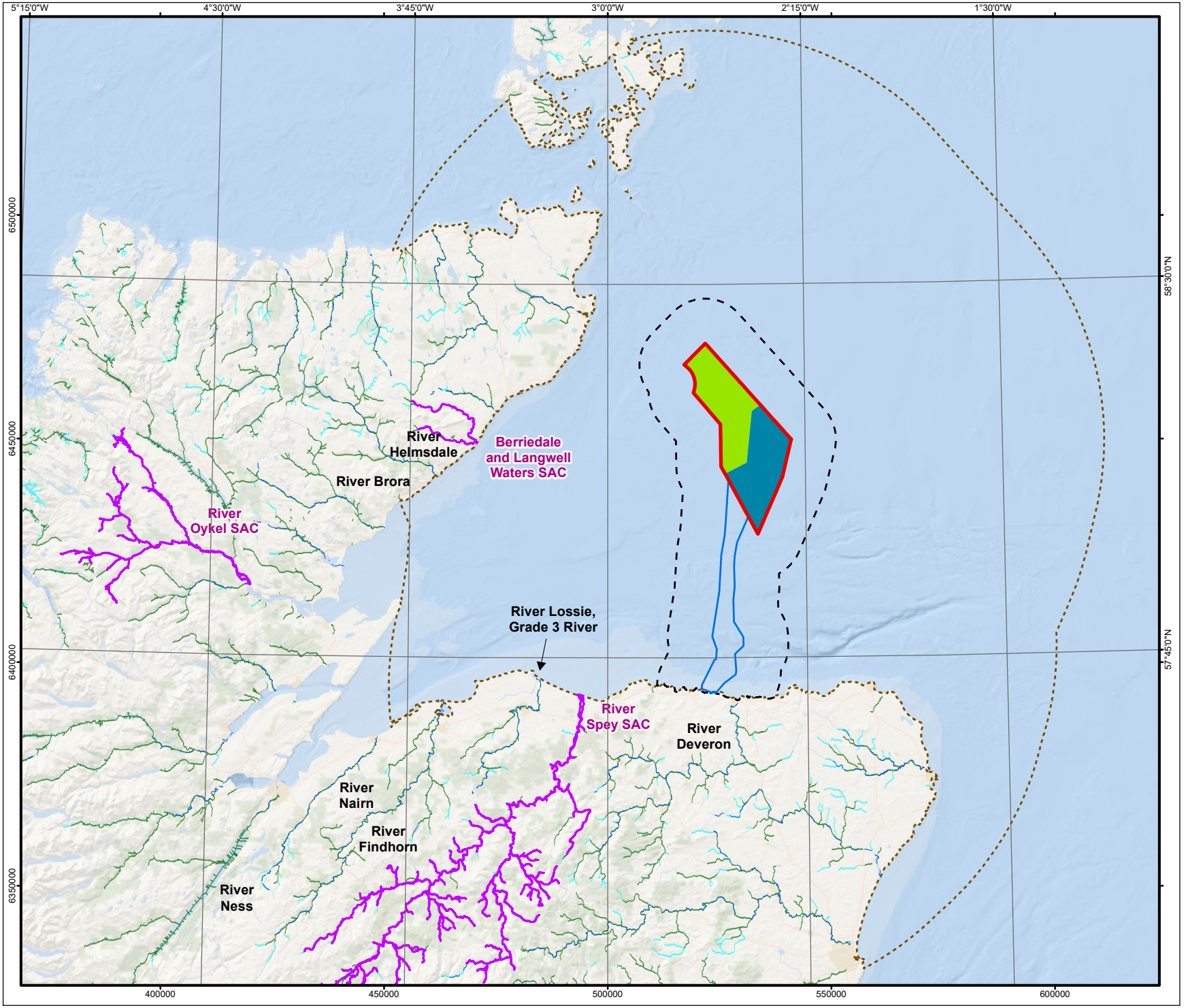
3.4.4.10 The presence of whiting was not recorded in site specific eDNA surveys, although whiting were recorded in other OWF development surveys, and regional surveys as detailed in Section 3.2 of this report. Spawning grounds for whiting are also located within the study area. Based on the recorded presence of whiting in the study area, and the commercial importance of the species to the region, the presence of whiting in the study area can be assumed with confidence.

3.5 Diadromous Species

3.5.1.1 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 occur in the study area, migrating to and from rivers and other freshwater bodies in the area.

3.5.1.2 Migratory fish species such as Atlantic salmon, sea trout, European eel, smelt (*Osmerus eperlanus*), twaite shad (*Alosa fallax*), allis shad (*Alosa alosa*), sea lamprey (*Petromyzon marinus*) and river lamprey (*Lampetra fluviatilis*) have the potential to occur in the rivers and estuaries near to and within the study area. 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).

3.5.1.3 The rivers of particular importance such as Grade 3 rivers for salmon, and rivers and estuaries designated as Special Areas of Conservation (SAC) for diadromous species are identified in Figure 3-14 and Figure 3-16. Grade 3 rivers are characterised by a probability of less than 60% to achieve their conservation limit, which is based on the chance that the salmon stock reached its egg requirement during each of the last 5 years. The allocation of a Grade 3 to a river, then leads to the enforcement of mandatory catch and release regulations as a measure to support conservation objectives within these river systems (Scottish Government, 2023[176]). The nearest grade 3 river to the study area is the River Lossie, which has an average chance of the egg requirement being met of 32.8% from 2018 to 2022. The River Lossie flows into the Moray Firth, to the west of the Caledonia OWF within the defined underwater noise ZoI (Figure 3-14). The River Spey SAC and the Berriedale and Langwell Waters SAC are the closest SACs to the study area, with both rivers flowing into the underwater noise ZoI. The River Oykel SAC lies outside of the study area, but flows into the Moray Firth, to the west of Caledonia OWF and Caledonia OECC (Figure 3-14).



Caledonia OWF
Caledonia North Site
Caledonia South Site
Offshore Export Cable Corridor
70km Primary Underwater Noise Zone of Influence
10km Secondary Zone of Influence
Special Areas of Conservation
Salmon Present (Scottish Government, 2008)
Salmon Likely Present (Scottish Government, 2008)
Main Rivers

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0 10 20 30 40 km

REV	DATE	DOC STATUS	ORIGIN	REVIEW	APP
01	24/09/2024	Approved	EV	BB	DH

CALEDONIA Offshore Wind Farm
GoBe APEM Group

CONTRACTOR DRAWING NO: UKCAL1_GO_WNF_FAS_MAP_00103	CONTRACTOR REV: 01
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-14: Rivers of Importance for Migrating Salmon in Relation to the Study Area

STATUS: Approved	SCALE: 1:1,150,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

Atlantic Salmon

3.5.1.4 Atlantic salmon are designated under Annex II of the Bern convention and freshwater populations on The Conservation of Habitats and Species Regulations (UK Government, 2017[127]) Atlantic salmon are also a UK Biodiversity Action Plan (BAP) priority fish species. Additionally, Atlantic salmon have been reclassified by the International Union for the Conservation of Nature (IUCN) as "Endangered" in the UK with projected population decline from 50-80% between 2010 and 2025 and listed as "Near threatened" internationally (IUCN, 2023[128]).

3.5.1.5 Atlantic salmon are anadromous fish, spawning in freshwater and feeding at sea. Salmon typically spawns in upper reaches of rivers or where suitable spawning gravel is located (Vladić and Petersson, 2015[129]).

3.5.1.6 For the first of the freshwater life history stages of Atlantic salmon they are referred to as Alvins. This is after they hatch, are roughly 10mm in size, still have a yolk sac and remain in interstitial gravel (Thorstad *et al*., 2011[130]). After Alvin have used their yolk sac and grown to roughly 20mm they are then referred to as fry and are found to inhabit slightly larger rocks and stones in river. After approximately one year after hatching Atlantic salmon are referred as par and then after two to three years par undergo metamorphosis (often called smoltification) to survive in the marine environment and are referred to as smolts (Thorstad *et al*., 2011[130]). External triggers are believed to be the cue for downstream smolt migration and include water discharge (flow and velocity) and temperature (McCormick *et al*.,1998[131]; Thorstad *et al*.,2011[130]).

3.5.1.7 The timing of spring migration is believed to significantly influence marine survival, ensuring that smolts arrive at the sea when ocean conditions, such as temperature and prey availability, are optimal. In Scottish rivers, smolt migration generally spans three to seven weeks between April and June. However, the majority of smolts tend to migrate within a more concentrated period of one to two weeks. Smolts frequently travel downstream in groups or shoals, potentially providing them with some protection against predators. The smolt migration period, especially when smolts enter estuaries, is often marked by high mortality rates, primarily due to predation (Kocik *et al*., 2009[132]; Thorstad *et al*., 2012[133]).

3.5.1.8 Upon reaching the sea, the movement of salmon smolts can be complex. Some smolts head directly out to sea, while others move in various directions, yet the overall movement is consistently seaward and active rather than passive (Thorstad *et al*.,2007[134]).

3.5.1.9 The duration salmon spend at sea before returning to their natal rivers varies. In most Scottish west coast rivers, the majority return after a single winter at sea, and these fish are called grilse or single winter salmon (SWS). Two and three-sea winter salmon, also referred to as multi-winter salmon (MWS) also

exist but are generally less abundant than grilse. In the past ten to fifteen years, telemetry has provided insights into the movements of salmon at sea. Studies have shown that adult salmon are typically surface-oriented (Davidsen *et al*., 2013[135]; Holm *et al*., 2006[136]). Recent studies by Marine Scotland Science (MSS) into salmon swimming depth, particularly in relation to the marine renewable energy sector, confirmed that salmon spend most of their time near the surface (Godfrey *et al*., 2014[137]; 2015[138]). Out of 117 salmon that provided reliable data, the median proportion of time spent in the top 5 metres of the water column was 84% (though individual variation ranged from 8% to 99%). Despite their surface orientation, salmon were found to utilize the full range of available depths. It is important to note that MSS studies mainly focus on salmon in the open sea and Pentland Firth.

3.5.1.10 Salmon in the open sea travel quickly, covering 50 to 100km per day relative to the ground (Stewart *et al*., 2006[139]). However, their migration speed decreases in coastal areas, likely because they need time to identify their natal region and river. In fact, salmon might not home directly to their natal river and sometimes enter other rivers where they may remain for a variable period before moving downstream to find their natal river (Stewart *et al*., 2006[139]). Upon reaching the natal river, salmon can wait around the estuarine reaches for many days or even weeks until conditions, usually increased discharge, are suitable for them to pass into freshwater (Solomon and Sambrook, 2004[140]). Many salmon die after spawning and those that survive will return to sea as kelts, and some of these will regain condition and spawn again (Mills, 1989[141]).

3.5.1.11 A study by Newton *et al*. (2017[142]) investigated the movements of Atlantic salmon smolt in the Cromarty and Moray Firths; the study observed relatively rapid downstream migration, with the fish taking an average of eight days to travel approximately 62km. An eastern movement of smolt was observed from the Cromarty Firth, with observations made up to 30km from shore in the marine environment, and less than 60km from the river mouth. This is supported by Thorstad *et al*. (2004[143]) and Finstad *et al*. (2005[144]) 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[145]), suggests that smolt utilise nearshore areas at the commencement of their marine migration. The main smolt runs within the wider Moray Firth study area have been identified to principally occur from April to June. Malcolm *et al*. (2015[146]) reported a peak period of smolt migration between mid-April to late-May following analysis of pre-existing smolt data leaving Scottish rivers.

3.5.1.12 A study investigating the migratory routes of adult Atlantic salmon in Scotland observed a general migratory pattern, whereby salmon migrate through the North Sea, and then travel along the coast back to their home river (Malcolm *et al*., 2010[145]). Atlantic salmon are known to present in several rivers which have been given SAC designation due to their presence. These include the

River Spey SAC, River Oykel SAC and Berriedale and Langwell SAC, which suggests that migrating salmon may pass through the study area during migration. Additionally, Atlantic salmon are known to be present in several other non-designated rivers and water bodies which enter the Moray Firth. These rivers and water bodies include the River Deveron, River Ness, River Nairn, River Findhorn, River Brora, River Helmsdale and the rivers which enter the Cromarty Firth and subsequently the Moray Firth. Figure 3-16, shows rivers known for the presence of Atlantic salmon as well as those designated as SACs for the presence of Atlantic salmon.

3.5.1.13 Assessment of the juvenile salmon stocks in the River Deveron through the National Electrofishing Programme for Scotland (NEPS) has evaluated juvenile stocks in the River Deveron as Grade 2, suggesting that there are significant issues with recruitment and survival within the catchment (Gardiner *et al*., 2018[147]; Malcolm *et al* 2023[148]).

3.5.1.14 According to the Scottish Fisheries Statistics (2023[149]) in 2023, Scottish fisheries caught fewer Atlantic salmon than in the previous year. The total reported rod catch of wild salmon was 32,477, the lowest since records began in 1952. This represents a 24% decrease compared to 2022 and 77% of the previous five-year average. In 2023, 96% of the total rod catch and 99% of the rod-caught spring multi sea-winter fish (caught before May 1) were released. The reported spring catch was 2,366, a 35% decrease from the 2022 season and 89% of the previous five-year average. 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. A total of 48 fish were reported as being of farmed origin, representing 0.15% of the total catch by all methods in 2023. Figure 3-15 shows temporal trends in annual total (SWS and MWS) rod caught wild Atlantic Salmon within the Moray Firth district from 1952 to 2022. There is large interannual-variation in the total number of Atlantic salmon caught in the Moray Firth region, however there is a general decline in the number caught.

3.5.1.15 There is high likelihood for Atlantic salmon to occur in the study area. Results from the site specific eDNA survey record the presence of two OTUs of native Salmonids (Salmonidae) within the Caledonia OWF and of two OTUs of native Salmonids in the Caledonia OECC.

Sea Trout

3.5.1.16 Sea trout spend a number of years in fresh water before migrating to sea. The species often return to freshwater to spawn. Netting and tracking data for post-smolt sea 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[144]; as cited in Malcolm *et al*., 2010[145]). There is little consistency in observed migratory patterns of adult sea 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[145]).

3.5.1.17 In 2023, Scottish fisheries caught fewer sea trout than in the previous year, across all methods. The total reported rod catch of sea trout was 14,823, the fifth lowest since records began in 1952. This is a 1% increase compared to 2022 and 103% of the previous five-year average. Finnock catch, reported since 2004, totalled 5,874 in 2023, the second lowest on record (Scottish Fisheries Statistics, 2023[149]). This represents a 29% decrease compared to 2022 and 80% of the previous five-year average. In 2023, 92% of the total sea trout rod catch was released, the highest percentage of released rod-caught fish since records began in 1994. The reported retained catch and effort for net fisheries were among the lowest recorded. Released net-caught fish were reported for the first time in 2021. Figure 3-15 shows temporal trends in annual rod caught wild sea trout within the Moray Firth district from 1952 to 2022. There is large interannual-variation in the total number of Sea Trout caught in the Moray Firth region, however there is a general decline in the number caught. It can be considered with confidence that sea trout will be present within the study area during their migration to and from their spawning rivers.

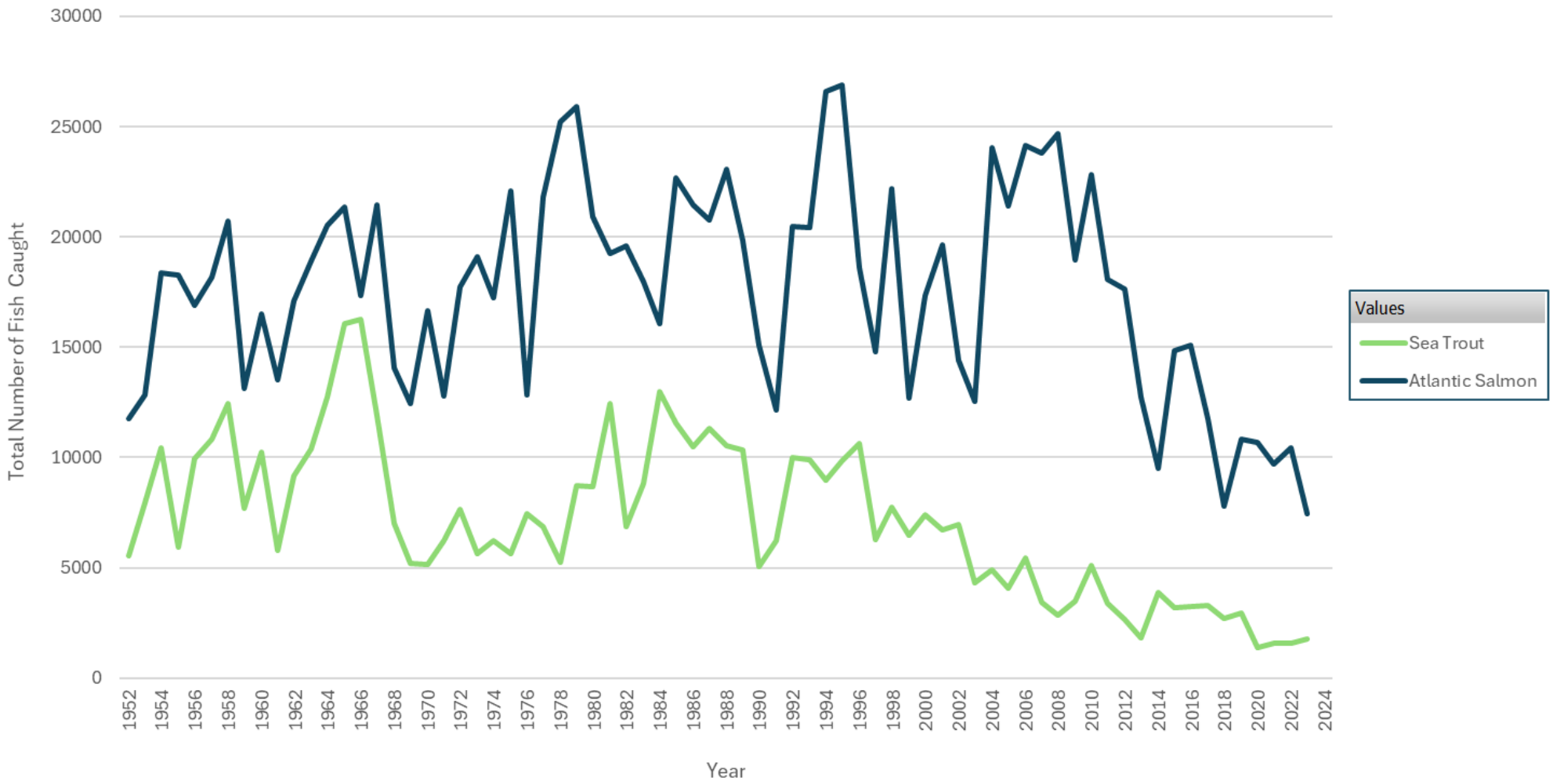


Figure 3-15: Sum of annual rod caught Atlantic salmon and sea trout within the Moray Firth Region from 1952 to 2022 (Scottish Fisheries Statistics, 2023[149]). The sum of Atlantic salmon represents the total number of Multiple Winter Salmon (MWS) and Single Winter Salmon (SWS).

Pink Salmon

3.5.1.18 One count of Pink salmon was reported in the eDNA dataset in the Caledonia OWF. Pink salmon smolts have been recorded in the Rivers Thurso and Oykel in Scotland (Skora *et al*., 2023[151]). This is a non-native species for the UK, with a native distribution across the rivers in North America and Pacific. Pink Salmon are a diadromous species and have a life history analogous to native sea trout and migrate to the sea from rivers. Spawning in rivers was observed in Scotland in 2017 in the Rivers Spey, Ness, Dee and Thurso (Armstrong *et al*., 2017[150]; Skora *et al*., 2023[151]). The observations of smolt migration presented by Skora *et al*. (2023[151]) provide the first evidence of successful completion of the freshwater phase of the life cycle in Scotland. This is of potential concern, specifically regarding impacts to native Atlantic salmon populations which are already in decline. The establishment of pink salmon populations could impact the regional Atlantic salmon population at various life history stages through interactions such as increased competition for food resources and spawning substrate (ICES, 2021[152]; Skora *et al*., 2023[151]). The potential for the presence of pink salmon within the study area is low, despite being present within the eDNA data set.

European Eel

3.5.1.19 European eel are listed as critically endangered on the IUCN Red List and are UK 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, 2015[153]). 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[145]). 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[145]). Although possible, the likelihood of European eel being present in the study area is low.

Lamprey Species

3.5.1.20 River lamprey and sea lamprey are designated under Appendix III of the Bern Convention (The Council of Europe, 1979[154]), The Conservation of Habitats and Species Regulations (2017) (UK Parliament, 2017[155]), Schedule 5 of the Wildlife and Countryside Act (1981) (UK Parliament, 1981[156]) and are on the Scottish Biodiversity List. River lampreys are widespread in the UK, typically occurring close to the coast (Igoe, 2004[157]). 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, 2015[158]). During the National Lamprey Survey of Scotland from 2003-2005 (National Biodiversity Network (NBN), 2020[159]) river lamprey were recorded at various locations in the River Ugie which flows into the southeast edge of the 70km UWN ZoI (Figure 3-14). Although possible, the likelihood of river lamprey being present within the study area is low, with no records in site specific eDNA data.

3.5.1.21 Sea lamprey occur offshore throughout the UK, migrating upstream of rivers to spawn (Igoe *et al.*, 2004[157]). 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[158]). Although possible, the likelihood of sea lamprey being present within the study area is low, with no records in site specific eDNA data.

3.5.1.22 Additionally, all though not an Annex II species, Brooke lamprey (*Lampetra planeri*) are an important species in Scottish Rivers, spawning between April and June. However, these have extremely low propensity to occur within the study area due to being a freshwater species, rarely found in even estuarine environments let alone marine coastal waters.

Allis Shad and Twaite Shad

3.5.1.23 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[160]). 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 800km 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[161]). The eDNA dataset does indicate that shads have the potential to pass through the study area, however the likelihood of allis shad and the twaite being present within the study area is expected to be low.

Smelt

3.5.1.24 Two OTUs for smelt (Argentinidae) where recorded in site specific eDNA surveys within the both the Caledonia OWF and Caledonia OECC. 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[162]). Smelt spawn in 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 smelt would be found within the study areas, however the eDNA dataset does indicate that they have the potential to pass through the study area.

3.6 Elasmobranchs

3.6.1.1 Elasmobranchs are a particularly sensitive species group due to their slow growth rates and low fecundity (Jorgensen *et al*., 2022[163]). All sharks and rays living in Scottish waters are included in the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) list of threatened and/or declined species. These include tope, common smooth hound (*Mustelus mustelus*), stary smooth hound (*Mustelus asterias*), throwback ray, blonde ray (*Raja brachyura*), spotted ray, spurdog and small-spotted catshark (*Scyliorhinus canicula*) (OSPAR, 2024[164]). There are low intensity nursery grounds for common skate, spotted ray, spurdog and tope shark throughout the study area (Coull *et al*., 1988[43]; Ellis *et al*., 2010[56]; Figure 3-6) .

3.6.1.2 Elasmobranchs are electrosensitive and can detect 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.

Basking Sharks

3.6.1.3 Basking sharks (*Cetorhinus maximus*) are the largest fish in the North Atlantic, reaching up to 12m 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 (Marlin, 2023[165]). Basking sharks are a long-lived species, with some individuals reaching up to 100 years old. Males are believed to reach sexual maturity between 12-16 years and females in the region of 16-20 years. They are thought to breed at the start of summer and offspring gestation takes between one to three and a half years (Marlin, 2023[165]). It is yet to be understood where basking sharks breed as a mating has never been observed.

3.6.1.4 Basking sharks are currently listed as Endangered on the IUCN Red List (IUCN, 2023[128]) and protected under Schedule 5 of the Wildlife and

Countryside Act (1981[156]); Countryside Rights of Way Act (2000[166]) and the Nature Conservation (Scotland) Act (2004[167]).

3.6.1.5 Basking sharks are often found along ocean fronts likely due to the availability of food and are known to migrate from the western English Channel in spring, to west Scottish waters where they spend the summer and early autumn before moving offshore in winter. It is important to note that the migration of basking sharks is not fully understood and remains uncertain in waters around the UK (Marlin, 2023[165]).

3.6.1.6 A study carried out by Austin *et al*. (2019[168]) 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. In addition, there have been reports of exceptionally high numbers of basking sharks on the north-east coast of Scotland recently (Marlin, 2023[165]). Findings for this area indicate that it is a region already frequented by basking sharks, albeit in small numbers, or it could be a potential area for future population as the north-east Atlantic basking shark population recovers from past exploitation. Further to this, site specific aerial surveys carried out on 22nd November 2022 recorded a single sighting of a basking shark in the south-west of Caledonia South indicating their recent presence in the study area, however this is in low numbers and the likelihood of basking sharks occurring through the study area is very low (APEM, 2024[169]).

3.7 Species of Conservation Importance

3.7.1.1 Within the northern North Sea region, there are records of several marine and estuarine species protected under national, European, and international legislation.

3.7.1.2 It should be noted that in addition to all the species already mentioned, the freshwater pearl mussel (*Margaritifera margaritifera*) has been included in this baseline due to their presence near the study area, in the River Spey and River Deveron and due to their designation as a species of conservation importance (classification as an Annex II species for SAC designation). Fresh water pearl mussels have a complex life history, involving an obligatory host phase on either Atlantic salmon or sea trout (Cosgrove *et al*., 2012[170]). Species of conservation importance which are protected or considered threatened/declining, which are potentially present within the study area and wider geographic region are listed below in Table 3-4, alongside their associated designations.

3.7.1.4 On account of the conservation importance of these species to the region, all species are considered sensitive receptors within the study area, and therefore potential impacts on these species from the Proposed Development (Offshore) have been taken into consideration in the Fish and Shellfish Ecology assessment (Volumes 2, 3 and 4, Chapter 5: Fish and Shellfish Ecology).

Table 3-4: Species of conservation importance potentially present within the study area.

Species	OSPAR Threatened and/or Declining Species	UK POST 2010 Priority Species	Scottish Priority Marine Feature	Nature Conservation (Scotland) Act 2004	ICUN Red List	Annex II Fish Species EU Habitats Directive (92/43/EEC)
Allis shad	✓	✓				✓
Angler fish		✓	✓			
Atlantic salmon	✓				Vulnerable	✓
Basking shark	✓	✓	✓	✓	Endangered	
Blue ling (*Molva dipterygia*)		✓	✓			
Blue shark		✓			Near Threatened	
Cod	✓	✓			Vulnerable	
Common skate	✓	✓	✓			
European eel	✓	✓			Critically Endangered	✓
Fresh water pearl mussel					Vulnerable	✓
Greenland halibut (*Reinhardtius hippoglossoides*)	✓	✓			Near Threatened	

Species	OSPAR Threatened and/or Declining Species	UK POST 2010 Priority Species	Scottish Priority Marine Feature	Nature Conservation (Scotland) Act 2004	ICUN Red List	Annex II Fish Species EU Habitats Directive (92/43/EEC)
Gulper shark (*Centrophorus granulosus*)	✓	✓			Vulnerable	
Hake		✓				
Herring		✓	✓			
Horse mackerel		✓				
Lesser sandeel		✓	✓			
Ling		✓	✓			
Mackerel		✓	✓			
Norway pout			✓			
Ocean quahog	✓		✓			
Plaice		✓				
Porbeagle (*Lamna nasus*)	✓	✓			Vulnerable	
Portuguese dogfish (*Centroscymnus coelolepi*)		✓			Near Threatened	

Species	OSPAR Threatened and/or Declining Species	UK POST 2010 Priority Species	Scottish Priority Marine Feature	Nature Conservation (Scotland) Act 2004	ICUN Red List	Annex II Fish Species EU Habitats Directive (92/43/EEC)
Raitt's sandeel		✓	✓			
River lamprey						✓
Sand ray		✓			Vulnerable	
Sea trout		✓				
Sea lamprey	✓					✓
Smelt		✓				
Spotted ray	✓					
Spurdog	✓	✓	✓		Vulnerable	
Thornback ray	✓				Near Threatened	
Tope		✓			Vulnerable	
Twaite shad		✓				✓
Whiting		✓	✓			

3.8 Designated Sites

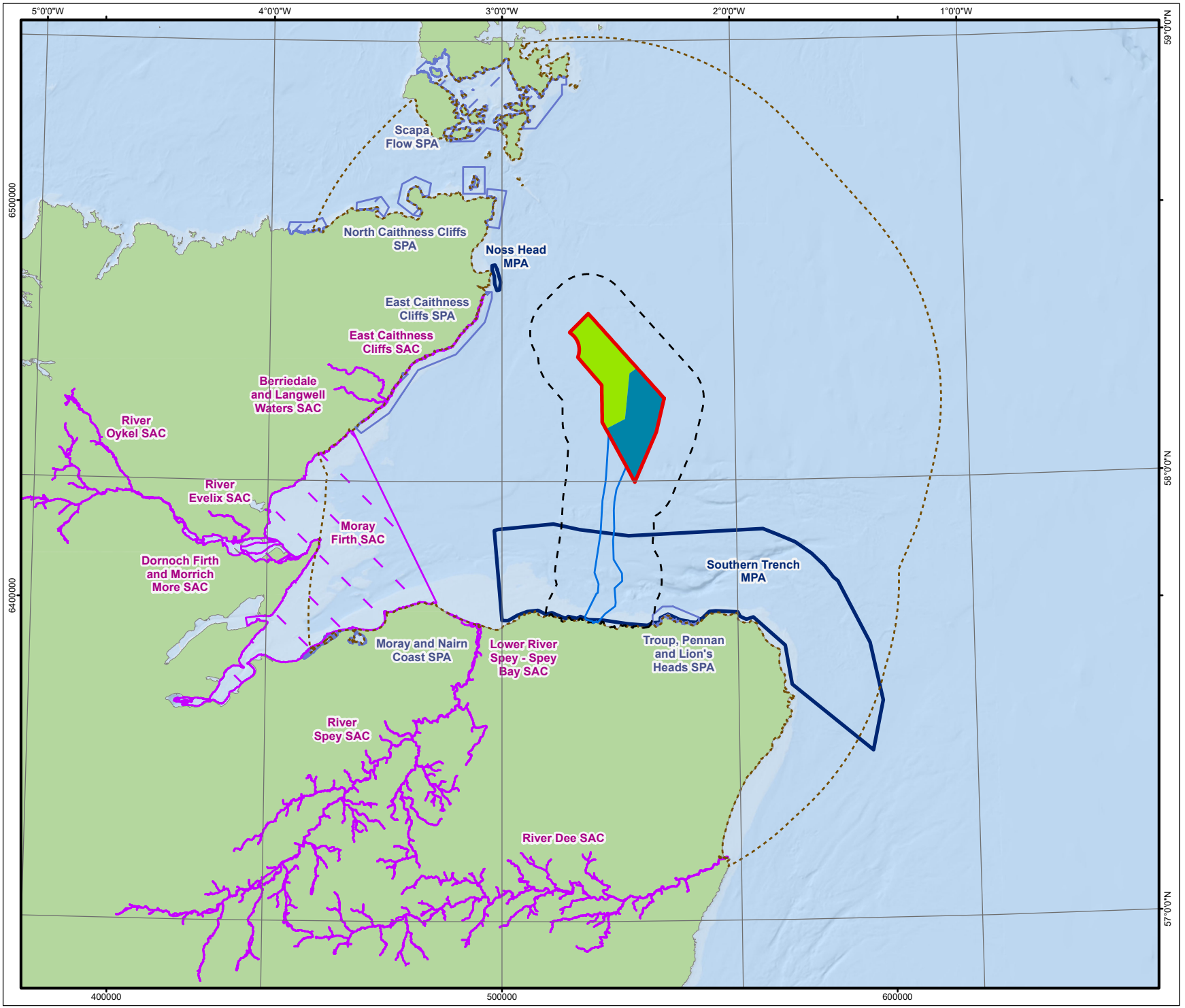
3.8.1.1 Several sites designated for nature conservation are located within the study area and have been detailed in Table 3-5 and represented in Figure 3-16. These sites include the Moray Firth SAC, River Spey SAC, River Evelix SAC, River Oykel SAC, Berriedale and Langwell Waters SAC, Moray Firth Special Protection Area (SPA), East Caithness SPA, Southern Trench nature conservation MPA and Noss Head nature conservation MPA. All of these sites that have qualifying features related to Fish and Shellfish Ecology, or a qualifying feature that is dependent on fish and shellfish populations (e.g., as prey species), have been listed within Table 3-5.

3.8.1.2 The Southern Trench Nature Conservation Marine Protected Areas (NCMPA) intersects with the Caledonia OECC and has been designated for minke whale (*Balaenoptera acutorostrata*). The NCMPA has a conservation objective to maintain productivity and feeding conditions for local mobile species and the minke whale as both juveniles and adults are regularly observed feeding on non-spiny fish such as sandeel, herring, whiting and cod, squid and sprat in the NCMPA.

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

Table 3-5: Sites designated for nature conservation in the vicinity of the study area.

Site	Location Relative to the Proposed Development (Offshore)	Qualifying Features
Southern Trench NCMPA	Intersects with the entire inshore region of the Caledonia OECC	Minke whale (Scottish Priority Marine feature (PMF)). Included due to the presence of herring, mackerel, and cod which are important prey species for minke whale.
Noss Head NCMPA	North-west of the northern edge of the Caledonia OWF (approximately 20km)	Horse mussel beds (Annex I habitat, OSPAR threatened and/or declining habitat and a BAP priority habitat)
Moray Firth SAC	West of the Caledonia OWF and Caledonia OECC	Bottlenose dolphins (Annex II species). Included due to presence of herring and mackerel as important prey species for bottlenose dolphin.
River Spey SAC	South-west of the Caledonia OECC	Freshwater pearl mussel (Annex II species), sea lamprey and Atlantic salmon
Berriedale and Langwell Waters SAC	West of the Caledonia OWF	Atlantic salmon (Annex II species)
River Evelix SAC	Enters the Moray Firth to north-east of the Caledonia OWF	Fresh water pearl mussel (Annex II species)
River Oykel SAC	Enters the Moray Firth to the west of the Caledonia OWF	Atlantic salmon (Annex II species)



- Caledonia OWF
- Caledonia North Site
- Caledonia South Site
- Offshore Export Cable Corridor
- 70km Primary Underwater Noise Zone of Influence
- 10km Secondary Zone of Influence
- Special Areas of Conservation
- Special Protection Areas
- Marine Protected Areas

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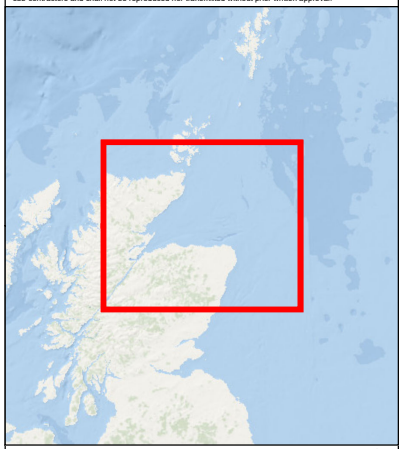

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REV	DATE	DOC STATUS	ORIGIN	REVIEW	APP
01	24/09/2024	Approved	EV	BB	DH

CALEDONIA Offshore Wind Farm

GoBe APEM Group

CONTRACTOR DRAWING NO: UKCAL1_GO_WNF_FAS_MAP_00104	CONTRACTOR REV: 01
GEODETIC PARAMETERS: WGS 84 / UTM zone 30N (EPSG: 32630)	

DRAWING TITLE

Figure 3-16: Designated Sites in Relation to the Study Area

STATUS: Approved	SCALE: 1:1,300,000	
DRAWING NUMBER: N/A	SHEET NO: 01 of 01	REV: N/A

3.9 Important Ecological Features

3.9.1.1 The value of Important Ecological Features (IEF) is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (Chartered Institute of Ecology and Environment Management (CIEEM), 2018[171]). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g., species listed on The Conservation of Habitats and Species Regulations (2017[155]); UK BAP species or species of principal importance listed under the Natural Environment and Rural Communities Act (NERC, 2006[172]), and species listed as features of existing or Recommended Marine Conservation Zones (rMCZs)). Evaluation has also assessed the receptor value in accordance with the functional role of the habitat or species. The criteria used to inform this assessment are listed in Table 3-6, and a summary of fish and shellfish IEFs is in Table 3-7.

Table 3-6: Criteria used to inform the valuation of ecological receptors in the study area, derived from guidance published by CIEEM (2018[171]).

IEF Value	IEF 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 study area. Species protected under national legislation, including The Conservation of Salmon (Scotland) Regulations (2016[173]) and the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act (2003[174]). Species protected under the Scottish Eel Management Plan (2010[175]). Species protected under national policy, including the Scottish Wild Salmon Strategy (Scottish Government, 2022[176]) and the Eel Management plans for the United Kingdom: Scotland River Basin District (Defra, 2021[177]). Species listed as a Priority Marine Feature (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. Species listed on the Scottish Biodiversity list; species Scottish Ministers consider to be of principal importance for biodiversity conservation in Scotland.

IEF Value	IEF Criteria Used to Define Value
	UK BAP priority species (including grouped action plans) that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, Marine Conservation Zones (MCZ)/rMCZ features (species classified as features of conservation importance and broad scale habitats), species of principal importance and Nationally Important Marine Features (NIMF) that have nationally important populations within study area, particularly in the context of species/habitat that may be rare or threatened in the UK. Species that have spawning or nursery areas within the study area that are important nationally (e.g., may be primary spawning/nursery area for that species).
Regional	UK BAP priority species (these include grouped action plans) that continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework, MCZ/rMCZ features (species classified as features of conservation importance, and broadscale habitats), species of principal importance and NIMF that have regionally important populations within the study area (are locally widespread and/or abundant). Species of commercial importance, to fisheries in the area. Species of ecological importance (i.e., are an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages in the study area. Species that have spawning or nursery areas within the study area that are important regionally.
Local	Species of commercial importance, but do not form a key component of the fish assemblages within the study area. The spawning/nursery area for the species is located outside of the study area, or of low intensity. The species is common throughout the UK but forms a component of the fish assemblages in the study area.

3.9.1.2 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 study area has been provided in Table 3-7.

Table 3-7: Summary of fish and shellfish IEFs and their value/importance within the study area.

Species	Source	Valuation	Justification
Fish IEFs			
Atlantic salmon	Beatrice OWF salmon survey; Marine Scotland Survey (2016b[25]); 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, and River South Esk SAC designated for Atlantic salmon protection; and ▪ Potential to transit through the study area.
Allis shad	Literature review (various sources)	National	▪ OSPAR list of threatened and/or declining species and habitats; ▪ Scottish Biodiversity list.
Basking shark	Nature Conservation Act, (2004[167]); Schedule 5, Wildlife and Countryside Act (1981[156]).	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.
European eel	Literature review (various sources).	International	▪ OSPAR list of threatened and/or 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 area.
Sea lamprey	Literature review (various sources).	National	▪ OSPAR list of threatened and/or declining species and habitats;

Species	Source	Valuation	Justification
			▪ Protected under the BERN convention; ▪ Protected under the Salmon Act; ▪ PMF (Scotland); ▪ Scottish Biodiversity list; and ▪ Potential to transit through the study area.
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 MPA designated for sandeel (important prey species); and ▪ Study area overlaps with high intensity spawning grounds and low intensity nursery grounds
Cod	North Sea bottom trawl data; Hywind OWF trawl survey and Beatrice OWF otter trawl survey.	National	▪ 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, designated as an important prey species for minke whale in the nearby Southern Trench MPA; and ▪ Study area overlaps with low intensity spawning and nursery grounds.
European hake	Site specific eDNA survey (Volume 7B, Appendix 4-1 and Volume 7B, Appendix 4-2) and literature review (various sources).	Regional	▪ Scottish Biodiversity list; and ▪ Study area overlaps with 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 MPA designated for sandeel (important prey species); and ▪ Study area overlaps with high intensity spawning grounds and low intensity nursery grounds
Atlantic herring	Site specific eDNA survey (Volume 7B, appendix 4-1 and Volume 7B,	National	▪ PMF (Scotland); ▪ Scottish Biodiversity list;

Species	Source	Valuation	Justification
	Appendix 4-2 - ECC area most abundant species); North Sea bottom trawl data and Hywind OWF trawl survey.		▪ Commercially important species in the region; ▪ Important prey species for minke whale, designated as an important prey species for minke whale in the nearby Southern Trench MPA. Also an important prey species for bottlenose dolphin in the nearby Moray Firth SAC; and ▪ Study area overlaps with spawning grounds (undetermined intensity) and high intensity nursery grounds within the Caledonia OECC
Atlantic mackerel	Site specific eDNA survey (Volume 7B, Appendix 4-1 and Volume 7B, Appendix 4-2); MMO landing statistics and North Sea bottom trawls.	Regional	▪ PMF (Scotland); ▪ Scottish Biodiversity list; ▪ Commercially important species in the region; ▪ Important prey species for Minke whale, designated as an important prey species for minke whale in the nearby Southern Trench MPA. Also an important prey species for bottlenose dolphin in the nearby Moray Firth SAC; and ▪ Study area overlaps with low intensity nursery grounds
River lamprey	Literature review (various sources)	Regional	▪ PMF (Scotland); and ▪ Scottish Biodiversity list.
Whiting	North Sea bottom trawl data; Hywind OWF trawl survey and Beatrice OWF otter trawl survey.	National	▪ PMF (Scotland); ▪ Scottish Biodiversity list; ▪ Commercially important species in the region; and ▪ Study area overlaps with low intensity spawning grounds and high intensity nursery grounds within the Caledonia OECC.
Blue whiting	MMO landing statistics and literature review (various sources)	National	▪ PMF (Scotland); ▪ Scottish Biodiversity list; and ▪ Study area overlaps with low intensity nursery grounds.
Plaice	Site-specific camera and video transects; North Sea bottom trawl; Hywind OWF trawl survey and Moray West OWF	Local	▪ Scottish Biodiversity list; and ▪ Study area overlaps with low intensity spawning and nursery grounds.

Species	Source	Valuation	Justification
	epibenthic beam trawl surveys.		
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 area overlaps with low intensity nursery grounds.
Ling	Hywind OWF trawl survey and literature review (various sources).	National	▪ PMF (Scotland); ▪ Scottish Biodiversity list; and ▪ Study area overlaps with low intensity nursery grounds.
Norway pout	Site specific eDNA survey (Volume 7B, Appendix 4-2); North Sea bottom trawl data and Hywind OWF trawl survey.	National	▪ PMF (Scotland); ▪ Scottish Biodiversity list; and ▪ Study area overlaps with low intensity spawning and nursery grounds.
Sea trout	Site specific eDNA survey (Volume 7B, Appendix 4-1) and literature review (various sources).	National	▪ PMF (Scotland); ▪ Scottish Biodiversity list; ▪ Protected under the Salmon Act ▪ Evidence of transit through the study area.
Haddock	North Sea bottom trawl; Hywind OWF trawl survey and Beatrice OWF otter trawl survey.	Regional	▪ Commercially important species in the region; and ▪ Study area overlaps with nursery grounds (unspecified intensity).
Lemon sole	Hywind OWF trawl survey and Moray West OWF epibenthic beam trawl surveys.	Regional	▪ Study area overlaps with low intensity spawning and nursery grounds.
Sprat	Hywind OWF trawl survey.	Regional	▪ Study area overlaps with low intensity spawning and nursery grounds.
Elasmobranchs			
Spurdog	Hywind OWF trawl survey and Scottish government fishing statistics data	Regional	▪ OSPAR list of threatened and/or declining species and habitats; ▪ 'Vulnerable' on the IUCN red list of threatened species; ▪ PMF (Scotland);

Species	Source	Valuation	Justification
			▪ Scottish Biodiversity list; and ▪ Study area overlaps with low intensity nursery grounds.
Tope Shark	Hywind OWF trawl survey.	Regional	▪ 'Vulnerable' on the IUCN red list of threatened species; ▪ PMF (Scotland); ▪ Scottish Biodiversity list; and ▪ Study area overlaps with low intensity nursery grounds.
Spotted ray	Hywind OWF trawl survey.	Regional	▪ PMF (Scotland); ▪ OSPAR list of threatened and/or declining species and habitats; and ▪ Study area overlaps with low intensity nursery grounds.
Common skate	Hywind OWF trawl survey.	Regional	▪ OSPAR list of threatened and/or declining species and habitats; ▪ 'Critically Endangered' on the IUCN Red List ▪ PMF (Scotland); ▪ Scottish Biodiversity list; and ▪ Study area overlaps with low intensity nursery grounds.
Thornback skate	Site-specific camera and video transects and Scottish government fishing statistics data	Regional	▪ OSPAR list of threatened and/or declining species and habitats; ▪ 'Near Threatened' on the IUCN Red List ▪ Scottish Biodiversity list; and ▪ Evidence of presence in the study area.
Shellfish			
Freshwater pearl mussel	Nearby designated sites	National	▪ 'Endangered' on the IUCN red list of threatened species; and ▪ Nearby River Spey SAC, River Dee SAC, River South Esk SAC and River Evelix SAC designated for freshwater pearl mussel.
Brown crab	Hywind OWF surveys.	Regional	▪ Commercially important species in the region; and ▪ Potential to be present in the study area.
Scallop	Hywind OWF surveys.	Regional	▪ Commercially important species in the region; and ▪ Potential to be present in the study area.

Species	Source	Valuation	Justification
Norway lobster (Nephrops)	Hywind OWF surveys.	Regional	▪ Commercially important species in the region; and ▪ Potential to be present in the study area; and ▪ Study area overlaps 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 area.

3.10 Summary of Baseline Conditions

3.10.1.1 This technical baseline report has provided detail on the fish and shellfish communities present within the study area. Additionally, it has identified several key IEFs including, Atlantic salmon, sea trout, herring and sandeel. All the species groups identified in this technical baseline report have been carried across into the subsequent EIAR Fish and Shellfish Ecology Chapter and assessed against the potential impacts arising from the Proposed Development (Offshore), with additional detail and focus towards these key IEFs.

3.10.1.2 This technical baseline report has identified the spatial distribution and probability of the Proposed Development (Offshore) interacting with Buchan and Orkney/Shetland herring spawning grounds (Coull *et al*., 1998[21]), sandeel spawning grounds and migratory routes for Atlantic salmon and sea trout to River Spey SAC, Berriedale and Langwell Waters SAC and River Oykel SAC.

4 Conclusion

4.1.1.1 This technical baseline report for Fish and Shellfish Ecology comprises of site-specific survey data collected within the Caledonia OWF and Caledonia OECC supplemented by existing baseline data from the wider region and other OWF developments. The use of site-specific data from PSA analysis, camera transects, grab sampling and eDNA sampling, provides a robust evidence base to ground truth and reinforce existing datasets from the region.

4.1.1.2 This ecological baseline assessment appropriately describes the fish and shellfish communities present encompassing a detailed description of migratory species, commercial species and species of conservation importance, such that it is considered further survey work will not be required to identify any additional receptors that may constitute IEFs for the purposes of undertaking an EIA.

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

5 References

[1] Popper, A.N. and Hastings, M.C. (2009) 'The effects of anthropogenic sources of sound on fishes'. Journal of Fish Biology 75(3): 455-489

[2] Hawkins, A.D., Pembroke, A.E. and Popper, A.N. (2015) 'Information gaps in understanding the effects of noise on fishes and invertebrates'. Reviews in Fish Biology and Fisheries 25: 39-64

[3] Marine Scotland (2024) 'Marine Science: open data network'

[4] IHLS (2011/2012 – 2023/2024. 'International Herring Larval Survey'

[5] MMO (2022). 'UK sea fisheries annual statistics report'. Available at: https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2022 (Accessed 01/10/2024)

[6] EUSeaMap (2021) 'EMODnet broad-scale seabed habitat map for Europe | European Marine Observation and Data Network (EMODnet)'. Available at: https://emodnet.ec.europa.eu/en/euseamap-2021-emodnet-broad-scale-seabed-habitat-map-europe (Accessed 01/10/2024)

[7] Langton, R., Boulcott, P. and Wright, P. J. (2021) 'A verified distribution model for the lesser sandeel, *Ammodytes marinus*'. Marine Ecology Progress Series 667: 145–159

[8] Scottish Sea Fisheries Statistics (2020). Available at: https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2020/ (Accessed 01/10/2024)

[9] NatureScot (2020) 'Feature Activity Sensitivity Tool (FeAST)'. Available at: https://www.nature.scot/professional-advice/protected-areas-and-species/priority-marine-features-scotlands-seas/feature-activity-sensitivity-tool-feast (Accessed 01/10/2024)

[10] Boyle, G. and New, P. (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'

[11] González-Irusta, J.M. and Wright, P.J. (2017) 'Spawning grounds of whiting (*Merlangius merlangus*)'. Fisheries Research 195: 141-151

[12] González-Irusta, J.M. and Wright, P.J. (2016) 'Spawning grounds of Atlantic cod (*Gadus morhua*) in the North Sea'. ICES Journal of Marine Science 73(2): 304-315

[13] British Geological Survey (BGS) (2015) 'GeoIndex (offshore) Marine Sediment Particle Size dataset - British Geological Survey'. Available at: https://www.bgs.ac.uk/map-viewers/geoindex-offshore (Accessed 01/10/2024)

[14] Aires, C., González-Irusta, J.M., Watret, R. (2014) 'Updating Fisheries Sensitivity Maps in British Waters'. Scottish Marine and Freshwater Science Vol 5 No 10. Edinburgh: Scottish Government, 88pp.

[15] Latto, P.L., Reach, I.S., Alexander, D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R. and Seiderer, L.J. (2013) 'Screening spatial interactions between marine aggregate application areas and sandeel habitat'. A Method Statement produced for BMAPA

[16] Reach, I.S., Latto, P., Alexander, D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R. and Seiderer, L.J. (2013) 'Screening spatial interactions between marine aggregate application areas and Atlantic herring potential spawning areas'. A Method Statement produced for BMAPA

[17] ICES (2012-2022a). 'North Sea International Bottom Trawl Survey'. Available at: https://www.ices.dk/data/dataset-collections/Pages/IBTS-IYFS-.aspx (Accessed 01/10/2024)

[18] ICES (2012-2022b). 'ICES Beam Trawl Survey Data'

[19] Ellis J.R., Milligan S.P., Readdy L., Taylor N., and Brown M.J. (2012) 'Spawning and nursery grounds of selected fish species in UK waters'. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

[20] ICES (2011-2012) 'Scottish Rockall Groundfish Survey Data'

[21] Coull, K. A., Johnstone, R. and Rogers, S. I. (1998) 'Fisheries Sensitivity Maps in British Waters'. Published and distributed by UKOOA Ltd

[22] Beatrice Offshore Wind Farm Limited (BOWL) (2021), 'Beatrice OWF Farm Post-Construction Baseline Sandeel Survey – Technical Report'. Available at: https://marine.gov.scot/sites/default/files/bowl_-_post-construction_sandeel_survey_-_technical_report_redacted.pdf (Accessed 01/10/2024)

[23] Beatrice Offshore Wind Farm Limited (BOWL) (2021b) 'Beatrice OWF Farm Post-Construction Baseline Sandeel Survey – Technical Report'. Available at: https://marine.gov.scot/sites/default/files/bowl_-post-construction_sandeel_survey-_technical_report_redacted.pdf (Accessed 01/10/2024).

[24] Moray Offshore Windfarm (West) Ltd (2018) 'Environmental Statement. Chapter 8: Fish and Shellfish Ecology'. Available at: https://marine.gov.scot/data/moray-west-offshore-windfarm-environmental-impact-assessment-report (Accessed 01/10/2024)

[25] Beatrice Offshore Wind Farm Limited (BOWL) (2016b) 'Atlantic Salmon Salmo Salar Smolt Movements Survey'. Available at: https://marine.gov.scot/sites/default/files/bowl_salmon.pdf (Accessed 01/10/2024).

[26] Beatrice Offshore Wind Farm Limited (BOWL) (2016a) 'Beatrice OWF Pre-Construction Baseline Herring Larval Surveys Summary Technical Report'. Available at: https://marine.gov.scot/sites/default/files/00499204.pdf (Accessed 01/10/2024)

[27] Statoil (2015) 'Hywind Scotland Pilot Park Environmental Statement'. Available at: https://marine.gov.scot/datafiles/lot/hywind/Environmental_Statement/Environmental_Statement.pdf (Accessed 01/10/2024)

[28] Beatrice Offshore Wind Farm Limited (BOWL) (2015) 'Pre-construction Baseline Cod Spawning Survey – Technical Report'. Available at: https://marine.gov.scot/sites/default/files/pre-construction_cod_spawning_survey_results_-_technicla_report.pdf (Accessed 01/10/2024)

[29] Beatrice Offshore Wind Farm Limited (BOWL) (2014). 'Beatrice OWF Pre-Construction Baseline Sandeel Survey – Technical Report'. Accessed at: https://marine.gov.scot/sites/default/files/00489856.pdf (Accessed 01/10/2024)

[30] Statoil (2013) 'Hywind Scotland Pilot Park Project EIA Scoping Report'. Available at: https://marine.gov.scot/sites/default/files/00435569.pdf (Accessed 01/10/2024)

[31] Moray Offshore Windfarm Renewables Ltd (2012) 'Environmental Statement, Technical Appendix 4.3 C – Sandeel Survey Report'. Available at: https://marine.gov.scot/datafiles/lot/morl/Environmental_statement/Volumes%208%20to%2011%20-%20Technical%20Appendices/Volume%2010%20Part%201%20-%20Biological%20Environment%20Technical%20Appendices/Appendix%204.3%20C%20-%20Sandeel%20Survey.pdf (Accessed 01/10/2024)

[32] Beatrice Offshore Wind Farm Limited (BOWL) (2012a) 'Beatrice OWF Environmental Statement - Annex 11A: Fish and Shellfish Ecology Technical Report'. Available at: https://marine.gov.scot/datafiles/lot/bowl/ES/ES%20Volume%204%20-%20Annexs/11A%20Fish%20and%20Shellfish/Annex%2011A%20Fish%20and%20Shellfish%20Ecology%20Technical%20Report.pdf (Accessed 01/10/2024)

[33] Beatrice Offshore Wind Farm Limited (BOWL) (2012b) 'Beatrice OWF Environmental Statement - Chapter 11: Fish and Shellfish Ecology'. Available at: https://marine.gov.scot/datafiles/lot/bowl/ES/ES%20Volume%201%20-%20ES%20Sections/11_Fish%20and%20Shellfish%20Ecology.pdf (Accessed 01/10/2024)

[34] Moray Offshore Windfarm Renewables Ltd (2011) 'Environmental Statement, Chapters 7.2 and 10.2: Fish and Shellfish Ecology'. Available at: https://www.morayeast.com/download_file/133/219 and https://www.morayeast.com/download_file/136/219 (Accessed 01/10/2024)

[35] Moray Offshore Windfarm Renewables Ltd (2011) 'Environmental Statement, Technical Appendix 4.3 A – Fish and Shellfish Ecology Technical Report'. Available at: https://marine.gov.scot/datafiles/lot/morl/Environmental_statement/Volumes%208%20to%2011%20-%20Technical%20Appendices/Volume%2010%20Part%201%20-

%20Biological%20Environment%20Technical%20Appendices/Appendix%204.3%20A%20-%20Fish%20&%20Shellfish%20Ecology.pdf (Accessed 01/10/2024)

[36] Folk, R.L. (1954) 'The distinction between grain size and mineral composition in sedimentary rock nomenclature'. Journal of Geology 62.4: 344-359

[37] Denzer, W. and Kaiser, H. (2023) 'Naming and gaming: The illicit taxonomic practice of 'nomenclatural harvesting and how to avoid it'. Journal of Zoology 320(3): 161-168

[38] Boyle, G. and New, P. (2018) 'ORJIP Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options. Final report - June 2018', The Carbon Trust, United Kingdom, 247 pp.

[39] MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd and Marine Ecological Surveys Ltd, (2013a) 'Environmental Effect Pathways between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Habitat: Regional Cumulative Impact Assessments. Version 1.0'. A report for the British Marine Aggregates Producers Association

[40] MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd and Marine Ecological Surveys Ltd (2013b) 'Environmental Effect Pathways'

[41] Folk, R.L. (1954) 'The distinction between grain size and mineral composition in sedimentary rock nomenclature'. Journal of Geology 62.4: 344-359

[42] Jensen, H., Rindorf, A., Wright, P.J. and Mosegaard, H. (2011) 'Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery'. ICES Journal of Marine Science 68(1): 43-51

[43] Coull *et al*. (1988) 'Fisheries Sensitivity Maps in British Waters'. Available at: https://www.cefas.co.uk/media/o0fgfobd/sensi_maps.pdf (Accessed 01/10/2024)

[44] British Geological Survey (BGS) (2024) 'Datasets'. Available at: https://www.bgs.ac.uk/geological-data/datasets/ (Accessed 01/10/2024)

[45] Hinz, S., Coston-Guarini, J., Marnane, M. and Guarini, J.M. (2022) 'Evaluating eDNA for Use within Marine Environmental Impact Assessments'. Journal of Marine Science and Engineering 2022, Vol. 10, Page 375

[46] Merten Cruz, M., Sauvage, T., Chariton, A. and de Freitas, T.R.O. (2023) 'The challenge of implementing environmental DNA metabarcoding to detect elasmobranchs in a resource-limited marine protected area'. Journal of Fish Biology 103(1): 172-178

[47] Ip, Y.C.A., Chang, J.J.M., Lim, K.K.P., Jaafar, Z., Wainwright, B.J. and Huang, D. (2021) 'Seeing through sedimented waters: environmental DNA reduces the phantom diversity of sharks and rays in turbid marine habitats'. BMC Ecology and Evolution 21(1): 1-14

[48] Joint Nature Conservation Committee (JNCC) (2022) 'Nature Conservation Marine Protected Areas'. Available at: https://jncc.gov.uk/our-work/nature-conservation-mpas/ (Accessed 01/10/2024)

[49] Moray Offshore Windfarm (East) Limited (2018) 'Moray East OWF Herring Larval Annual Review, 2018'. Available at: https://marine.gov.scot/sites/default/files/herring_larvae_annual_review_report_-_january_2018.pdf (Accessed 01/10/2024)

[50] Scottish Government (2020) 'Scottish Sea Fisheries Statistics 2020'. Available at: https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2020/ (Accessed 01/10/2024)

[51] ICES (2022) 'UK Sea Fisheries Annual Statistics Report 2022'. Available at: https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2022 (Accessed 01/10/2024)

[52] ICES (2023) 'Offshore Beam Trawl'. Available at: ICES Survey Protocols – Offshore Beam Trawl Surveys, Coordinated by Working group on Beam Trawl Surveys (WGBEAM) (figshare.com) (Accessed 01/10/2024)

[53] Scotland Marine Atlas (2011) 'Scotland's Marine Atlas'. Available at: https://www.gov.scot/publications/scotlands-marine-atlas-information-national-marine-plan/ (Accessed 01/10/2024)

[54] Ellis, J.R., Cruz-Martinez, A., Rackham, B.D. and Rogers, S.I. (2005) 'The distribution of chondrichthyan fishes around the British Isles and implications for conservation'. Journal of Northwest Atlantic fishery science 35(195-213): p.113

[55] Scottish Government (2022) 'Case Study: Basking Sharks in Scottish Waters'. Available at: https://marine.gov.scot/sma/assessment/case-study-basking-sharks-scottish-waters (Accessed 01/10/2024)

[56] Ellis, J.R., Silva, J.F., McCully, S.R. and Catchpole, T. (2010) 'UK fisheries for skates (Rajidae): History and development of the fishery, recent management actions and survivorship of discards'

[57] Keltz, S. and Bailey, N. (2010) 'Fish and Shellfish stocks 2010. Marine Scotland, the Scottish Government'. ISSN 2044-0359

[58] Fox, C.J., Taylor, M., Dickey-Collas, M., Fossum, P., Kraus, G., Rohlf, N., Munk, P., van Damme, C.J., Bolle, L.J., Maxwell, D.L. and Wright, P.J. (2008) 'Mapping the spawning grounds of North Sea cod (*Gadus morhua*) by direct and indirect means'. Proceedings of the Royal Society B: Biological Sciences 275(1642): 1543-1548

[59] ICES (2007) 'Report of the Working Group on Working Group on North Atlantic Salmon (WGNAS)'. Available at: https://www.ices.dk/sites/pub/CM%20Doccuments/CM-2007/ACFM/ACFM1307.pdf (Accessed 01/10/2024)

[60] Hutchinson, W.F., Carvalho, G.R. and Rogers, I. (2001) 'Marked genetic structuring in localised spawning populations of cod *Gadus morhua* in the North Sea and adjoining waters, as revealed by microsatellites'. Marine Ecology Progress Series 223: 251–260

[61] Wright, P.J., Gibb, F.M., Gibb, I.M., Heath, M.R. and McLay, H.A. (2003) 'North Sea cod spawning grounds'. Fisheries Research Services Internal Report No 17/03

[62] Grabowski, T.B, Thorsteinsson, V. and Marteinsdóttir, G. (2009) 'Assessing the lekking hypothesis for the mating system of Atlantic cod (*Gadus morhua*) using electronic data-storage tags'

[63] Nordeide, J.T. and Folstad, I. (2000) 'Is cod lekking or a promiscuous group spawner?' Fish and Fisheries 1: 90-93

[64] Brown and May Marine (2013) '[Wind Farm] Project Environmental Monitoring Programme'. Available at: https://marine.gov.scot/sites/default/files/moray_east_wf_pemp_version_4_v1.0_redacted.pdf (Accessed 01/10/2024)

[65] De Groot, S.J. (1980) 'The consequences of marine gravel extraction on the spawning of herring, *Clupea harengus Linné'*. Journal of Fish Biology 16(6): 605-611

[66] Maucorps, A. (1969) 'Biologie et peche du hareng en Mer du Nord, son exploitation rationelle'. Science et Pêche, Bull. Insf. Pêches marif., no 186, Novembre 1969

[67] Munro, J., Gauthier, D. and Gagné, J.A. (2008) 'Description of a herring spawning ground (*Clupea harengus L.*) on Île aux Livèvres, in the upper St. Lawrence Estuary'. Regional Science Branch, Department of Fisheries and Oceans, Maurice Lamontagne Institute

[68] Parrish, B.B., Saville, A., Craig, R.E., Baxter, I.G. and Priestley, R. (1959) 'Observations on herring spawning and larval distribution in the Firth of Clyth in 1958'. Journal of the Marine Biological Association of the United Kingdom 38: 445-453

[69] Blaxter, J.H.S. (1985) 'The herring: A successful species?' Canadian Journal of Fisheries and Aquatic Sciences 42(Suppl.1): 21-30

[70] Hodgson, W.C. (1957) 'The herring and its fishery'. London, Routledge and Kegan Paul

[71] Lambert, T.C. (1987) 'Duration and intensity of spawning in herring *Clupea harengus* as related to the age structure of the mature population'. Marine Ecology Progress Series 39: 209-220

[72] Enger, P.S. (1967) 'Hearing in herring. Comp. Biochem. Physiol. 22, 527-538'. Cited in de Groot (1980).

[73] Heath, M., Leaver, M., Matthews, A. and Nicoll, N. (1989) 'Dispersion and feeding of larval herring (*Clupea harengus L.*) in the Moray Firth during September 1985'. Estuar. Coast. Shelf Sci. 28: 549- 566

[74] ICES (2009) 'Report of the Benchmark Workshop on Short-lived Species (WKSHORT)'. Available at: https://www.ices.dk/sites/pub/CM%20Doccuments/CM-2009/ACOM/ACOM3409.pdf (Accessed 01/10/2024)

[75] ICES (2022) 'DATRAS North Sea Sandeel Survey (NSSS)'. Available at: https://gis.ices.dk/geonetwork/srv/api/records/3ee3208a-89dd-482f-8be3-ef1d94ee812b (Accessed 01/10/2024)

[76] Hirst, N.E., Clark, L. and Sanderson, W. (2012) 'The distribution of selected MPA search features and Priority Marine Features off the NE coast of Scotland'

[77] Van der Kooij, J., Scott, B.E. and Mackinson, S. (2008) 'The effects of environmental factors on daytime sandeel distribution and abundance on the Dogger Bank. Journal of Sea Research 60: 201-209'

[78] Gauld, J.A. and Hutcheon, J.R. (1990) 'Spawning and fecundity in the lesser sandeel, *Ammodytes marinus* Raitt, in the northwestern North Sea'. Journal of Fish Biology 36: 611-613

[79] Bergstad, O.A., Hoines, A.S. and Kruger-Johnsen, E.M. (2001) 'Spawning time, age and size at maturity, and fecundity of sandeel, *Ammodytes marinus*, in the north-eastern North Sea and in unfished coastal waters off Norway'. Aquatic Living Resources 14: 293-301

[80] Winslade, P. (1974) 'Behavioural studies on the lesser sandeel *Ammodytes marinus* (*Raitt*) III'. The effect of temperature on activity and the environmental control of the annual cycle of activity'. Journal of Fish Biology 6: 587-599

[81] Macer, C.T. (1965). The distribution of larval sand eels (Ammodytidae) in the southern North Sea. Journal of the Marine Biological Association of the United Kingdom 45: 187-207

[82] Langham, N.P.E. (1971) 'The distribution and abundance of larval sand-eels (Ammodytidae) in Scottish waters'. Journal of the Marine Biological Association of the United Kingdom 51: 697-707

[83] Wright P.J. and Bailey M.C. (1993) 'Biology of Sandeel in the vicinity of Seabird colonies at Shetland'. Fisheries Research Report No. 15/93

[84] Wright, P.J., Jensen, H. and Tuck, I. (2000) 'The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*'. Journal of Sea Research 44(3-4): 243-256

[85] Holland, G.J., Greenstreet, S.P., Gibb, I.M., Fraser, H.M. and Robertson, M.R., (2005) 'Identifying sandeel *Ammodytes marinus* sediment habitat preferences in the marine environment'. Marine Ecology Progress Series 303: 269-282

[86] Greenstreet, S.P., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser, H.M. and Gibb, I.M. (2010) 'Combining hydroacoustic seabed survey and grab sampling techniques to assess "local" sandeel population abundance'. ICES Journal of Marine Science 67(5): 971-984

[87] MMO (2022) 'UK Sea Fisheries Statistics 2022'. Available at: https://assets.publishing.service.gov.uk/media/662761cdd29479e036a7e504/UK_Sea_Fisheries_Statistics_2022_101123___.pdf (Accessed 01/10/2024)

[88] Scottish Government (2022) 'Scottish Fisheries Statistics 2022'. Available at: https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2022/ (Accessed 01/10/2024)

[89] Sabatini, M. and Hill, J.M. (2008) '*Nephrops norvegicus*. Norway lobster'

[90] Marine Scotland (2022) 'Marine Scotland National Marine Plan Interactive (NMPI)'. Available at: https://marine.gov.scot/maps/334 (Accessed 01/10/2024)

[91] Marine Scotland (2021) 'Moray Firth SMR'. Available at: https://marine.gov.scot/sma/region/moray-firth-smr#Healthy%20and%20biologically%20diverse (Accessed 01/10/2024)

[92] Cefas (2019) 'Crab Assessments 2019'. Available at: https://assets.publishing.service.gov.uk/media/60631425e90e072d929ec8d9/Crab_assessments_2019__March_21_update.pdf (Accessed March 2024)

[93] Moffat, C., Baxter, J., Berx, B., Bosley, K., Boulcott, P., Cox, M., Cruickshank, L., Gillham, K., Cox, A., Haynes, V., Roberts, A., Vaughan, D. and Webster, L. (Eds.) (2020) 'Scotland's Marine Assessment 2020'. Scottish Government

[94] Bennett, D.B. and Brown, C.G. (1983) 'Crab (*Cancer pagurus*) migrations in the English Channel'. Journal of the Marine Biological Association of the United Kingdom 63: 371-398

[95] Bridges, T.J. (2017) 'Crab and Lobster Stock Assessment'. Eastern Inshore Fisheries and Conservation Authority Annual Research Report

[96] Tonk, L. and Rozemeijer, M.J.C. (2019) 'Ecology of the brown crab (*Cancer pagurus*): and production potential for passive fisheries in Dutch offshore wind farms (No. C064/19A)'. Wageningen Marine Research

[97] Mesquita, C., Dobby, H., Sweeting, S., Jones, C.S. and Pierce, G.J. (2020) 'Size-at-maturity of Brown Crab (*Cancer pagurus*) in Scottish waters based on gonadal and morphometric traits'. Fisheries Research 229: p.105610

[98] Edwards, E. (1979) 'The Brown Crab and Its Fishery in British Waters'. Buckland Foundation Books/Fishing News Books Ltd., Bath, Great Britain/Farnham, Surrey, England

[99] Bennett, D.B. and Brown, C.G. (1983) 'Crab (*Cancer pagurus*) migrations in the English Channel'. Journal of the Marine Biological Association of the United Kingdom 63(2): 371-398

[100] Hunter, E., Eaton, D., Stewart, C., Lawler, A. and Smith, M.T. (2013) 'Edible crabs "Go West": migrations and incubation cycle of *Cancer pagurus* revealed by electronic tags'. PLoS One 8(5): p.e63991

[101] Jones G., Gibson P., Dobby H., McLay A. (2010) 'Brown crab (*Cancer pagurus*) migrations off the Northern Scottish Coast'. Scottish Industry Science Partnership Report 02/10. 16 pp.

[102] Coleman, M. and Rodrigues, E. (2016) 'Orkney Shellfish Project End of Year Report: January–December 2015'

[103] Bennett, D.B. (1974) 'Growth of the brown crab (*Cancer pagurus L.*) off south-west England'. Journal of the Marine Biological Association of the United Kingdom 54(4): 803-823

[104] Bennett, D.B. (1995) 'Factors in the life history of the brown crab (*Cancer pagurus L.*) that influence modelling and management'

[105] Robinson, M. and Tully, O. (2000) 'Seasonal variation in community structure and recruitment of benthic decapods in a sub-tidal cobble habitat'. Marine Ecology Progress Series 206: 181-191

[106] Marine Scotland (2016) 'Scottish Scallop Stocks Results 2016'. Available at: https://data.marine.gov.scot/dataset/scottish-scallop-stocks-results-2016-stock-assessments (Accessed 01/10/2024)

[107] Scottish Government (2022) 'Scotland's Marine Assessment'. Available at: https://www.gov.scot/publications/national-marine-plan-2-strategic-environmental-assessment-scoping-report/ (Accessed 01/10/2024)

[108] Marshall, Charlotte E., and Emily Wilson (2008) '*Pecten maximus*. Great scallop'

[109] Young, I.A.G., Pierce, G.J., Stowasser, G., Santos, M.B., Wang, J., Boyle, P.R., Shaw, P.W., Bailey, N., Tuck, I. and Collins, M.A. (2006) 'The Moray Firth directed squid fishery'. Fisheries Research 78: 39-43

[110] BOWL (2011) 'Fish and Shellfish Ecology Technical Report'. Available at: http://marine.gov.scot/datafiles/lot/bowl/ES/ES%20Volume%204%20-%20Annexs/11A%20Fish%20and%20Shellfish/Annex%2011A%20Fish%20and%20Shellfish%20Ecology%20Technical%20Report.pdf (Accessed 01/10/2024)

[111] Lum-Kong, A., Pierce, G. J. and Yau, C. (1992) 'Timing of spawning and recruitment in *Loligo forbesi* Steenstrup (Cephalopoda: Loliginidae) in Scottish waters'. Journal of the Marine Biological Association of the UK 72: 301-311

[112] Pierce G.J., Boyle P.R., Hastie L.C. and Kye, L. (1994) 'The life history of *Loligo forbesi* (Cephalopoda: Loliginidae) in Scottish waters'. Fisheries Research 21: 17-41

[113] Boyle P.R., Pierce G.J. and Hastie, L.C. (1995) 'Flexible reproductive strategies in the squid *Loligo forbesi*'. Marine Biology 121: 501-508

[114] Collins, M.A., Pierce, G.J. and Boyle, P.R. (1997) 'Population indices of reproduction and recruitment in *Loligo forbesi* (Cephalopoda: Loliginidae) in Scottish and Irish waters'. Journal of Applied Ecology 34: 778-786

[115] Viana, M., Pierce, G.J., Illian, J., MacLeod, C.D., Bailey, N., Wang, J. and Hastie L.C. (2009) 'Seasonal movements of veined squid *Loligo forbesi* in Scottish (UK) waters'

[116] Rocha F., Guerra A. and González A.F. (2001) 'A review of reproductive strategies in cephalopods'. Biol Rev. 76: 291-304

[117] Campbell, R. and McLay, A. (2007) 'The Moray Firth Squid Fishery 2006'. Fisheries Research Services Internal Report No 15/07. RSE 2004. The Royal society of Edinburgh. Inquiry into the future of the Scottish Fishing Industry

[118] Scottish Government (2023) 'Sandeel fishing - closure proposals: strategic environmental assessment - post adoption statement'. Available at: https://www.gov.scot/publications/strategic-environmental-assessment-proposals-close-fishing-sandeel-scottish-waters-post-adoption-statement/ (Accessed 01/10/2024)

[119] Scottish Government. (2024) 'Sandeel fishing - proposed closure - consultation analysis: Scottish Government response'. Available at: https://www.gov.scot/publications/proposals-close-fishing-sandeel-scottish-waters-scottish-government-response-consultation-analysis-report/#:~:text=On%2021%20July%202023%20the%20Scottish%20Government%20issued,sandeel%2C%20seabirds%2C%20marine%20mammals%2C%20and%20other%20fish%20species (Accessed 01/10/2024)

[120] Greenstreet, S., Fraser, H., Amrstrong, E., Gibb, I. (2010) 'Monitoring the Consequences of the Northwestern North Sea Sandeel Fishery Closure'. Scottish Marine and Freshwater Science Vol 1 No 6. Edinburgh: Scottish Government, 31pp.

[121] Greenstreet, S., Fraser, H., Amrstrong, E., Gibb, I. (2010) 'Monitoring the Consequences of the Northwestern North Sea Sandeel Fishery Closure'. Scottish Marine and Freshwater Science Vol 1 No 6. Edinburgh: Scottish Government, 31pp.

[122] Scottish Government (2011) 'Commercial Fisheries Report BMM'. Available at: https://marine.gov.scot/sites/default/files/chapter_11_commercial_fisheries.pdf (Accessed 01/10/2024)

[123] ICES (2011b) 'United Kingdom Fish Landings by ICES Rectangle 2011'. Available at: https://www.data.gov.uk/dataset/4358f340-ae6f-4fe1-8d0e-97a0dccdc329/united-kingdom-fish-landings-by-ices-rectangle-2011 (Accessed April 2024)

[124] Hedger, R., McKenzie, E., Heath, M., Wright, P., Scott, B., Gallego, A. and Andrews, J. (2004) 'Analysis of the spatial distributions of mature cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) abundance in the North Sea (1980-1999) using generalised additive models'. Fisheries Research 70(1): 17-25

[125] Wright, P.J., Neat, F.C., Gibb, F.M., Gibb, I.M. and Gallego, A. (2007) 'Cod movements in relation to substock structure in the North Sea and west of Scotland'. Fisheries Research Services Internal

[126] Zheng, X., Pierce, G.J., Reid, D.G. and Jolliffe, I.T. (2002) 'Does the North Atlantic current affect spatial distribution of whiting? Testing environmental hypotheses using statistical and GIS techniques'. ICES Journal of Marine Science 59(2): 239-253

[127] UK Government (2017) 'The Conservation of Habitats and Species Regulations 2017'. Available at: https://www.legislation.gov.uk/uksi/2017/1012/contents (Accessed 01/10/2024)

[128] IUCN (2023) 'IUCN Red List of Threatened Species'. Available at: https://www.iucnredlist.org (Accessed 01/10/2024)

[129] Vladić, T. and Petersson, E. (2015) 'Relationship between size, age and maturity in atlantic salmon'. VLADIĆ, T. and PETERSSON, E. Evolutionary Biology of the Atlantic Salmon. CRC Press, Boca Raton, 165-184

[130] Thorstad, E.B., Whoriskey, F., Rikardsen, A.H. and Aarestrup, K. (2011) 'Aquatic nomads: the life and migrations of Atlantic salmon'. Page 1-32 in Aas, Ø., Einum, S., Klemetsen, A. and Skurdal, J. Atlantic Salmon Ecology. Wiley-Blackwell

[131] McCormick, S.D., Hansen, L.P., Quinn, T. and Saunders, R.L. (1998) 'Movement, migration and smolting of Atlantic salmon (*Salmo salar*)'. Canadian Journal of Fisheries and Aquatic Sciences 55 (suppl. 1): 77-92

[132] Kocik, J.F., Hawkes, J.P., Sheehan, T.F., Music, P.A. and Beland, K.F. (2009) 'Assessing estuarine and coastal migration and survival of wild Atlantic salmon smolts from the Narraguagus River, Maine using ultrasonic telemetry'. In American Fisheries Society Symposium (Vol. 69, pp. 293-310)

[133] Thorstad E.B, Whoriskey, F., Uglem, I., Moore, A., Rikardsen, A.H. and Finstad, B. (2012) 'A critical life stage of the Atlantic salmon *Salmo salar*: behaviour and survival during the smolt and initial postsmolt migration'. Journal of Fish Biology 81: 500-542

[134] Thorstad, E.B., Økland, F., Finstad, B., Sivertsgård, R., Plantalech, N., Bjørn, P.A. and McKinley, R.S. (2007) 'Fjord migration and survival of wild and hatchery-reared Atlantic salmon and wild brown trout post-smolts'. Hydrobiologia 582: 99-107

[135] Davidsen, A., Rikardsen, A.H., Thorstad, E.B., Halttunen, I., Mitamura, H., Præbel, K., Skarðhamar, J. and Fredrik, T. (2013) 'Homing behaviour of Atlantic salmon (*Salmo salar*) during final phase of marine migration and river entry'. Canadian Journal of Fisheries and Aquatic Sciences 70(5): 794-802

[136] Holm, M., Jacobsen, J.A., Sturlaugsen, J. and Holst, J.C. (2006) 'Behaviour of Atlantic salmon (*Salmo salar L*) recorded by data storage tags in the NE Atlantic – implications for interception by pelagic trawls'. ICES, ASC-CM2006/Q:12

[137] Godfrey, J.D., Stewart, D.C., Middlemas, S.J. and Armstrong, J.D. (2014) 'Depth use and migratory behaviour of homing Atlantic salmon (*Salmo salar*) in Scottish coastal waters. ICES Journal of Marine Science 72(2): 568-575

[138] Godfrey, J.D., Stewart, D.C., Middlemas, S.J. and Armstrong, J.D. (2015) 'Depth use and migratory behaviour of homing Atlantic salmon (*Salmo salar*) in Scottish coastal waters in relation to marine renewables developments'. Scottish Marine and Freshwater Science 5, No. 18

[139] Stewart, D.C., Middlemas, S.J. and Youngson, A.F. (2006) 'Population structuring in Atlantic salmon (*Salmo salar*): evidence of genetic influence on the timing of smolt migration in sub-catchment stocks'. Ecology of Freshwater Fish 15(4): 552-558

[140] Solomon, D.J. and Sambrook, H.T. (2004) 'Effects of hot dry summers on the loss of Atlantic salmon, *Salmo salar*, from estuaries in South West England'. Fisheries Management and Ecology 11(5)

[141] Mills, D.M. (1989) 'Biology and Management of Atlantic Salmon'. Chapman and Hall

[142] Newton, M., Main, R. and Adams, C. (2017) 'Atlantic Salmon Salmo Salar smolt movements in the Cromarty and Moray Firths, Scotland'. The University of Glasgow

[143] Thorstad, E.B., ØKland, F., Finstad, B., Sivertsgård, R., Bjorn, P.A. and McKinley, R.S. (2004) 'Migration speeds and orientation of Atlantic salmon and sea trout post-smolts in a Norwegian fjord system'. Environmental Biology of Fishes 71: 305-311

[144] Finstad, B., Økland, F., Throstad, E.B., BjØrn, A.B. and McKinley, R.S. (2005) 'Migration of hatchery reared Atlantic salmon and wild anadromous brown trout post-smolts in a Norwegian fjord system'. Journal of Fish Biology 66 (1): 86-96

[145] Malcolm, I.A., Godfrey, J. and Youngson, A.F. (2010) 'Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables'. Marine Scotland Science. Available

at: https://data.marine.gov.scot/dataset/review-migratory-routes-and-behaviour-atlantic-salmon-sea-trout-and-european-eel-scotland%E2%80%99s (Accessed 01/10/2024)

[146] Malcolm, I.A., Millar, C.P. and Millidine, K.J. (2015) 'Spatio-temporal variability in Scottish smolt emigration times and sizes'. Scottish Marine and Freshwater Science. Volume 6, Number 2

[147] Gardiner, R., Main, R. K., Gilbey, J., Kynoch, R. J. and Davies, I. M. (2018) 'Salmon smolt trawl work in connection with marine renewables developments 50th year and 100th meeting of the Scottish Freshwater Group, Stirling, UK, 19-20 April 2018'

[148] Malcolm, I.A., Millidine, K.J., Jackson, F.L., Glover, R.S. and Fryer, R.J. (2023) 'The national electrofishing programme for Scotland (NEPS) 2019'. Scottish Marine and Freshwater Science Reports 14(2): p.63

[149] Scottish Government (2023) 'Scottish Fisheries Statistics 2023' Available at: https://www.gov.scot/publications/scottish-salmon-sea-trout-fishery-statistics-2023/ (Accessed 01/10/2024)

[150] Armstrong, J.D., Bean, C.W. and Wells, A., (2018) 'The Scottish invasion of pink salmon in 2017'. Journal of Fish Biology 93(1): 8-11

[151] Skóra, M.E., Jones, J.I., Youngson, A.F., Robertson, S., Wells, A., Lauridsen, R.B. and Copp, G.H. (2023) 'Evidence of potential establishment of pink salmon *Oncorhynchus gorbuscha* in Scotland'. Journal of Fish Biology 102(3): 721-726

[152] ICES (2021) 'Working group on North Atlantic Salmon (WGNAS)'. ICES Scientific Reports. 3:29. 407

[153] Defra (2015) '2010 to 2015 Grnment Policy Freshwater Fisheries'. Available at: https://www.gov.uk/government/publications/2010-to-2015-government-policy-freshwater-fisheries/2010-to-2015-government-policy-freshwater-fisheries (Accessed 01/10/2024)

[154] The Council of Europe (1979) 'Appendix III of the Bern Convention'. Available at: https://www.coe.int/en/web/bern-convention/appendices (Accessed 01/10/2024)

[155] UK Government (2017) 'The Conservation of Habitats and Species Regulations (2017)'. Available at: https://www.legislation.gov.uk/uksi/2017/1012/contents/made (Accessed 01/10/2024)

[156] UK Government (1981) 'Schedule 5 of the Wildlife and Countryside Act'. Available at: https://www.legislation.gov.uk/ukpga/1981/69/schedule/5 (Accessed 01/10/2024)

[157] Igoe, F., Quigley, D.T.G., Marnell, F., Meskell, E., O'Connor, W. and Byrne, C. (2004) 'The sea lamprey *Petromyzon marinus* (*L.*), river lamprey *Lampetra fluviatilis* (*L.*) and brook lamprey *Lampetra planeri* (*Bloch*) in Ireland: general biology, ecology, distribution and

status with recommendations for conservation. Biology and Environment'. Proceedings of the Royal Irish Academy, Section B, 104B-S: 43-56

[158] Maitland, P.S., Renaud, C.B., Quintella, B.R., Close, D.A. and Docker, M.F. (2015) 'Conservation of native lampreys'. Lampreys: Biology, Conservation and Control: Volume 1: 375-428

[159] National Biodiversity Network (NBN) (2020) 'National Lamprey Survey of Scotland (2003-2005)'. Available at: https://registry.nbnatlas.org/public/show/dr2127 (Accessed 01/10/2024)

[160] Joint Nature Conservation Committee (JNCC) (2021c) 'Natural England and JNCC guidance on key sensitivities of habitats and Marine Protected Areas in English waters to aggregate resource extraction'. Available at: https://data.jncc.gov.uk/data/6e02f22c-846f-400b-80a4-38f549e52c00/JNCC-Report-694-FINAL-WEB.pdf (Accessed 01/10/2024)

[161] JNCC (2021d) 'Twaite shad *Alosa fallax'*. Available at: https://sac.jncc.gov.uk/species/S1103/ (Accessed 01/10/2024)

[162] Arula, T., Shpilev, H., Raid, T., Vetemaa, M. and Albert, A. (2017) 'Maturation at a young age and small size of European smelt (*Osmerus eperlanus*): A consequence of population overexploitation or climate change?'. Helgoland Marine Research 71: 1-9

[163] Jorgensen, S.J., Micheli, F., White, T.D., Van Houtan, K.S., Alfaro-Shigueto, J., Andrzejaczek, S., Arnoldi, N.S., Baum, J.K., Block, B., Britten, G.L., Butner, C., Caballero, S., Cardeñosa, D., Chapple, T.K., Clarke, S., Cortés, E., Dulvy, N.K., Fowler, S., Gallagher, A.J., Gilman, E., Godley, B.J., Graham, R.T., Hammerschlag, N., Harry, A.V., Heithaus, M.R., Hutchinson, M., Huveneers, C., Lowe, C.G., Lucifora, L.O., MacKeracher, T., Mangel, J.C., Martins, A.P.B., McCauley, D.J., McClenachan, L., Mull, C., Natanson, L.J., Pauly, D., Pazmiño, D.A., Pistevos, J.C.A., Queiroz, N., Roff, G., Shea, B.D., Simpfendorfer, C.A., Sims, D.W., Ward-Paige, C., Worm, B. and Ferretti, F. (2022) 'Emergent research and priorities for shark and ray conservation'. Endangered Species Research 47: 171–203

[164] OSPAR (2024) 'List of Threatened and/or Declining Species and Habitats | OSPAR Commission'. Available at: https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats (Accessed 01/10/2024)

[165] Marlin (2023) 'Marine life Information Network'. Available at: https://www.marlin.ac.uk/ (Accessed 01/10/2024)

[166] UK Parliament (2000) 'Countryside Rights of Way Act 2000'. Available at: https://www.legislation.gov.uk/ukpga/2000/37/contents (Accessed 01/10/2024)

[167] Scottish Parliament (2004) 'Nature Conservation (Scotland) Act 2004'. Available at: Nature Conservation (Scotland) Act 2004 (legislation.gov.uk) (Accessed 01/10/2024)

[168] Austin, R.A., Hawkes, L.A., Doherty, P.D., Henderson, S.M., Inger, R., Johnson, L., Pikesley, S.K., Solandt, J.L., Speedie, C. and Witt, M.J. (2019) 'Predicting habitat suitability

for basking sharks (*Cetorhinus maximus*) in UK waters using ensemble ecological niche modelling'. Journal of Sea Research 153: 101767

[169] APEM (2024) 'Final Report – Ocean Winds Caledonia OWF Digital Aerial Surveys, May 2021 to April 2023'. APEM Scientific Report P6477. Ocean Winds UK Ltd, 14/03/2024, 718pp., v1.4

[170] Cosgrove, P., Hastie, L., Watt, J., Sime, I. and Boon, P.J. (2012) 'Scotland's freshwater pearl mussels: the challenge of climate change'. River conservation and management: 121-132

[171] Chartered Institute of Ecology and Environmental Management (CIEEM) (2018) 'Guidelines for Ecological Impact Assessment (EcIA)'. Available at: https://cieem.net/resource/guidelines-for-ecological-impact-assessment-ecia/ (Accessed 01/10/2024)

[172] UK Parliament (2006) 'Natural Environment and Rural Communities Act 2006 (NERC)'. Available at: https://www.legislation.gov.uk/ukpga/2006/16/contents (Accessed 01/10/2024)

[173] Scottish Parliament (2016) 'The Conservation of Salmon (Scotland) Regulations 2016'. Available at: https://www.legislation.gov.uk/ssi/2016/115/contents/made (Accessed 01/10/2024)

[174] Scottish Parliament (2003) 'Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003'. Available at: https://www.legislation.gov.uk/asp/2003/15/contents (Accessed 01/10/2024)

[175] Scottish Government (2010) 'Scottish Eel Management Plan (2010)'. Available at: https://www.gov.scot/publications/eel-management-plan/ (Accessed 01/10/2024)

[176] Scottish Government (2022) 'Scottish Wild Salmon Strategy'. Available at: https://www.gov.scot/publications/scottish-wild-salmon-strategy/ (Accessed 01/10/2024)

[177] Defra (2021) 'Implementation of UK Eel Management Plans (2017 to 2020). Available at: https://www.gov.uk/government/publications/implementation-of-uk-eel-management-plans-2017-to-2020 (Accessed 01/10/2024)

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