Liverpool Bay CCS Ltd
HYNET CARBON DIOXIDE TRANSPORTATION AND STORAGE PROJECT - OFFSHORE

Environmental Statement
Volume 3, appendix I: Marine Biodiversity Technical Report

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Liverpool Bay CCS Limited
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Marine Biodiversity Technical Report

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Glossary

Term	Meaning
Annelid	A worm of the phylum Annelida. Also known as the ringed worms or segmented worms, they are a large phylum represented in the marine environment by ragworms, lugworms and tubeworms.
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment
Benthic fish	Fish that live on or near the sea bottom, irrespective of the depth of the sea. Many benthic species have modified fins, enabling them to crawl over the bottom; others have flattened bodies and can lie on the sand; others live among weed beds, rocky outcrops, and coral reefs
Benthopelagic fish	Benthopelagic fish, a group of demersal fish that typically usually float or swim in the water column just above the sea floor both in shallow coastal waters or deep waters offshore. Examples of benthopelagic species in the Irish Sea include dogfish, cod, haddock, whiting, monkfish and saithe.
Biotope	A well-defined geographical area characterised by specific ecological conditions which supports a particular community of organisms.
Bivalve	A large class of molluscs, also known as pelecypods. They have a hard calcareous shell made of two parts or 'valves'.
Celtic Seas ecoregion	The Celtic Seas ecoregion covers the north-western European continental shelf and seas, from west Brittany (France) to the north of Shetland (Scotland).
Circalittoral	The subtidal zone that extends from the lower limit of the area dominated by seaweeds and algae (the infralittoral) to the maximum depth at which photosynthesis is still possible.
Crustacean	A member of the subphylum Crustacea, including crabs, lobsters, shrimps, barnacles and sand hoppers.
Demersal fish	Fish species that live close to the sea floor and are generally bottom feeders. This includes benthic fish which rest on the sea floor and benthopelagic fish that swim or float above it (see above).
Echinoderm	Radially symmetrical animals belonging to the phylum Echinodermata that includes sea stars, brittle stars, feather stars, sea urchins and sea cucumbers.
Elasmobranchs	Fish with a cartilaginous skeleton including sharks, rays and skates).
Environmental Impact Assessment	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Impact Assessment (EIA) Report.
Epifauna	Animals living on the surface of the seabed.
Habitat	The environment that a plant or animal lives in.
Infauna	The animals living in the sediments of the seabed.
Intertidal area	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS).
Littoral	The coastal zone which extends from the high water mark to areas that are permanently submerged. In ecology, the lower extent is defined by the area within which sunlight reaches the seabed. In physical oceanography it includes areas with significant tidal flows and energy dissipation, thus may cover most of the continental shelf.

Term	Meaning
Mollusc	Invertebrate animal belonging to the phylum Mollusca that includes the snails, clams, chitons, tusk shells, and cephalopods (octopus, squid, cuttlefish).
Multivariate	Having or involving a number of independent mathematical or statistical variables.
Neritic	Shallow seas near a coastline.
Nursery	A habitat where juveniles of a species regularly occur as a population.
Pelagic fish	Fish species that inhabit the middle and upper part of the water column. Examples in Irish waters include herring, mackerel and sprat.
Polyaromatic hydrocarbons (PAHs)	A class of chemicals containing multiple ring structures made of carbon atoms, that commonly occur in coal, crude oil, and refined products.
Polychlorinated biphenyls (PCBs)	A family of manmade substances containing carbon ring structures with chlorine atoms bound to them. They are highly carcinogenic and though most were banned in 1986, they persist in the environment and organisms for many decades.
Porifera	A phylum of aquatic invertebrate animals comprising the sponges.
Project	The HyNet Carbon Dioxide Transportation and Storage Project.
Proposed Development	The offshore components of the Project which are subject of this Environmental Statement, as described in chapter 3: Proposed Development Description.
SIMPER (Similarities Percentage)	Calculates the contribution of each species (%) to the dissimilarity between each two groups.
SIMPROF (Similarity Profile Routine)	A series of numerical tests run on biotic data which looks for statistically significant evidence of genuine clusters of sites which were previously unstructured.
Species	A group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.
Redds	Areas of river bed where fish make hollows to spawn in.
Shellfish	For the purposes of this assessment, shellfish is considered a generic term to define molluscs and crustaceans.
Spawning grounds	The areas where species spawn or produce their eggs.
Special Area of Conservation (SAC)	A site designation specified in the Habitats Directive (Council Directive 92/43/EEC). Each site is designated for one or more of the habitats and species listed in the Directive. The Directive requires that a management plan be prepared and implemented for each SAC to ensure the favourable conservation status of the habitats or species for which it was designated. In combination with SPAs, these sites contribute to the 'Natura 2000' or 'European' Sites network.
Sublittoral	Also termed subtidal. The area extending seaward of low tide to the edge of the continental shelf.
Subtidal	See above.
The Applicant	This is Liverpool Bay CCS Ltd.

Acronyms and Initialisations

Acronym and Initialisation	Description
AFDW	Ash Free Dry Weight
AL	Action Level
As	Arsenic
BEIS	Department for Business, Energy, and Industrial Strategy
BGS	British Geological Survey
BSH	Broadscale Habitat
CCS	Carbon Capture and Storage
CCME	Canadian Council of Ministers of the Environment
CCW	Countryside Council for Wales
Cd	Cadmium
Cefas	Centre for Environment, Fisheries, and Aquaculture Science
CFP	Common Fisheries Policy
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMACS	Centre for Marine and Coastal Studies Ltd.
CO_2	Carbon Dioxide
Cr	Chromium
Cu	Copper
CV	Coefficient of Variation
DAERA	Department of Agriculture, Environment and Rural Affairs
DDC	Drop Down Cameras
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food, and Rural Affairs
EIA	Environmental Impact Assessment
EIRPHOT	Irish and Celtic Sea Database for Grey Seal
EMODnet	European Marine Observation and Data Network
EPA	Environmental Protection Agency
ERL	Effect Range Low
ES	Environmental Statement
EUNIS	European Nature Information Systems
FIL	Flesh and Intravalvular Liquid

Acronym and Initialisation	Description
FOCI	Feature of Conservation Interest
FSA	Food Standards Agency
GPS	Global Positioning System
gS	Gravelly Sand
gmS	Gravelly Muddy Sand
(g)mS	Slightly Gravelly Muddy Sand
Hg	Mercury
HPI	Habitat of Principal Importance
HRA	Habitats Regulation Appraisal
IAMMWG	Inter-Agency Marine Mammal Working Group
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Seas
IEF	Important Ecological Feature
IFCA	Inshore Fisheries and Conservation Authority
IHLS	International Herring Larval Survey
INNS	Invasive Non-Native Species
ISQG	Interim Sediment Quality Guidelines
JCP	Joint Cetacean Protocol
JNCC	Joint Nature Conservation Committee
LBA CCS T&S Project	Liverpool Bay Carbon Capture, Transport and Storage Project
MarLIN	Marine Life Information Network
MCZ	Marine Conservation Zone
MHWS	Mean High Water Springs
MLS	Minimum Landing Size
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MNR	Marine Nature Reserve
MPA	Marine Protected Area
MPN	Most Probable Number
msG	Muddy Sandy Gravel
MU	Management Unit
MWDW	Manx Whale and Dolphin Watch
NBN	National Biodiversity Network
NEA	Norwegian Environmental Agency

Acronym and Initialisation	Description
Ni	Nickel
NIHLS/NINEL	Northern Irish Herring Larvae Survey
NJDEP	New Jersey Department of Environmental Protection
NMBAQC	North East Atlantic Marine Biological Analytical Quality Control
nMDS	Non-Metric Multidimensional Scaling
NPWS	National Parks and Wildlife Service
NRW	Natural Resources Wales
NW	North-west
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	Oslo and Paris Convention
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PCB	Polychlorinated Biphenyls
PEL	Probable Effect Level
PoA	Point of Ayr
PSA	Particle Size Analysis
Q1	Quarter 1
Q4	Quarter 4
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCOS	Special Committee on Seals
SE	Standard Error
SEA	Strategic Environmental Assessment
sG	Sandy Gravel
SIMPER	Similarities Percentage
SIMPROF	Similarity Profile Routine
SMRU	Sea Mammal Research Unit
SPI	Species of Principal Importance
SSSI	Site of Special Scientific Interest
SW	South West
TEL	Threshold Effects Levels
THC	Total Hydrocarbon Content
WoRMS	World Register of Marine Species
Zn	Zinc

Units

Unit	Description
cm	Centimetre (distance)
g	Grammes (mass)
km	Kilometre (distance)
km^2	Square kilometre (area)
L	Litre (volume)
m	Metre (distance)
m^2	Square metre (area)
mg/kg	Milligrams per kilogram (concentration)
ml	Millilitre (volume)
mm	Millimetre (distance)
µg/kg	Micrograms per kilogram (concentration)
µm	Micrometres (size)
%	Percentage

Contents

Tables

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1 MARINE BIODIVERSITY TECHNICAL REPORT

1.1 Introduction

This Marine Biodiversity Technical Report presents the baseline environmental information for the HyNet Carbon Dioxide Transportation and Storage Project (hereafter referred to as ‘the Project’). The Project has both onshore and offshore components, and the Environmental Statement (ES) has been prepared for the offshore components, referred to as ‘the Proposed Development’.

The purpose of this Marine Biodiversity Technical Report is to provide a detailed review of the marine ecological receptors that are found within and adjacent to the Proposed Development. These receptors include subtidal and intertidal benthos, fish and shellfish, marine mammals, and marine turtles.

The Proposed Development includes the construction of the Carbon Dioxide (CO_2) onshore pipeline network, the repurposing of the existing Point of Ayr (PoA) natural gas terminal for CO_2 service, the CO_2 storage offshore and associated transportation and injection facilities, including pipelines and wells.

1.2 Scope

The Proposed Development includes both Onshore and Offshore elements. This Marine Biodiversity Technical Report only includes the baseline characterisation for receptors that can be found seaward of Mean High Water Spring (MHWS).

1.3 Structure

This Marine Biodiversity Technical Report is structured as follows:

- section 2: Benthic Subtidal and Intertidal Ecology;
- section 3: Fish and Shellfish Ecology; and
- section 4: Marine Mammals and Marine Turtles.

2 BENTHIC SUBTIDAL AND INTERTIDAL ECOLOGY

2.1 Introduction

This section of the Biodiversity Technical Report provides a detailed baseline characterisation of the benthic subtidal and intertidal ecology within the Proposed Development and the wider region. Data have been collated through a detailed desktop review of relevant material within the region, and through the results of site-specific surveys.

2.2 Methodology

An initial desktop review has been undertaken to inform that baseline, which includes a range of academic reports and the results of site-specific surveys conducted for other projects within the regional benthic subtidal and intertidal ecology study area. This desktop review provides further context to the results of the site-specific surveys undertaken for the Proposed Development. Further detail on data sources is provided in Section 2.3.1.

An overview of the field surveys is provided in section 2.2.4, while a summary of the methodology and results are presented in sections 2.3.2 and 2.3.3. The full survey reports are included in volume 3, appendix I1, volume 3, appendix I2.

2.2.1 Study area

Two study areas were defined to characterise benthic subtidal and intertidal ecology:

- The Proposed Development benthic ecology study area: This is defined as the area encompassing the Eni Development Area, offshore pipeline (including intertidal habitats up to the MHWS), and associated cables in Liverpool Bay (Figure 2.1). This is the area within which site-specific benthic surveys have been undertaken, the results of which have informed the baseline characterisation within this Technical Report.
- The regional benthic ecology study area: This is defined as the area encompassing the wider Irish Sea habitats and includes the neighbouring consented Offshore Wind Farms (OWFs) and designated sites (Figure 2.1). This area has been characterised using desktop data and provides a wider context to the site-specific data collected within the benthic ecology study area.

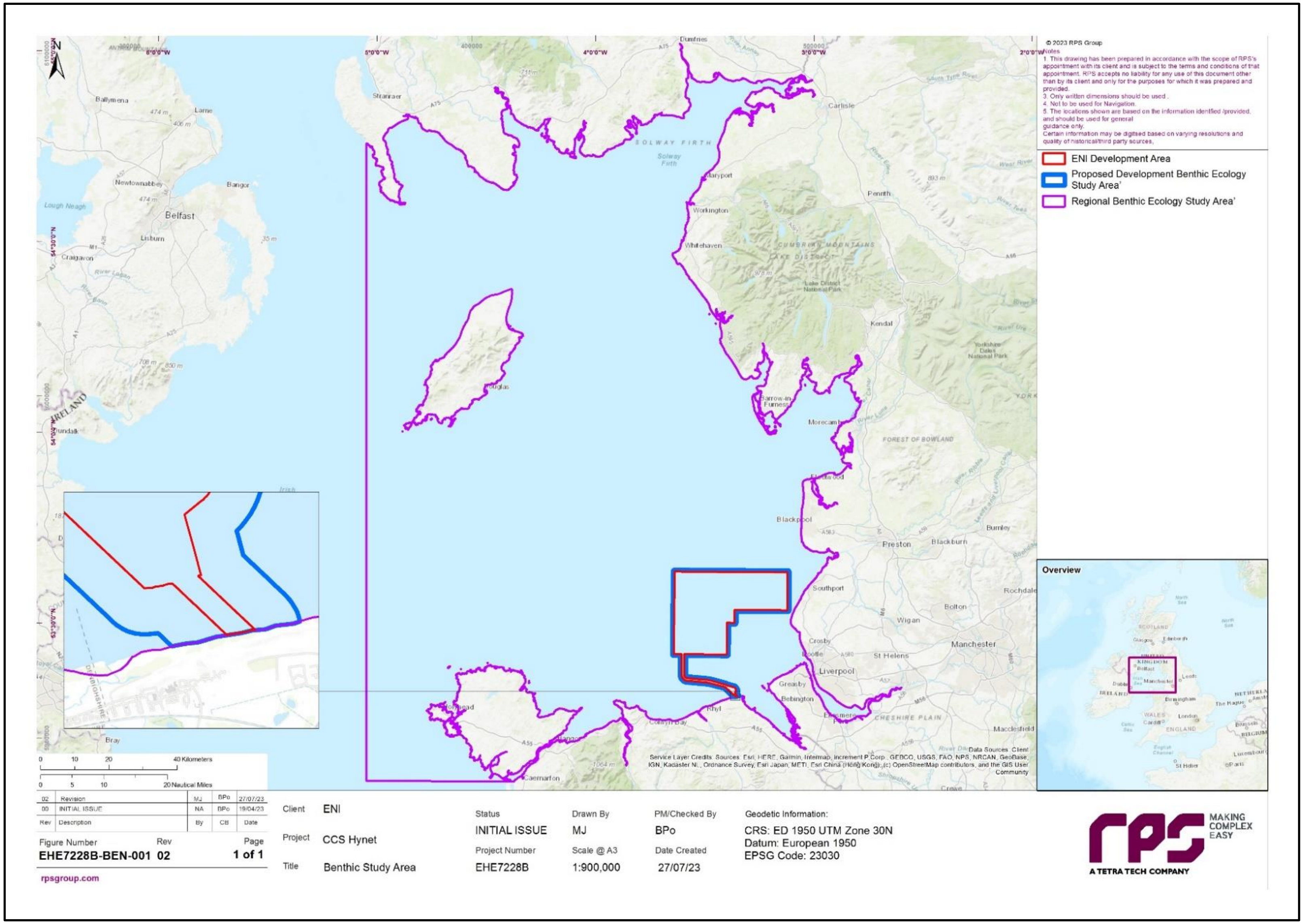

Figure 2.1: Benthic Ecology Study Areas

2.2.2 Consultation

A summary of the key issues raised during consultation specific to benthic ecology is presented in Table 2.1 below.

Table 2.1: Summary Of Key Consultation Issues Raised During Consultation Activities Undertaken For The Project Relevant To Benthic Ecology

Date	Consultee and type of response	Issues raised
30 March 2022	Natural Resources Wales (NRW) advice during a meeting on the intertidal ecological survey approach	NRW recognised that the timing and spatial extent of the intertidal survey was proportionate for the spatial and temporal extent of the proposed shore works.
		RPS presented the proposed methodology for the subtidal survey and showed that a cruciform sampling pattern would be applied at each platform site. Triplicate sampling and physicochemical analysis would be carried out at for each sample location. NRW confirmed that the methodology was proportionate to identified risks and that it reflected standard approaches
		NRW advised that the existing datasets, combined with those available from the British Geological Survey (BGS), and the proposed project-specific surveys should provide an adequate baseline for the offshore baseline.
27 January 2023	Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) Scoping Opinion response	*"All relevant environmental data is expected to be sourced, analysed, and presented in relation to the Project. A non-exhaustive list of potential sources of environmental information is provided in Annex 2 but the Developer is expected to consult such other sources as it considers necessary."* *"Relevant local environmental data should also be sourced from the appropriate local bodies which may include local environmental records centre, the local wildlife trust, local geo-conservation groups or other recording societies."*
		"The ES should assess the environmental effects of the Project upon features of nature conservation interest. It is recommended that the ES thoroughly assesses the potential for the Project to affect national or international sites of nature conservation importance. This should include a full assessment of the direct and indirect effects of the Project on the features of all important nature conservation sites including, but not limited to, Natural England's Impact Risk Zones, Site of Special Scientific Interest (SSSIs), and Marine Conservation Zones (MCZs)."
		"The distance of the offshore elements of the Project to the Dee Estuary SAC is stated as 12km in Table 7-2 [Of the Scoping Report]. However, it is

Date	Consultee and type of response	Issues raised
		noted that a section of the Power and Fibre-Optic Cable from the PoA to the Douglas Platform falls within the Dee Estuary SAC, and so the distance should be revised to account for this.”
		“*The following Annex I habitats that are also present as a qualifying feature of Menai Strait and Conwy Bay SAC, should be included in the table even though they are not a primary reason for selection of the site: Large shallow inlets and bays; and submerged or partially submerged sea caves*.”

2.2.3 Desktop study

Information on benthic ecology was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 2.2, below.

Table 2.2: Summary Of Key Reports For The Desktop Characterisation Of The Benthic Ecology Baseline

Title	Source	Year	Author
UK Offshore Energy Strategic Environmental Assessment Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil & Gas and Gas Storage and Associated Infrastructure OESEA4 2022 Environmental Report	Department for Business, Energy, and Industrial Strategy (BEIS)	2022	BEIS
National Biodiversity Network (NBN) Atlas	NBN Atlas	2021	NBN Atlas
Awel y Môr Preliminary Environmental Information Report: Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology	RWE Renewables UK	2021a	RWE Renewables UK
Awel y Môr Preliminary Environmental Information Report: Volume 4: Annex 5.3: Benthic Ecology Intertidal Characterisation	RWE Renewables UK	2021b	RWE Renewables UK
JNCC Marine Protected Area (MPA) Mapper	JNCC	2020	JNCC
European Union (EU) SeaMap	European Marine Observations and Data Network (EMODNet)	2019	EMODnet

Title	Source	Year	Author
Subtidal Ecology: In: Manx Marine Environmental Assessment (2nd Edition)	The Government of the Isle of Man	2018a	Howe
A big data approach to macrofaunal baseline assessment, monitoring and sustainable exploration of the seabed	Centre for Environment, Fisheries, and Aquaculture Science (Cefas)	2017	Cooper and Barry
Dredged material disposal site monitoring around the coast of England: results of sampling (2015-2016).	Cefas	2016	Bolam *et al.*
Burbo Bank OWF Benthic and Annex I Habitat Pre-construction Survey Field Report	Burbo Bank OWF (UK) Ltd and DONG Energy	2015	Centre for Marine and Coastal Studies (CMACS)
Rhiannon OWF Preliminary Environmental Information Chapter 9 Benthic Ecology	Celtic Array Ltd.	2014a	Celtic Array Ltd.
Walney OWF Year 3 postconstruction benthic monitoring technical survey report (2014 survey).	Walney OWF (UK) Ltd and DONG Energy	2014	CMACS
Burbo Bank Extension OWF ES Volume 2 – Chapter 12: Subtidal and Intertidal Benthic Ecology	DONG Energy	2013a	DONG Energy
Volume 1 ES Walney Extension, Chapter 10: Benthic Ecology	DONG Energy	2013b	DONG Energy
Ormonde OWF Year 1 post-construction benthic monitoring technical survey report (2012 survey)	RPS Energy	2012a	CMACS
Walney OWF Year 1 post construction benthic monitoring technical survey report (2012 survey)	Walney OWF (UK) Ltd and DONG Energy	2012b	CMACS
Burbo Bank Extension OWF Environmental Impact Assessment (EIA) Scoping Report	DONG Energy	2010	Sørensen *et al*., 2010

Title	Source	Year	Author
Burbo Bank OWF Pre-construction Contaminants Investigation	Burbo Bank OWF (UK) Ltd and DONG Energy	2005a	CMACS,
Gwynt y Môr OWF Marine Ecology Technical Report	CMACS	2005b	CMACS
Gwynt y Môr OWF ES Volume 1	npower renewables Ltd. and Gwynt y Môr OWF	2005	npower renewables Ltd.
Post-construction Results from The North Hoyle OWF	North Hoyle OWF	2005	May
Broadscale seabed survey to the east of the Isle of Man	The University of Liverpool for British Petroleum	1997	Holt *et al.*
Offshore benthic communities of the Irish Sea	Mackie	1990	Mackie

2.2.4 Site-specific surveys

Two site-specific benthic surveys were used to support the characterisation of the baseline. One survey was undertaken by Ocean Ecology aboard the dedicated survey vessel, the ‘Argyll Explorer’ in 2022. This survey was undertaken to support multiple projects, but included sample collection from across the Eni Development Area. Samples were taken at the Carbon Capture Storage (CCS) area, which encompassed the pipelines and associated infrastructure for CCS, and at existing Eni oil and gas infrastructure that is proposed to be fully or partially decommissioned (Figure 2.2). These decommissioning works are outwith the scope of this assessment, however, the data have been included in order to provide a more comprehensive baseline across the Eni Development Area, although it should be noted that the decommissioning scope is considered a separate project, therefore data are not integrated with that collected at the CCS stations. Given the format of the Ocean Ecology report and how the data was analysed, the results are presented for the CCS area, and the partial and full decommissioning areas, and are not aggregated into one dataset.

The second survey was undertaken along the intertidal zone in North Wales, at either side of the existing pipeline connecting the PoA to the Douglas platform. A summary of these surveys is presented in Table 2.3. A brief overview of the results are provided in section 2.3.2, and section 2.3.3, with the full reports provided in volume 3, appendix I1 and volume 3, appendix I2.

Table 2.3: Summary Of Site-Specific Survey Data

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Hynet CCS and Decommissioning Benthic Characterisation Survey	Samples were collected at various locations across the Eni Development Area: (1) the CCS	Data were collected at 85 sampling stations using Drop Down Cameras (DDCs) and grab	Ocean Ecology	2022	Summarised in section 2.3.2 and presented in full in volume 3, appendix I1

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
	area and all associated infrastructures, and (2) existing Eni oil and gas infrastructure that is proposed to be either partly or fully decommissioned and repurposed.	sampling (0.1 m^2 Day grab, 0.2 m^2 dual Van Veen grab, and a 0.1 m^2 mini-Hamon grab).			
Phase 1 Intertidal Walkover Survey	A 500 m buffer either side of the existing 20" natural gas pipeline connecting the PoA Terminal to the Douglas platform was surveyed from MHWS to approximately Mean Low Water Springs (MLWS). This was undertaken near Prestatyn, North Wales.	A walkover survey was conducted over two days. Detailed notes on shore type, wave exposure, and sediments and species/biotopes present were collected. Exploratory digging for sub-surface fauna was undertaken on an ad hoc basis. Sieving was undertaken at seven sampling stations using a 0.5 mm mesh.	RPS	2022	Summarised in section 2.3.3 and presented in full in volume 3, appendix I2

2.2.4.1 Benthic characterisation survey

Sample collection

A total of 85 sampling stations were targeted (Figure 2.2) across the Eni Development Area, using DDC and grab sampling. Grab samples were collected for macrobenthos, Particle Size Analysis (PSA) and chemical analyses (Table 2.4).

Table 2.4: Sampling Strategy

Site	Number of Sampling Stations Proposed		
	DDC	Macrobenthic Grab and PSA	Chemical Analysis
CCS Area	26	24	14
Decommissioning Area			
Partial	32	32	32
Full	27	21	21
Total	85	77	67

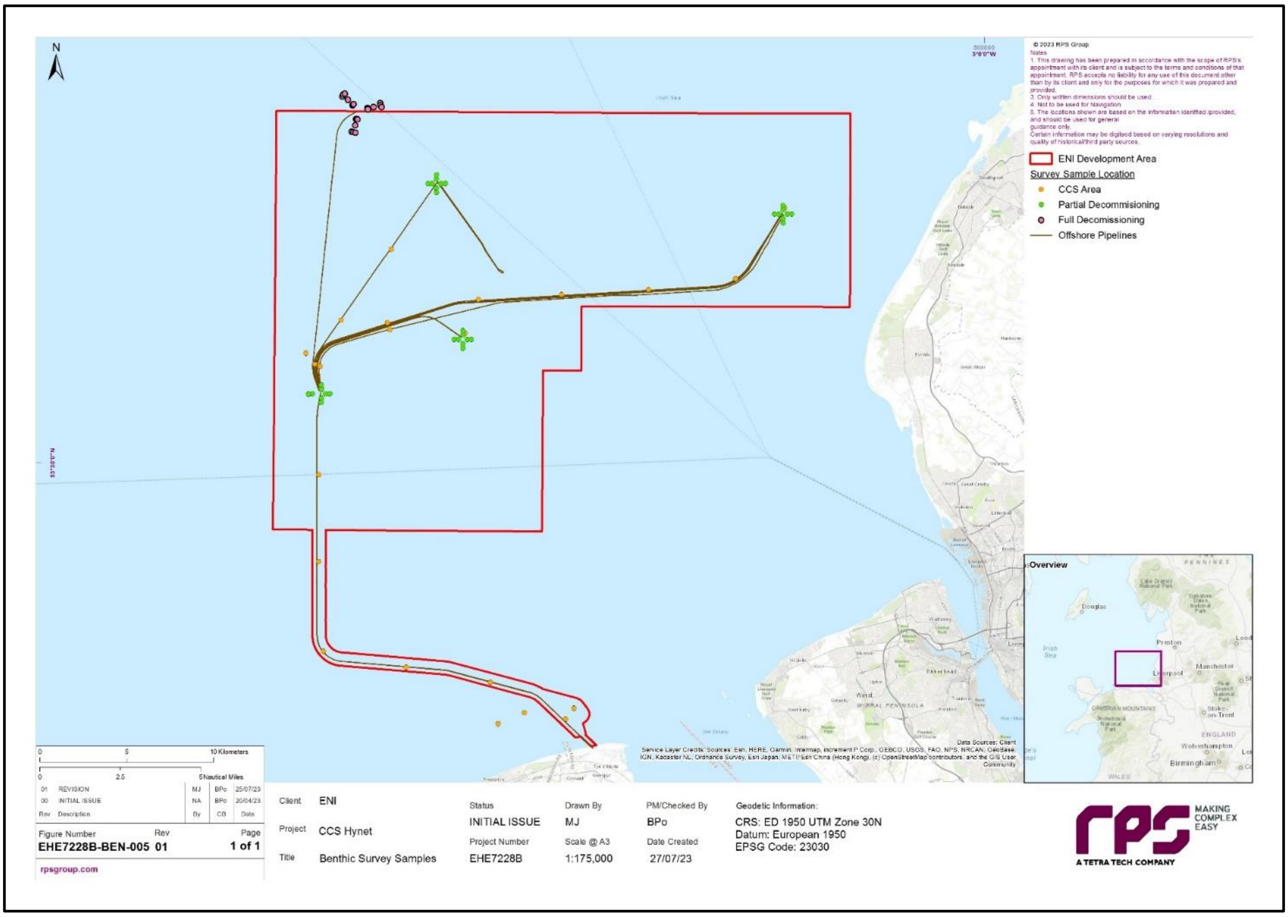

Figure 2.2: Site-Specific Survey Sampling Locations

All seabed imagery was collected in following JNCC epibiota remote monitoring operational guidelines (Hitchin *et al*. 2015). At each DDC station, a minimum of two minutes of video footage and five seabed stills images were obtained. The vessel was positioned within a 20 m radius of the target location to adequately characterise the target area. All video footage was reviewed *in situ* by Ocean Ecology's environmental scientists. The camera was kept as close to the seabed as possible to gain a clear image where possible, while also being high enough in the water column to prevent accidental collisions with the seabed.

Grabs were deployed using an A-frame mounted winch equipped with a Dyneema line. To ensure consistency in sampling, grab samples were screened by the lead marine ecologist and considered unacceptable if:

- the sample was less than 5 L (i.e. the sample represented less than half the 10 L capacity of the grab used);
- the jaws failed to close completely or were jammed open by an obstruction, allowing fines to pass through (washout or partial washout); and
- the sample was taken at an unacceptable distance from the target location (beyond 20 m).

Where a suitable sample was not collected after three attempts within 20 m of the target sampling locations, the sampling location was moved up to 50 m from the original target location. If the original location was close to subsea infrastructure, the vessel was moved in the opposite direction to the hazard. Where samples of less than 5 L were continually achieved, these were assessed on-site to establish if the sample volume was acceptable to allow subsequent analysis. No pooling of samples was undertaken.

Sample processing

Macrobenthic and PSA samples

Initial grab sample processing was undertaken onboard the survey vessel in line with the following methodology:

- Initial visual assessment of sample size and acceptability made.
- A photograph of the sample with station details taken in grab and once released.
- 10% of the sample was removed for PSA and transferred to a labelled tray.
- The remaining sample was emptied onto a 0.5 mm sieve net laid over a 4.0 mm sieve table and washed through using gentle rinsing with a seawater hose (note that all samples were sieved at 0.5 mm in the field to remove the risk of partial or full decommissioning samples being sieved at 1.0 mm. CCS samples were then sieved at 1.0 mm during sample processing upon return to Ocean Ecology's laboratory).
- The remaining sample for faunal sorting and identification was back washed into a suitable-sized sample container and diluted 10% formalin solution was added to fix the sample prior to laboratory analysis.
- Sample containers were clearly labelled internally and externally with the date, sample identification number, and project name.
- The PSA samples were frozen immediately on board the vessel.
- Detailed field notes were taken, including station number, fix number, number of attempts, sample volume, sediment type, conspicuous fauna, any sign of protected features and water depth.

Sediment contaminant samples

Detailed notes were taken of visible sediment conditions and seabed features, obvious fauna, and habitat-related features whilst in the field. Sample processing was undertaken onboard the survey vessel using the following methodology:

- Initial visual assessment of sample size and acceptability made.
- A photograph of the sample with station details taken of the grab.
- Two sub-samples for metals contaminant analysis ('A rep' and back up 'B rep') were taken from undisturbed sediment within the grab using a plastic trowel cleaned in acetone.
- Samples stored in 500 ml plastic sample containers clearly labelled externally with date, sample identification number, and project name.
- Three sub-samples for hydrocarbon contaminant analysis (2 x 'A rep' and back up 'B rep') were taken from undisturbed sediment within the grab, using a metal trowel cleaned in acetone.
- Samples were stored in 150 ml glass sample containers sealed with metal foil and clearly labelled externally with the date, sample identification number, and project name.
- All contaminant samples were frozen immediately on board.

Sample analysis

PSA

Analysis of sediment PSA was undertaken by in-house laboratory technicians at Ocean Ecology's Marine Management Organisation (MMO) validated laboratory in line with North East Atlantic Marine Biological Analytical Quality Control (NMBAQC) best practice guidance (Mason, 2016).

Frozen sediment samples were first transferred to a drying oven and thawed at 80 °C for at least six hours before visual assessment of sediment type. Before any further processing (e.g. sieving, or sub-sample removal), samples were mixed thoroughly with a spatula and all conspicuous fauna (>1 mm), which appeared to have been alive at the time of sampling removed from the sample. A representative sub-sample of the whole sample was then removed for laser diffraction analysis before the remaining sample was screened over a 0.5 mm sieve for the decommissioning sampling stations and a 1 mm sieve for the CCS sampling stations. This procedure was carried out to sort coarse and fine fractions. Care was taken so as not to overload the sieve and allow a continual flow of sediment through until the water ran clear.

The >0.5 mm and >1 mm fractions were then returned to a drying oven and dried at 80 °C for at least 24 hours before dry sieving. Once dry, the sediment samples were run through a series of Endecott BS 410 test sieves (nested at 0.5 φ intervals) using a Retsch AS200 sieve shaker to fractionate the samples into particle size classes. The samples were then transferred onto the coarsest sieve at the top of the sieve stack and shaken for a standardised period of 20 minutes. The sieve stack was checked to ensure the components of the sample had been fractioned as far down the sieve stack as their diameter would allow. A further 10 minutes of shaking was undertaken if there was evidence that particles had not been properly sorted.

The sub-samples for laser diffraction were first screened over a 0.5 mm sieve (decommissioning sampling stations) and a 1 mm sieve (CCS sampling stations), and the fine fraction residue was transferred to a suitable container and allowed to settle for 24 hours before excess water was syphoned from above the sediment surface until a paste texture was achieved. The fine fraction was then analysed by laser diffraction using a Beckman Coulter LS13 320. For silty sediments, ultrasound was used to agitate particles and prevent aggregation of fines.

The dry sieve and laser data were then merged for each sample, with the results expressed as a percentage of the whole sample at 0.5 φ intervals from -5.5 (45 mm) to >14.5 (<0.04 µm). Once data were merged, particle size distribution statistics and sediment classifications were generated from the percentages of the sediment determined for each sediment fraction using Gradistat v9 software.

Sediment descriptions were defined by their size class based on the Wentworth classification system (Wentworth, 1922). Statistics such as mean and median grain size, sorting coefficient, skewness, and bulk sediment classes (percentage silt, sand, and gravel) were derived following the Folk classification (Folk, 1954).

Sediment contamination

Sediment samples for chemical contaminant analysis were collected at all decommissioning stations and at some selected CCS stations (Table 2.4). Grab samples taken for chemical analyses were analysed for heavy and trace metals, Polycyclic Aromatic Hydrocarbon (PAH) and Total Hydrocarbon Content (THC), Organotins and Polychlorinated Biphenyls (PCBs). A total of eight main heavy and trace metals were analysed from sediment samples and could be compared to national and international reference levels. These were: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), and Zinc (Zn). Raw sediment chemistry data are provided in volume 3, appendix I1.

As the Cefas Action Levels (ALs) 1 and 2 are the only UK-specific environmental quality standards for sediment contamination, the following assessment criteria and guidelines were also used:

- Assessment criteria from the Canadian Council of Ministers of the Environment (CCME): the Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL) (CCME, 1995, 2001).
- The Oslo and Paris Convention (OSPAR) Background Assessment Concentration (BAC) (OSPAR *et al*. 2009).
- United States Environmental Protection Agency (USEPA) Effect Range Low (ERL) (New Jersey Department of Environmental Protection (NJDEP) 2009).
- Condition classes established by the Norwegian Environmental Agency (NEA) for contamination in coastal sediments (NEA, 2016, revised 2020).

Please refer to volume 3, appendix I1 for a full outline of the sediment contaminant guidelines and quality standards used for assessment.

Macrobenthic analysis

All processing of the grab samples was undertaken at Ocean Ecology's NMBAQC scheme participating laboratory in line with the NMBAQC Processing Requirement Protocol (Worsfold *et al.* 2010). All macrobenthos present was identified to species level, where possible, and enumerated by trained benthic taxonomists using the most up-to-date taxonomic literature and checks against existing reference collections.

Following identification, all specimens from each sample were pooled into five major groups (Annelida, Crustacea, Mollusca, Echinodermata, and Miscellaneous taxa) to measure blotted wet weight major group biomass to 0.0001 g. As a standard, the conventional conversion factors as defined by Eleftheriou and Basford (1989) were applied to provide equivalent dry-weight biomass. The conversion factors applied are as follows:

- Annelida = 15.5%;
- Crustacea = 22.5%;
- Mollusca = 8.5%;
- Echinodermata = 8.0%; and
- Miscellaneous = 15.5%.

Macrobenthic data analysis

The macrobenthic species list was checked using the R package 'worms' (Holstein, 2018) to check against the World Register of Marine Species (WoRMS) taxon lists and to standardise species nomenclature to accepted names. The species list was then examined carefully by a senior taxonomist to truncate the data, combining species records where differences in the taxonomic resolution were identified.

All data processing and statistical analysis were undertaken using R v.1.2 1335 (R Core Team, 2020) and PRIMER v7 (Clarke and Gorley 2015) software packages. Note that no replicate samples were available for macrobenthic analysis. Thus, no mean values could be calculated per sampling station.

The PRIMER v7 software package (Clarke and Gorley, 2015) was used to undertake the multivariate statistical analysis on the macrobenthos dataset. To fully investigate the multivariate patterns in the data, macrobenthic assemblages were characterised based on their community composition, with hierarchical clustering and non-Metric Multidimensional Scaling (nMDS) used to group sampling stations into habitat type or community clusters. Similarities Percentage Analysis (SIMPER) was then applied to identify which taxa contributed most to the similarity within each cluster.

European Nature Information Systems (EUNIS) classifications were then assigned to each group based on the latest JNCC guidance.

Seabed imagery analysis

All seabed imagery analysis was undertaken using the Bio-Image Indexing and Graphical Labelling Environment annotation platform (Langenkämper *et al.* 2017) and in line with JNCC epibiota remote monitoring interpretation guidelines (Turner *et al.* 2016). A full reef habitat assessment was conducted on all images to determine whether habitats met the definitions of Annex I reef habitats as detailed in Irving (2009) and Gubbay (2007).

Habitat classification

Habitats were identified and classified in accordance with the EUNIS habitat classification system, in line with JNCC guidance on assigning benthic biotopes (Parry, 2019). Classifications were assigned based on the combined analysis of seabed imagery and data derived from the PSA, alongside existing habitat maps (EMODnet, 2021). Seabed features were assigned as high-level a classification as possible based on the macrobenthic community observed across the survey area.

2.2.4.2 Phase 1 intertidal walkover survey

Sample collection

The survey was undertaken with reference to standard intertidal survey methodologies as outlined by Davies *et al.* (2001), Wyn and Brazier, (2001) and Wyn *et al.* (2000; 2006). The survey was carried out by an experienced marine biotope and coastal habitat surveyor with survey assistance and a health and safety presence from ecologist. The fieldwork was undertaken in April 2022 during the optimal period for intertidal biotope survey mapping namely April to October (Wyn *et al.*, 2006).

During the walkover survey, notes were made on the shore type, wave exposure, sediments/substrates present and descriptions of species/biotopes present (JNCC, 2015). The spatial relationships between these features were observed and waypoints were recorded by a hand-held Global Positioning System (GPS) device, in conjunction with hand-written descriptions and photographs. All biotopes present were identified, and their extents mapped with the aid of aerial photographs and the GPS. Biotope mosaics were mapped where biotopes coincided. Any other features within the intertidal zone were also noted including any habitats/species of conservation importance.

Exploratory digging for infauna was conducted at various locations across the beach. In addition, on-site sieving of sediments was undertaken in different biotopes at seven sampling stations (Figure 2.3). The locations of sieving stations were determined in the field to include all of the biotopes identified. The procedure involved the collection of four spade-loads (approximately 0.02 m^2) of sediment dug to a depth of 20 to 25 cm, which were then sieved through a series of stacked sieves, the finest of which was 0.5 mm mesh. All macrofauna species present were identified to as close to species level as possible in the field and counted. on site. Field notes were also taken on the physical characteristics including sediment type (Wentworth, 1922) and presence of anoxic layers in the sediment.

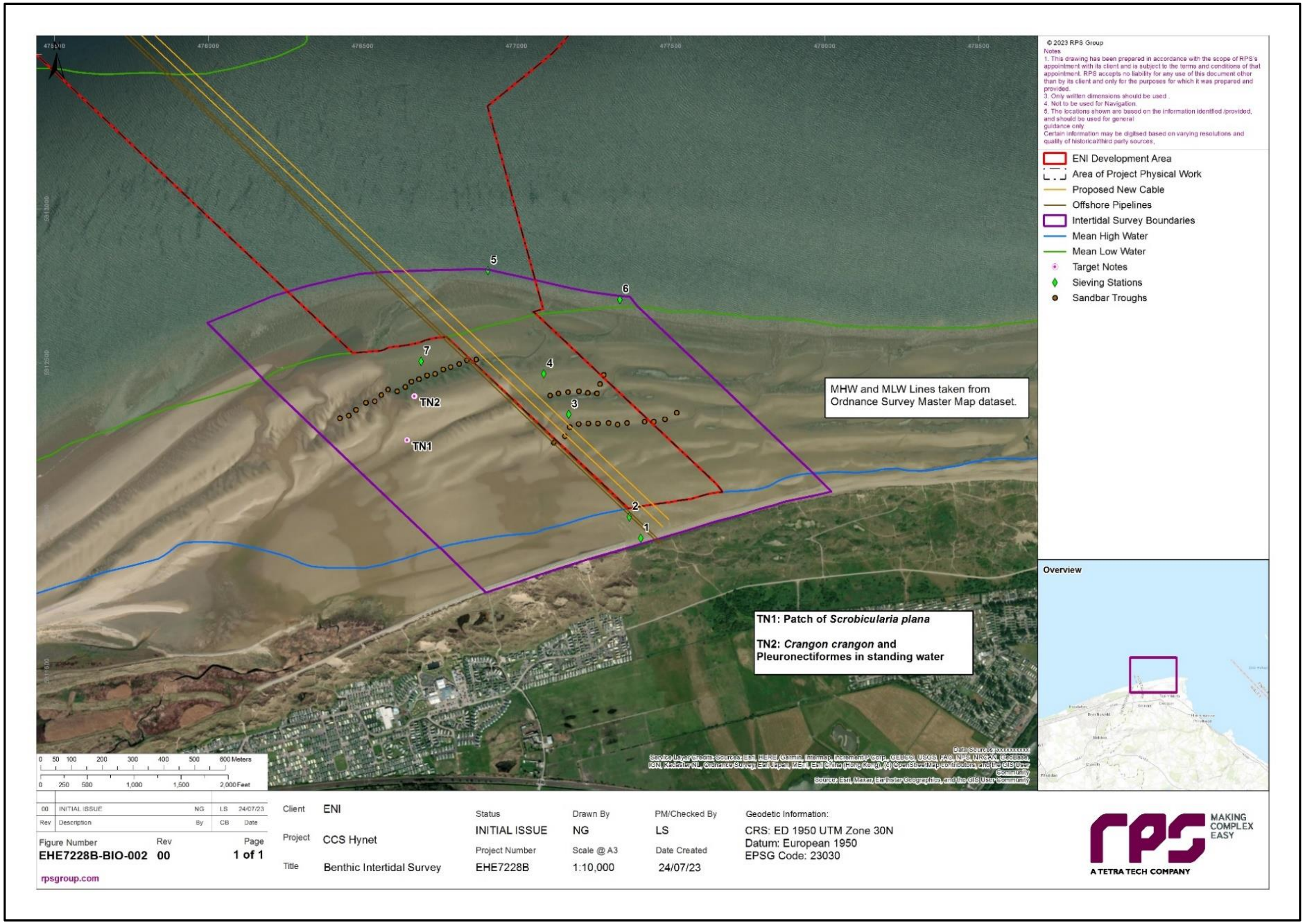

Figure 2.3: Phase 1 Intertidal Walkover Survey Location Map

2.2.5 Data limitations

The desktop data used are the most up-to-date publicly available information which can be obtained from the sources cited within Table 2.2. Species records from primary and grey literature (such as the NBN Atlas) have been consulted and used to inform the baseline and identification of Important Ecological Features (IEFs).

Site-specific surveys were undertaken to characterise the benthic ecology baseline (section 2.3). However, it should be noted that there is a small possibility for the benthic communities to have developed and evolved in the intervening period since the site-specific surveys were carried out in 2022, however as survey operations were within a period of less than five years prior to application submission, the results are considered fully valid. The sampling design and collection process for the survey data has provided robust data on the benthic communities, interpreting these data has limitations. It is often difficult to interpolate data collected from discrete sample locations to cover a very extensive area and define the precise extent of each biotope. Benthic communities generally show a transition from one biotope to another and therefore boundaries indicate where communities grade into one another rather than where one ends and another begins. The classification of the community data into biotopes is not always straightforward, as some communities do not readily fit the available descriptions in the biotope classification system. Due to the limitations described above, the biotope maps in section 2.3 should not be interpreted as showing definitive areas. However, this study does provide a suitable baseline characterisation which describes the main habitats and communities within the Proposed Development and wider area.

2.3 Baseline environment

This section characterises the benthic subtidal and intertidal ecology within the Proposed Development study areas.

2.3.1 Desktop review

2.3.1.1 Regional benthic ecology study area

Designated sites

Seventeen designated sites occur within the regional benthic ecology study area (Table 2.5) (Figure 2.4). The Fylde MCZ, and the Dee Estuary SAC/Aber Dyfrdwy SAC are located within the Eni Development Area and are of particular relevance to this study.

Table 2.5: Designated Sites Within The Regional Benthic Ecology Study Area With Relevant Receptors

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
Fylde MCZ	0.00	The Fylde MCZ was designated in 2013 to maintain the broadscale habitat “subtidal sand” and the habitat of conservation importance “subtidal sands and gravels”, which are situated within the MCZ boundary. **Relevant Qualifying Features:** subtidal sand (EUNIS Habitat A5.3) and subtidal mud (EUNIS Habitat A5.3). These habitats are highly productive and have been shown to support diverse bivalve mollusc populations, including species the nut-shell *Nucula nitidosa*, razor shell *Pharus legumen* and white furrow shell *Abra alba* (Natural England, 2019).

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
Dee Estuary SAC/Aber Dyfrdwy SAC	0.00	The Dee Estuary is one of the largest estuaries within the UK, comprising an area of over 140 km^2, with an intertidal area made up of predominantly mudflats, sandflats and saltmarsh. The estuary lies on the boundary between England and Wales. **Relevant Qualifying Features:** the following Annex I habitats are primary reasons for the designation of this SAC: Mudflats and sandflats that are not covered by seawater at low tide (1140), *Salicornia* and other annuals colonizing mud and sand (1310), and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) (1330). Annex 1 Estuaries (1130) are also present, but not a primary reason for designation (JNCC, 2023a).
Ribble Estuary SSSI	2.70	The Ribble Estuary SSSI is located on the coast of Lancashire and Merseyside and covers an area of 92.26 km^2. The SSSI also contains the Ribble Marshes National Nature Reserve. **Relevant Qualifying Features:** Sheltered muddy shores (including estuarine muds) are recorded as a feature of this SSSI (Natural England, 2023). The fauna in sediments on the lower shore area identified high numbers of juvenile brittlestars and fragments of hydroids and bryozoans (Natural England, 2015).
Menai Strait and Conwy Bay SAC/Y Fenai a Bae Conwy SAC	13.54	The Menai Strait and Conwy Bay SAC is located in north-west Wales and is characterised as having unique physiographic conditions that are critical for marine wildlife (NRW, 2018). The variations in sediment composition, water clarity, and tidal regime result in a diverse collection of marine communities (NRW, 2018). **Relevant Qualifying Features:** the following Annex I habitats are primary reasons for the designation of this SAC: Mudflats and sandflats that are not covered by seawater at low tide (1140), Sandbanks which are slightly covered by sea water all the time (1110), and Reefs (1170). Annex 1 Large shallow inlets and bays (1160) and Submerged or partially submerged sea caves (8330) are also present, but not a primary reason for designation (JNCC, 2023c).
Shell Flat and Lune Deep SAC	15.18	The Shell Flat and Lune Deep SAC is located approximately 3 and 20 km from the east of the Lancashire Coast, at the mouth of Morecambe Bay, and is named after the deep water channel at Lune Deep and large sandbank features (Shell Flat) in the north and south of the SAC (JNCC, 2023b). **Relevant Qualifying Features:** Annex I Sandbanks which are slightly covered by sea water all the time (1110) and Reefs (1170) are the primary reasons for the designation of the SAC (JNCC, 2023b).
Creigiau Rhiwledyn/Little Ormes Head SSSI	15.45	Creigiau Rhiwledyn/Little Ormes Head SSSI is located on the north Wales coastline and overlaps the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay SAC. This SSSI covers an area of 0.36 km^2 (Countryside Council for Wales (CCW), 2002).

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
		Relevant Qualifying Features: This site is notable for various marine biological features including specialised and nationally scarce cave, rockpool, overhang and rock-boring bivalve biotopes (physical habitats and their associated community of species including animals and plants) within the intertidal zone (CCW, 2002).
Pen Y Gogarth/Great Ormes Head SSSI	18.29	Pen Y Gogarth/Great Ormes Head SSSI is located on the north Wales coastline and overlaps the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay SAC, and covers an area of 3.03 km^2 (CCW, 2013). **Relevant Qualifying Features:** This site is notable for having a large area of moderately exposed rock, supporting a complete zonation of marine biotopes. It also has specialised and nationally scarce flora and fauna, most typically associated with rock pool, cave and limestone rock habitats found between the Great Orme and the Solway Firth (CCW, 2013).
Aber Afon/Conwy SSSI	21.43	Aber Afon/Conwy SSSI is located on the north Wales coastline, at the mouth of the river Conwy and overlapping with the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay SAC, and covers an area of 12.95 km^2 (CCW, 2003). **Relevant Qualifying Features:** This site is notable as a high-quality example of an intertidal estuarine community (CCW, 2003). The site supports nationally important ‘piddock’ communities on eulittoral peat, eulittoral firm clay with blue mussel *Mytilus edulis*, lower eulittoral soft rock with toothed wrack *Fucus serratus* and sublittoral fringe soft rock with oarweed *Laminaria digitata* (CCW, 2003). In addition, the site supports specialised communities of shallow pools on mixed substrata with hydroids, ephemeral algae and common periwinkle *Littorina littorea* (CCW, 2003).
Morecambe Bay SAC	26.5	The Morecambe Bay SAC is a predominantly sandy bay at the confluence of the Leven, Kent, Lune and Wyre estuaries. It is one of the largest areas of intertidal flats in Britain and includes various habitat and sediment types (JNCC, 2023d). **Relevant Qualifying Features**: the following Annex I habitats are primary reasons for the designation of this SAC: Estuaries (1130), Mudflats and sandflats that are not covered by seawater at low tide (1140), Large shallow inlets and bays (1160), Salicornia and other annuals colonizing mud and sand (1310), and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) (1330). Annex 1 Sandbanks which are slightly covered by seawater all the time (1110), Coastal lagoons (1150), and Reefs (1170) are also present, but not a primary reason for designation (JNCC, 2023d).
West of Walney MCZ	28.73	The West of Walney MCZ is located offshore of Walney Island, Cumbria, and covers a total area of 388 km^2. The seabed habitat within the West of Walney MCZ is predominantly comprised of subtidal mud. This broad-scale habitat feature is considered part of an area known as the eastern Irish Sea mud belt. Sea-pen and burrowing megafauna communities (which is considered Threatened

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
		and/or Declining habitat in the north-east Atlantic, and specifically in the Irish Sea, by the OSPAR commission) makes up a component part of the subtidal mud habitat occurring within the site's boundary. This habitat is characterised by the presence of sea-pens (feather-like soft corals) and burrowing animals such as mud shrimp *Corophium volutator* and the Norway lobster *Nephrops norvegicus*, which is a commercially important species (JNCC, 2021a). **Relevant Qualifying Features:** Subtidal sand (EUNIS Habitat A5.3), Subtidal mud (EUNIS Habitat A5.3), and Sea-pen and burrowing megafauna communities (OSPAR list of threatened or declining habitats).
West of Copeland MCZ	47.13	The West of Copeland MCZ covers an area of 158 km^2, with seabed of predominantly subtidal sand and subtidal coarse sediments. These habitats support a range of benthic species, such as worms, sea urchins, anemones, crustaceans, molluscs, and sea mats (JNCC, 2021b). **Relevant Qualifying Features:** subtidal coarse sediments (A5.1), subtidal sand (A5.2), and subtidal mixed sediments (A5.4) (JNCC, 2021b).
Drigg Coast SAC	70.06	The Drigg Coast SAC encompasses around 11 km and is composed of extensive sand dunes, saltmarsh, intertidal mudflats and sandflats, and estuaries (MMO, 2019). **Relevant Qualifying Features:** The Annex I habitat, Estuaries (1130), present as a primary feature for site designation. Furthermore, the following Annex I habitats are also present as qualifying features but not primary reasons for site designation: Mudflats and sandflats not covered by seawater at low tide (1140), Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) (1330), and *Salicornia* and other annuals colonizing mud and sand (1310) (JNCC, 2023g).
Isle of Man Marine Nature Reserves (MNRs)	70.06 to 91.05	There are ten MNRs around the Isle of Man, encompassing 10.8% of Manx waters: Baie Ny Carrickey, Calf and Wart Bank, Douglas Bay, Langness, Laxey Bay, Little Ness, Niarbyl Bay, Port Erin Bay, Ramsay Bay, and West Coast (Manx Wildlife Trust, 2023). **Relevant Qualifying Features:** although it varies between site, these MNRs are collectively designated for maerl, rocky reefs, kelp forests, eelgrass beds, brittlestar beds, sea caves, subtidal sandbanks, sea anemones, ocean quahog *Arctica islandica*, and the nudibranch *Cumanotus beaumonti*, (Designation of MNR Guidance Notes, undated). Under Section 33 of the Wildlife Act (1990), the following benthic subtidal and intertidal features cannot be removed or damaged in any of the Isle of Man MNRs: maerl, rocky reefs, sea anemones, ocean quahog, and sea caves (Manx Marine Nature Reserves Byelaw, 2018).
Cumbria Coast MCZ	73.09	The Cumbria Coast MCZ is located on the west coast of England and stretches for approximately 27 km along the coast, covering a total area of 22 km^2 (Department for Environment, Food, and Rural Affairs (DEFRA), 2019d). This

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
		site is notable as it is an extensive and important example of intertidal rocky shore habitats and associated communities on the sedimentary coast of north-west England (DEFRA, 2019d). **Relevant Qualifying Features:** high energy intertidal rock, honeycomb worm *Sabellaria alveolata* reefs, intertidal biogenic reefs, intertidal sand and muddy sand, intertidal underboulder communities, moderate energy infralittoral rock, and peat and clay exposures (DEFRA, 2019d).
Allonby Bay MCZ	116.32	The Allonby Bay MCZ is an inshore site on the English side of the Solway Firth, covering approximately 40 km^2. **Relevant Qualifying Features:** intertidal biogenic reefs, intertidal coarse sediment, intertidal sand and muddy sand, moderate energy infralittoral rock, subtidal biogenic reefs, subtidal coarse sediments, subtidal sand, subtidal mixed sediments, and *S. alveolata* beds (DEFRA), 2016).
Luce Bay and Sands SAC	122.06	The Luce Bay and Sands SAC is located on the south-west coast of Scotland. The variation in physical and environmental conditions throughout the site, including rock and soft sediment types, water clarity and exposure to tidal currents and wave action result in a wide range of habitats and associated marine communities (JNCC, 2023t). **Relevant Qualifying Features:** The Annex I habitats Large shallow inlets and bays (1160) and Shifting dunes along the shoreline with marram grass (*Ammophila arenaria)* (2120) are present as primary features for site designation. Furthermore, the Annex I habitats Reefs (1170), Sandbanks which are slightly covered by seawater at all time (1110), and Mudflats and sandflats not covered by seawater at low tide (1140) are present as qualifying features, but not a primary reason for site designation (JNCC, 2023t).
Solway Firth SAC	123.85	Solway Firth SAC is a large, shallow, and complex estuary with a diverse mix of intertidal habitats (tidal rivers, estuaries, mud flats, sand flats, lagoons, salt marshes and salt steppes) (JNCC, 2023f). **Relevant Qualifying Features:** The Annex I habitats Estuaries (1130), Sandbanks which are slightly covered by sea water at all times (1110), Mudflats and sandflats not covered by seawater at low tide (1140), *Salicornia* and other annuals colonizing mud and sand (1310), and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) are present as primary features for site designation. Furthermore, the Annex I habitat: Reefs (1170) is present as a qualifying feature, but not a primary reason for site designation (JNCC, 2023f).

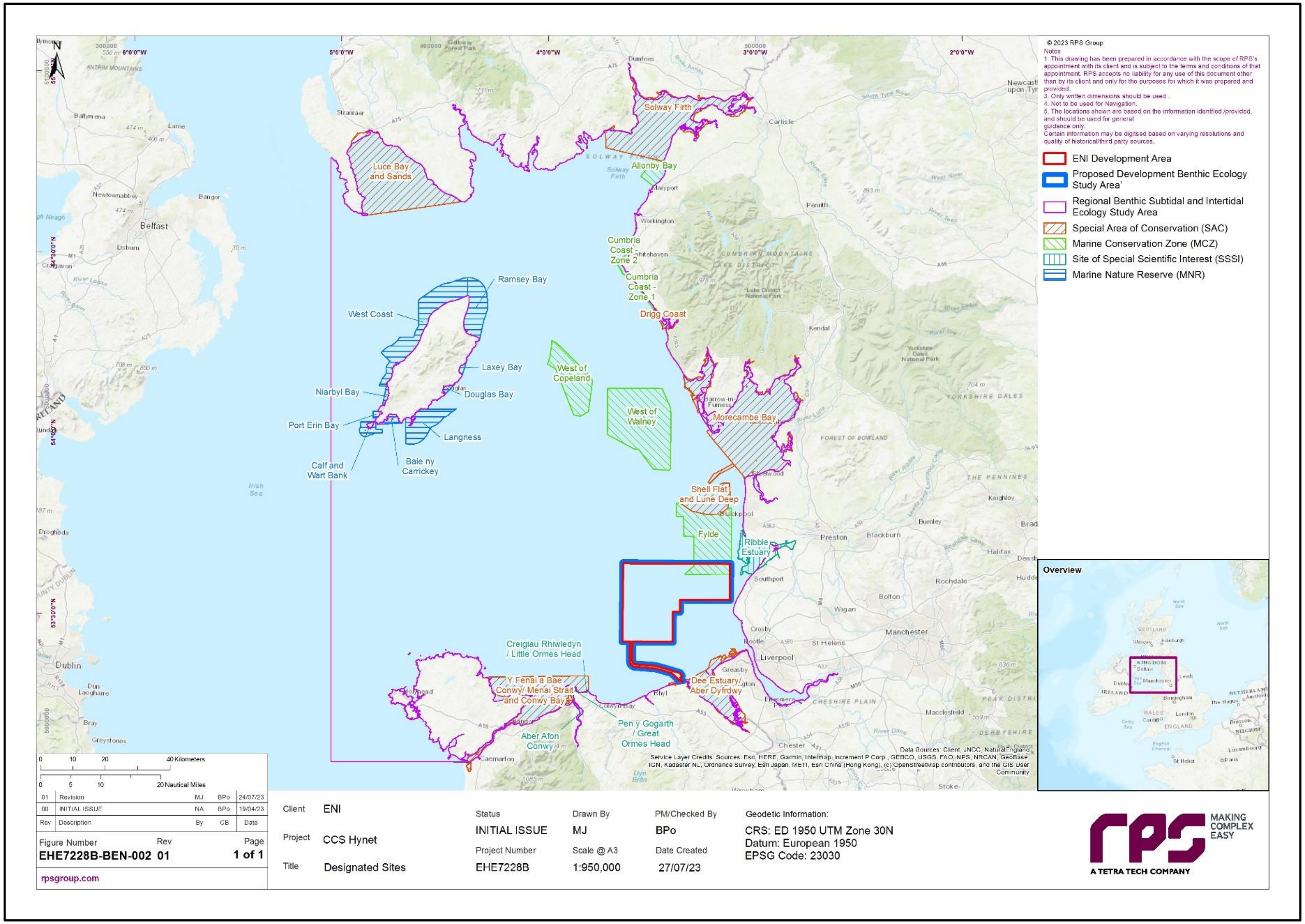

Figure 2.4: Designated Sites With Relevant Benthic Qualifying Features Within The Regional Benthic Ecology Study Area

Subtidal sediments

The Offshore Energy Strategic Environmental Assessment 4 (SEA) has compiled a baseline of the UK's offshore benthic environment (BEIS), 2022) and divides the UKs Exclusive Economic Zone into regional seas. The regional benthic ecology study area lies within regional sea 6, the Irish Sea.

The offshore seabed in regional sea 6 is predominantly sedimentary, mainly of glacial origin, consisting mostly of sands and muddy sands, coarse and mixed sediments (BEIS, 2022). Tide-swept circalittoral mixed sediments are present in deeper sections, such as in the south of the regional subtidal and intertidal benthic ecology study area. In the nearshore along the north Wales coast and west coast of England, the sediment is largely sandy mud or muddy sand (where it has been defined) (BEIS, 2022). Sandbanks within the regional benthic ecology study area include East Hoyle Bank, portions of Great Burbo Bank, West Hoyle Bank, Dutchman Bank, and the Chester and Rhyl Flats (Natural England, 2010).

There are large areas of high energy infralittoral habitat at the mouth of the River Mersey, the River Dee and River Conwy in the south and south-east of the regional benthic ecology study area, as well as the River Kent, River Leven, River Lune and the River Duddon in the east around Morecambe Bay (EMODnet, 2019). High energy infralittoral habitat is also predicted in Luce Bay and Wigtown Bay in the north of the regional benthic subtidal and intertidal study area (EMODnet, 2019). There is also a large area of infralittoral sand at the entrance of the Solway Firth which is determined to be a moderate energy environment (EMODnet, 2019). Deep circalittoral coarse sediments were recorded to the south and east of the Isle of Man, while infralittoral coarse sediments were recorded to the north of the Isle of Man, while circalittoral coarse and infralittoral coarse sediments were present around the east and west (EMODnet, 2019).

Within the regional benthic ecology study area, a large broadscale subtidal survey was undertaken to characterise the benthos on the east of the Isle of Man (Holt *et al.,* 1997). The survey showed the area to be relatively uniform, consisting of fine and medium sands with varying proportions of stones and shells. Widespread areas of fine scale sand waves or ripples were also identified, which consisted of much coarser sands, stones and gravel often with very large proportions of dead shell material (Holt *et al.,* 1997). Muddy sediments were recorded in only a few patches in the regional benthic ecology study area, the largest of which were to the west of the Isle of Man (Holt *et al.,* 1997). The Isle of Man territorial waters are also encompassed by the regional benthic ecology study area. A marine environmental assessment was undertaken to create an extensive characterisation of the subtidal environment around the Isle of Man (Howe, 2018a). The subtidal habitats to the west of the island were shown to be predominantly mixed gravel, mixed stone and mixed sand seabed which extended to the north and the south with a small area of sand/muddy sand in the south-east. The seabed located to the south-west of the island comprises an extensive area of mud/fine sand. The EUSeaMap (Figure 2.5) is aligned with data from Howe (2018a) showing that sediment around the Isle of Man is made of coarse material with sections of fine sand in the south-east as well as the north-east.

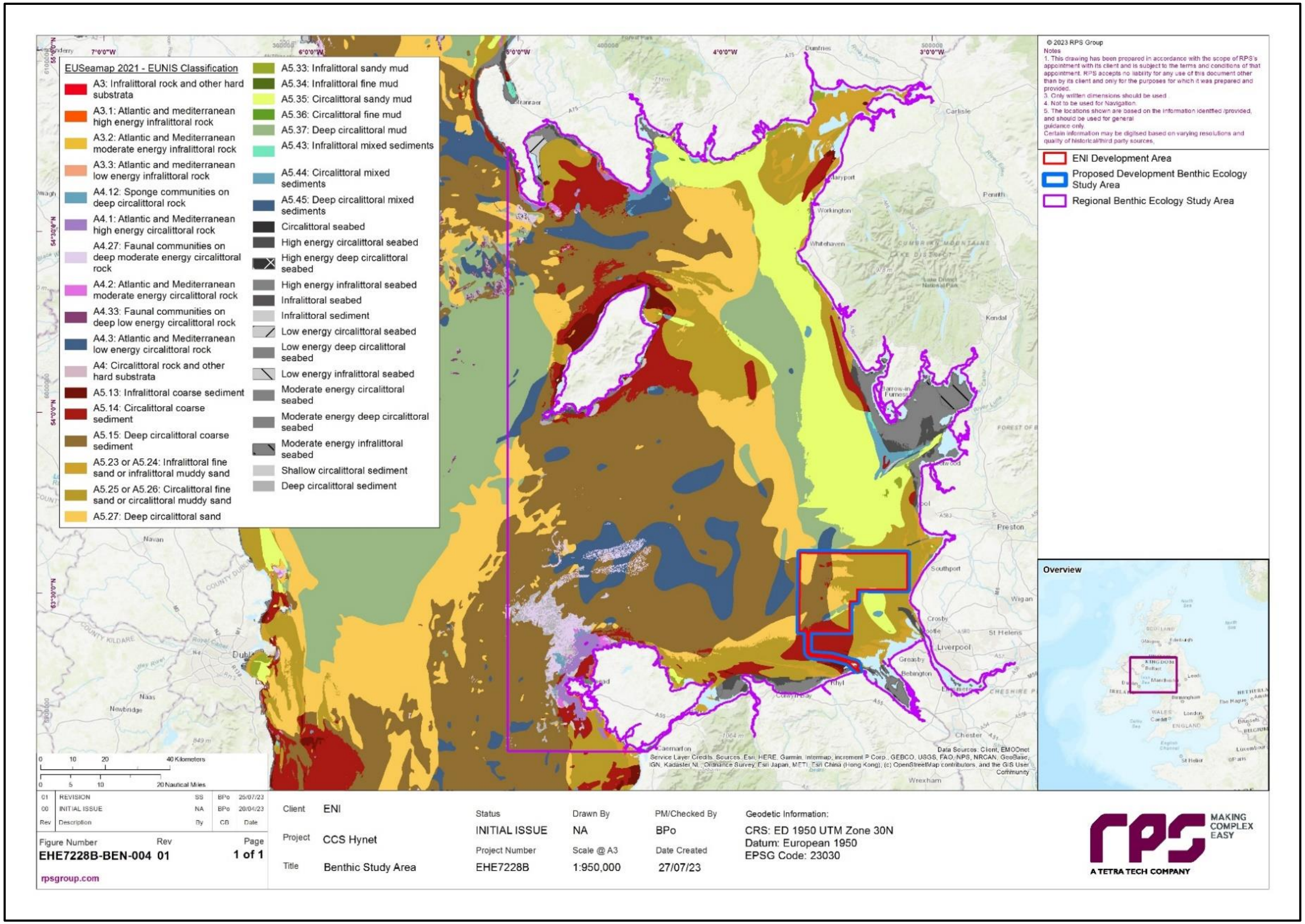

Figure 2.5: Subtidal Sediments Across The Regional Benthic Ecology Study Areas (Source: EMODnet, 2021)

Site-specific surveys undertaken for a range OWFs in the regional benthic ecology study area provide context to the baseline (Figure 2.6). The results of these site-specific surveys are summarised in Table 2.6. Circalittoral sands, gravels, and muds were consistent throughout, which aligns with the broad-scale EUSeaMap data (EMODnet, 2021). Within the north coast of Wales, fine and sandy sediments are dominant in inshore waters and particle sizes range from 260 to 420 µm in areas with stronger currents and from 190 to 250 µm in areas with contrasting, weaker currents (Eni UK, 2019).

Table 2.6: Summary Of Subtidal Sediment Recorded During Site-Specific Surveys For Projects Within The Regional Benthic Ecology Study Area

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Subtidal Sediments Recorded	Reference
Awel y Môr Preliminary Environmental Information Report: Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology	0.00	2020	The seabed was predominantly gravelly sand (47 sample stations) and sand (10 sample stations), with gravelly muddy sand, muddy sandy gravel, and sandy gravel recorded in lower numbers. Sand waves and mega ripples were present in the eastern array area.	RWE Renewables UK, 2021a
Rhiannon OWF Preliminary Environmental Information Chapter 9 Benthic Ecology	25.31	2010 to 2012	Two large sandbanks were recorded off Lynas point (north Anglesey), and in the east of the regional benthic ecology study area. These were composed of very well-sorted mobile sand that remained submerged at all times. These sands were medium and coarse sands with minimal mud or gravel content. These banks were considered to be examples of the Annex I habitat sandbanks which are slightly covered by seawater at all times.	Celtic Array Ltd. 2014a
Walney OWF Year 3 postconstruction benthic monitoring technical survey report (2014 survey)	36.69	2014	Subtidal sediments were dominated by circalittoral sandy mud or circalittoral muddy sand.	CMACS, 2014

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Subtidal Sediments Recorded	Reference
Burbo Bank Extension OWF ES Volume 2 – Chapter 12: Subtidal and Intertidal Benthic Ecology	0.55	2011	The majority of sediments recorded throughout the Burbo Bank Project Area were dominated by slightly gravelly sands but with a strip of finer, silty material running through the area.	DONG Energy, 2013a
Walney OWF Benthic Characterisation Surveys for the ES	36.69	2011	Subtidal sediments were dominated by circalittoral sandy mud or circalittoral muddy sand. The array area was shown to be dominated by sandy mud with sediments transitioning to coarse sediment further offshore and inshore of the array area during the 1-year post-construction survey	DONG Energy, 2013b
Ormonde OWF Year 1 post-construction benthic monitoring technical survey report (2012 survey)	42.95	2009	The subtidal sediments were dominated by circalittoral sandy mud or circalittoral muddy sand. A higher percentage of mud further offshore and a lower percentage of mud in the southerly inshore areas were recorded.	CMACS, 2012a
Walney OWF Year 1 post construction benthic monitoring technical survey report (2012 survey)	36.69	2009	Subtidal sediments were dominated by circalittoral sandy mud or circalittoral muddy sand.	CMACS, 2012b
Post-construction Results from The North Hoyle OWF	3.85	2002 to 2004	The seabed was composed of fine and medium sands with varying amounts of coarser material. No obvious differences were reported in comparison to pre-construction sediment composition.	May, 2005

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Subtidal Sediments Recorded	Reference
Gwynt y Môr OWF Marine Ecology Technical Report	0.00	2002	The area was found to be predominantly composed of medium and coarse sands, poorly sorted with varying degrees of coarser materials, such as stones and gravel. These findings agree with those evidenced by the BGS and information obtained from the 2019 EUSeaMap datasets (EMODnet, 2021), describing the area as being composed predominantly of sand with varying degrees of mud, gravel and stone content.	CMACS, 2005b

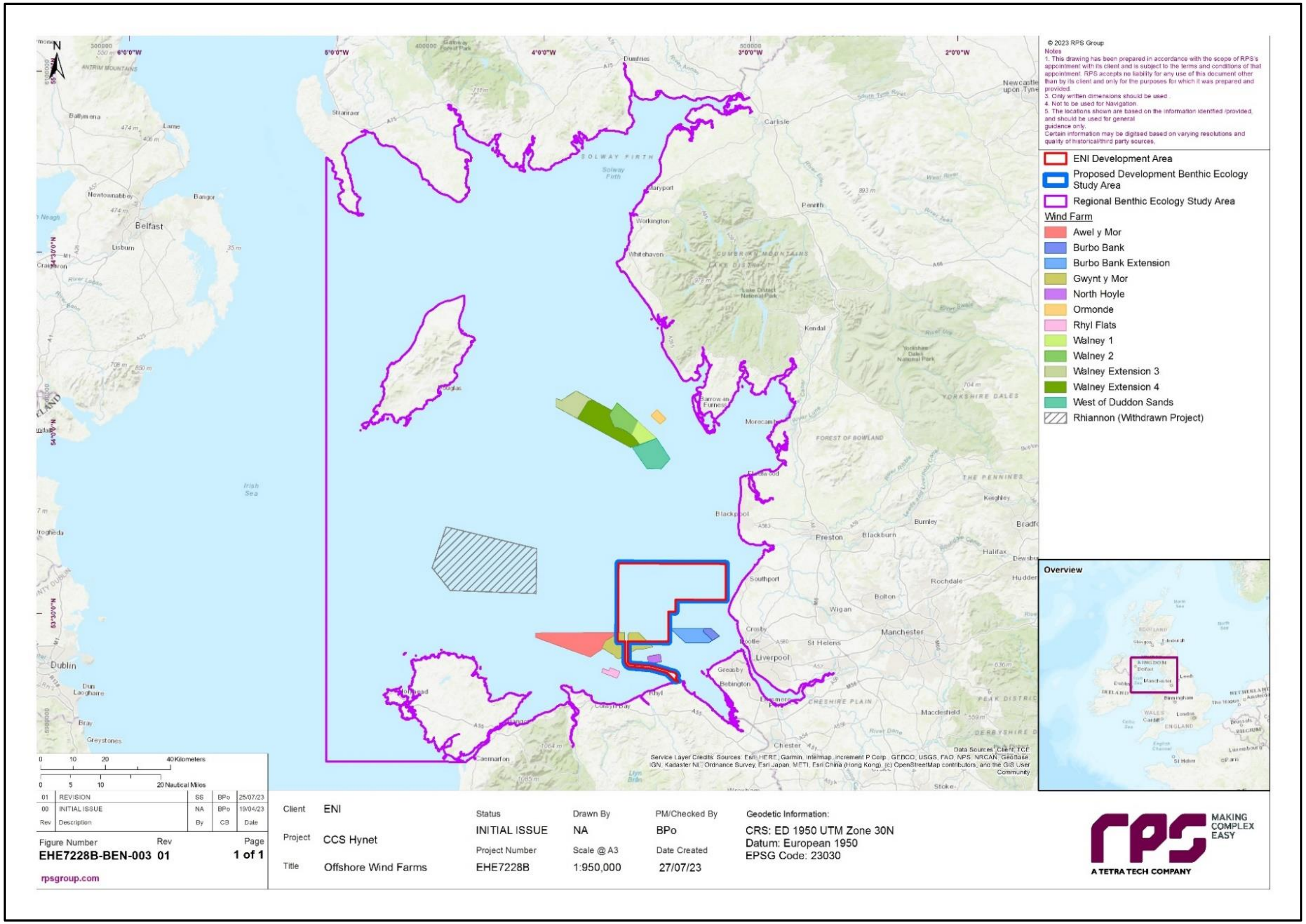

Figure 2.6: Offshore Wind Farms In The Vicinity Of The Proposed Development Benthic Ecology Study Area

Subtidal benthic communities

Subtidal benthic communities are characterised by sedimentary habitats. Mackie (1990) described most of the east Irish Sea (and thus the regional benthic ecology study area) as being dominated by *Venus* communities. These communities contained species such as purple heart urchin *Spatangus purpureus,* bivalves (*Glycimeris spp.,* and *Asarte sulcate),* and *Venus* clams, and occurred at depths between 40 m and 100 m in coarse sand, gravel, and shelly sediments (Mackie, 1990). Much of the inshore area of the regional benthic ecology study area was also characterised by shallow *Venus* communities on nearshore sand. These occurred in waters between 5 m and 40 m deep, with strong currents and sand. Patches of *Abra* communities were also observed along the north Wales coastline and in the east of the regional benthic subtidal and intertidal ecology study area. These *Abra* communities were dominated by the white furrow shell and the bristleworm *Lagis koreni* (Rees *et al.,* 1972) and the biotope *A. alba* and shiny nut clam in circalittoral muddy sand or slightly mixed sediment (SS.SSa.CMuSa.AalbNuc).

The 2019 EUSeaMap broad-scale predictive model classifies and maps seabed sediment types according to the EUNIS classification criteria (EMODnet, 2019). The system can identify keystone species that have been evidenced to inhabit areas with certain environmental conditions and can therefore act as an indicator, allowing inferences of overall community composition.

According to EUSeaMap 2019 data, the following EUNIS seabed classifications dominate the seabed within and surrounding the Eni Development Area (Figure 2.5) (EMODnet, 2019):

- A5.14: Circalittoral Coarse Sediment – This habitat may be characterised by robust infaunal polychaetes, mobile crustacea and bivalves. Certain species of sea cucumber (e.g. Neopentadactyla) may also be prevalent in these areas along with the lancelet *Branchiostoma lanceolatum*.
- A5.15: Deep Circalittoral Coarse Sediment – Animal communities in this habitat are closely related to offshore mixed sediments and in some areas settlement of Modiolus larvae may occur and consequently these habitats may occasionally have large numbers of juvenile horse mussel *Modiolus*. In areas where the mussels reach maturity, their byssus threats bind the sediment together, increasing stability and allowing an increased deposition of silt.
- A5.25: Circalittoral Fine Sand – Characterised by a range of echinoderms including the pea urchin *Echinocyamus pusillus*, polychaetes and bivalves. This habitat is generally more stable than infralittoral fine sand and subsequently supports a more diverse faunal assemblage.
- A5.26: Circalittoral Muddy Sand – Characterised by a variety of polychaetes, bivalves (*A. alba* and *N. nitidosa*) and echinoderms (*Amphiura spp., Ophiura spp. and Astropecten irregularis*). These circalittoral habitats tend to be more stable than their infralittoral counterparts and as such support a richer infaunal community.
- A5.27: Deep–Circalittoral Sand - Offshore deep habitat with fine sand or non-cohesive muddy sands. Communities are typically dominated by polychaetes, amphipods, bivalves and echinoderms.

The regional benthic ecology study area also encompasses the Isle of Man. Howe (2018a) describes White's (2011) analysis of 7,325 seabed images from a 2008 benthic survey around the Isle of Man and identified 20 different biotopes. Some of the most common included spiny mudlark *Brissopsis lyrifera* and brittlestar *Amphiura chiajei* in circalittoral mud (SS.SMu.CFiMu.BlyrAchi) which was recorded over a broad area in the south-west of the Isle of Man. The biotope sea tube anemone *Cerianthus lloydii* with the *Nemertesia* spp. and other hydroids in circalittoral muddy mixed sediment (SS.SMx.CMx.ClloMx.Nem) characterises an extensive area of the south-west of the Isle of Man. There are also a number of intermittent rocky biotopes including sparse sponges, *Nemertesia spp*. and sea chervil (*Alcyonidium diaphanum)* on circalittoral mixed substrata (CR.HCR.XFa.SpNemAdia) and faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock (CR.MCR.EcCr.FaAlCr). Three OSPAR priority habitats were also identified: horse mussel reefs, maerl beds and Ross worm habitats *Sabellaria spinulosa* (Howe, 2018a).

Multiple surveys undertaken in Liverpool Bay in connection with OWF developments have confirmed the benthic habitats and communities previously detailed in this section (Table 2.7). It has therefore been established that Liverpool Bay, and more specifically the regional benthic ecology study area, are largely comprised of sandy, gravelly and muddy sediments, with polychaete, bivalve, and amphipod species being predominantly present. It been demonstrated that benthic habitats classified by sandy sediments tend to support larger numbers of infaunal communities and fewer epifaunal species (Sørensen *et al*., 2010; Henseler *et al.,* 2019; Somerfield *et al*., 2019). Organisms within these communities tend to have shorter lifespans and exhibit higher degrees of natural variability and recoverability, traits common in benthic communities located within energetic environments (Sørensen *et al*., 2010). These organisms are also well adapted to the surrounding high energy conditions and are therefore more tolerant to the overall changes in sediment movement and disturbance.

Table 2.7: Summary Of Subtidal Communities Recorded During Site-Specific Surveys For Projects Within The Regional Benthic Ecology Study Area

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Subtidal Communities Recorded	Reference
Awel y Môr Preliminary Environmental Information Report: Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology	0.00	2020	The majority of samples (45 out of 66) in the array area were classified as the biotope *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand (SS.SCS.CCS.PKef). The remaining samples were assigned the biotopes *B. lanceolatum* in circalittoral coarse sand with shell gravel (SS.SCS.CCS.Blan) and white cat worm *Nephtys cirrosa* and *Bathyporeia spp.* in infralittoral sand (SS.SSa.IFiSa.NcirBat).	RWE Renewables UK, 2021a
Rhiannon OWF Preliminary Environmental Information Chapter 9 Benthic Ecology	25.31	2010 to 2014	The dominant biotopes were circalittoral coarse sediment (SS.SCS.CCS) and *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx). This consisted of circalittoral sediments dominated by brittlestars forming dense beds, living on boulder, gravel or sedimentary substrate. Large patches of circalittoral fine sand (SS.SSa.CFiSa) were recorded further west and to the north of the Rhiannon OWF survey area. There were some very small areas of CR.MCR and *B. lanceolatum* in circalittoral coarse sand with shell gravel (SS.SCS.CCS.Blan) identified in the south-west.	Celtic Array Ltd. 2014a
Burbo Bank Extension OWF ES Volume 2 – Chapter	0.55	2011	The array area was dominated by the biotope bivalve *Fabulina fabula* and worm *Magelona mirabilis* with	DONG Energy, 2013a

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Subtidal Communities Recorded	Reference
12: Subtidal and Intertidal Benthic Ecology			venerid bivalves and amphipods in infralittoral compacted fine muddy sand (SS.SSa.IMuSa.FfabMag). There was also a small section of *A. alba* and *N. nitidosa in* circalittoral muddy sand or slightly mixed sediment (SS.SSa.CMuSa.AalbNuc) identified in the east. The wider area around the array area was classified as *N. cirrosa* and *Bathyporeia spp.* in infralittoral sand (SS.SSa.IFiSa.NcirBat).	
Walney OWF Benthic Characterisation Surveys for the ES	36.69	2011	The main biotopes comprised of brittlestar *Amphiura filiformis,* two-toothed Montagu shell *Kurtiella bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit) in the east of the site along the export cable corridor and *Thyasira* sp. and *Ennucula tenuis* in circalittoral sandy mud (SS.SMu.CSaMu.ThyEten) in the west. The *F. fabula* and *M. mirabilis* with venerid bivalves and amphipods (SS.SSa.IMuSa.FfabMag) was also recorded along the export cable corridor.	DONG Energy, 2013b
Pre-construction monitoring at the Gwynt y Môr OWF	0.00	2010	The most extensive biotopes were: *Moerella* sp. with venerid bivalves in infralittoral gravelly sand (SS.SCS.ICS.MoeVen) and circalittoral fine sand (SS.SSa.CFiSa). The biotope *N. cirrosa* and *B.* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat) was identified at a few locations but was more dominant at inshore sites. The *F. fabula* and *M. mirabilis* with venerid bivalves and amphipods (SS.SSa.IMuSa.FfabMag) biotope was also described close to the Welsh coast.	CMACS, 2011
Burbo Bank Extension OWF EIA Scoping Report	0.55	2010	Two main biotopes were recorded: IGX.FabMag (*F. fibula* and *M. mirabilis* with venerid bivalves present in infralittoral compacted sand) and IGS.NcirBat (*N. cirrosa* and *Bathyporeia spp*. in infralittoral sand).	Sørensen *et al*., 2010

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Subtidal Communities Recorded	Reference
			These biotopes are known to support various polychaete and bivalve species.	
Gwynt y Môr OWF Marine Ecology Technical Report	0.00	2002 to 2004	Of the 256 collected samples, 44,445 individuals from 487 taxa were recorded. The surveys evidenced that the most abundant group by taxa were annelid worms (mostly polychaetes) (51%), followed by crustacea (18%), and echinoderms (5%). The diversity and richness of fauna were not significantly high within the Gwynt y Môr OWF	CMACS, 2005b
Post-construction Results from The North Hoyle OWF	3.85	2002 to 2004	The benthic community resembled Mackie's (1990) shallow *Venus* community. The communities identified at the North Hoyle OWF were similar to communities typical to coarse and stony grounds with species such as hydroids, bryozoans and soft corals such as dead man's fingers *Alcyonium digitatum*. There was no indication that biotopes had been altered by the construction of the OWF.	May, 2005
Ormonde OWF ES	42.95	2004 to 2005	The array area was mostly composed of *A, filiformis, K, bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit) with bands of bristleworm *L. koreni* and transparent razor shell *Phaxas pellucidus* in circalittoral sandy mud (SS.SMu.CSaMu.LkorPpel) and *A. alba* and *N. nitidosa in* circalittoral muddy sand or slightly mixed sediment (SS.SSa.CMuSa.AalbNuc) towards the coast.	Unicomarine Ltd, 2005

The Walney OWF overlaps with an Annex I stony reef within the Shell Flats and Lune Deep Special Area of Conservation (SAC) (Table 2.5) which is located inshore of the Walney OWF array area in the central east section of the regional benthic subtidal and intertidal study area (rocky reef criteria of Irving *et al.* (2009) and redescribed for stony reef in Limpenny *et al*. (2010); Dong Energy, 2013b). Stony reefs were also identified at several locations along the Walney OWF extension export cable corridor and within Morecambe Bay. These were all classified as having low 'reefiness' (Dong Energy, 2013b).

Furthermore, areas of stony and rocky reefs have also been identified within and around the Rhiannon OWF array area, and all of which coincide with the regional benthic ecology study area. The stony and rocky reefs identified have low to high 'reefiness' classifications (Celtic Array Ltd, 2014a). *S. spinulosa* reefs were identified 20 km north-west of the Rhiannon OWF array area with some small areas closer (Celtic Array Ltd. 2014a). All were deemed to be of low or low to medium 'reefiness' when assessed against the criteria proposed by Gubbay (2007). There were no Annex I *S. spinulosa* reefs recorded within the Rhiannon OWF array area but a small area (0.22 km^2) of low to moderate 'reefiness' was recorded within the export cable corridor area (Celtic Array Ltd., 2014a). The pre-construction benthic surveys for Gwynt y Môr OWF recorded seven *S. spinulosa* individuals across five stations out of a total of 126 stations overall, however no reefs were identified in these pre-construction surveys (CMACS, 2011). Horse mussel was also recorded within the site-specific surveys for the Rhiannon OWF (Centrica Energy and DONG Energy, 2012).

The habitat, 'burrowed mud', was recorded in the east of the Walney OWF array area, which is listed under 'seapens and burrowing megafauna' on the OSPAR list of threatened or declining habitats in the North Atlantic. This biotope was also recorded in the Ormonde OWF and Walney OWF extension, within the West of Walney Marine Conservation Zone (MCZ) zone. This MCZ has been designated for the protection of sea pens and burrowing megafauna (Table 2.5). Although no sea pens were recorded at the sample sites within the Walney OWF during the post-construction monitoring surveys, evidence of burrowing megafauna was present (CMACS, 2014).

Constable Bank is located to the west of the Eni Development Area within the nearshore environment. This is an Annex I sandbank lying out with any SACs, in shallow coastal waters with high wave stress (NRW, 2015). Constable Bank has been recognised as unusual as it extends from offshore right to the coastline with no gap between it and the beach (Kenyon and Cooper, 2005). The bank is over 20 km long and up to 2 km wide in its outer part widening towards the coast and is up to 10 m high (Kenyon and Cooper, 2005). Furthermore, the nationally scarce thumbnail crab *Thia scutellata* has been recorded on Constable Bank (Rees, 2001).

Intertidal benthic communities

The Solway Firth is located in the north of the regional benthic ecology study area. Within the Solway Firth, reef building *S. alveolata* reach their most northerly extent, growing primarily on intertidal and subtidal rock. This species is a protected feature of both the Allonby Bay MCZ and the Cumbria Coast MCZ (Table 2.5). Intertidal mudflats and sandflats, saltmarshes and intertidal scars (exposed boulders and rocks) characterise the remainder of the Cumbria coast. Morecambe Bay is also encompassed by the regional benthic ecology study area, and the Morecambe Bay SAC is designated for Annex I habitats including large shallow inlets and bays, reefs, salicornia and other annuals colonizing mud and sand, Glauco-Puccinellietalia maritimae and mudflats and sandflats not covered by seawater at low tide (Antil and Pérez-Domínguez, 2021) (Table 2.5). In 2015, intertidal surveys were undertaken in the Morecambe Bay SAC, which demonstrated that the most common biotopes were:

- Blue mussel beds on littoral mixed substrata (LS.LBR.LMus.Myt.Mx).
- Barnacles and *Littorina* sp. on unstable eulittoral mixed substrata (LR.FLR.Eph.BLitX).
- Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata (LR.FLR.Eph.EphX) (Antil and Pérez-Domínguez, 2021).

Elsewhere in the regional benthic ecology study area, the north Wales coastline includes large areas of moderately wave exposed sandy shores (CCW, 2007). The infauna in these areas consists of similar polychaete and amphipod species throughout the shore, but abundance of certain species varies. For example, raised, and consequently drier, areas of sand tend to support populations of the lugworm *Arenicola marina*, catworms *Nephtys* spp. and amphipods *Bathyporeia* spp. (CCW, 2007). Lower lying areas of sand, which typically remaining wet at low water, support communities of molluscs such as Baltic tellin *Macoma balthica*, *E. tenuis*, common cockle *Cerastoderma edule,* the sand mason worm *Lanice conchilega* and *A. Marina* (CCW, 2007). Sheltered sediment shores are dominated by mud, muddy sands, sandy muds and muddy gravel. These less mobile sediments typically support high invertebrate communities of species such as ragworm *Hediste diversicolor*, *M. balthica*, *A. marina* and peppery furrow shell *Scrobicularia plana* (CCW, 2007). The Isle of Anglesey has a large proportion of rocky coastline, especially along its north coast, which has moderately wave exposed rocky shores. Wracks (*Fucus spiralis*, *F. vesiculosus* and *Ascophyllum nodosum*) dominate the upper and mid shore rock with zones dominated by the snails *Pomacea canaliculata*.

The under boulder community includes the porcelain crab *Porcellana platycheles*, the tube worm *Pomatoceros triqueter*, the cushion star *Asterina gibbosa* and gastropods including the dog whelk *Nucella lapillus*, and *L. littorea* (CCW, 2007).

Sediment contamination

Many metals occur naturally within marine sediments. Elevated concentrations can originate from natural mineralisation or anthropogenic sources. For example, some elevated metal levels in the regional ecology study area can be attributed to inputs from industrial areas in the north-west of England (Rowlatt and Lovell, 1994), and As has regularly been recorded at elevated levels in the east Irish Sea (Camacho-Ibar *et al.,* 1992).

The results of the sediment contamination analyses conducted during the site-specific surveys of the Eni Development Area are summarised in section 2.3.2, and presented in full in the volume 3, appendix I1 In addition, a summary of sediment contaminants recorded during site-specific surveys of other projects within the regional benthic ecology study area are presented in Table 2.8.

Table 2.8: Summary Of Sediment Contaminants Recorded During Site-Specific Surveys For Projects Within The Regional Benthic Ecology Study Area

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Sediment Contamination Recorded	Reference
Awel y Môr Preliminary Environmental Information Report: Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology	0.00	2020	Bioavailable metals concentrations were all below respective Cefas ALs. The median PAH values were broadly comparable to the SEA 6 Irish Sea Surveys.	RWE Renewables UK, 2021a
Burbo Bank Extension OWF ES Volume 2 – Chapter 12: Subtidal and Intertidal Benthic Ecology	0.55	2011	No contaminants present above PEL, however elevated levels of iron, aluminium, arsenic, copper, zinc, and lead were recorded above natural background levels. No organochlorine or organophosphorus pesticides were detectable. No PCBs were present in excess of ISQC level. PAHs were present above the limit of detection in one sample.	DONG Energy, 2013a
Walney OWF Benthic Characterisation Surveys for the ES	36.69	2011	One mercury sample above ISQG and Canadian Threshold Effects Levels (TELs).	DONG Energy, 2013b
Pre-construction monitoring at the Gwynt y Môr OWF	0.00	2010	Total Organic Carbon (TOC) ranged from 0.36% to 17.3%, with an average value of 4.19%.	CMACS, 2011
Burbo Bank OWF Pre-Construction	0.55	2005	Seven out of nine samples contained metals at or	CMACS, 2005a

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Sediment Contamination Recorded	Reference
Contaminants Investigation			above the ISQG levels and Canadian TELs. Additionally, lead and mercury were present in excess of the Canadian PEL. A greater proportion of surface sediment samples, especially in the top metre, contained metals above ISQG/TEL, while no metals were in excess of ISQG/TEL below 1.5 m.	
Gwynt y Môr OWF Marine Ecology Technical Report	0.00	2002-2004	Offshore sediments were relatively low in TOC, with the richest site containing <1%. Higher values were observed further inshore, with a maximum value of 2.5%.	CMACS, 2005b

2.3.1.2 Proposed development benthic subtidal and intertidal ecology study area

Subtidal sediments

Based on the available EUSeaMap data, the sediments present across the Proposed Development benthic ecology study area primarily consisted of circalittoral fine sand (A5.25), circalittoral muddy sand (A5.26), deep circalittoral sand (A5.27), deep circalittoral coarse sediment (A5.15) and circalittoral coarse sediment (A5.14), as illustrated in (Figure 2.5) (EMODnet, 2019). The Proposed Development benthic ecology study area also encompasses moderate/high energy infralittoral coarse sediment near the coastline of North Wales (Figure 2.5) (EMODnet, 2019). The results of the site-specific surveys for the Proposed Development have also been used to characterise the seabed. These are summarised in section 2.3.2 and provided in full volume 3, appendix I1.

Subtidal benthic communities

Some site-specific surveys conducted for OWFs in the regional benthic ecology study area overlap with the Proposed Development benthic ecology study area, such as the Awel y Môr OWF and Gwynt y Môr OWF (Figure 2.6). Similarly, the Burbo Bank OWF Extension and the North Hoyle OWF are located a minimum of 0.55 km and 3.85 km away, respectively. The results of these can be applied to the Proposed Development benthic subtidal and intertidal ecology study area on a more local scale and are summarised in Table 2.8. Most importantly, however, the results of the site-specific surveys for the Proposed Development serve to characterise the subtidal benthic ecology baseline. These are summarised in section 2.3.2 and provided in full in volume 3, appendix I1.

Liverpool Bay is home to a historical disposal site known as Site Z, located within the Eni Development Area which was first licensed for the disposal of dredged materials in 1982 (Whomersley *et al.,* 2008; Bolam *et al.,* 2016). In 2014, samples were taken from areas surrounding the Site Z marine disposal site and were found to be predominantly composed of gravelly sand and slightly gravelly and muddy sand (Bolam *et al.,* 2016). Benthic sampling was additionally undertaken at Site Y disposal grounds, just north of the Site Z disposal grounds during a 2015 survey (Bolam *et al.,* 2016). While Site Z analyses focused primarily on sediment contamination and the presence of heavy metals, the Site Y analyses prioritised understanding the macrofaunal assemblages that were present within Liverpool Bay. Benthic grab samples were collected at 16 distinct sites within Site Y and were found to comprise a total of 138 taxa (Bolam *et al.,* 2016). Results illustrated that the transparent razor shell and the bivalve *Mysella bidentata* were the most abundant taxa, present in 16 and 15 of the sample locations respectively (Bolam *et al.,* 2016). In addition, the polychaete *Scalibregma inflatum* and Nemertea spp. (ribbon worms) were both present in 15 sample locations (Bolam *et al.,* 2016). Further analysis evidenced that annelids were typically the most prevalent macroinvertebrate encountered in stations outside of the main disposal area and molluscan taxa were most abundant within the disposal area and less common in the peripheral reference sites (Bolam *et al.,* 2016).

Recently, as part of the Regional Seabed Monitoring Programme, Cooper and Barry (2017) described results of a baseline assessment of the UK's infauna. Although the authors focussed on the aggregates industry, a "big data" approach was taken which collated data from across UK waters, including within the Proposed Development benthic ecology study area. These data were collated from various industries, including offshore wind farms, oil and gas, nuclear, and port and harbour sectors. Cooper and Barry (2017) categorised benthic macrofaunal communities into broad groups, based on similarities in their community composition.

The samples collected within the Proposed Development benthic ecology study area were characterised by circalittoral sands and circalittoral coarse sediment and associated benthic infaunal communities of polychaetes (D1, D2a, D2b, D2c and D2d faunal groups*:* Spionidae, Nephtydae, Lumbrineridae, Oweniidae, Cirratulidae, Capitellidae, Ampharetidae, Opheliidae, Magelonidae), bivalve molluscs (D1, D2a, D2b and D2d faunal groups*:* Semelidae and Tellinidae) and nemerteans (D2b faunal group) (Cooper and Barry, 2017).

Using data supplied by the JNCC and EMODnet, there were no known Annex I Sandbanks, or OSPAR threatened and declining habitats located within the Proposed Development benthic ecology study area.

There is a small area of Annex I Reef located within the Eni Development Area along the northern border, and a small area of intertidal biogenic reef (blue mussel and horse mussel beds) located along the coast. However, this area of Annex I Reef does not overlap with the area of physical work for the Proposed Development (Figure 2.7) and is a minimum of 4.73 km away.

Subtidal Mixed Muddy Sediment, which is listed as a Habitat of Principal Importance (HPI) under the UK Post-2010 Biodiversity Framework, was identified across the south-west of the Eni Development Area. This habitat may support a wide range of infauna and epibiota, including polychaetes, bivalves, echinoderms, anemones, hydroids and Bryozoa.

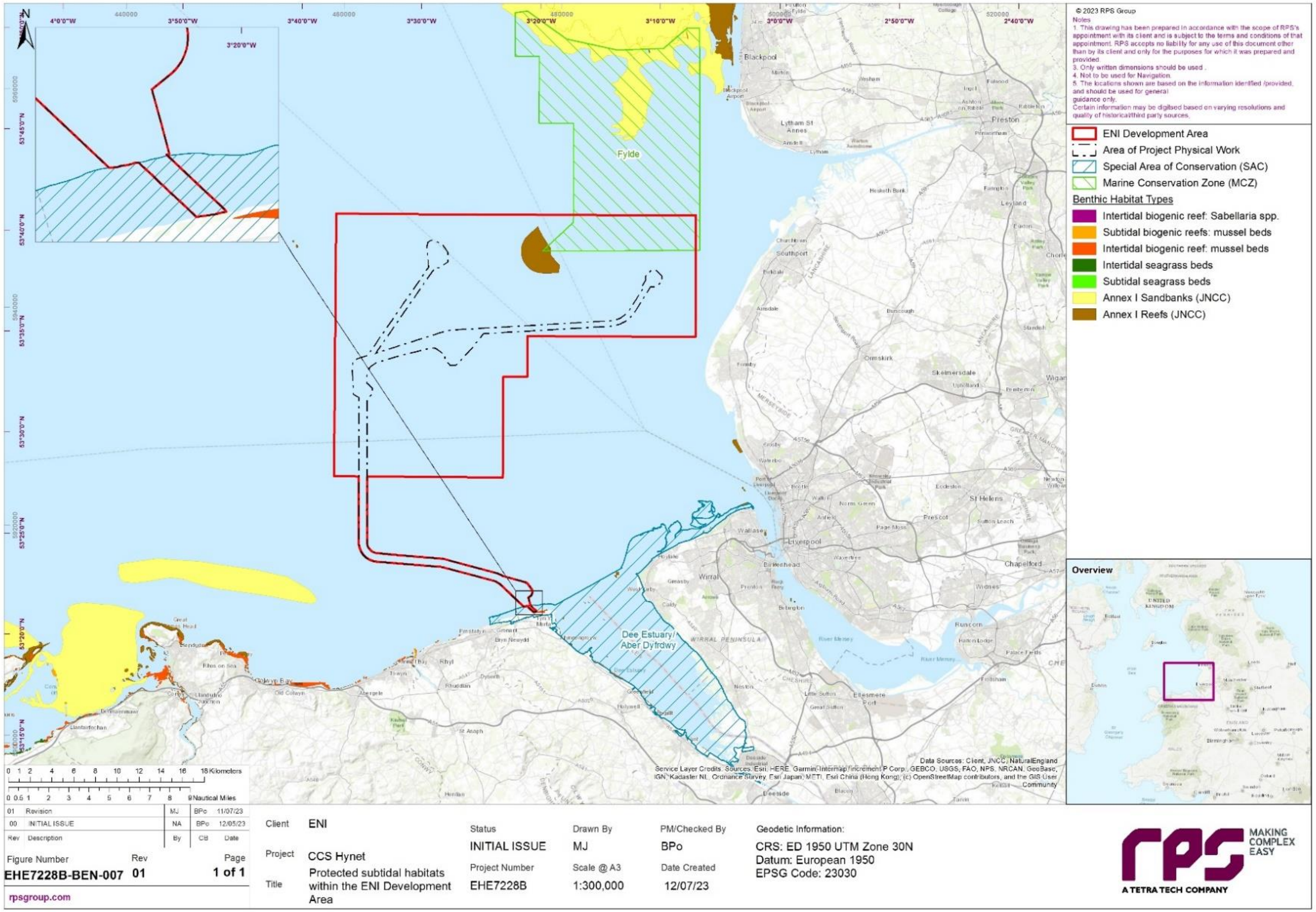

Figure 2.7: Annex I Sandbanks, Annex I Reefs, Designated Sites, And OSPAR Threatened And Declining Habitats In Proximity To The Eni Development Area

Intertidal benthic communities

The offshore export cable landfall location for Gwynt y Môr OWF is near the Proposed Development benthic ecology study area. Intertidal walkover surveys at Pensarn, North Wales, identified two dominant biotopes on the beach, LGS.S.Aeur and mid shore clean sand with burrowing amphipods, and the polychaetes *N. 36irrose* and *A. marina* (LGS.S.AP.P) (npower renewables Ltd, 2005). A small patch of blue mussel beds on eulittoral mixed substrata (SLR.MX.MytX) was also recorded. The top of the shore line was reported to consist of an extended band of barren shingle with no evident fauna (LGS.Sh.BarSh) (npower renewables Ltd. 2005). The intertidal surveys conducted in 2020 for the Awel y Môr OWF also fall in proximity to the Proposed Development benthic subtidal and intertidal ecology study area. There were no sensitive habitats or species recorded in the survey, and the habitats and species recorded were typical of the coastline of North Wales, such as*:*

- Polychaetes in littoral fine sand (LS.Lsa.FiSa.Po).
- Barren littoral shingle (LS.LCS.Sh.BarSh).
- Common rock barnacle *Semibalanus balanoides* and *Littorina* spp. On exposed to moderately exposed eulittoral boulders and cobbles (LR.HLR.MusB.Sem.LitX) (RWE Renewables UK, 2021b).

The results of the site-specific intertidal survey for the Proposed Development have also been used to characterise the intertidal community baseline. These are summarised in section 2.3.3 and provided in full in volume 3, appendix I2.

Sediment contamination

Some site-specific surveys conducted for OWFs in the regional benthic ecology study area overlap with the Proposed Development benthic ecology study area, such as the Awel y Môr OWF and Gwynt y Môr OWF (Figure 2.6). Similarly, the Burbo Bank OWF Extension is located a minimum of 0.55 km away. The results of these are summarised in Table 2.8, and can be applied to the Proposed Development benthic subtidal and intertidal ecology study area on a more local scale.

In the 2014 survey of historic dredging disposal Site Z, which is situated within the Eni Development Area, 15 samples were collected from around the disposal site and were tested for sediment contamination and the presence of As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn (Bolam *et al.,* 2016). Results indicated that there were no significant differences between the dredged material and sediments in the vicinity of the disposal grounds (Bolam *et al.,* 2016). From the analysis of the 15 stations, only one was found to exceed the effects range for low molecular weight PAHs, and the values were typical of those recorded along the west coasts of England and Wales (Bolam *et al.,* 2016).

The results of the site-specific survey have been used to characterise the levels of sediment contamination. These are summarised in section 2.3.2 and provided in full in volume 3, appendix I1.

2.3.2 Site-specific benthic characterisation survey results

2.3.2.1 Sediment composition

Sediments were heterogenous across the sampling stations, with sand dominating all stations and highly variable contributions of gravel and mud. While full decommissioning stations had very little gravel content, all other stations showed variable contributions of gravel and mud. The mean proportion (± Standard Error, SE) of sands across all stations was 83% (± 2), the mean gravel and mud content across the survey area was 7% (± 1) and 10% (± 1) respectively. A clear spatial pattern was evident in the distribution of mean grain size across the survey area with coarser sediments characterising stations located within the western reaches.

CCS Sampling stations

Of the 23 CCS sampling stations, 11 were classified as EUNIS Broadscale Habitat (BSH) A5.2 (Sand and Muddy Sand) including the textural groups Slightly Gravelly Sand ((g)S) and Sand (S). Nine stations represented BSH A5.4 (Mixed Sediment) including the textural groups Gravelly Muddy Sand (gmS) and Muddy Sandy Gravel (msG), two stations belonged to BSH A5.1 (Coarse Sediments) being made of Gravelly Sand (gS) and Sandy Gravel (sG), and one Slightly Gravelly Muddy Sand ((g)mS) station was classified as BSH A5.3 (Mud and Sandy Mud).

52% of the samples were classified as very poorly sorted. The remaining stations were classified as moderately well sorted (26.1%), well sorted (13.0%), poorly sorted (4.4%), and moderately sorted (4.4%). This variation results from a mixed composition of different size fractions of all three principal sediment types (gravel, sand, and mud).

Decommissioning sampling stations

Of the 32 partial decommissioning stations, 16 represented EUNIS BSH A5.2 including (g)S, S and (g)mS. Nine stations were classified as BSH A5.4, all being made of gmS. Five stations belonged to BSH A5.1 all being gS, and two stations represented BSH A5.3 both being (g)mS. Of the 21 full decommissioning stations sampled, 14 represented BSH A5.2 and were made of mS, S, (g)mS and (g)S. The remaining stations classified as BSH A5.3 and included textural groups mS and (g)mS.

39.62% of all decommissioning sediment samples were classified as very poorly sorted, 22.64% as poorly sorted, 18.87% moderately sorted, and the remainder of the samples were split evenly as moderately well sorted (9.43%) and well sorted (9.43%).

It is also noteworthy that finer sediments were found at decommissioning stations, which could be associated with drill cuttings.

2.3.2.2 Sediment contaminants

Metals

The full results of the metal contamination across the sampling stations are provided in tables and in greater detail in volume 3, appendix I1. Within the CCS stations, none of the main heavy and trace metals exceeded Cefas AL1. Station GS10 exceeded the OSPAR BAC reference levels for Hg; however, it was a very minor exceedance of 0.01 mg/kg, and the BAC for Hg is considerably lower than any of the other reference levels. Nine stations were above TEL and seven stations were above ERL for As. The most abundant metal was zinc which ranged from 19.80 mg/kg at station GS85 to 49.80 mg/kg at station GS10, with an average concentration across all stations of 30.90 mg/kg (± 2.60 mg/kg). Zinc was always recorded below reference levels at all stations.

Within the partial decommissioning stations, both As and Cd exceeded Cefas AL1 at one station. As was above Cefas AL1 at station GS23 whilst Cd was elevated at station GS34. As was also above OSPAR ERL at 29 stations and TEL at 32 stations. Cd also exceeded the OSPAR BAC at stations GS34 and GS38. Hg was above OSPAR BAC at four stations. None of the heavy or trace metals exceeded Cefas AL2 guidelines. The most abundant metal was zinc which ranged from 25.60 mg/kg at station GS26 to 62.50 mg/kg at station GS51, with an average concentration across all stations of 37.90 mg.kg (±1.50 mg/kg). Zinc was always recorded below reference levels at all stations.

Within the full decommissioning stations, none of the metals analysed exceeded Cefas AL1. As was above the TEL at stations GS58 and GS61. Hg exceeded OSPAR BAC reference levels at two stations, GS66 and GS68, and exceeded the TEL at station GS68. The most abundant metal at the stations within the full decommissioning scope was Zn which ranged from 24.30 mg/kg at station GS77 to 60.50 mg/kg at station GS81 with an average concentration across all stations of 34.00 mg/kg (±2.10 mg/kg). Zinc was always recorded below reference levels at all stations.

PAHs

The full range of Environmental Protection Agency (EPA) PAHs was tested and the raw data are reported in volume 3, appendix I1. PAH concentrations were compared to Cefas AL1 (however, there are no Cefas AL2 available for PAHs), OSPAR BAC levels and ERLs, and TEL and PEL where possible.

Within the CCS stations, none of the reference levels were exceeded for any of the measured PAHs. The most abundant PAHs across the CCS survey stations was Benzo[b]fluoranthene which ranged from below the limit of detection at five stations to 21.10 mg/kg at station GS10, with an average concentration of 5.40 mg/kg (±1.9 mg/kg).

Within the partial decommissioning stations, Cefas AL1 was exceeded at station GS36 for both Chrysene and Benzo[a]pyrene. These two PAHs are found in coal tar and more in general can be the result of incomplete combustion of organic matter (oil and gas products). OSPAR BAC was exceeded at three stations for Naphthalene, two stations for Pyrene and Benzo[a]anthracene and one station for Anthracene, Benzo[k]fluoranthene and Benzo[a]pyrene. Station GS36 reported concentrations above the TEL for Acenaphthene, Fluorene, Benzo[a]anthracene, Benzo[a]pyrene and Dibenzo[a,h]anthracene.

Within the full decommissioning stations, none of the measured PAHs exceeded Cefas AL1 guidelines. However, OSPAR BAC reference levels were exceeded for multiple PAHs, including Naphthalene at three stations, Anthracene at two stations, Fluoranthene and Benzo[a]pyrene at station GS68, Pyrene and Benzo[a]anthracene at two stations. The most abundant PAH was Benzo[b]fluoranthene ranging from below the limit of detection to 43.80 mg/kg at station GS68, with an average concentration across all full decommissioning stations of 12.10 mg/kg (±2.50 mg/kg).

THCs

The THC in sediment samples collected from the CCS stations ranged from 969 µg/kg at station GS85 to 16,500 µg/kg at station GS10 with an average value for the whole area of 4,926 µg/kg (±1,274 µg/kg). A detailed description is provided in volume 3, appendix I1.

The THC in sediment samples collected from partial decommissioning stations ranged from 1,320 µg/kg at station GS23 to 30,600 µg/kg at station GS36 with an average value for the whole of the cruciform areas of 7,446 µg/kg (±1,205 µg/kg).

The THC in sediment samples collected from full decommissioning stations ranged from 2,080 µg/kg at station GS61 to 26,100 µg/kg at station GS68 with an average value for the whole of the cruciform areas of 9,534 µg/kg (±1,452 µg/kg).

PCBs

The seven PCB congeners (PCB28, PCB52, PCB101, PCB118, PCB138, PCB153 and PCB180) were analysed from the sediments taken at each station and raw data are reported in full in volume 3, appendix I1 and volume 3, appendix I2. The seven PCBs are widely used in environmental monitoring as they cover the range of toxicological properties of the group. Most PCBs had concentrations below the detection limit of 0.08 µg/kg across the survey area. No Cefas ALs exist for each individual PCB, but for the sum of the seven PCBs (ΣICES7), the AL1 Is 10 µg/kg.

All of the CCS stations all analysed PCBs were measured below the limit of detection.

PCB138 had the highest concentrations across the partial decommissioning stations, ranging from below the limit of detection at 26 stations, to 0.41 µg/kg at GS29 with an average of 0.10 µg/kg (±0.006 µg/kg) from the remaining five stations. ΣICES7 was below Cefas AL1 at all stations.

PCB138 had the highest concentrations across the full decommissioning stations ranging from below the limit of detection at 13 stations, to 0.30 µg/kg at station GS61 with an average of 0.13 µg/kg (±0.02 µg/kg) at the remaining 7 stations. ΣICES7 was below Cefas AL1 at all 21 stations.

2.3.2.3 Faunal assemblage from DDC imagery

DDC acquisition was successfully conducted at 86 stations resulting in the collection of 442 still images and approximately three hours of video footage.

CCS Sampling stations

Three BSHs, five EUNIS Level 4 (biotope complexes) and one EUNIS Level 5 biotope were identified in the seabed imagery collected across the 137 images taken within the CCS stations. The most common classification was A5.44 "Circalittoral mixed sediments", which was identified in 34.30% (n=47) of images, and broadly located in the western CCS stations. This was followed by A5.26 'Circalittoral muddy sand' identified in 30 images. Biotope A5.445 "*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment" was found in six images and may occur as part of the Feature of Conservation Interest (FOCI) 'Sheltered Muddy Gravels'. No Annex I reef features were found across the site.

Within the CCS stations, the green sea urchin *Psammechinus miliaris*, the brittlestar *Ophiura albida* and *Serpulidae* tubes were amongst the most abundant epibenthic taxa present. Faunal burrows were also notable across these stations. Additionally, the bed forming brittlestar *O. fragilis* was observed at stations GS03, GS04, GS11, GS14 and GS86.

Decommissioning sampling stations

Three BSHs, four EUNIS Level 4 (biotope complexes) and one EUNIS Level 5 biotope were identified in the seabed imagery collected across the 168 images taken within the partial decommissioning stations. The most common classification was A5.44 "Circalittoral mixed sediments", being identified in 33.30% (n=56) of images and was predominantly found in the southern area of the site. This was followed by A5.26 "Circalittoral muddy sand" identified in 48 images. Biotope A5.445 '*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment' was found in 12 images and may occur as part of the FOCI 'Sheltered Muddy Gravels'. Brittlestar beds were interspersed within the mixed sediment found in the southern area of the site. No Annex I reef features were found.

Partial decommissioning stations displayed a sparser faunal cover than CCS stations with the dominant taxon being the brittlestar *Ophiura sp.* Faunal burrows were also noted. In stations GS33, GS34 and GS52, there was clear presence of *O. fragilis* beds.

Three BSHs and three EUNIS Level 4 (biotope complexes) were identified in the seabed imagery collected across the 140 images taken within the full decommissioning stations. The most common classification was A5.44 "Circalittoral sandy mud" identified in 48.50% (n=68) of images and was mostly recorded in stations to the south. This was followed by A5.26 'Circalittoral muddy sand' identified in 66 images. Sandy substrates supported ripple bedforms which were not as frequently observed in areas with a higher mud content.

Full decommissioning stations also exhibited a sparser faunal cover than CCS stations, with dominance of Paguridae and faunal burrows.

2.3.2.4 Macrobenthic composition

CCS Sampling stations

A diverse assemblage was identified across the survey area from CCS sampling stations, with a total of 2,001 individuals and 215 taxa recorded. The mean (± SE) number of taxa per station was 23 ± 3, mean (± SE) abundance per station was 871 ± 32, and mean (± SE) biomass per station was 0.4571 ± 0.145 g Ash Free Dry Weight (AFDW).

The brittlestar *A. filiformis* was the most abundant infaunal taxon sampled, accounting for 15.30% of all individuals recorded. It also accounted for the maximum abundance in a sample and greatest average density per sample. Other key infaunal taxa were Nemertea and Nematoda which were the most frequently occurring taxa, recorded in 78% of samples.

The tubeworm *Spirobranchus triqueter* was the most abundant epifaunal taxon sampled, accounting for 20% of all individuals recorded. It also accounted for the maximum abundance and greatest average density per sample. Other key epifaunal taxa were Actinaria, which was the most frequently occurring taxa, recorded in 30% of samples. This was followed by *O. albida* and juveniles of Mytilidae, both occurring in 13% of samples.

Figure 2.8 illustrates the relative contributions to total abundance, diversity, and biomass of the major taxonomic groups in the community sampled across all CCS stations. Annelida taxa dominated infaunal abundance as they accounted for 35% of all individuals recorded, while Crustacea taxa dominated epifaunal abundance as they accounted for 38% of all individuals recorded. Annelida taxa also contributed the most to infaunal diversity at 50%, while Miscellaneous taxa[1] dominated epifaunal diversity at 61%.

Biomass was measured by major group without discriminating between infaunal and epifaunal species, however for ease of comparison is presented in Figure 2.8 under the infauna heading as infaunal taxa made up most of the community across all CCS sampling stations. Biomass was dominated by Mollusca, contributing to 48% of the total biomass.

The highest infaunal abundance and diversity was recorded at station GS09 with 757 individuals recorded and 44 taxa counted, this is consistent with the substrate type of sandy mud, and the habitat description of *Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud (A5.351). Epifaunal abundance and diversity was greatest at station GS15 with 58 individuals recorded and 20 taxa counted and is reflective of the presence of sublittoral mixed sediments (EUNIS A5.4) (Figure 2.9).

Three notable taxa were recorded across the CCS stations (Table 2.9). The common whelk *Buccinum undatum* is an economically important species as it as a significant fishery associated with it. However, only one specimen was recorded at station GS13. Further information on *B. undatum* ecology and fisheries is provided in section 3.3.1 and volume 3, appendix M, respectively. Ross worm is a protected species under the OSPAR list of threatened and/or declining species and the Habitats Directive when in reef habitat form. Four individuals were recorded at CCS stations with no signs of reef forming features. Three individuals were counted at station GS08 and one at Station GS15. Thumbnail crab is a nationally scarce marine species, with two specimens recorded at station GS20.

Table 2.9: Notable Taxa Recorded Across The CCS Sampling Stations

Common Name	Scientific Name	Designation	Total Abundance
Common whelk	*Buccinum undatum*	Economically Important	1
Ross Worm	*Sabellaria spinulosa*	OSPAR and Habitats Directive	4
Thumbnail Crab	*Thia scutellata*	Nationally scarce marine species	2

[1] Miscellaneous taxa comprise Bryozoa, Cnidaria (Anthozoa, Hydrozoa), Porifera and Animalia (Folliculinidae) across all survey scopes (CCS and decommissioning).

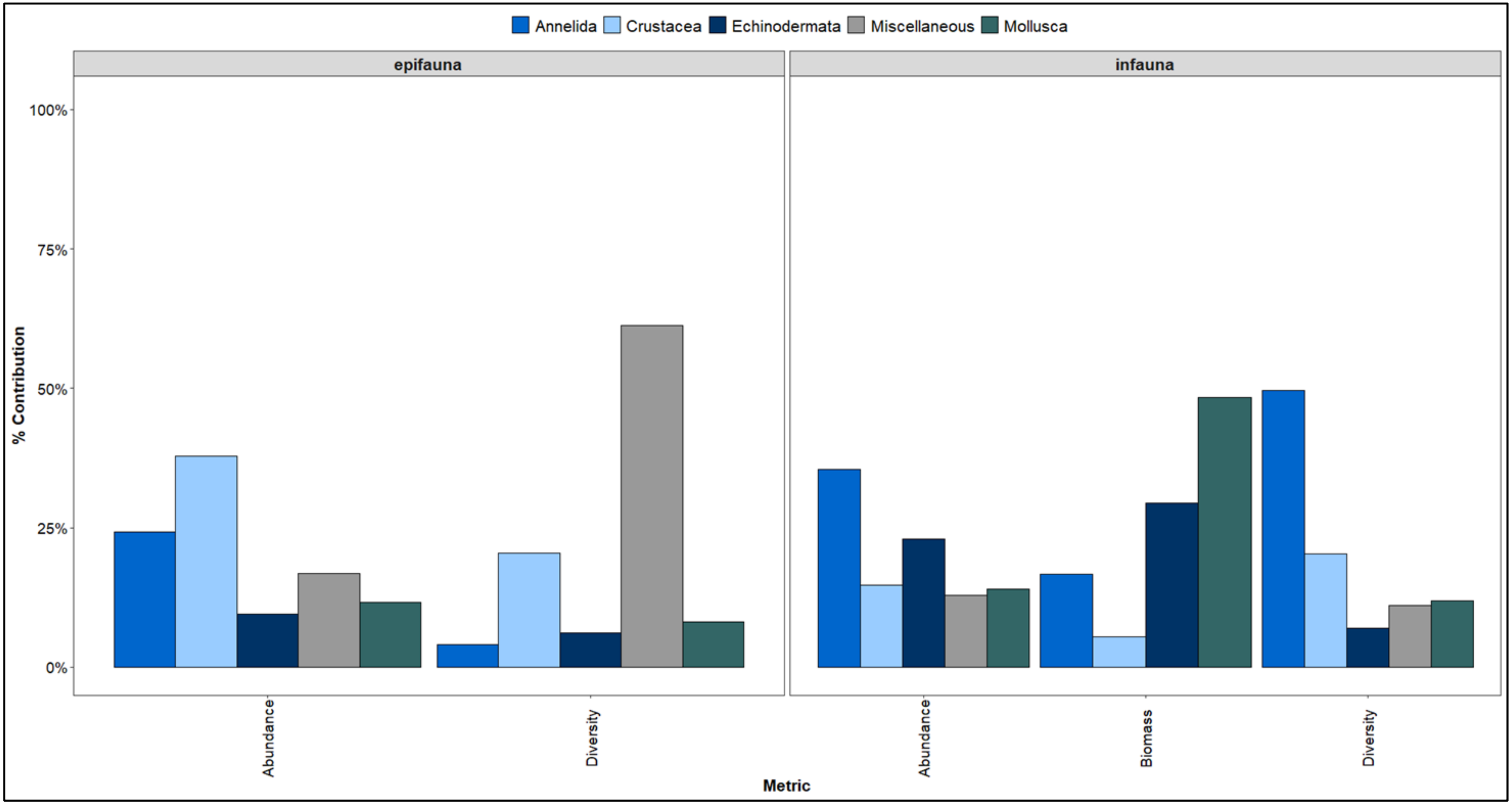

Figure 2.8: Relative Contribution Of The Major Taxonomic Groups To The Total Abundance, Diversity, And Biomass Of The Infaunal And Epifaunal Taxa Sampled At CCS Sampling Stations

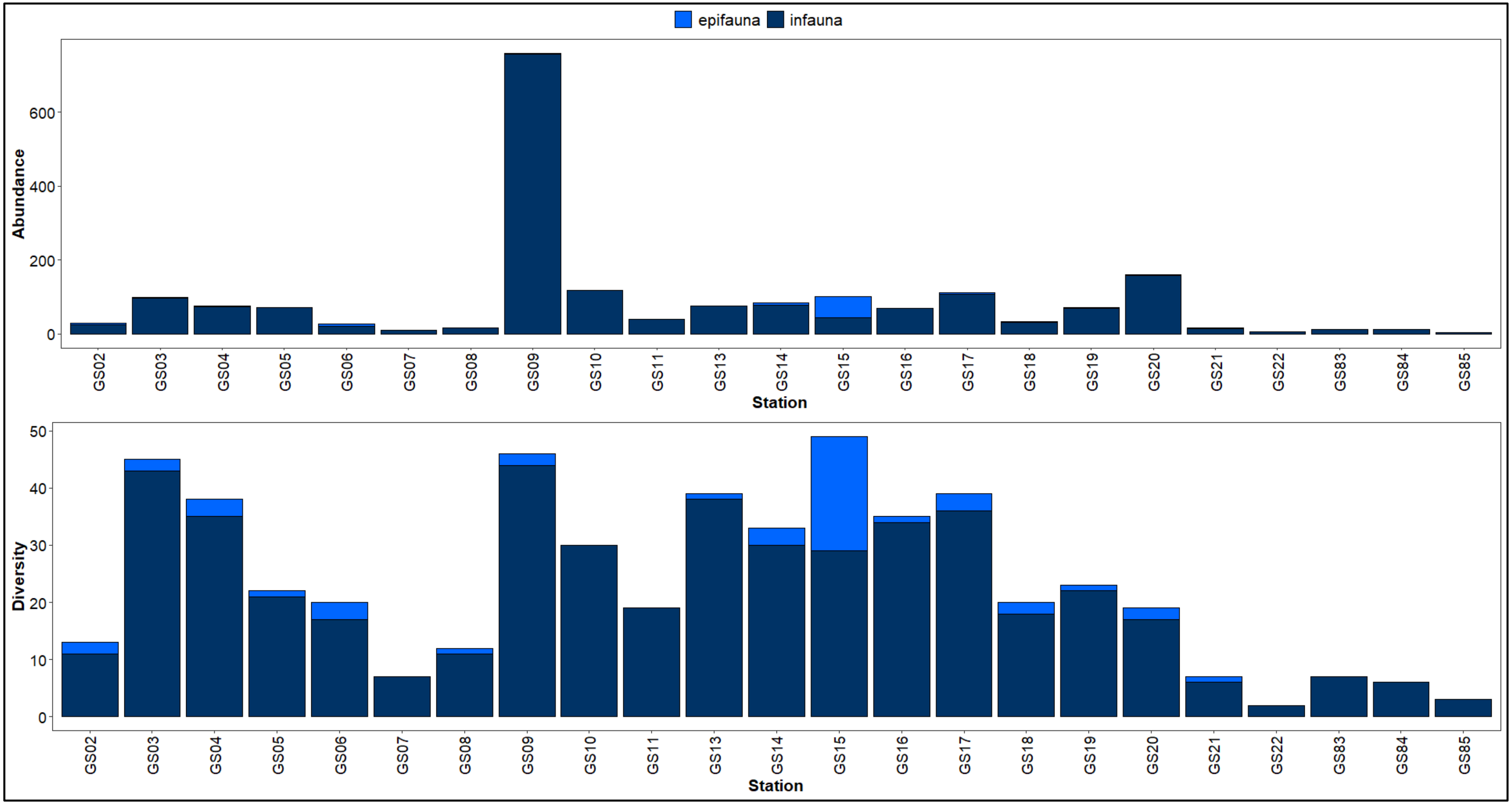

Figure 2.9: Abundance And Diversity Across All CCS Sampling Stations. Colours Denote Epifauna (Light Blue) And Infauna (Navy Blue) Contributions To Abundance (Number Of Individuals) And Diversity (Number Of Taxa)

Decommissioning sampling stations

A diverse assemblage was identified across the decommissioning sampling stations, with a total of 13,332 individuals and 322 taxa recorded. The mean (± SE) number of taxa per station was 22 ± 3 for the partial decommissioning dataset and 20 ± 3 for the full decommissioning. Mean (± SE) abundance per station was 121 ± 22 for the partial decommissioning dataset and 133 ± 26 for the full decommissioning. Mean (± SE) biomass per station was 0.2449 ± 0.0609 g AFDW for the partial decommissioning dataset and 0.0566 ± 0.0084 g AFDW for the full decommissioning.

Nematoda was the most abundant infaunal taxon sampled, accounting for 24% of all individuals recorded. It also accounted for the maximum abundance in a sample and greatest average density per sample. Other key taxa were Nemertea and the bivalve *K. bidentata* which were the most frequently occurring, recorded in 98% of samples.

The brittlestar *O. fragilis* and sea anemones (Actiniaria) were the most abundant epifaunal taxa sampled, accounting for 18% of all individuals recorded and accounted for the greatest average density per sample. *O. fragilis* also accounted for the maximum abundance in a sample, while Actinaria was the most frequently occurring taxon being recorded in 21% of samples.

Figure 2.10 illustrates the relative contributions to total abundance, diversity, and biomass of the major taxonomic groups in the community sampled across all decommissioning stations. At partial decommissioning stations, Annelida dominated infaunal abundance, accounting for 25% of all individuals recorded, while Echinodermata dominated epifaunal abundance accounting for 39% of all individuals recorded. Annelida also contributed the most to infaunal diversity at 50%, while Miscellaneous taxa dominated epifaunal diversity at 63% (Figure 2.10). At full decommissioning stations, Miscellaneous taxa dominated both infaunal and epifauna abundance, contributing to 38% and 43% respectively of all individuals recorded. Annelida dominated infaunal diversity at 44%, while Miscellaneous taxa dominated epifaunal diversity at 90% (Figure 2.10).

Biomass was measured by major group without discriminating between infaunal and epifaunal species, however Figure 2.10 is presented for ease of comparison under infauna, as infaunal taxa dominated the community across all decommissioning stations. Biomass was dominated by Annelida (contributing to 41% of the total biomass) at partial decommissioning stations, and by Echinodermata (contributing to 37% of the total biomass) at full decommissioning stations.

At partial decommissioning stations, the highest infaunal abundance was recorded at station GS34 with 1,053 individuals recorded (Figure 2.11). The greatest epifaunal abundance of 17 individuals was recorded at stations GS31 and GS34. Infaunal diversity was the highest at station GS32 with 71 taxa counted, while epifaunal diversity was the highest at station GS31 with seven taxa counted (Figure 2.11). At full decommissioning stations, the highest infaunal abundance was recorded at station GS76 with 497 individuals recorded. Epifaunal abundance was the highest at station GS69 with four individuals recorded. Diversity was the highest at station GS79 for both infauna and epifauna with 55 and three taxa counted, respectively (Figure 2.11). In general, more epifaunal taxa were recorded at partial decommissioning than at full decommissioning stations.

Four notable taxa were recorded across all decommissioning stations (Table 2.10). Ocean quahog is protected under the OSPAR list of threatened and/or declining species and habitats and two juvenile specimens were recorded. one at partial decommissioning station GS38 the other at full decommissioning station GS81. The polychaete *Goniadella gracilis* is an Invasive Non-Native Species (INNS) that was first introduced to Liverpool Bay in 1970, most likely by shipping from the east coast of North America. Only one specimen was recorded at partial decommissioning station GS28. No evidence of *S. spinulosa* reef features were noted across all decommissioning stations, as only three individuals were recorded; two at partial decommissioning station GS31 and one at partial decommissioning station GS37. Three thumbnail crabs were found across all decommissioning stations at partial decommissioning stations GS26 and GS38 and full decommissioning station GS57.

Table 2.10: Notable Taxa Recorded Across All Decommissioning Stations

Common Name	Scientific Name	Designation	Total Abundance
ocean quahog	*Arctica islandica*	OSPAR	2
polychaete	*Goniadella gracilis*	INNS	1
Ross worm	*Sabellaria spinulosa*	OSPAR and Habitats Directive	3
thumbnail crab	*Thia scutellata*	Nationally scarce marine species	3

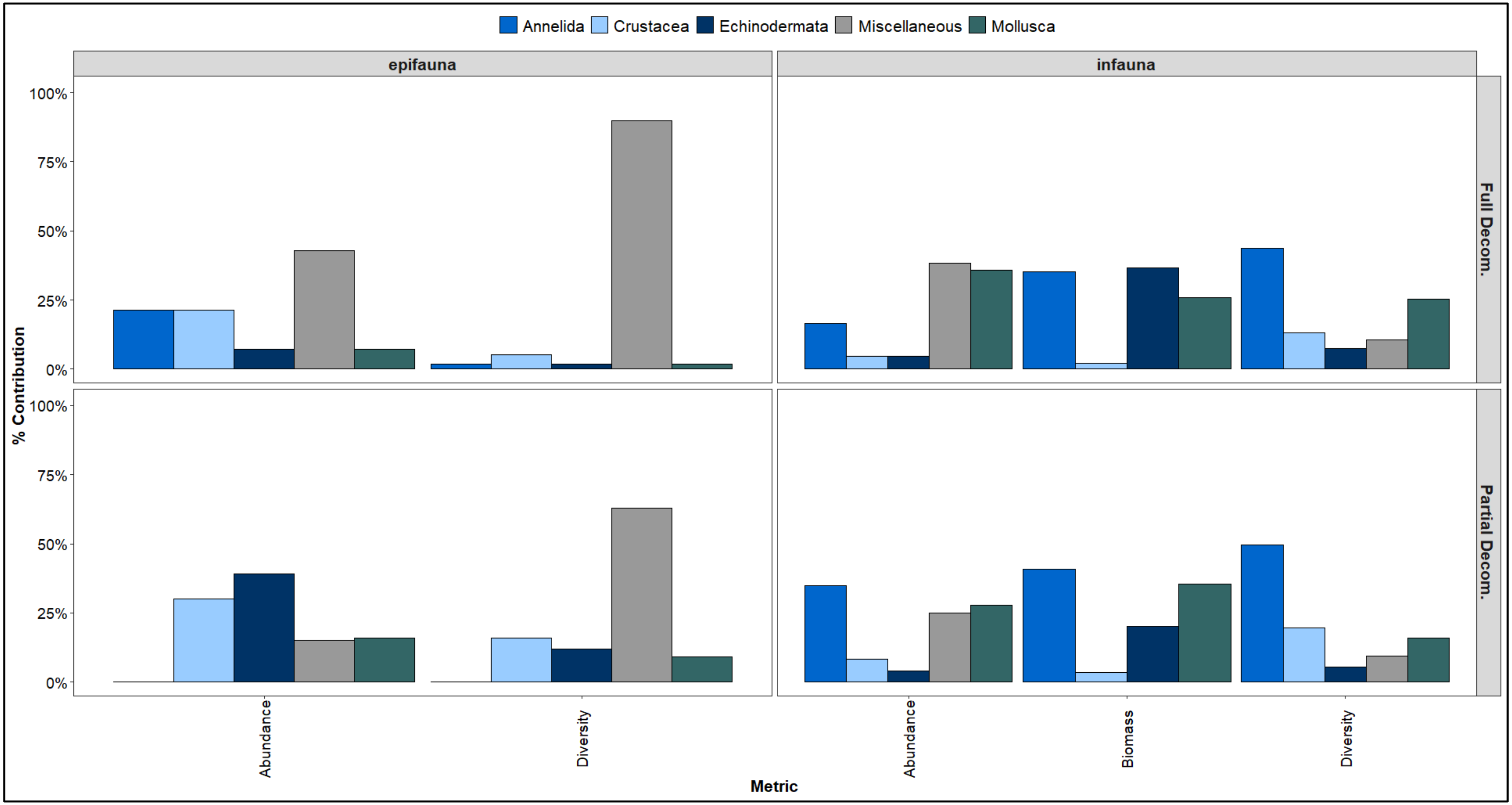

Figure 2.10: Relative Contribution Of The Major Taxonomic Groups To The Total Abundance, Diversity, And Biomass Of The Infaunal And Epifaunal Taxa Sampled At Full And Partial Decommissioning Stations

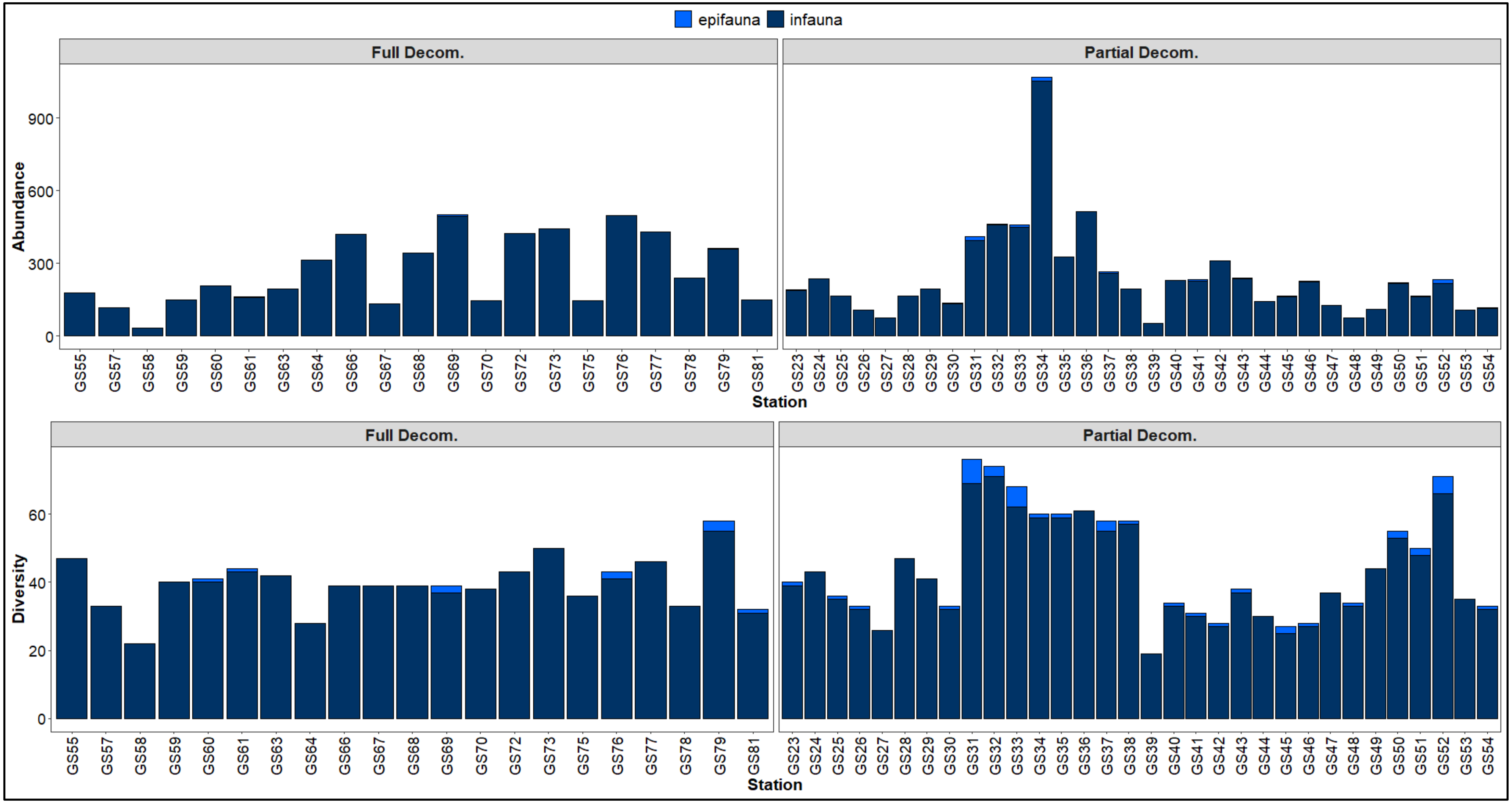

Figure 2.11: Abundance And Diversity Per Full And Partial Decommissioning Sampling Station. Colours Denote Epifauna (Light Blue) And Infauna (Navy Blue) Contributions To Abundance (Number Of Individuals) And Diversity (Number Of Taxa)

2.3.2.5 Macrobenthic groups

Multivariate analysis was undertaken on the grab abundance data, to identify spatial distribution patterns in the assemblages across the survey area and identify characterising taxa present.

CCS Sampling stations

Four statistically significantly similar groups and two outlier stations (GS15 and GS18) that did not belong to any group (p >0.05) were identified from cluster analysis and Similarity Profile Routine (SIMPROF) testing (Table 2.11; Figure 2.12). SIMPER was used to identify the key taxa contributing to the within group similarity of the group recognised; the full SIMPER results are provided in volume 3, appendix I1.

Table 2.11: Macrobenthic Groups Identified At The Ccs Sampling Stations

Macrobenthic Group	Description
Macrobenthic Group A	Two stations GS09 and GS10 belonged to this group and were characterised by the polychaete *Pholoe baltica*, *K. bidentata* and the brittlestar *A. filiformis,* all together contributing to about 42% of the group average similarity of 39.1%.
Macrobenthic Group B	Seven stations belonged to this group and were characterised by the polychaete *Lumbrineris47irrose47ta*, the amphipod *Ampelisca spinipes*, Nemertea and Nematoda all together contributing to about 32% of the group average similarity of 38.8%.
Macrobenthic Group C	Six stations belonged to this group and were characterised by *N.47irrosea* contributing to about 81% of the group average similarity of 29.8%.
Macrobenthic Group D	Six stations belonged to this group and were characterised by, Nemertea*, N.47irrosea*, Nematoda, Actinaria all together contributing to about 51% of the group average similarity of 21.1%.

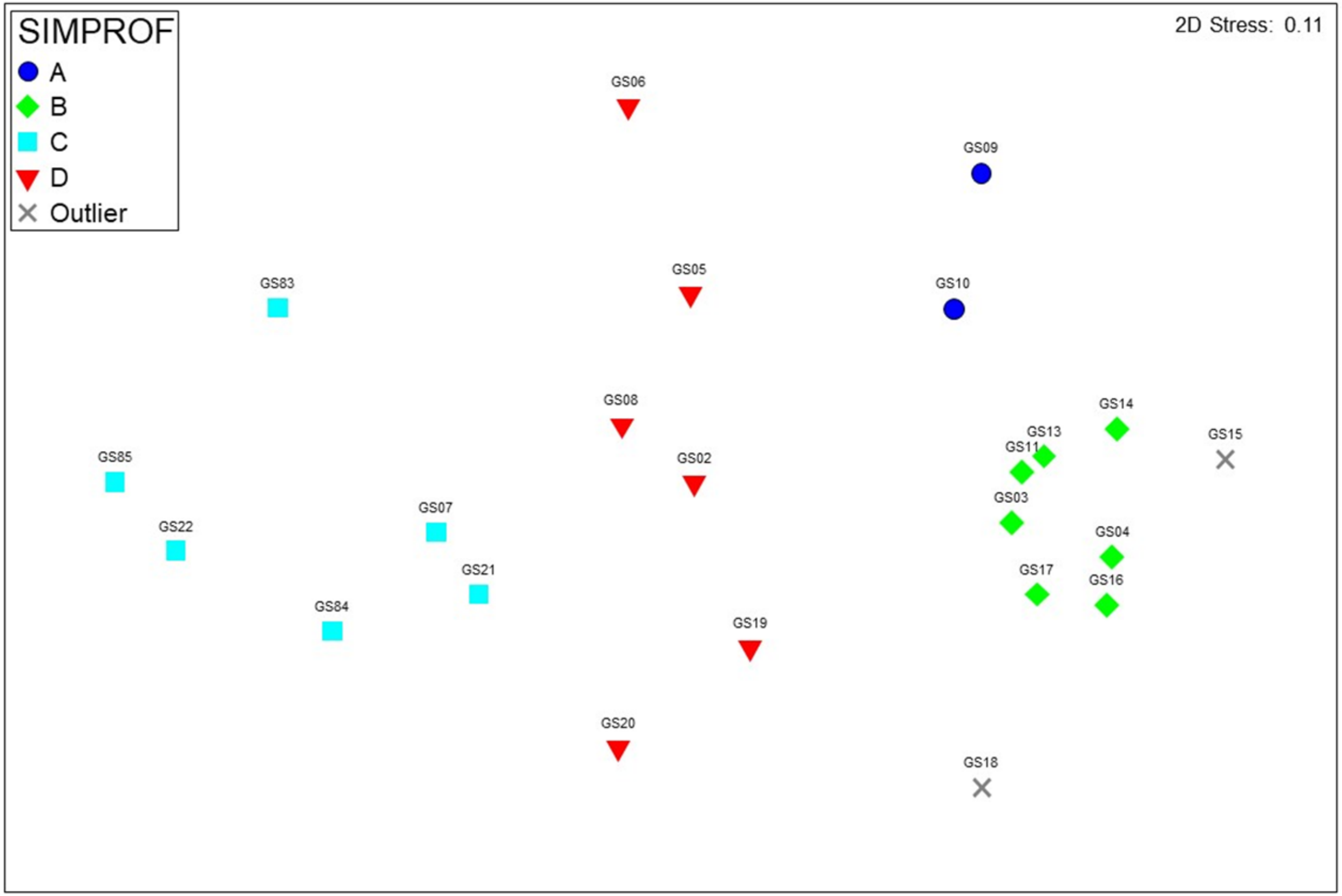

Figure 2.12: Two-Dimensional nMDS Ordination Of Macrobenthic Communities At CCS Sampling Stations Based On Square Root Transformed And Bray-Curtis Similarity Abundance Data

Decommissioning sampling stations

Partial decommissioning

Seven statistically significantly similar groups and two outlier stations that did not belong to any group (p >0.05) were identified. To enable a broad interpretation of the community present, a similarity slice at 35% was used to amalgamate the seven SIMPROF groups into four broader groups (Table 2.12; Figure 2.13). SIMPER was used to identify the key taxa contributing to the within group similarity of the group recognised; the full SIMPER results are provided in volume 3, appendix I1.

Table 2.12: Macrobenthic Groups Identified At The Partial Decommissioning Sampling Stations

Macrobenthic Group	Description
Macrobenthic Group A	Eight stations belonged to this group and were characterised by juveniles of Tellininae and *Nephtys* sp., *K. bidentata*, and Nemertea all together contributing to about 54% of the group average similarity of 49%.
Macrobenthic Group B	Eight stations belonged to this group and were characterised by Nematoda, the amphipod *Urothoe marina*, Nemertea, *K. bidentata*, and the polychaete *Paradoneis lyra* all together contributing to about 35% of the group average similarity of 45.7%.
Macrobenthic Group C	Eight stations belonged to this group and were characterised by Nematoda, *K. bidentata*, Nemertea and the polychaetes (*Mediomastus fragilis* and *P. baltica*) all together contributing to about 35% of the group average similarity of 54.9%.
Macrobenthic Group D	Eight stations belonged to this group and were characterised by Nematoda, the oligochaete *Grania sp.*, Nemertea and the basket shell *Varicorbula gibba* all together contributing to about 38% of the group average similarity of 48.7%.

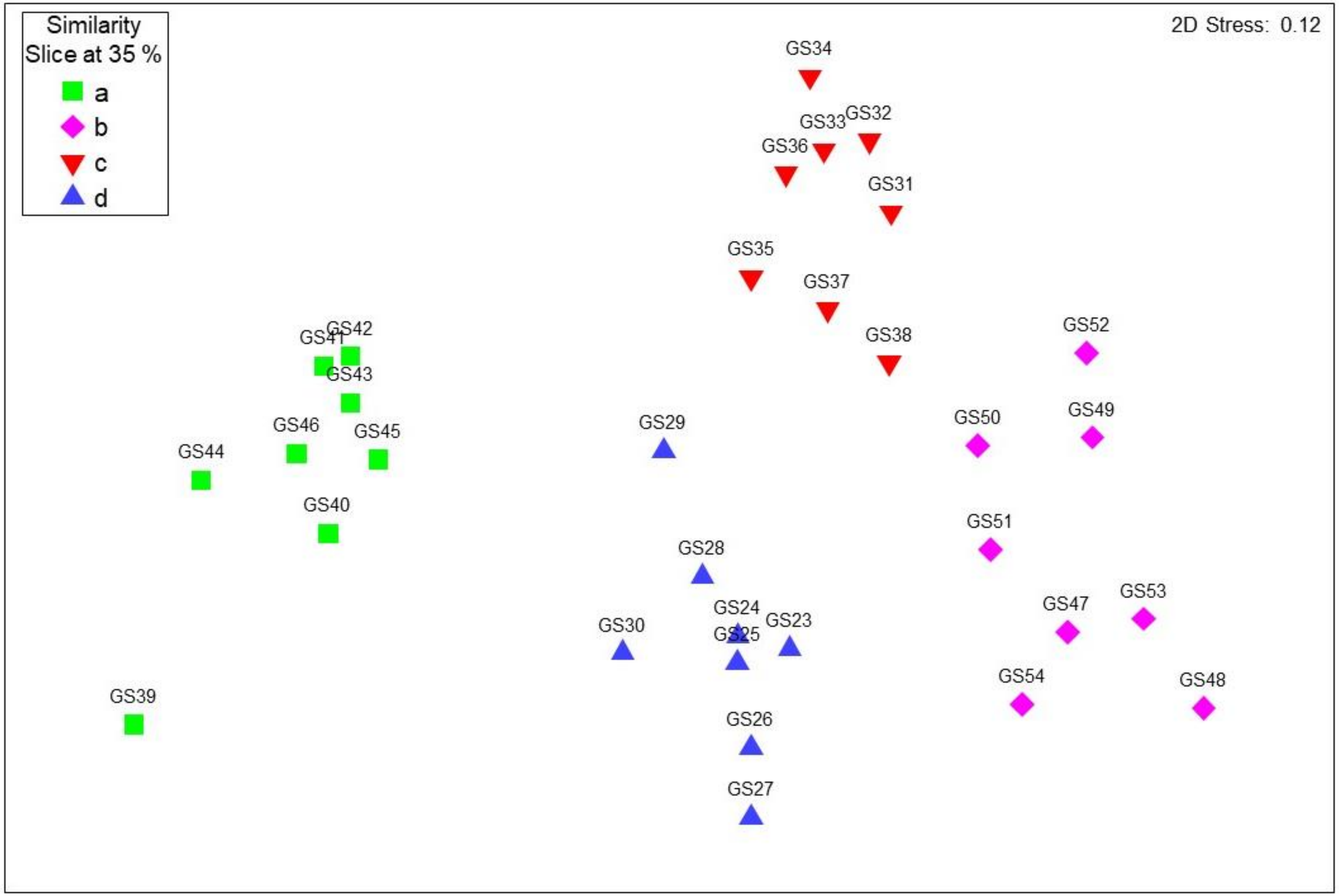

Figure 2.13: Two-Dimensional nMDS Ordination Of Macrobenthic Communities At The Partial Decommissioning Sampling Stations Based On Square Root Transformed And Bray-Curtis Similarity Abundance Data

Full decommissioning

Three statistically significantly similar groups and four outlier stations that did not belong to any group ($p > 0.05$) were identified. To enable a broad interpretation of the community present, a similarity slice at 51% was used to amalgamate the SIMPROF groups and outliers into two broader groups and one outlier station GS58 (Table 2.13; Figure 2.14). SIMPER was used to identify the key taxa contributing to the within group similarity of the group recognised; the full SIMPER results are provided in volume 3, appendix I1

Table 2.13: Macrobenthic Groups Identified At The Full Decommissioning Sampling Stations

Macrobenthic Group	Description
Macrobenthic Group A	Nine stations belonged to this group and were characterised by Nematoda, the oligochaete *Tubificoides pseudogaster*, Nemertea, and juveniles of the bivalve *Thracioidea* sp., all together contributing to about 34% of the group average similarity of 57.29%.
Macrobenthic Group B	11 stations belonged to this group and were characterised by *K. bidentata*, Nematoda, *P. baltica*, *A. filiformis* and the amphipod *Harpinia antennaria* all together contributing to about 47% of the group average similarity of 57.82%.

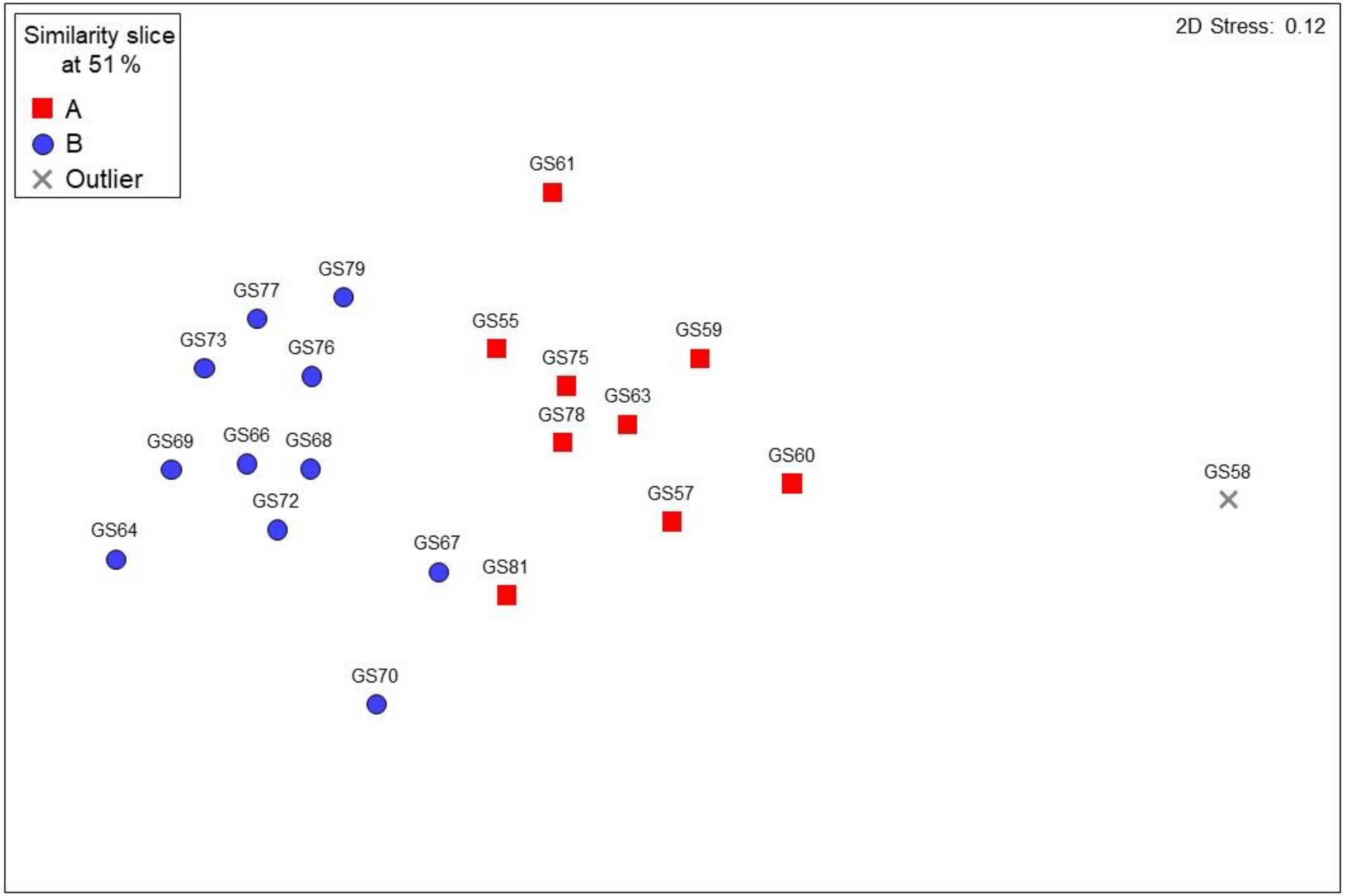

Figure 2.14: Two-Dimensional nMDS Ordination Of Macrobenthic Communities At The Full Decommissioning Sampling Stations Based On Square Root Transformed And Bray-Curtis Similarity Abundance Data

Biotope assignment

For each of the Macrobenthic Groups determined using cluster analysis, biotopes were assigned in consideration of industry-standard practices and guidance (Parry, 2019) based upon their faunal and physical characteristics (Table 2.14). Further detail (including figures showing the spatial distribution of these groups) is provided in volume 3, appendix I1.

Table 2.14: Biotope Assignment From The CCS And Partial, And Full Decommissioning Sampling Stations

Macrobenthic Group	Description
Macrobenthic Group A	Best aligned – with biotope A5.351–- *A. filiformis, M. bidentata* and *A. nitida* in circalittoral sandy mud. Only two stations belonged to this group: GS09, which was classified as BSH A5.3 based on PSA, and GS10 classified as BSH A5.4 based on PSA but with a relatively high mud contribution at 14%; the latter being a biotope mismatch.
Macrobenthic Group B	Made up of seven stations all classified as BSH A5.4 based on PSA data except for station GS13 which was classified as A5.1. Al stations had more than 20% of gravel in the sediment. No infralittoral or circalittoral mixed sediment biotope matched the assemblage characterising this group. Of the coarse sediment biotopes, A5.142 -*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel shared some similarity with the community composition observed in this group, characterised by *L.53irrose53ta, E. pusillus,* Nemertea, and *A. spinipes*. However other taxa were present in this group that were unmatched such as Nematoda, *P. balthica, Phoronis, P. lyra, Ampharete lindsstroemi, Glycinde nordmanni, Chaetozone zetlandica, Cerianthus lloydii, U. elegans* and *Nototropis vedlomensis*. Mixed sediment stations belonging to this group were therefore assigned to EUNIS classification A5.44 - Circalittoral mixed sediments due to the inability of matching the observed community with a specific known biotope. It should be noted that biotope A5.445 – *O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment was observed in the seabed imagery in proximity of the area covered by this group.
Macrobenthic Group C	Made up of six stations all classified as BSH A5.2 based on PSA data. These stations are all located in proximity to the coast and dominated by *N.53irrosea,* suggesting that the biotope A5.233 – *N.53irrosea* and *Bathyporeia* spp. in infralittoral sand is present at these locations. This is also consistent with the results of the imagery analysis.
Macrobenthic Group D	Included six stations all classified as BSH A5.2 based on PSA data but station GS19 which was deemed to be representative of A5.1. None of the circalittoral fine sand or muddy sand biotopes matched the community observed for this group which was dominated by Nemertea, *N. irrosea*, Nematoda, Actinaria and *K. bidentata*. Therefore, this group was assigned to EUNIS classification A5.25 – Circalittoral fine sand, with station GS19 assigned to A5.14 – Circalittoral coarse sediments.
Macrobenthic Group A	Was made up of eight stations all classified as BSH A5.2 based on PSA data. These stations were all located close to the coast and dominated by *K. bidentata*, Nemertea, Nematoda, and amphipods *Megaluropus agilis* and *Bathyporeia guilliamsoniana*. None of the sand biotopes matched the above community and therefore these stations were assigned to EUNIS classification A5.23 - Infralittoral fine sand.

Macrobenthic Group	Description
Macrobenthic Group B	Included eight stations all having at least 10% gravel in their sediments. Four stations were classified as BSH A5.1 and the other four as A5.4 based on PSA data. Due to the heterogeneity in the substrate characterising this group a diverse community was observed that did not match any one biotope. Part of the community aligned with that describe– in biotope A5.142–- *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel, with *L. irroseta, E. pusillus*, Nemertea, and *A. spinipes* being among the characterising taxa. However other taxa also dominated the community but remained unmatched as no coarse or mixed sediment biotope aligned with it. These included *U. marina, P. lyra, Lysilla nivea, Grania, Polycirrus* and *Leptocheirus hirsutimanus*. Therefore, stations belonging to BSH A5.1 were assigned to biotope A5.142, while stations belonging to BSH A5.4 were assigned to EUNIS classification A5.44. It should be noted that biotope A5.445 – *O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment was observed in the seabed imagery in proximity of the area covered by this group.
Macrobenthic Group C	Was made up of eight stations all having at least 10% mud in their sediments except for station GS38 which had only 4%. Five stations belonged to BSH A5.4 based on PSA data while the remaining three stations were classified as A5.1, A5.2 and A5.3. As this group covered a range of substrates no one biotope matched the community observed at these stations. The community characterising this group included Nematoda, *K. bidentata,* Nemertea, *M. fragilis, P. baltica, P. lyra, Grania* and *T. pseudogaster.* Therefore, stations belonging to this group were assigned to EUNIS classifications A5.44, A5.14, A5.26 and A5.35 – Circalittoral sandy mud, based on the corresponding BSHs determined by PSA.
Macrobenthic Group D	Included eight stations, seven of which were classified as BSH A5.2 based on PSA data and with station GS29 being classified as A5.3. None of the fine or muddy sand biotopes matched the community observed at these stations, which was characterised by Nematoda, *Grania,* Nemertea, *V. gibba, K. bidentata*, Chaetognatha, and *Polygordius*. All stations were therefore assigned to EUNIS classification A5.25 – Circalittoral fine sand, apart from station GS30 which was assigned to EUNIS classification A5.26–- Circalittoral muddy sand and station GS29 which was assigned to EUNIS classification A5.35.

Macrobenthic Group A	Comprised nine stations all classified as BSH A5.2 based on PSA data except for station GS81 which was classified as A5.3. None of the fine or muddy sand biotopes matched the community observed at these stations which was characterised by Nematoda, *T. pseudogaster,* Nemertea, Thracioidea, Chaetognatha, *E. pusillus*, and *K. bidentata*. All sand dominated stations were therefore assigned to EUNIS classification A5.26–- Circalittoral muddy sand, based on PSA and imagery analysis, while station GS81 was assigned to A5.35.
Macrobenthic Group B	Included 11 stations, of which six were classified as BSH A5.3 and five as A5.2 based on PSA data. Due to the heterogeneity in the substrate characterising this group, a diverse community was observed that did not match any one biotope. Part of the community aligned with that described in biotope A5.351 – *A. filiformis*, bivalve *M. bidentata* and *A. nitida* in circalittoral sandy mud, with *K. bidentata, A. filiformis, Phoronis, P. baltica* and *N. nitidosa* being among the characterising taxa. However other taxa also dominated the community but remained unmatched as no sand or mud biotope aligned with them. These included Nematoda, *H. antennaria,* Nemertea, mollusc *Cylichna cylindracea,* and polychaete *Parexogone hebes*. Therefore, stations belonging to BSH A5.3 were assigned to EUNIS classification A5.351, while stations classified as BSH A5.2 were assigned to EUNIS classification A5.26–- Circalittoral muddy sand based on PSA and imagery analysis.

2.3.3 Site-specific intertidal survey results

2.3.3.1 Overview

The site specific survey showed the beach to be mainly dissipative in terms of wave energy with some reflective characteristics. It was an exposed high energy system with a breaker zone and well developed surf and swash zones (Figure 2.15). The majority of the shore had a gentle slope with a narrow steep reflective foreshore at the top of the beach. A moderately sloping backshore was fringed by steep sand dunes built up by marram grass *A. arenaria.* The incoming tide predominantly flooded the beach from north-east to south-west and entered the surf zone up short sand bar cuts in this direction. Once through the cuts, the incoming tide flowed from east to west along long sandbar troughs. Drainage for the most part occurred in the opposite direction.

The upper swash zone of the beach was widest (~400 m) in the west of the intertidal survey area, though was virtually absent at the eastern end of the site. Sands in this location were fine, low lying and permanently waterlogged due to groundwater seepage which effectively extended the area which bivalves can inhabit up to the foreshore. An anoxic layer was patchily distributed.

The mid-section of the beach was dominated by wide mobile sandbars comprised mainly of fine to medium grained sand, with small amounts of large shell fragments and gravels. An anoxic layer was not present. The sand here was elevated, mobile, free draining and consequently supported a low density of life. Typically, three large parallel sandbars occurred at any transect line down the intertidal zone, comprising a surf zone spanning a distance of approximately 400 m. Narrow waterlogged depressions (troughs) lay between sandbars and contained a finer grained sand with a slightly higher mud content. These areas contained a moderate density of fauna.

The lowest part of the shore was comprised predominantly of fine to medium sand and although the mud content was relatively low it was highest in this location. An anoxic layer was generally present though this was often only faintly visible in the top 25 cm of sediment. This layer occurred at variable depths below the surface across the lower shore and appeared absent in places. Very high densities of invertebrates were present at the lowest part of the shore.

2.3.3.2 Biotopes

Upper shore

A narrow strip of medium to coarse sands and pebbles was present at the top of the beach with moderately abundant populations of amphipods under vascular plant-based detritus along the strandline. These areas are characteristic of the biotope: Talitrids on upper shore and strand-line (LS.lSa.St.Tal).

Mid shore

The biotope Polychaete/bivalve-dominated muddy sand shores (LS.lSa.MuSa) occurred near the upper shore and in mid-shore areas in narrow low-lying troughs at the base of sandbars. The lugworm *A. marina* occurred in moderate to low densities of approximately 0.2 per m^2 and was accompanied by occasional specimens of the bivalves *M. balthica* and *Macomangulus tenuis.*

A few specimens of the common cockle *C. edule* were encountered during dig over sampling. A single specimen of the blue mussel *M. edulis* was found in a trough feature attached to a cobble present just under the sandy surface. The green shore crab *Carcinus maenas* and common periwinkle *L. littorea* were encountered rarely. A single live necklace shell *Polinices catenus* was found at the edge of a trough and similarly three individuals of the bivalve mollusc *Scrobicularia plana* were located in the western part of the survey area.

The amount of waterlogging in troughs varied from damp sand to standing water up to 30 cm deep. The brown shrimp *Crangon crangon* and coin sized juvenile flatfish (Pleuronectiforms) were observed in standing water in the western part of the intertidal survey area (Figure 2.15).

The biotope Barren or Amphipod dominated mobile sand (LS.lSa.MoSa) occurred on sandbars intersecting troughs in the mid shore. The elevated sandbars were the predominant mid-shore habitat and drained quickly so that the invertebrate density was very low. Two amphipods were observed over the entire site. A soft-shelled individual *C. maenas*, likely seeking shelter from predators during the vulnerable process of ecdysis, was recorded during sieve sampling.

The intricate pattern of sandbars and troughs occurred over a wide area and in this setting the two habitats are mapped as a mosaic (Figure 2.15). The individual distributions of these features were not mappable in a timeous fashion particularly in the absence of recent aerial photography. Sandbars are mobile habitats and their positions change over time to varying extents on a daily, seasonal and annual basis. Maps of such habitats are therefore only accurate temporarily though may give a good indication of the seasonal distribution of sediments. The major sandbar troughs present during the survey are presented in Figure 2.15.

Lower shore

The biotope *M. balthica* and *A. marina* in littoral muddy sand (LS.lSa.MuSa.MacAre) was present in the lower shore with *A. marina* occasional and one individual of *M. balthica* obtained via sieve sampling.

The lowest section of shore contained dense populations of invertebrates. The bristleworm *L. koreni* was particularly abundant (up to 900 per m^2) in patches in this location. *A.marina* was largely displaced by *A. defodiens* as noted in distribution of casts and confirmed via collection of a partial specimen of the latter during digging and sieving. Other species in this band included the polychaete worms (*Owenia fusiformis* and *Glycera* sp.*),* and sand mason worm *L. conchilega* which occurred occasionally, and molluscs (*M. balthica* and *C. edule),* a few specimens of which were obtained during exploratory digging and sieve sampling. This community is a variant of the *M. balthica-A. marina* community though is not named or referred to within the Marine Habitat Classification for Britain and Ireland (JNCC, 2015).

2.3.3.3 Habitats of conservation importance

The survey area was within the Dee Estuary/Aber Dyfrdwy SAC. A primary reason for the designation of this SAC was the Annex I Habitat (1140) Mudflats and sandflats not covered by seawater at low tide. This habitat includes the following biotopes which were recorded in the survey area (Figure 2.15):

- Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal).
- Polychaete/bivalve-dominated muddy sand shores (LS.lSa.MuSa).
- Barren or amphipod-dominated mobile sand shores (LS.lSa.MoSa).
- *M. balthica* and *A. marina* in littoral muddy sand (LS.lSa.MuSa.MacAre).

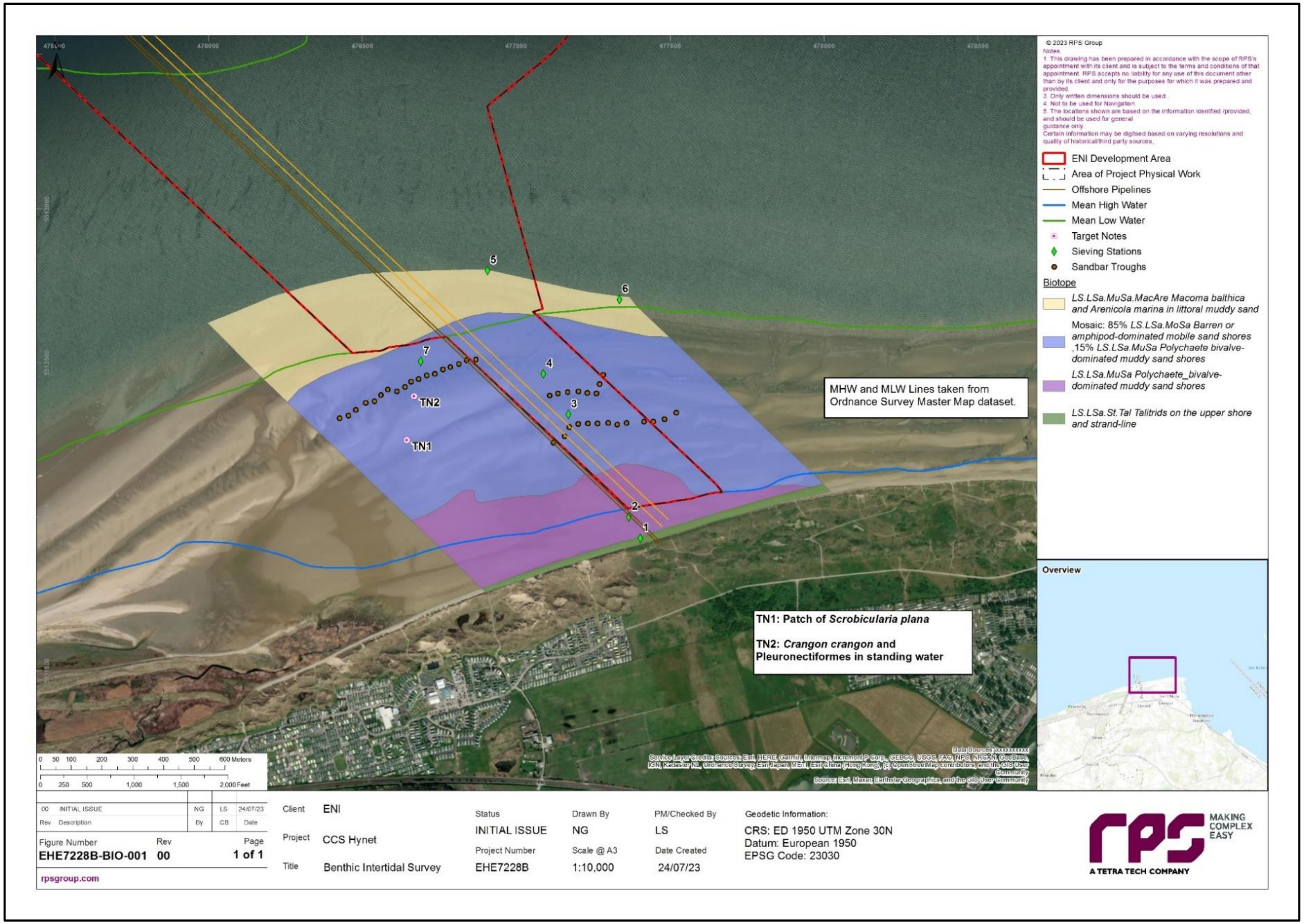

Figure 2.15: Biotope Map Of The Phase 1 Intertidal Walkover Survey

2.4 Summary

2.4.1 Regional Benthic Ecology Study Area

Overall, the regional benthic ecology study area is predominantly comprised of deep circalittoral coarse sediment, circalittoral sandy mud, circalittoral fine sand, circalittoral muddy sand, and deep circalittoral sand (Figure 2.5) (EMODnet, 2019). Tide-swept circalittoral mixed sediments are present in deeper sections, such as in the south of the regional benthic ecology study area (BEIS, 2022). In the nearshore, along the north Wales coast and west coast of England, the sediment is largely sandy mud or muddy sand (BEIS, 2022). Liverpool Bay, and more specifically the regional benthic ecology study area, is therefore largely comprised of sandy, gravelly and muddy sediments, with polychaete, bivalve, and amphipod species dominating the benthos.

There are a range of designated sites with benthic ecology qualifying features (Table 2.5). These include the Fylde MCZ and the Dee Estuary SAC/Aber Dyfrdwy SAC, which both overlap with Proposed Development benthic ecology study area.

2.4.2 Proposed Development Benthic Ecology Study Area

Overall, the Proposed Development benthic ecology study area predominantly comprises deep circalittoral coarse sediment, circalittoral coarse sediment, circalittoral find sand or circalittoral muddy sand, and deep circalittoral sand (Figure 2.5) (EMODnet, 2019). The results of the site-specific survey demonstrated varying amounts of mud, gravel, and sand across the sampling stations, with sand being the main component. Finer sediments were also recorded in the decommissioning sampling stations, which could be associated with drill cuttings. No known Annex I Sandbanks, or OSPAR threatened and declining habitats found to be located within the Proposed Development benthic subtidal and intertidal ecology study area. However, there was a small area of Annex I Reef located within the Eni Development Area along the northern border (Figure 2.7). Furthermore, Subtidal Mixed Muddy Sediment, which is listed as a HPI under the UK Post-2010 Biodiversity Framework, was identified across the south-west of the Eni Development Area.

As and Cd exceeded Cefas AL1 within two sampling stations, and Hg was above the OSPAR BAC levels in seven sampling stations. Zn was the most abundant metal across all samples; however, concentrations never exceeded any reference levels. All metals occurred in concentrations comparable to existing background data or in line with the range of concentrations known for areas located in proximity of active platforms. None of the PAHs exceeded Cefas AL1 at any of the CCS and full decommissioning stations, while Chrysene and Benzo[a]pyrene were above Cefas AL1 at one partial decommissioning station (GS36). A positive correlation was observed between Chrysene, Benzo[a]pyrene and mud content with higher PAHs concentrations in muddier sediments apart from station GS36 which had the highest Chrysene and Benzo[a]pyrene concentrations but an average mud content. No relationship was observed between the concentration of PAHs and proximity to platforms that could have indicated dispersal of drill cuttings. THC was the highest (30,600 µg/kg) at partial decommissioning station GS36, where Chrysene and Benzo[a]pyrene were found to exceed Cefas AL1. In the North Sea, THC concentrations at locations between 1 km and 2 km from an active platform range between 32,710 µg/kg and 33,810 µg/kg, in line with the findings at station GS36 which was located in proximity of a platform. All PCBs were measured below detection limits at all CCS stations and did not exceed Cefas AL1 at any of the decommissioning stations. All organotins measured were below the detection limit at all sampling stations.

A diverse macrobenthic assemblage was identified during the site-specific benthic characterisation survey, including both CCS and decommissioning areas. A total of 2,001 individuals and 215 taxa recorded across CCS stations, with the brittlestar *A. filiformis* being the most abundant taxon accounting for 15.3% of all individuals identified. Key epifaunal taxa identified in CCS samples were the tube worm *S. triqueter*, which accounted for 20% of all individuals, and sea anemones (Actinaria) which were identified in 30% of all samples. A total of 13,332 individuals and 322 taxa were recorded within decommissioning samples. Most decommissioning stations were characterised by the presence of Nemertea and the bivalve *K. bidentata*, which occurred in 98% of samples. The epifaunal community was characterised by relatively high numbers of the common brittlestar *O. fragilis* and Actinaria, with the latter being also the most frequently occurring taxon.

The PSA and the data clearly indicated the presence of a heterogeneous substrate and a diverse community across the site-specific survey area. Despite sand being the dominant size fraction at all sapling stations, the relative contributions of mud and gravel varied greatly among stations, resulting in the presence of an intricate mosaic of substrates across the survey area. Sediment heterogeneity and the diverse community observed meant that no clear biotopes could be defined. As such, EUNIS classifications were limited to a EUNIS level 4 at most stations, however, several biotopes illustrative of the HPIs ‘Subtidal sands and gravels’ and ‘Mud habitats in deep water’ were identified (Table 2.14, Table 2.15).

The Phase 1 Intertidal Walkover survey recorded a range of species and biotopes typical for the area, and commonly occurring around the UK. There were four biotopes recorded, which are included under the Annex I Habitat (1140) Mudflats and sandflats not covered by seawater at low tide:

- Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal).
- Polychaete/bivalve-dominated muddy sand shores (LS.lSa.MuSa).
- Barren or amphipod-dominated mobile sand shores (LS.lSa.MoSa).
- *M. balthica* and *A. marina* in littoral muddy sand (LS.ISa.MuSa.MacAre).

Species recorded during this intertidal survey included polychaetes (*A. marina, L. koreni, A. defodiens, O. fusiformis, L. conchilega*, and *Glycera* sp.), bivalves (*M. Balthica, M. Tenius,* and *S. plana*), gastropods (*L. littorea* and *P. catenus*), and various fish and shellfish species (such as green shore crab, common cockle, brown shrimp, and juvenile flatfish, which are included in section 3: Fish and Shellfish Ecology).

Overall, the following IEFs have been defined based on benthic subtidal and intertidal receptors that are likely to be present within the Proposed Development benthic ecology study area (Table 2.15). These will be taken forward for consideration during the ES, with further detail on their importance as potential receptors, along with any regulatory considerations, provided in volume 2, chapter 7.

Table 2.15: Benthic IEFs Within The Proposed Development Benthic Ecology Study Area

IEF	Description and Illustrative Biotopes	Importance within the Proposed Development Benthic Ecology Study Area	Justification
Subtidal Habitats and Species			
Subtidal Sands and Gravels	Subtidal sands and gravel sediments are the most common habitats found below the level of the lowest low tide around the coast of the United Kingdom and Ireland. Illustrative biotopes identified within the Eni Development Area were: • Circalittoral coarse sediment (SS.SCS.CCS; A5.14); – *M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen); • Infralittoral fine sand (SS.sSa.IfiSav; A5.23); – *N.60irrosea* and *Bathyporeia* spp. in infralittoral sand (SS.sSa.iFiSa.NcirBat); • Circalittoral fine sand (SS.sSa.CfiSa; A5.25); and • Circalittoral muddy sand (SS.sSa.CmuSa; A5.26).	National	HPI under the UK Post-2010 Biodiversity Framework
Mud Habitats in Deep Water	Mud habitats in deep water (circalittoral muds) that occur below 20 m to 30 m in many areas of the UK and Ireland's marine environment. Illustrative biotopes identified within the Eni Development Area were: • Circalittoral sandy mud (SS.sMu.CsaMu; A5.35) – *A. filiformis, M. bidentata* and *A. nitida* in circalittoral sandy mud (SS.sMu.cSaMu.AfilKurAnit)	National	HPI under the UK Post-2010 Biodiversity Framework

IEF	Description and Illustrative Biotopes	Importance within the Proposed Development Benthic Ecology Study Area	Justification
Subtidal Mixed Muddy Sediment	Subtidal Mixed Muddy Sediment was identified across the southern Eni Development Area. This habitat may support a wide range of infauna and epibiota, including polychaetes, bivalves, echinoderms, anemones, hydroids and Bryozoa. Illustrative biotopes identified within the Eni Development Area were: • *O, fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx).	National	OSPAR list of threatened and/or declining habitats and a HPI under the UK Post-2010 Biodiversity Framework.
Annex I Reef	An area of Annex I Reef was identified within the north of the Eni Development Area (Figure 2.7). Representative biotopes are not available for this reef, however, based on existing habitat mapping derived from the JNCC, bedrock or stony reefs are thought to be present. In the assessment, it will be assessed alongside the other subtidal habitats and species IEFs.	National	Annex I Habitat out with an SAC boundary that overlaps with the Eni Development Area.
Ross Worm *S. spinulosa*	A filter-feeding polychaete worm which can form biogenic reefs on the seabed and intertidal zone.	Local	*S. spinulosa* reefs are listed on the OSPAR list of threatened and/or declining habitats and a HPI under the UK Post-2010 Biodiversity Framework. However, no reefs were identified, only individual animals.

IEF	Description and Illustrative Biotopes	Importance within the Proposed Development Benthic Ecology Study Area	Justification
Intertidal Habitats and Species			
Mudflats and sandflats not covered by seawater at low tide	The following habitats were recorded during the Phase 1 Intertidal Walkover Survey, and are included in the Annex I Habitat Mudflats and sandflats not covered by seawater at low tide (1140): • Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal); • Polychaete/bivalve-dominated muddy sand shores (LS.lSa.MuSa); • Barren or amphipod-dominated mobile sand shores (LS.lSa.MoSa); and • *M. balthica* and *A. marina* in littoral muddy sand (LS.lSa.MuSa.MacAre).	International	Annex I Habitat that overlaps with the Eni Development Area. This habitat is a qualifying feature of the Dee Estuary/Aber Dyfrdwy SAC (see row below).
Designated Sites			
Dee Estuary/Aber Dyfrdwy SAC	The Dee Estuary is one of the largest estuaries within the UK, comprising an area of over 140 km^2, with an intertidal area made up of predominantly mudflats, sandflats and saltmarsh. The estuary lies on the boundary between England and Wales. The SAC is designated for the following Annex I Habitats: Mudflats and sandflats not covered by seawater at low tide (1140) and 1130 Estuaries (1130) (JNCC, 2023a). Mudflats and sandflats not covered by seawater at low tide are extensive throughout the site and are present in the intertidal sections which overlap with the Eni Development Area. For example, the sandy areas between Prestatyn and the PoA mainly consist of mobile sands dominated by amphipods and polychaetes (Natural England and CCW, 2010). Although no	International	The Dee Estuary/Aber Dyfrdwy SAC is an internationally designated site which overlaps with the Eni Development Area. The SAC overlaps with 0.21 km^2, which accounts for 0.13% of the total SAC area. Several Annex I Habitats are listed as qualifying features of this SAC.

IEF	Description and Illustrative Biotopes	Importance within the Proposed Development Benthic Ecology Study Area	Justification
	defined biotopes are available, those presented for the Mudflats and sandflats not covered by seawater at low tide IEF above will also be applicable to the Dee Estuary/Aber Dyfrdwy SAC and used in the assessment.		
Fylde MCZ	Highly productive sediments of subtidal sand and subtidal mud that support a range of crustaceans, starfish, and shellfish, such as small nut-shell, razor shell, and white furrow shell. The area of the Fylde MCZ which overlaps with the Eni Development Area has been assigned the biotope: Sublittoral sands and muddy sands (SS.sSa) (Envision Mapping, 2015), however has not been assigned more specific biotopes. As this area overlaps with the Subtidal sands and gravels IEF identified during the site-specific survey within the Eni Development Area, the representative biotopes will also be used to characterise the Fylde MCZ in the assessment.	National	The Fylde MCZ is a nationally designated site which overlaps with the Eni Development Area at parts. It overlaps with 41.40 km^2, which accounts for 15.87% of the total MCZ area.

3 FISH AND SHELLFISH ECOLOGY

3.1 Introduction

This section of the Marine Biodiversity Technical Report provides a detailed baseline characterisation of the fish and shellfish ecology within the Eni Development Area and the wider region. Data has been collated through a detailed desktop review of relevant material within the region.

3.2 Methodology

3.2.1 Study area

Fish and shellfish are known to be highly variable, both spatially and temporally. Therefore, to effectively analyse findings related to the fish and shellfish ecology baseline data, two study areas have been defined:

- The regional fish and shellfish ecology study area, which includes waters within England, Ireland, Wales, and Scotland. The regional fish and shellfish ecology study area will allow for the characterisation of fish and shellfish receptors within the eastern Irish Sea, accounting for migration and additional spatial and temporal variability. The regional fish and shellfish ecology study area is therefore defined as ICES Statistical Area VIIa, which also covers the Eni Development Area, offshore pipeline (including intertidal habitats up to the MHWS), and associated cables in Liverpool Bay (Figure 3.1).
- Where available, fish and shellfish ecology has been described on a local scale, within the Proposed Development fish and shellfish ecology study area. This area is the same as the Eni Development Area, which includes the offshore pipeline (including intertidal habitats up to the MHWS) and associated cables in Liverpool Bay (Figure 3.1). For brevity, this is referred to as the Eni Development Area.

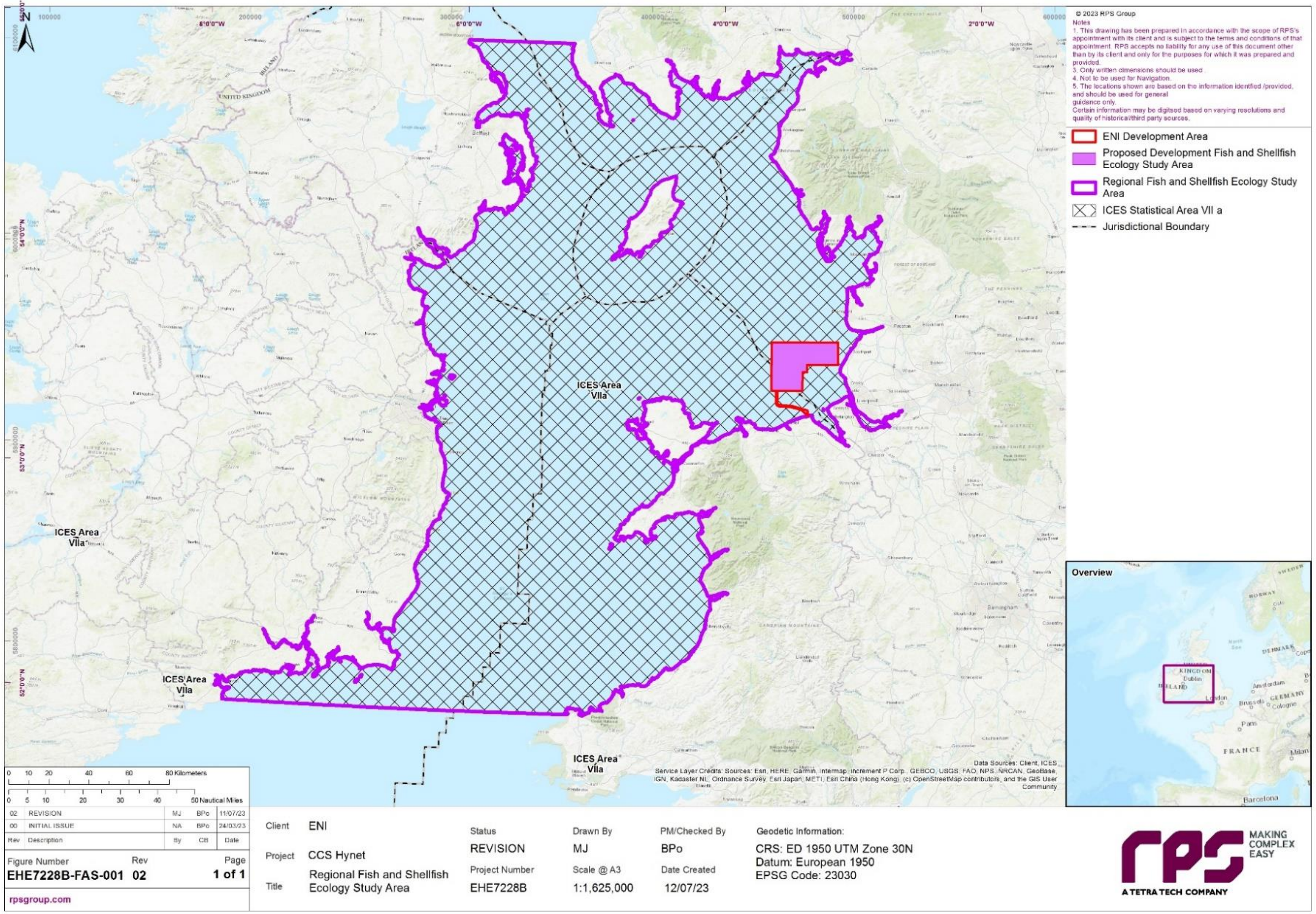

Figure 3.1: Fish And Shellfish Ecology Study Areas

3.2.2 Consultation

A summary of the key issues raised during consultation activities undertaken to date specific to fish and shellfish ecology is presented in Table 3.1 below.

Table 3.1: Summary Of Key Consultation Issues Raised During Consultation Activities Undertaken For The Project Relevant To Fish And Shellfish Ecology

Date	Consultee and type of response	Issues raised
30 March 2022	NRW advice during a meeting on the intertidal ecological survey approach	Advised that for the offshore elements, a lot of information potentially already exists from the surveys and assessments that have been carried out for the OWFs. There would be merit in looking at the existing OWF documentation that should be available online
		Advised that there would be a need to look at sandeel Ammodytidae spp habitats and spawning areas, as well as those for herring *Clupea harengus*. Advised that sandeel habitat going to be of most interest.
		NRW raised the requirement for fish surveys and noted that autumn is best time of year for species richness. However, NRW recognised that the spatial and temporal extent of works is not thought to be a concern for fish, and that there is also considerable information already available regarding fish interests in this area. NRW therefore recommended that, in light of existing knowledge, fish surveys would not add further to this knowledge and would not be required for the project. NRW therefore advised the use of available data to assess the impacts on the fish assemblage rather than undertake the planned survey work.
27 January 2023	OPRED Scoping Opinion response	"*All relevant environmental data is expected to be sourced, analysed, and presented in relation to the Project. A non-exhaustive list of potential sources of environmental information is provided in Annex 2 but the Developer is expected to consult such other sources as it considers necessary*." "*Relevant local environmental data should also be sourced from the appropriate local bodies which may include local environmental records centre, the local wildlife trust, local geo-conservation groups or other "recording societies."*"
		""*The ES should assess the environmental effects of the Project upon features of nature conservation interest. It is recommended that the ES thoroughly assesses the potential for the Project to affect national or international sites of nature conservation importance. This should include a full assessment of the direct and indirect effects of the Project on the features of all important nature*

Date	Consultee and type of response	Issues raised
		conservation sites including, but not limited to, Natural England's Impact Risk Zones, SSSIs, MCZs, and Designated Sites with Fish and Shellfish Qualifying Features. In particular, it is noted that the following Welsh sites have been omitted in Table 7-7 (Designated Sites with Fish and Shellfish Qualifying Features) of the ES scoping report: • *Dee Estuary SAC, designated for river and sea lamprey;* • *River Dee and Bala lake SAC, designated for Atlantic salmon, river and sea lamprey;* • *Afon Gwyrfai a Llyn Cwellyn SAC, designated for Atlantic salmon;* • *Afon Eden SAC–- Cors Goch Trawsfynydd, designated for Atlantic salmon and Freshwater peal mussel; and* *River Teifi SAC, designated for Atlantic salmon" river and sea lamprey*"
		"*The distance of the offshore elements of the Project to the Dee Estuary SAC is stated as 12 km in Table 7-2 [Of the Scoping Report]. However, it is noted that a section of the Power and Fibre-Optic Cable from the PoA to the Douglas Platform falls within the Dee Estuary SAC, and so the distance should be revised to account for this*."
		""' *It is recommended that the following reports are included:* • *Campanella, F. and van der Kooij, J. (2021). Spawning and nursery grounds of forage fish in Welsh and surroundings waters. Cefas Project Report for RSPB, 65 pp; and* *Van der Kooij, J., Campanella, F., and Rodríguez Climent, S., (2021). Pressures on forage fish in Welsh Waters. Cefas Project "Report for RSPB, 35 pp"*'
		"*Key protected sites for diadromous fish in Wales have been omitted*."

3.2.3 Desktop study

To provide a wider context, information on fish and shellfish ecology within the regional fish and shellfish ecology study area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 3.2 below.

Table 3.2: Summary Of Key Desktop Reports For The Characterisation Of The Fish And Shellfish Ecology Baseline

Title	Source	Year	Author
Marine Life Information Network (MarLIN): Biology and Sensitivity Key Information Reviews	MarLiN and Plymouth Marine Biological Association of the United Kingdom	2007 – 2020	MarLIN (assorted authors)
Fishbase Species Records	Fishbase	2023	Fishbase
National Parks and Wildlife Service (NPWS) Designations Viewer	NPWS	2023	NPWS
Celtic Seas ecoregion – Fisheries overview, including mixed-fisheries considerations	International Council for the Exploration of the Seas (ICES)	2022	ICES
Review of the Irish Sea	Irish Sea Network	2022	Irish Sea Network
CMACS Rhly Flats OWF Benthic Grab Survey, 2006 Survey	Ryhl Flats OWF	2021	Marine Data Exchange
NBN Atlas	NBN Atlas	2021	NBN Atlas
Spawning and nursery grounds of forage fish in Welsh and surrounding waters	Cefas	2021	Campanella and van der Kooij
Pressures on forage fish in Welsh Waters	Cefas	2021	van der Kooij *et al.*
JNCC Marine Protected Area (MPA) Mapper	JNCC	2020	JNCC
Bass and Ray Ecology in Liverpool Bay	Bangor University	2020	Moore *et al.*
Application for Offshore Carbon Storage Licence Environmental Appendix Liverpool Bay Area Environmental Sensitivity Assessment	Eni	2019	Eni UK
Sectoral Marine Plan for Offshore Wind Energy. Strategic Habitat Regulations Appraisal (HRA): Screening and Appropriate Assessment Information Report – Final. Appendix I: Fish Literature Review	ABPMer	2019	ABPMer
Welsh Waters Scallop Surveys and Stock Assessment	Bangor University	2019	Delargy *et al.*
Updating fisheries sensitivity maps in British Waters	Marine Scotland	2014	Aires *et al.*

Title	Source	Year	Author
Ormonde OWF Adult and Juvenile Fish and Epi-benthic Post-construction Survey	Ormonde OWF	2013a	Brown and May Marine Ltd.
Walney Offshore Wind Farm, Year 2 Post-construction Monitoring Fish and Epibenthic Survey.	Walney OWF	2013b	Brown and May Marine Ltd
Burbo Bank Extension Adult and Juvenile Fish Characterisation Surveys	Burbo Bank OWF	2013a	DONG Energy
Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat	MarineSpace	2013	Latto et al.
Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas	MarineSpace	2013	Reach *et al.*
Spawning and nursery grounds of selected fish species in UK waters	Cefas	2012	Ellis *et al.*
Ormonde OWF Adult and Juvenile Fish and Epi-benthic Post-construction Survey	Ormonde OWF	2012a	Brown and May Marine Ltd.
West of Duddon Sands Offshore Wind Farm, Adult and Juvenile Fish and Epibenthic Pre-Construction Surveys	West of Duddon Sands OWF	2012b	Brown and May Marine Ltd
EIA Scoping Report	Rhiannon Wind Farm Limited	2012	Centrica Energy and DONG Energy
Pre-construction monitoring 2010 survey	Gwynt y Môr OWF	2011	CMACS
Burbo Bank OWF, Year 3 Post-construction 2m beam trawl report (2009 survey)	Burbo Bank OWF	2011	SeaScape
Autumn fish trawl survey	Celtic Array (Zone 9)	2010	CMACS
Burbo Bank OWF, First Post-Construction 2m beam trawl report (2007 survey)	Burbo Bank OWF	2008	SeaScape
Burbo Bank OWF Post-construction Marine Fish 4m Beam Trawl Survey	Burbo Bank OWF	2006	CMACS
Post-construction Results from The North Hoyle OWF	North Hoyle OWF	2005	May

Title	Source	Year	Author
Gwynt y Môr Offshore Wind Farm Marine Ecology Technical Report	Gwynt y Môr OWF	2005b	CMACS
Fisheries Sensitivity Maps in British Waters	Cefas	1998	Coull *et al.*

3.2.4 Site-specific surveys

There were no site-specific surveys undertaken to characterise the fish and shellfish ecology within the Proposed Development fish and shellfish ecology study area. However, several fish and shellfish species were recorded during the Phase 1 Intertidal Walkover survey which was conducted to characterise the intertidal benthic baseline. Details on this survey are presented in section 2.2.4, and records of species recorded are presented in section 3.3, where relevant. There were no fish and shellfish species recorded in the site-specific benthic characterisation survey (details presented in section 2.2.4.1).

3.2.5 Herring and sandeel spawning habitat suitability

PSA was conducted on sediment samples collected during the site-specific benthic characterisation survey (see section 2.2.4). These data were used to assess spawning habitat suitability for herring and sandeel according to the guidance produced by Latto *et al.* (2013) and Reach *et al.* (2013). Habitat suitability was assessed using the percentage contribution of mud, sand, and gravel that were determined by the PSA (Table 3.3). The results of this are provided in section 3.3.1.

Table 3.3: Sediment Particle Percentage Contributions Used To Determine Herring And Sandeel Spawning Suitability (Sources: Latto *et al.*, 2013; Reach *et al.*, 2013)

% Particle Contribution	Habitat Preference	Reference
Herring		
<5% mud, >50% gravel	Prime	Reach *et al.*, 2013
<5% mud, >10% gravel	Sub-prime	
<5% mud, >25% gravel	Suitable	
>5% mud, <10% gravel	Unsuitable	
Sandeel		
<1% mud, >85% sand	Prime	Latto *et al.*, 2013
<4% mud, >70% sand	Sub-prime	
<10% mud, >50% sand	Suitable	
>10% mud, <50% sand	Unsuitable	

3.2.6 Data limitations

The desktop data used are the most up to date publicly available information which can be obtained from the applicable data sources as cited. Data that has been collected is based on existing literature, consultation with stakeholders and identification of habitats to inform likely fish and shellfish species. It should be noted that some datasets are over a decade old (e.g. Coull *et al.* (1998) and Ellis *et al.* (2012)). However, these are industry standard datasets, and are included with the caveat that they are now quite dated. Long-term time series of data, such as the International Bottom Trawl Survey (IBTS), International Herring Larval Survey (IHLS) and Northern Irish Herring Larvae Survey (NIHLS/NINEL) have demonstrated the continued validity of both Coull *et al.* (1998) and Ellis *et al*. (2012), with spawning and nursery grounds continuing to remain broadly consistent with these studies. Where available, more recent literature has been consulted (e.g. Campanella and van der Kooij (2021)).

As there were no site-specific surveys that had been carried out to inform the baseline characterisation, it is possible that all potential fish and shellfish species have not been identified. However, given the detailed desktop study completed and the precautionary approach adopted, which has included the identification of a regional fish and shellfish ecology study area, it is unlikely that key species have been omitted from the baseline characterisation. Where fish and shellfish species were identified during the Phase 1 Intertidal Walkover survey, which was undertaken to characterise the benthic intertidal environment, they have been included in this Fish and Shellfish section, where relevant. It is noted that no fish and shellfish species were recorded during the site-specific benthic characterisation surveys undertaken in 2022.

3.3 Baseline environment

3.3.1 Desktop review

3.3.1.1 Designated sites

There are a number of designated sites that occur within the regional fish and shellfish ecology study area. These sites are further detailed in Table 3.4 and presented in Figure 3.2. The Dee Estuary/Aber Dyfrdwy SAC is of particular interest as it overlaps with the Eni Development Area.

Table 3.4: Sites Designated For Relevant Fish And Shellfish Qualifying Features Located Within The Regional Fish And Shellfish Study Area

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Relevant to Fish and Shellfish
Dee Estuary/Aber Dyfrdwy SAC	0.00	The Dee Estuary is one of the largest estuaries within the UK, comprising an area of over 140 km², with an intertidal area made up of predominantly mudflats, sandflats, and saltmarsh (Eni, 2021). The estuary lies on the boundary between England and Wales. **Relevant Qualifying Features:** Annex II sea lamprey *Petromyzon marinus*, and river lamprey *Lampetra fluviatilis* are present as a qualifying feature but not a primary reason for site designation (JNCC, 2023a).
Ribble Estuary MCZ	9.58	The Ribble Estuary MCZ I is located on the north-west coast of England, near Preston, and covers an area of approximately 15 km². **Relevant Qualifying Features:** Smelt *Osmerus eperlanus* is a protected feature within the MCZ, which provides crucial habitat that is necessary for smelt to complete their lifecycle (DEFRA, 2019a).

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Relevant to Fish and Shellfish
Wyre-Lune MCZ	21.45	The Wyre-Lune MCZ is located in the southern part of Morecambe Bay and covers an area of approximately 92 km^2. **Relevant Qualifying Features:** Smelt is a protected feature within the MCZ (DEFRA, 2019b).
River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC	22.53	The River Dee is one of North Wales' premier rivers for Atlantic salmon populations, and also supports important populations of migratory lampreys and non-migratory fish, such as the brook lamprey *Lampetra planeri* and bullhead *Cottus gobio*. **Relevant Qualifying Features:** Annex II Atlantic salmon *Salmo salar* is present as a primary reason for site designation, while Annex II sea lamprey and river lamprey are present as qualifying features but not the primary reason for site designation (JNCC, 2023j).
Afon Gwyrfai a Llyn Cwellyn SAC	50.95	Afon Gwyrfai a Llyn Cwellyn is representative of small montane rivers in north-west Wales. **Relevant Qualifying Features**: Annex II Atlantic salmon are a primary reason for site designation (JNCC, 2023p).
Afon Eden – Cors Goch Trawsfynydd	60.81	The tributary of the Afon Mawddach supports the only known viable freshwater pearl mussel population in Wales. **Relevant Qualifying Features**: Annex II freshwater pearl mussel *Margaritifera margaritifera* are a primary reason for site designation, and Annex II Atlantic salmon are present as a qualifying feature but not a primary reason for site designation (JNCC, 2023q).
Isle of Man MNRs	70.06 – 91.05	As detailed in Table 2.5, there are ten MNRs around the Isle of Man, encompassing 10.8% of Manx waters (Manx Wildlife Trust, 2023). **Relevant Qualifying Features:** although it varies between site, these MNRs are collectively designated for basking shark *Cetorhinus maximus*, common skate *Dipturus batis*, European eel *Anguilla anguialla*, flame shell *Limaria hians*, horse mussel, ocean quahog, sandeel, and spiny lobster *Palinurus elephas* (Designation of MNR Guidance Notes, undated). Under Section 33 of the Isle of Man Wildlife Act (1990), the following fish and shellfish features cannot be removed or damaged in any of the Isle of Man MNRs: European eel (except by catch and release), flame shell, horse mussel, ocean quahog, spiny lobster *Palinurus elephas*, king scallop *Pecten maximus*,

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Relevant to Fish and Shellfish
		and queen scallop *Aequipecten opercularis* (Manx Marine Nature Reserves Byelaws, 2018).
River Derwent and Bassenthwaite Lake SAC	87.43	The River Derwent and Bassenthwaite Lake SAC is an inland body of water and river of approximately 18 km^2. **Relevant Qualifying Features:** Annex II sea lamprey, river lamprey, and Atlantic salmon are present as primary reasons for site designation (JNCC, 2023i).
River Ehen SAC	91.14	The River Ehen SAC supports England's largest population of Freshwater pearl mussel, which is listed on the IUCN Red List as 'critically endangered' in Europe. Atlantic salmon are also present and are involved in the complicated life histories of freshwater pearl mussel (Natural England, 2022). **Relevant Qualifying Features:** Annex II Freshwater pearl mussel are a primary reason for site selection, and Annex II Atlantic salmon are present but not a primary reason for site designation (JNCC, 2023h).
Allonby Bay MCZ	116.32	The Allonby Bay MCZ is an inshore site on the English side of the Solway Firth, covering approximately 40 km^2. **Relevant Qualifying Features:** blue mussel beds (DEFRA, 2016).
River Teifi/ Afon Teifi SAC	119.81	The Teifi is a predominantly mesotrophic river in mid Wales. **Relevant Qualifying Features**: Annex II Atlantic salmon and river lamprey are a primary reason for site designation, and Annex II sea lamprey are present as a qualifying feature but not a primary reason for site designation (JNCC, 2023r)
Cardigan Bay SAC/Bae Ceredigion SAC	122.76	Cardigan Bay SAC is located between Pembrokeshire and Ceredigion, extending 20 km from the coast, and protecting an area of the sea greater than 1,000 km^2. **Relevant Qualifying Features:** Annex II sea lamprey and river lamprey are present as a qualifying feature but not a primary reason for site designation (JNCC, 2023e).
Solway Firth SAC	123.85	Solway Firth SAC is a large, shallow, and complex estuary with a diverse mix of intertidal habitats (tidal rivers, estuaries, mud flats, sand flats, lagoons, salt marshes and salt steppes) (JNCC, 2023f). **Relevant Qualifying Features:** Annex II sea lamprey and river lamprey are a primary reason for site selection (JNCC, 2023f).
Solway Firth MCZ	131.87	The Solway Firth MCZ is an inshore site of approximately 45 km^2.

Designated Site	Minimum Distance to Eni Development Area (km)	Site Description and Qualifying Features Relevant to Fish and Shellfish
		Relevant Qualifying Features: Smelt is a protected feature within the MCZ, which provides critical habitat for feeding and post-larval development (DEFRA, 2019c).
Slaney River Valley SAC	198.26	The Slaney River Valley SAC overlaps Raven Point Nature Reserve SAC, The Raven SPA and Wexford Harbour and Slobs SPA (NPWS, 2011). **Relevant Qualifying Features**: The Slaney River Valley SAC is designated in part for Annex II freshwater pearl mussel, sea lamprey, river lamprey, Atlantic salmon, and twaite shad *Alosa fallax* (NPWS, 2011a).

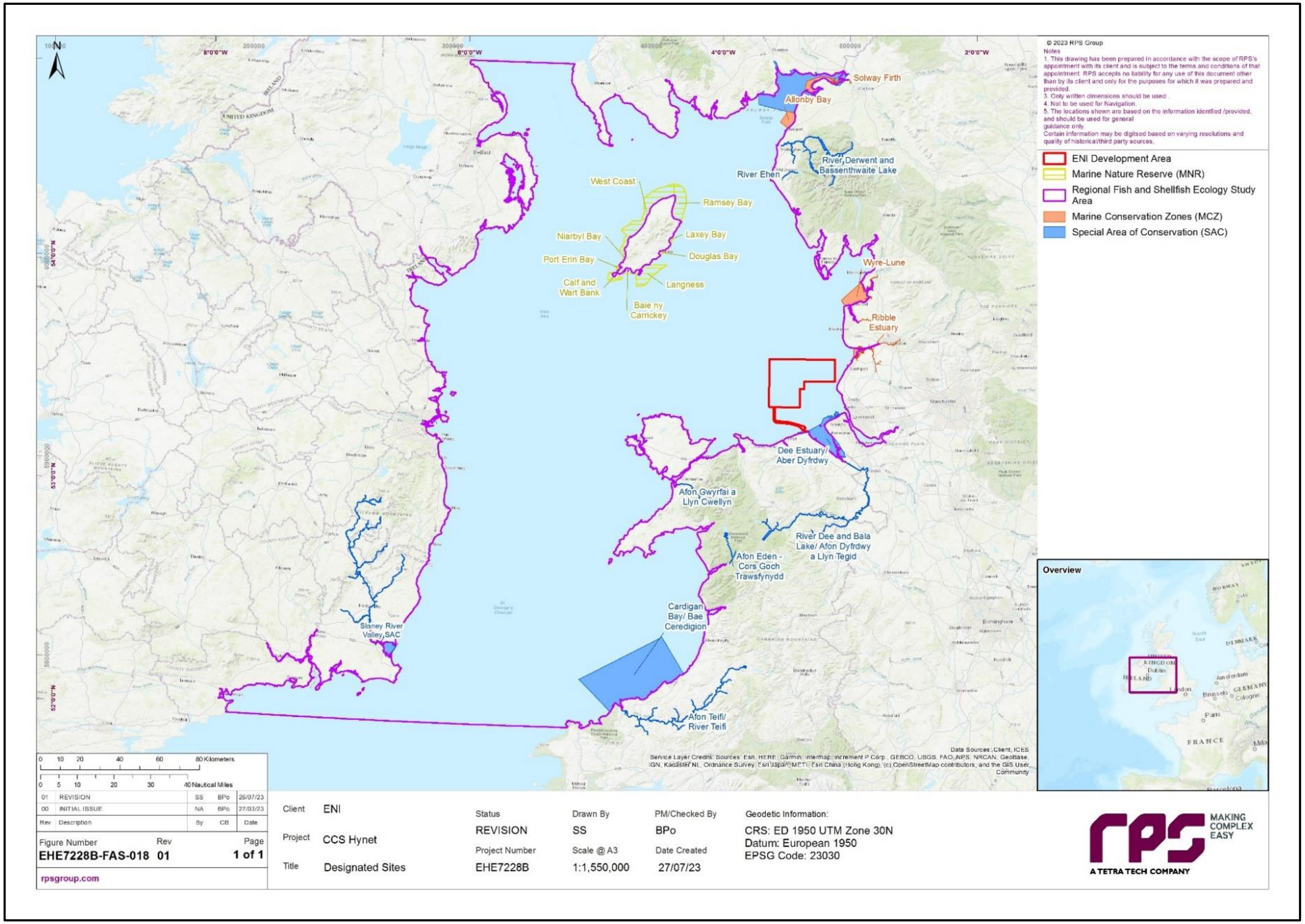

Figure 3.2: Designated Sites With Relevant Fish And Shellfish Qualifying Features Within The Regional Fish And Shellfish Ecology Study Area

3.3.1.2 Fish assemblages

Fish present within the regional fish and shellfish ecology study area include demersal, pelagic, and diadromous species. This includes numerous species of both bony (teleost) and cartilaginous (elasmobranch) fish, as well as the jawless lampreys (agnatha).

Pelagic fish are defined as shoals swimming in mid-levels of the water, typically making extensive seasonal movements or migrations between sea area. Demersal species can be further divided into benthic fish and benthopelagic fish; with benthic fish tending to live on or in the seabed and benthopelagic fish swimming or floating close to the seabed.

Pelagic fish species found in the regional fish and shellfish ecology study area include herring and mackerel *Scomber scombrus*, while demersal fish species include anglerfish *Lophius piscatorius*, brill *Scophthalmus rhombus*, cod *Gadus morhua*, common goby *Pomatoschistus microps*, haddock *Melanogrammus aeglefinus,* lemon sole *Microstomus kitt*, ling *Molva*, plaice *Pleuronectes platessa,* sand goby *Pomatoschistus minutus*, sandeels, turbot *Scophthalmus maximus*, sole *Solea solea*, solenette *Buglossidium leteum* and whiting *Merlangius merlangus* (CMACS, 2010).

Diadromous species are those which migrate between freshwater and seawater habitats in order to complete their life cycle. The term ‘diadromous’ encompasses species which live in seawater as adults and migrate to freshwater to spawn (anadromous) and those which live in freshwater as adults and migrate to seawater to spawn (catadromous). Diadromous fish species include Atlantic salmon, European eel, river lamprey, sea lamprey, sea trout *Salmo trutta*, smelt, and allis shad *Alosa*, and twaite shad (Lockwood, 2005; CMACS, 2010).

Elasmobranchs have a skeleton made of cartilage. They include the pelagic basking shark and demersal species such as blonde ray *Raja brachyura*, common smoothhound *Mustelus mustelus*, cuckoo ray *Raja naevus,* lesser spotted dogfish *Scyliorhinus canicula*, nursehound *Scyliorhinus stellaris*, spotted ray *Raja montagui*, spurdog *Squalus acanthias*, thornback ray *Raja clavata*, and tope shark *Galeorhinus galeus* (CMACS, 2010, 2011; Centrica Energy and DONG Energy, 2012; Celtic Array Ltd, 2013).

Fish communities within the eastern Irish Sea and more specifically, Liverpool Bay, were recorded as being dominated by pelagic, demersal and cartilaginous species including plaice, brill, cod, turbot, whiting, haddock and anglerfish, thornback ray, cuckoo ray, and spurdog (Eni UK, 2019).

Fishery trawl surveys conducted in Liverpool Bay were undertaken by Cefas from 1992-2004. Findings from these surveys illustrated that more than 100 fish species were recorded throughout the Irish Sea, while less than 70 species were enumerated in Liverpool Bay (Parker-Humphreys, 2004). The regional fish and shellfish ecology study area (and therefore the Eni Development Area) is located within the Celtic Seas ecoregion, as defined by ICES. Pelagic midwater trawl fisheries for blue whiting *Micromesistius poutassou*, boarfish *Capros aper*, herring, horse mackerel *Trachurus*, mackerel and sprat *Sprattus* account for the highest catches (by weight) in the Celtic Seas ecoregion (ICES, 2022). The largest demersal fishery in the ecoregion targets European hake *Merluccius* along the shelf edge, and there are also large mixed bottom-trawl fisheries which target benthic species, such as Norway lobster, and gadoids (e.g. cod, haddock, ling, whiting) (ICES, 2022). Further information on commercial fisheries within the Eni Development Area is presented in volume 3, appendix M.

European seabass *Dicentrarchus labrax* and grey mullet Muglidae spp. are seasonally abundant in inshore waters, with abundance decreasing further north, away from the Eni Development Area (Department of Energy and Climate Change (DECC), 2016). Fisheries targeted European seabass have been found to predominantly be comprised of female individuals, illustrating a potential localised spawning area in proximity to the Eni Development Area (Moore *et al.,* 2020).

Many of the fish species mentioned are important prey species (i.e. ‘forage fish’) for a range of higher predators, such as marine mammals and seabirds. Forage fish are typically small schooling fish and are important ecologically as they provide the main pathway for energy to flow from the plankton to higher tropic levels (van der Kooij *et al.,* 2021). Important forage fish species within Welsh waters include herring, sprat, European anchovy *Engraulis encrasicolus*, European sardine *Sardina pilchardus*, sandeels, horse mackerel, garfish *Belone belone*, poor cod *Trisopterus minutus*, and juvenile cod and whiting (van der Kooij *et al.,* 2021).

The results of site-specific surveys undertaken for other developments in the regional fish and shellfish study area provide further characterisation of the fish and shellfish ecology baseline. A summary of these is presented in Table 3.5. Some projects, such as the Burbo Bank Extension, Rhyl Flats OWF, and North Hoyle OWF are in very close proximity to the Eni Development Area (<5 km) (Table 3.5; Figure 2.6). Similarly, the Gwynt y Môr OWF and Awel y Môr OWF overlap with the Eni Development Area, (Table 3.5; Figure 2.6). Despite the age of many of the studies outlined in Table 3.5, regional long-term survey data from the IBTS has indicated consistent fish assemblages over the last decade, showing a high level of agreement with the snapshot assemblages reported within the listed project-specific pre-construction and post-construction monitoring surveys extending to over 20 years ago (ICES, 2023). Dominant species captured within the IBTS programme between 2012 and 2022 include plaice, lesser-spotted dogfish, whiting, herring, dab (*Limanda limanda*), common dragonet (*Callionymus lyra*), thornback ray, Norway lobster, haddock and grey gurnard (*Eutrigla gurnardus*) (ICES, 2023).

Table 3.5: Summary Of Fish Species Recorded During Site-Specific Surveys For Projects Within The Regional Fish And Shellfish Ecology Study Area And The Eni Development Area

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Key Fish Species Recorded	Reference
Awel y Môr Offshore Wind Farm Commercial Fisheries Baseline Report	0.00	2005 to 2018	Whiting, haddock, lesser spotted dogfish, plaice, and herring dominated landings.	MacNab and Nimmo, 2021
2013 Adult and Juvenile Fish and Epibenthic Post-construction Survey for Ormonde OWF	42.95	2013	Plaice, dab *Limanda*, and whiting were the most common species recorded in otter trawls. Dab, solenette, and plaice were the most common in the beam trawls. Elasmobranchs included lesser spotted dogfish, thornback ray, common smoothhound, and blonde ray.	Brown and May Marine Ltd. 2013a
2012 Adult and Juvenile Fish and Epibenthic Post-construction Survey for Ormonde OWF	42.95	2012	Solenette, dab, and gobies were the most common species recorded in the other trawls, while plaice, dab, and lesser spotted dogfish were the most common species in the otter trawls. Elasmobranchs included: blonde ray, common smoothhound, nursehound, spotted ray, spurdog, thornback ray, and tope.	Brown and May Marine. 2012a

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Key Fish Species Recorded	Reference
Walney OWF	36.69	2013	Plaice, dab, solenette, and lesser spotted dogfish were the most abundant species. Sea trout was also recorded.	Brown and May Marine Ltd. 2013b
West of Duddon Sands OWF	29.1	2012		Brown and May Marine Ltd. 2012b
Burbo Bank Extension Adult and Juvenile Fish Characterisation Surveys	0.55	2011	Dab, flounder *Platichthys flesus*, herring, plaice, sprat, and whiting. Thornback ray and lesser spotted dogfish were also present.	DONG Energy, 2013a
Celtic Array Round 3 Irish Sea Zone, Rhiannon Wind Farm Limited, EIA Scoping Report	25.31	2010 and 2011	Poor cod and thickback sole *Microchirus variegatus* were the most abundant species in autumn and spring, respectively. Elasmobranchs were also recorded: lesser spotted dogfish, spotted ray, cuckoo ray, nursehound, thornback ray, blonde ray, and common smoothhound.	Centrica Energy and DONG Energy, 2012
Pre-construction monitoring at the Gwynt y Môr OWF	0.00	2010	Plaice, dab, sand goby, solenette, and lesser spotted dogfish were the most abundant species. Other elasmobranchs, such as lesser spotted dogfish, thornback ray, and blonde ray were also recorded.	CMACS, 2011
Post-Construction Beam Trawl Surveys at Burbo Bank OWF	10.67	2009	Most common species were solenette, dab, lesser weaver fish *Echiichthys vipera,* and sand goby. Elasmobranchs recorded were thornback ray and lesser spotted dogfish.	SeaScape, 2011
Post-Construction Beam Trawl Surveys at Burbo Bank OWF	10.67	2007	Most common species were solenette, dab, whiting, plaice, sole, lemon sole, and flounder. Elasmobranchs recorded were thornback ray and lesser spotted dogfish.	SeaScape, 2008

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Key Fish Species Recorded	Reference
Pre-Construction Beam Trawl Surveys at Burbo Bank OWF	10.67	2006	22 species recorded, with dab being the most abundant, plaice, solenettte, flounder, and sole. Three species of elasmobranchs (thornback ray, lesser spotted dogfish, and common smoothhound) and one individual sea trout were also recorded.	CMACS, 2006
Ryhl Flats OFW	2.96	2006	Dominated by sand goby and solenette, whilst dab and plaice were the most common commercial species recorded.	Marine Data Exchange, 2021
Benthic Ecology Characterisation for Gwynt y Môr OWF	0.00	2003 and 2004	Dominated by demersal species, such as dab, dragonet *Callionmyus lyra*, poor cod, sand goby, scaldfish *Arnoglossus laterna,* solenette, and sand goby.	CMACS, 2005b
Post-construction monitoring at North Hoyle OWF	3.85	2002 – 2004	Plaice, dab, sole, and dragonet. No change in species composition following the construction of the OWF was recorded.	May, 2005

3.3.1.3 Elasmobranchs

Elasmobranchs are a group of cartilaginous fish species that include sharks, skates, and rays. Elasmobranchs likely to be present within the regional fish and shellfish ecology study area are: basking shark, blonde ray, common smoothhound, cuckoo ray, lesser spotted dogfish, nursehound, thornback ray, tope shark, spotted ray, and spurdog (CMACS, 2010, 2011; Centrica Energy and DONG Energy, 2012; Celtic Array Ltd, 2014b).

Basking shark

Basking sharks are a cosmopolitan species and are protected under several international conventions and UK laws. They are listed as a Prohibited Species under the Common Fisheries Policy (CFP), under Annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and under Appendix I and II of the Bonn Convention on the Conservation of Migratory Species of Wild Animals. They are listed as a Species of Principal Importance (SPI) under the UK Post-2010 Biodiversity Framework. They are also listed as 'endangered' on the IUCN Red List (Rigby, *et al.,* 2021) and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Finally, they are protected in UK waters under the Wildlife and Countryside Act 1981.

Basking sharks have been recorded migrating through the Irish Sea, predominantly near the Isle of Man, approximately 91.6 km north-west of the Eni Development Area (NBN Atlas, 2021; Dolton *et al*., 2020). Satellite-tracked individuals have shown that basking sharks typically migrate north to south through the Irish Sea and therefore have the potential to be found within the regional fish and shellfish ecology study area (Dolton *et al*., 2020). Northerly movements have been exhibited by the species in the early summer months, while southerly movements have been found to take place during late summer and autumn (Sims, 2008; Wilding *et al.,* 2020). One basking shark was observed in the summer of 2016 in the west of the regional fish and shellfish study area during the ObSERVE aerial surveys (Rogan *et al.,* 2018).

To date, there have been sporadic recordings of basking shark within the Eni Development Area from the Dee Estuary and off the coast of Southport reported by the Marine Conservation Society during surveys between 1987 to 2016 (NBN Atlas, 2021).

Blonde ray

Despite its name, the blonde ray is a species of skate distributed all around the UK which typically favours sand and sand-rock substrates (Fishbase, 2023d; Wildlife Trusts, 2023a). Within the regional fish and shellfish ecology study area, blonde ray has been recorded in site-specific surveys for the Rhiannon, Gwynt y Môr, and Ormonde OWFs (Brown and May Marine, 2012a; 2013a; Centrica Energy and DONG Energy, 2012; CMACS, 2011) (Table 3.5). Blonde ray has been recorded annually within the offshore region of the Eni Development Area, during Agri-Food and Biosciences Institute Marine Surveys between 2012 to 2019 (NBN Atlas, 2021).

Common smoothhound

The common smoothhound is found on the continental shelves and uppermost slopes in the eastern Atlantic. They are present from the intertidal zone to depths of at least 350 m (Fishbase, 2023e).

While there are no records of common smoothhound within the Eni Development Area recorded on the NBN Atlas, multiple sources from the grey literature report that this species is present along the north Wales coastline, thus either overlapping with the Eni Development Area, or in reasonably close proximity (Fishing in Wales, 2023; Go Angling, 2023; Turners Tackle, 2023). Within the regional fish and shellfish ecology study area, common smoothhound has been recorded in site-specific surveys for the Burbo Bank, Rhiannon, and Ormonde OWFs (CMACS, 2006; Brown and May Marine, 2012a; 2013a; Centrica Energy and DONG Energy, 2012) (Table 3.5).

Cuckoo ray

The cuckoo ray is a species of skate found in warmer waters of the north-east Atlantic and Mediterranean Sea. The UK typically represents the northern limit of this species' range (Wildlife Trusts, 2023b).

Within the regional fish and shellfish ecology study area, cuckoo ray has been recorded in site-specific surveys for the Rhiannon OWF (Centrica Energy and DONG Energy, 2012) (Table 3.5). To date, there are no records of cuckoo ray within the Eni Development Area on the NBN Atlas, however there is a concentration of this species within the Celtic Sea and off the coast of Wales (The Shark Trust, 2020). There are various verified and unverified records of this species along the coastal sections of the Eni Development Area, with up to nine verified and 17 unverified records within the mouth of the Dee Estuary (The Shark Trust, 2020).

Lesser spotted dogfish

The lesser spotted dogfish is the most common dogfish in European waters and is widely distributed. It is also the most common shark in UK waters (Wildlife Trusts, 2023c). They are found on sandy, coralline, algal, muddy, or gravel bottoms, mainly between 10 m and 100 m deep in the north-east Atlantic (Fishbase, 2023f).

Within the regional fish and shellfish ecology study area, lesser spotted dogfish has been recorded in site-specific surveys for the Burbo Bank, Burbo Bank Extension, Gwynt y Môr, Ormonde, Rhiannon, Walney, and West of Duddon Sands OWFs (CMACS, 2006; 2011; SeaScape, 2008; 2011; Brown and May Marine, 2012a; 2012b; Centrica Energy and DONG Energy, 2012; Brown and May Marine Ltd., 2013a; 2013b; DONG Energy, 2013a) (Table 3.5). Lesser spotted dogfish have been recorded by Merseyside BioBank within the coastal sections of the Eni Development Area from 2005 to 2019 (NBN Atlas, 2021).

Nursehound

The nursehound is a small shark distributed around the north-east Atlantic in water between 1 m to 125 m. They typically inhabit rough, rocky, coralline and algal-covered substrates (Fishbase, 2023g). The species is listed as 'vulnerable' on the IUCN Red List (Finucci, *et al.,* 2021).

Within the regional fish and shellfish ecology study area, nursehound have been recorded in site-specific surveys for the Ormonde and Rhiannon OWFs (Brown and May Marine Ltd. 2012a; Centrica Energy and DONG Energy, 2012) (Table 3.5). Within the Eni Development Area, there have been two recordings of this species collected on Agri-Food and Biosciences Institute Marine Surveys in 2013 and 2014, with further recordings throughout Liverpool Bay and the eastern Irish Sea (NBN Atlas, 2021)

Thornback ray

The Thornback ray is a medium sized skate widely distributed throughout UK and Irish waters at depths between 10 m and 300 m. It is found on a wide variety of seabed types from mud, sand, shingle, and gravel (Fishbase, 2023h). It is listed on the OSPAR list of threatened and declining species, but not within OSPAR Region III (Celtic Seas) which encompasses the regional fish and shellfish study area.

Within the regional fish and shellfish ecology study area, thornback ray has been recorded in site-specific surveys for the Burbo Bank, Burbo Bank Extension, Gwynt y Môr, Ormonde, and Rhiannon OWFs (CMACS, 2006; 2011; SeaScape, 2008; 2011; Brown and May Marine, 2012a; Centrica Energy and DONG Energy, 2012; Brown and May Marine Ltd., 2013a; DONG Energy, 2013a) (Table 3.5).

The Eni Development Area overlaps with an area identified by Ellis *et al.* (2012) as being low intensity nursery grounds for this species (further information is provided below, and in Table 3.9 and Figure 3.8). Thornback ray has also been recorded annually within the offshore region of the Eni Development Area during Agri-Food and Biosciences Institute Marine Surveys between 2009 to 2019 (NBN Atlas, 2021). This species has also been recorded in the coastal region of the Eni Development Area (just south of Southport) between 2009 and 2019 during various surveys conducted by Merseyside BioBank, The Environment Agency, and the National Trust (NBN Atlas, 2021).

Tope shark

Tope sharks are distributed worldwide in temperate waters from near shore to depths of 550 m (Fishbase, 2023i). The species is listed as 'critically endangered' on the IUCN Red List (Walker, *et al.,* 2020), and as a SPI.

The Eni Development Area overlaps with an area identified by Ellis *et al.* (2012) as being low intensity nursery ground for this species (further information is provided below, and in Table 3.9 and Figure 3.8). While there are no records of this species within the Eni Development Area itself, tope shark have been regularly recorded elsewhere in Liverpool Bay (such as around the Isle of Man) during various surveys (NBN Atlas, 2021). Within the regional fish and shellfish ecology study area, tope sharks have been recorded in site-specific surveys for the Ormonde OWF (Brown and May Marine, 2012a) (Table 3.5).

Spotted ray

Spotted rays are distributed mainly along the continental shelf in the north-east Atlantic in waters between eight and 283 m. As with the blonde, cuckoo and thornback rays, the spotted ray is also a species of skate. They are one of the smallest sate species and tend to prefer habitats with sand or mud, with juveniles occurring on sandy sediments close to shore and adults utilizing coarser habitats, further offshore (Fishbase, 2023c). The population of spotted ray is stable throughout its range, despite being commonly landed in fisheries. The spotted ray is listed on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas).

The Eni Development Area overlaps with an area identified by Ellis *et al.* (2012) as being low intensity nursery grounds for this species (further information is provided below, and in Table 3.9 and Figure 3.7). Within the regional fish and shellfish ecology study area, spotted rays have been recorded in site-specific surveys for the Ormonde and Rhiannon OWFs (Brown and May Marine Ltd., 2012a; Centrica Energy and DONG Energy, 2012) (Table 3.5). The spotted ray has been recorded in the offshore region of the Eni Development Area, during Agri-Food and Biosciences Institute Marine Surveys between 2011 to 2019 (NBN Atlas, 2021).

Spurdog

The spurdog or spiny dogfish has a wide distribution throughout Europe and is typically found in waters between10 m to 200 m depth (Fishbase, 2023j). The species is listed as 'vulnerable' on the IUCN Red List (Fordham, *et al.,* 2016), is listed as a SPI, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas).

The west of the Eni Development Area overlaps with an area identified by Ellis *et al.* (2012) as being high intensity nursery ground for this species (further information is provided below, in Table 3.9 and Figure 3.7). Within the regional fish and shellfish ecology study area, spurdogs have been recorded in site-specific surveys for the Ormonde OWF (Brown and May Marine Ltd., 2012a; Centrica Energy) (Table 3.5). Further, there have been no recordings of this species within the Eni Development Area, however there are numerous and concentrated recordings in the western Irish Sea (NBN Atlas, 2021).

3.3.1.4 Diadromous fish

As stated above, there are a range of diadromous species potentially present in the regional fish and shellfish ecology study area: Atlantic salmon, sea trout, river lamprey, sea lamprey, smelt, European eel, allis shad, and twaite shad (Lockwood, 2005; CMACS, 2010). These species migrate to and from rivers in order to complete their life cycles and there is, therefore, the potential for these species to migrate to and from rivers in the vicinity of the Eni Development Area during certain periods of the year. The ES will assess whether a disruption to migration would occur due to the construction, operation and maintenance, and decommissioning of the Proposed Development. Therefore, the timing of different species' migration will be an important element of the baseline characterisation and has been compiled through a review of desktop data sources (Maitland and Hatton-Ellis, 2003; Malcolm et al., 2010, 2015; Gardiner *et al.,* 2018; ABPMer, 2019; NatureScot, 2023b, 2023c) (Table 3.6).

Atlantic salmon

Atlantic salmon are widely distributed around the UK and Ireland and are recognised as an Annex II species under the EU Habitats Directive. They are also listed as a SPI and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Sea). Their juvenile life stages typically lasts between one to four years before they migrate to sea. They undergo a metamorphosis involving morphological, biochemical, physiological and behavioural changes that preadapt them for life within the marine environment (Hoar, 1988; Høgasen, 1998; Thorpe *et al*., 1998; Finstad and Jonsson, 2001). Atlantic salmon are referred to as 'post-smolts' between their migration to sea until the spring of the following year. After one winter at sea, they are then referred to as 'grilse', and individuals that spend one to three years at sea before returning in spring are known as 'spring salmon' (Davies *et al.*, 2004). The length of time spent at sea varies from one to five years (Klemetsen *et al.*, 2003). Adults spend the majority of their lives at sea, where they grow rapidly and only return to rivers to spawn (NatureScot, 2023a). Armed with an acute sense of smell, most adults navigate back to their natal rivers in order to spawn (Dipper, 2001; Lockwood, 2005). The length of time an Atlantic salmon spends in the sea varies from one to five years.

There is currently limited information on the movements of salmon during their migration at sea. They are believed to school and move to feeding grounds in deeper water. Upstream migrations can occur all year, however there is a peak in late summer and autumn (Malcolm *et al.,* 2010, 2015, ABPMer, 2019).

Atlantic salmon share a complex obligate host-dependant relationship with the freshwater pearl mussel (Taeubert and Geist, 2017; Taskinen and Salonen, 2022), which is described in further detail in the shellfish section below.

Atlantic salmon have been recorded in the estuaries of rivers along the mainland UK within the regional fish and shellfish study area and the Eni Development Area (NBN Atlas, 2021). Further, Atlantic salmon are listed as qualifying interest features of various designated sites within the regional fish and shellfish ecology study area, such as the River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC, and Afon Gwyrfai a Llyn Cwellyn SAC (Table 3.4).

Sea trout

Sea trout is an Annex II species under the EU Habitats Directive, as a SPI and is on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Sea trout has a similar ecology to Atlantic salmon but are smaller in size. Further, sea trout has a much wider distribution and remain within nearshore waters rather than undertaking extensive offshore migration (Celtic Sea Trout Project, 2016; DECC, 2009a). The spawning season lasts from October to January, with the eggs deposited in redds (small deviations in the riverbed, cut by the female in the river gravel).

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

Sea trout were recorded in the regional fish and shellfish study area during surveys carried out in 2012 and 2013 for the West of Deddon Sands OWF and the Walney OWF (Brown and May Marine Ltd, 2012b, 2013b) (Table 3.5). These surveys were conducted a minimum of 29.1 km and 36.69 km away from the Eni Development Area (Table 3.5). They were also recorded in pre-construction beam trawl surveys undertaken for Burbo Bank OWF in 2006 (a minimum of 10.67 km from the Eni Development Area) (CMACS, 2006). On the NBN Atlas, they have also been recorded in the estuaries of rivers along the mainland UK within the regional fish and shellfish study area and in proximity to the Eni Development Area (NBN Atlas, 2021).

Sea lamprey

The sea lamprey is distributed throughout UK and Irish waters and has been designated as an EU Habitats Directive Annex II species, and is listed as an SPI and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas).

Spawning occurs between May and July, with the eggs deposited in redds. Upon hatching, lamprey larvae (ammocoetes) will often bury themselves in gravel, silt or sand, to evade predators (NatureScot, 2023b). The metamorphosis from an ammocoete to an adult can take between four weeks to four months. After up to five years in freshwater, sea lamprey progressively make their way to the open sea to mature (Maitland, 2003). The behaviour of this species at sea, including feeding ecology, is still misunderstood, and duration of the marine phase and habitat use are still subjects of debate (Quintella *et al.,* 2021; OSPAR, 2022).

Within the NBN Atlas, sea lamprey have been recorded sporadically in the estuaries of rivers along the mainland UK within the regional fish and shellfish study area, such as the Dee Estuary (NBN Atlas, 2021). It should be noted that these records date between the 1960s to the 1980s, and are now likely to be dated. Further, sea lamprey are listed as qualifying interest features of various designated sites within the regional fish and shellfish ecology study area (see Table 3.4), including the Dee Estuary/Aber Dyfrdwy SAC which overlaps with the Eni Development Area (Figure 3.2).

River lamprey

The river lamprey is distributed throughout UK and Irish waters and the western reaches of Europe and has been designated as an Annex II species under the EU Habitats Directive and as a SPI. River lamprey and sea lamprey share a similar life cycle; however, the river lamprey is smaller (Maitland, 2003). In either autumn or spring, river lamprey migrate upstream from nearshore feeding grounds (marine or brackish water) into freshwater to spawn. Spawning occurs in April and May on pebble and gravel substrates (NatureScot, 2023b).

River lampreys migrate to nearshore coastal or estuarine waters after four to five years in freshwater; however, some populations are freshwater resident and do not undertake this migration to the marine environment (Kelly and King, 2001).

River lamprey have been recorded in the estuaries of rivers within Liverpool Bay, in the vicinity of the Eni Development Area, such as the Dee Estuary (NBN Atlas, 2021). However, unlike the sea lamprey, river lampreys do not migrate to the open sea but remain close to their estuaries. River lamprey are listed as qualifying interest features of various designated sites within the regional fish and shellfish ecology study area (Table 3.4), including the Dee Estuary/Aber Dyfrdwy SAC, which overlaps with the Eni Development Area (Figure 3.2).

European eel

European eels have a complex and poorly understood life history, entering two stages of metamorphosis. The current range of the species encompasses almost the entire seaboard of Europe, from the Arctic Circle to North Africa, and is regarded as a single stock population (ICES, 2009; Malcolm *et al.,* 2010). They spawn in the Sargasso Sea (a gyre in the North Atlantic, just east of Bermuda), after which larval eels (leptocephali) cross the Atlantic Ocean towards the continental shelf. During this stage they metamorphose into a transparent post-larval 'glass eel'. Some individuals will remain at sea, while others (elvers) ascend rivers and move between marine, estuarine and freshwater environments. They develop pigmentation and are referred to as 'yellow eels' during this phase of their life cycle. Estimates of the length of the yellow eel stage are varied in the literature, from three to 60 years before they enter a final metamorphosis into 'silver eels' and return to the Sargasso Sea to spawn (Malcolm *et al.,* 2010, Fishbase, 2023a, Wildfowl and Wetlands Trust, 2023).

There is very little information available on the migratory routes undertaken by European eels. They have been found throughout the water column (up to 1,000 m deep; Antunes and Tesch, 1997a, 1997b) and can vary with the time of day and state of tide throughout their life cycle (Cresci *et al.,* 2017, 2019, 2020). For example, larvae exhibit diel vertical migration and are found between 100 m and 150 m during the day and 50 m and 100 m during the night (Castonguay and McCleave, 1987). Upon reaching the European continental slope, they are found between 300 m and 600 m during the day and 35 m and 100 m during the night (Tesch, 1980). This diel vertical migration continues throughout the metamorphosis phase, with glass eels showing similar vertical distributions, influenced by light and tides, in coastal water (Creutzberg, 1961, Bardonnet *et al.,* 2005). Diel vertical migration has also been observed in the silver eel life stage, with a mean swimming depth of 344 m during the day and 196 m during the night (Tesch, 1989).

European eels are widely distributed throughout UK and Irish waters; however, recruitment has declined since the early 1980's and the eel has now been designated as a SPI, an Annex II species, and is on the OSPAR list of threatened and declining species in OSPAR Region III (Celtic Seas). Furthermore, European eel has a European Union Management Plan, and is protected within England and Wales under the Eels (England and Wales) Regulations 2009.

Within the Eni Development Area, European eels have been recorded within the Dee Estuary in 1967, 1982, and 2018 (NBN Atlas, 2021).

Smelt

Smelt, also referred to as 'sparling' occur in coastal waters and estuaries of Western Europe, as far south as Spain. Smelt are listed as a SPI are not in Annex II of the Habitats Directive. They migrate into large, clean rivers in order to spawn (NatureScot, 2023c), usually in the upper tidal reaches with some saline influence. They move upstream at high spring tides between February to April, where they spawn on gravel, cobbles, boulders, and vegetation. They produce between 8,000 to 50,000 eggs, which adhere to the substrate and hatch within three to five weeks (Fishbase, 2023b). Most adults will die after spawning; however, some will survive to spawn in the following year (NatureScot, 2023c).

Smelt have been recorded in the estuaries of rivers along the mainland UK within the regional fish and shellfish study area and the Eni Development Area (NBN Atlas, 2021). Furthermore, smelt are listed as qualifying interest features of various designated sites in proximity to the Eni Development Area, such as the Ribble Estuary MCZ, Wyre-Lune MCZ, and Solway Firth MCZ located 9.58 km, 21.45 km, and 131.87 km away, respectively (Table 3.4).

Allis and twaite shad

Allis and twaite shad are both part of the herring family (Clupeidae) and are the only clupeids found in freshwater in the UK (Maitland and Hatton-Ellis, 2003). Both species are listed as Annex II species under the EU Habitats Directive and are listed as SPIs. Allis shad are on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Sea). They are mainly coastal and pelagic in habit, though their movements at sea are poorly understood (Maitland and Hatton-Ellis, 2003).

Mature shad that have spent most of their lives at sea stop feeding before moving into estuaries. Males will typically migrate upstream first, followed by females one or two weeks later. Spawning takes place in freshwater pools, with almost all adult allis shad dying afterwards (Maitland and Hatton-Ellis, 2003), however twaite shad may spawn several times in their lives (Aprahamian, 1982). The eggs are laid in gravelly, shallow water and hatch four to eight days later (Hass, 1965). The fry are around 10 mm when hatched, but grow rapidly and the majority will have descended into the sea by the end of their first year (Maitland and Hatton-Ellis, 2003).

There is limited information on the distribution of these species within the regional fish and shellfish ecology study area are no records of either species within Liverpool Bay or any rivers or estuaries flowing into it (NBN Atlas, 2021). Therefore, these species are less likely to occur within the Eni Development Area than the other diadromous species presented above. The Slaney River Valley SAC is designated for twaite shad, however this is located almost 200 km away from the Eni Development Area (Table 3.4).

Table 3.6: Key Life History Parameters For Diadromous Fish Species With The Potential To Be Within The Eni Development Area

Common name	Species	Timing of Downstream Migration	Timing Spent at Sea Before First Return	Timing of Upstream Migration	Reference
Allis and twaite shad	*Alosa*	Autumn (juveniles)	2 years spent in estuaries and marine areas do not return to fresh water until they are sexually mature.	April to June (to spawn in freshwater)	Maitland and Hatton-Ellis, 2003, ABPMer, 2019
Atlantic salmon	*Salmo salar*	April to June	1 to 4 years	All year, with a peak in late summer and autumn	Malcolm *et al.*, 2010, 2015, ABPMer, 2019
European eel	*Anguilla*	June to November	May not return to freshwater, many do not	Varies spatially with limited information available for Liverpool Bay. However, in Scotland, they typically arrive in coastal waters in December and	Malcolm *et al.*, 2010

Common name	Species	Timing of Downstream Migration	Timing Spent at Sea Before First Return	Timing of Upstream Migration	Reference
				may migrate upstream until June	
River lamprey	*Lampetra fluviatilis*	From late autumn onwards (to feed in estuaries)	Spends 1 to 2 years in estuaries	Winter and spring, when temperatures are <10º	NatureScot, 2023b, ABPMer, 2019
Sea lamprey	*Petromyzon marinus*	From late autumn onwards (to open sea) (timing varies between rivers)	18 to 24 months	April to May (to spawn in May to June)	NatureScot, 2023b, ABPMer, 2019
Sea trout	*S. trutta*	Spring	2 or more	April to June	Malcolm *et al.,* 2010
Smelt	*Osmerus eperlanus*	N/A (migration to estuaries only)	Spends time in estuaries	February to April (to spawn in estuaries and large rivers)	NatureScot, 2023c

3.3.1.5 Shellfish

The term 'shellfish' is both a colloquial and fisheries term for a range of crustaceans, molluscs, and echinoderms, and in this case is used to reflect commercially targeted species, with non-commercial species included within section 2: Benthic Ecology, where appropriate. Organisms such as cephalopods (e.g. octopus, cuttlefish, squid) are also considered shellfish, despite their lack of exoskeleton for most species within this class of molluscs.

Commercially important shellfish in the Irish Sea include blue mussel, brown crab *Cancer pagurus*, brown shrimp, common whelk, European lobster *Homarus gammarus*, king scallop, Norway lobster, queen scallop, and squid *Loligo* spp. Individual accounts for these species are presented below. Common cockles and native oysters *Ostrea edulis* are also abundant throughout the region, particularly in the Solway Firth, approximately 135.10 km north of the Eni Development Area (CMACS, 2011; Brown and May Marine Ltd, 2013b). European lobsters and brown crabs are abundant, particularly on the rocky shores of North Wales. Whelks are also abundant in specific areas, including around the Isle of Man and off the North Wales coast (DECC, 2016; Eni UK, 2019). Species such as the green shore crab *C. maenus*, spiny lobster, swimming crabs (*Liocarcinus depurator* and *L. navigator*), and velvet swimming crab *Necora puber* have also been recorded within Liverpool Bay (NBN Atlas, 2021).

In addition, the freshwater pearl mussel has a parasitic larval stage dependant on salmonid hosts (Atlantic salmon and sea trout) (Taeubert and Geist, 2017; Taskinen and Salonen, 2022). Although the freshwater pearl mussel only inhabits rivers and streams and is therefore located out with the scope of the regional fish and shellfish ecology study area, populations could potentially be affected indirectly due to their symbiotic life history with Atlantic salmon or sea trout.

Post-construction otter trawl and beam trawl surveys were undertaken at the Ormonde OWF in 2012 and 2013. Shellfish species recorded included Norway lobster, velvet swimming crab, European lobster, brown crab, squid (*Loligo forbesii* and *Alloteuthis sp.*), brown shrimp, swimming crabs, and common whelk (Brown and May Marine Ltd. 2012a; 2013a). Beam trawl surveys were undertaken at the Gwynt y Môr OWF in 2011 identified common mussel, common whelk, Norway lobster, pink shrimp *Pandalus montagui,* shrimp *Cragon allmanni*, and swimming crab *Liocarcinus* spp. (CMACS, 2011). Site-specific surveys for the Rhiannon OWF, West of Duddon Sands OWF, and the Walney OWF also recorded a range of shellfish species, such as Norway lobster, swimming crab, brown shrimp, common whelk, king scallop, and queen scallop (CMACS, 2011; Brown and May Marine Ltd, 2012b; 2013b) (Table 3.7).

Table 3.7: Summary Of Shellfish Species Recorded During Site-Specific Surveys For Projects Within The Regional Fish And Shellfish Ecology Study Area

Project	Minimum Distance to Eni Development Area (km)	Survey Year(s)	Key Shellfish Species Recorded	Reference
2013 Adult and Juvenile Fish and Epibenthic Post-construction Survey for Ormonde OWF	42.95	2013	Norway lobster, velvet swimming crab, European lobster, squid *Alloteuthis sp.,* common whelk, and brown shrimp.	Brown and May Marine Ltd. 2013a
2012 Adult and Juvenile Fish and Epibenthic Post-construction Survey for Ormonde OWF	42.95	2012	Brown crab, velvet swimming crab, squid *L. forbesii,* brown shrimp, and swimming crabs.	Brown and May Marine Ltd. 2012a
Walney OWF	36.69	2013	Norway lobster, swimming crab, brown shrimp, and common whelk.	Brown and May Marine Ltd. 2013b
West of Duddon Sands OWF	29.10	2012		Brown and May Marine Ltd. 2012b
Celtic Array Round 3 Irish Sea Zone, Rhiannon Wind Farm Limited, EIA Scoping Report	25.31	2010 and 2011	King scallop, queen scallop, common whelk, brown crab, European lobster, brown shrimp, and horse mussel. Queen scallop were the most numerous shellfish species recorded	Centrica Energy and DONG Energy, 2012
Pre-construction monitoring at the Gwynt y Môr OWF	0.00	2010	Norway lobster, swimming crab, shrimp, and common whelk.	CMACS, 2011

Blue mussel

Blue mussels are widely distributed throughout the northern hemisphere and along the coastlines of the UK and Ireland. They are commonly found along the intertidal to the shallow sublittoral regions attached by byssus threads to hard substrate. There are large commercial blue mussel beds within the regional fish and shellfish ecology study area, namely within Morecambe Bay, Conway Bay, and within estuaries in northern Wales and southern Scotland (Tyler-Walters, 2008). There are extensive records of blue mussels and blue mussel beds along the entire coast of Liverpool Bay, northern Wales, and north-west England, and within the intertidal regions of the Eni Development Area (NBN Atlas, 2021). Furthermore, there was one blue mussel recorded during the Phase 1 Intertidal Walkover surveys (see Section 2.3.3).

Brown crab

The brown crab, also known as edible crab, is a relatively long-lived species that is distributed around all UK and Irish coasts in the lower shore, shallow sublittoral zone, and in offshore waters to depths of around 100 m. They are typically found on bedrock, mixed coarse grounds, offshore muddy sands, and under boulders (Neal and Wilson, 2008). On the NBN Atlas, there are extensive records of brown crab in the offshore areas of the Eni Development Area and along the coast of Liverpool Bay, northern Wales, north-west England, and within the intertidal regions of the Eni Development Area (NBN Atlas, 2021).

Brown shrimp

The brown shrimp is a small crustacean (up to 8.5 cm) found on sandy and muddy bottoms around UK and Irish coasts to depths of 150 m (Neal, 2008). They are typically buried in the sand, with only their eyes and antennae visible (Pinn and Ansell, 1993). The brown shrimp is the most commonly encountered shrimp in sandy bays and estuaries. For example, in the Wadden Sea, peak densities of 60 individuals per m^2 have been recorded during the summer (Beukema, 1992).

Within the regional fish and shellfish ecology study area, brown shrimp are commercially fished in Morecambe Bay and the Solway Firth (Henderson *et al.,* 1990; Lancaster and Frid, 2002). There are numerous records of the brown shrimp along the coastlines of Liverpool Bay, northern Wales, and north-west England. This includes the waters of the Dee Estuary, which overlaps with the intertidal sections of the Eni Development Area (NBN Atlas, 2021). Furthermore, brown shrimp were recorded in standing water during the Phase 1 Intertidal Walkover surveys conducted to characterise the intertidal benthic environment of the Eni Development Area (see Section 2.3.3).

Cephalopods

Squid are common throughout the eastern Atlantic including along the UK and Irish coasts and are typically found over sandy and muddy bottoms. Squids of the genus *Loligo,* such as the common or European squid *Loligo vulgaris* and long finned squid *Loligo forbesii,* are neritic and mainly near-bottom species. Due to their distribution in the water column, they are often bycatch in demersal fisheries, despite being commercially exploited species themselves. They prey on small fishes, other cephalopods, crustaceans, and polychaetes. They have an extended breeding season, from January to May with a peak in February and March (Lum-Kong *et al*., 1992; Pierce *et al*., 1994) and die shortly after spawning at ~1 to 2 years old.

Short-finned squids (Ommastrephids) are fairly cosmopolitan in UK and Irish waters, but are not usually recorded in bottom trawl surveys due to their pelagic, oceanic habitat. As such, there are negligible landings and limited data on these species within the Irish Sea (Sacau *et al.,* 2005).

Two octopus species are found in the Irish Sea, with the most common species being the curled octopus *Eledone cirrhosa* and the less common, common octopus *vulgaris* (DECC, 2009b). The curled octopus is a small benthic species, that typically occurs in shallow coastal waters down to 300 m across a variety of substrata (Boyle, 1983). They live for one to two years, depending on individual growth and maturation rates (Boyle *et al.,* 1988). Females die after spawning, which occurs between July and September (Boyle, 1983; Hastie *et al.,* 2008). The common octopus is larger in size and inhabits rocky coastal areas (Wilson, 2006; DECC, 2009b). Populations of common octopus can fluctuate widely between years (DECC, 2009b).

Three cuttlefish species are also found in UK and Irish waters: the elegant cuttlefish *Sepia elegans,* common cuttlefish *Sepia officinalis,* and pink cuttlefish *Sepia orbignyana* (DECC, 2009b). The elegant cuttlefish is found in offshore waters down to 430 m, on sandy and muddy substrata (Wilson, 2007a). The pink cuttlefish is rare in Britain and Ireland, and typically found in muddy and detritus-rich continental shelf areas down to 450 m (Wilson, 2007b). The common cuttlefish is the largest of the three, with a mantle length of up to 45 cm (Gibson-Hall and Wilson, 2018). It is recorded in shallower water than the other two species, on sandy and muddy substrata, typically down to 100 m depth (Gibson-Hall and Wilson, 2018).

Common cockle

The common cockle is a bivalve mollusc widely distributed around UK and Irish intertidal zones. They are typically found on clean sand, muddy sand, mud, or muddy gravel and burrowing at a depth no more than 5 cm. They are harvested commercially within the Proposed Development fish and shellfish study area in Morecambe Bay, the Ribble Estuary, and in the Bury Inlet (Tyler-Walters, 2007). Within the Eni Development Area, they are harvested within the Dee Estuary (Tyler-Walters, 2007), where there are extensive records for this species on the NBN Atlas (2021). Individuals were occasionally recorded during dig over sampling undertaken during the Phase 1 Intertidal Walkover survey conducted to characterise the intertidal benthic environment of the Eni Development Area (see Section 2.3.3).

Common whelk

The common whelk is an opportunistic carnivorous marine gastropod mollusc distributed throughout the North Atlantic Ocean Common whelk will more normally inhabit subtidal areas, although they have been recorded on all types of seabed substratum including gravel, sand, mud and rock (Haig *et al.,* 2015). They are more typically found in areas of soft seabed from 0 to 50 m, in which whelk may spend some of their time buried in the sand and mud.

It is commercially exploited in UK and Irish waters and much of the catch is exported to East Asia (Eastern Inshore Fisheries and Conservation Authority (IFCA), 2020). They are vulnerable to exploitation as they are slow growing and slow to reach sexual maturity (Eastern IFCA, 2020). Furthermore, recent studies have shown that there are local differences in growth rates, which suggest that this species is being caught and landed before it reaches sexual maturity in some areas (Haig *et al.,* 2015; McIntyre *et al.,* 2015). The Eastern IFCA have set a Minimum Landing Size (MLS) of 55 mm, based on the principle that 50% of the population should have reached maturity at this size, although IFCAs in other regions have increased the MLS to up to 75 mm (Eastern IFCA, 2020).

Between 2016 to 2021, common whelk were the second most landed species (annual average of 817 tonnes), and the most valuable species (annual average of £1,003,000) within ICES Rectangles 35E6 and 36E6, which encompass the Eni Development Area (MMO, 2022). ICES Rectangles 35E6 and 36E6 span from the south-eastern tip of Anglesey until the southern opening of Morecambe Bay, therefore only include UK ports (X ref Figure 1.1 in volume 2, chapter 10). These values account for landings from UK vessels, with the majority of landings attributed to vessels registered in Scotland, England, and Wales, respectively. Further information is presented in volume 2, chapter 10. Common whelk were also the only shellfish species observed during the site-specific benthic characterisation surveys conducted within the Eni Development Area in 2022 (see section 2.2.4.1), with one individual observed (Table 2.9).

European lobster

The European lobster is capable of growing up to 1 m in total length, with 90% of females maturing at a carapace length of 10.20 cm (Hold *et al,* 2022). They are found on all UK and Irish coasts from the lower shore to approximately 60 m depth. They typically live in holes and tunnels within rocky substrates (Wilson, 2008).

There have been several records of European lobster within the Eni Development Area during various different surveys between 2011 and 2018 (NBN Atlas, 2021).

King and queen scallops

King and queen scallops display a preference for clean firm sandy substrates and sandy gravel and may be found in high densities on muddy sand on occasion. Distribution is typically patchy but areas with little mud and with good current strength tend to have the highest abundance (Carter, 2008; Marshall and Wilson, 2008). The main physical difference between the two species is their shells and overall size attainable; queen scallops possess two distinctive curved shells, while king scallops have a predominantly flat upper shell and are typically larger overall when mature.

The regional fish and shellfish ecology study area is also an important region for king scallops and queen scallops, with substantial populations found in Cardigan Bay, around the Isle of Man, the Solway Firth, Morecambe Bay and around islands in the Firth of Clyde. However, scallop research surveys conducted by Bangor University in Liverpool Bay found that king scallop populations have been recorded in consistently low densities and were dominated by larger, older individuals (Delargy *et al.,* 2019). Recruitment was low and highly sporadic, however evidence of pre-recruit king scallops (i.e. <110 mm) were recorded in 2019 (Delargy *et al.,* 2019). In 2012, king and queen scallops were the most valuable wild-caught commercial fish species landed in Wales; however, this has since decreased. Despite this decrease, king and queen scallops are economically important and were the third most valuable wild-caught seafood in Wales in 2017 (Delargy *et al*., 2019). Queen scallop were the most landed species (annual average landings of 1,078 tonnes) and second most valuable species (annual average of £879,000) within ICES Rectangles 35E6 and 36E6 between 2016 to 2021. King scallop were the third most landed species (annual average landings of 257 tonnes) and third most valuable (£609,000) within ICES Rectangles 35E6 and 36E6 between 2016 to 2021 (MMO, 2022). As above for common whelk, these values account for landings from UK vessels into UK ports, with further information presented in volume 2, chapter 10. There have also been several recordings of these species within the Eni Development Area on the NBN Atlas (2021).

Norway lobster

The Norway lobster is a slim, orange-pink lobster which grows up to 25 cm long and is considered to be the most commercially important crustacean in Europe (Bell *et al.,* 2006). It is widely distributed within the Atlantic, from Icelandic waters to the Mediterranean and the Moroccan coast, and commercially exploited throughout its range. They were the most abundant shellfish species recorded across the surveys for the Walney OWF, with a maximum of 3,296 individuals in a single trawl (Brown and May Marine Ltd, 2013b). They have also been regarded as important to the trawling fishery near the Cumbria coast (Walmsey and Pawson, 2007).

They inhabit muddy seabed sediments and display a strong preference for sediments with more than 40% silt and clay (Bell *et al.,* 2006). They build and spend significant amounts of time in semi-permanent burrows which vary in structure and size but typically range from 20 to 30 cm in depth (Dybern and Hoisaeter, 1965). Due to their strong habitat preferences, the presence of suitable habitat tends to determine their distribution patterns, with higher abundances found on more favourable substrates. They spawn in September, and females carry their eggs under their tails (described as being 'berried') until they hatch in April or May. The larvae develop in the plankton before settling to the seabed six to eight weeks later (Coull *et al.,* 1998).

Records are limited within the Eni Development Area (NBN Atlas, 2021), and there are spawning and nursery grounds of undetermined intensity located north of the Eni Development Area (Coull et al., 1998) (Figure 2 5).

Spiny lobster

The spiny lobster (also referred to as 'crawfish') is a large lobster, which grows up to a total length of 60 cm long. The main populations of spiny lobster are along the south and west coast of the UK, where they live on rocky, exposed coasts to depths of 400 m (Gibson-Hall *et al.,* 2020). Populations in the UK suffered due to overfishing in the 1960s and 70s and it has since been included under Section 7 of the Environment (Wales) Act 2016.

Within the regional fish and shellfish ecology study area, there are seven records of spiny lobster in the NBN Atlas in the south of the Isle of Man and the eastern coast of Anglesey (NBN Atlas, 2021). However, there are no records of this species within the Eni Development Area. It is important to note that this does not necessarily mean that the species is absent from the Eni Development Area, due to the limitations of the NBN Atlas.

Shellfish waters

There are classified bivalve mollusc harvesting areas and shellfish waters present within Liverpool Bay, around Anglesey, within Morecambe Bay, and within the Ribble Estuary (Figure 3.3) (Magic Map, 2023). These bivalve mollusc harvesting areas and shellfish waters are designated for the shellfish growth and production and are classified by criteria set out in Annex III of retained EU law regulation (EC) 853/2004 and Articles 53, 54, and 55 of retained EU law Regulation (EU) 2019/627 (Table 3.8). Classifications are based on the levels of bacteria (*Escherichia coli)* present in the shellfish flesh and are monitored by Cefas and the Food Standards Agency (FSA). Under EC Regulation 854/2004, levels of *E. coli* are used as an indicator for microbiological contamination in bivalves, as this bacterium is present in animal and human faeces in large numbers, and can, therefore, indicate contamination of faecal origin. The presence of *E. coli* can also indicate that other more harmful faecal bacteria may also be present. It can also indicate that viruses, such as Norovirus, are present, however there is currently no legal requirement to monitor these viruses (FSA, 2018).

E. coli, and other faecal bacteria, can be transported by suspended sediment particles (Jamieson *et al.,* 2005; Russo *et al.,* 2011; Bradshaw *et al.,* 2021). The level of suspended sediments and associated deposition resulting from the Proposed Development has been assessed in volume 2, chapter 6. As bacterial contamination of shellfish waters does not impact the shellfish species directly, this topic is discussed further in volume 2, chapter 10.

Table 3.8: Criteria For Classification Of Shellfish Production Areas (Source: FSA, 2018)

Class	Minimum Number of Samples Required per Year	Microbiological Standard	Post-harvest Treatment Required
A	10	80% of live bivalve molluscs from these areas must not exceed 230 Most Probable Number (MPN) of *E. coli* per 100 g Flesh and Intervalvular Liquid (FIL), and no samples may exceed 700 *E. coli* per 100 g FIL.	None, shellfish can be harvested for direct human consumption
B	8	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution MPN test of 4,600 *E. coli* per 100 g FIL in more than 10% of samples. No sample may exceed an upper limit of 46,000 *E. coli* per 100 g FIL	Shellfish can be supplied for human consumption after one of the following processes: purification in an approved establishment, relaying for at least one month in a Class A relating area, or by cooking with an approved heat treatment process.
C	8	All live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution MPN test of 46,000 *E. coli* per 100 g FIL	Shellfish can be supplied for human consumption after one of the following processes: relaying for at least two months in an approved Class B relaying area followed by treatment in a purification centre, relaying for at least two months in a Class A relating area, or cooking with an approved heat treatment process.
Prohibited	N/a	>46,000 *E. coli* per 100 g FIL	Harvesting not permitted

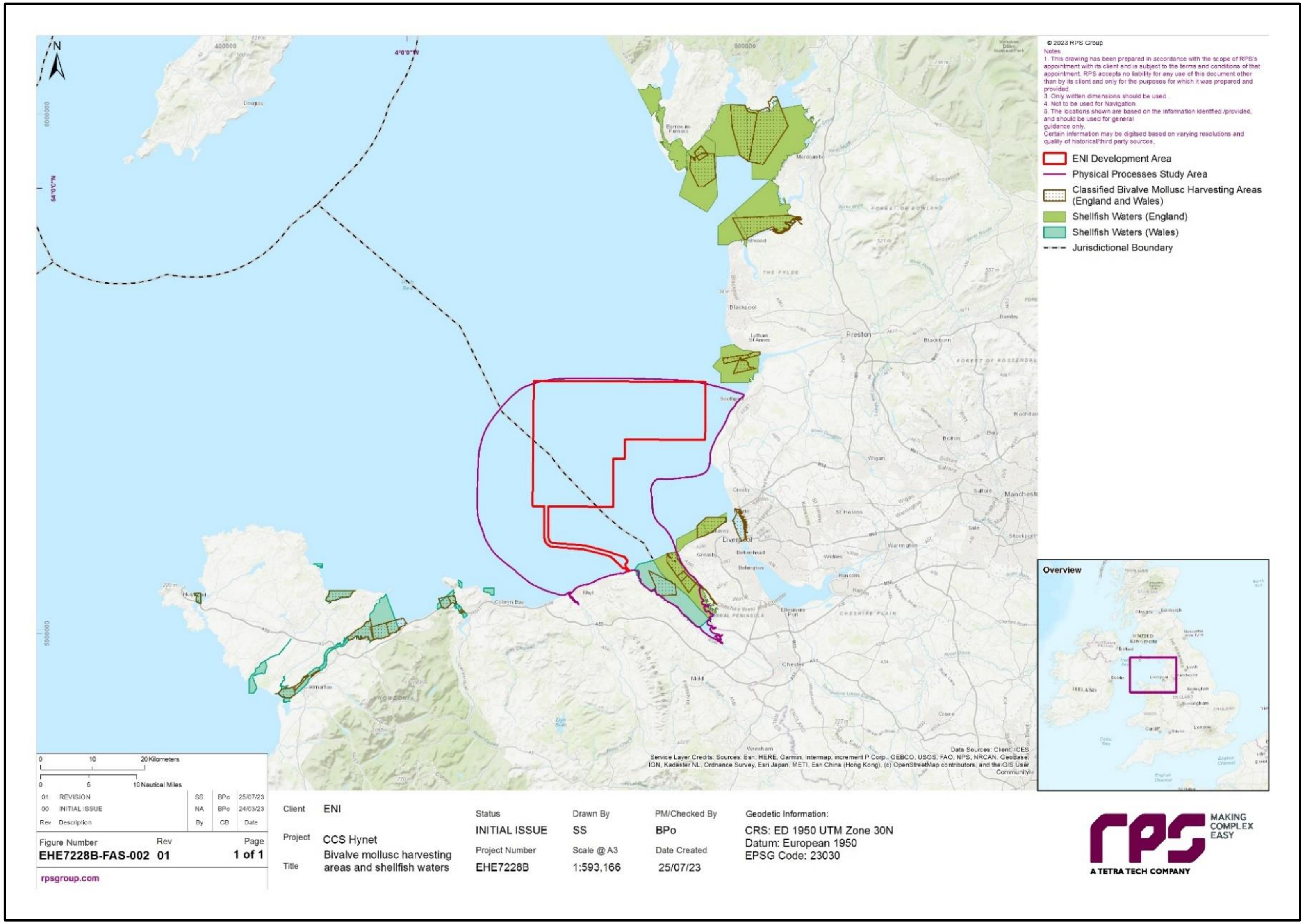

Figure 3.3: Bivalve Mollusc Harvesting Areas And Shellfish Waters In Proximity To The Eni Development Area And The Physical Processes Study Area (Source: Magic Map, 2023)

3.3.1.6 Spawning and nursery grounds

The regional fish and shellfish ecology study area and the Eni Development Area encompass spawning and nursery grounds for a number of ecologically and commercially important fish and shellfish species.

Data from Cefas (Ellis *et al.*, 2012) and fisheries sensitivity maps (Coull *et al.*, 1998) provide diagrams of the nursery and/or spawning areas for key species. These data illustrate that spawning grounds for species such as cod, European hake, horse mackerel, lemon sole, ling, mackerel, Norway lobster, plaice, sandeel, sole, and whiting are present in the vicinity of the Eni Development Area (Table 3.9; Figure 3.4 to Figure 3.8). Nursery grounds for anglerfish, cod, haddock, herring, lemon sole, mackerel, Norway lobster, plaice, sandeel, sole, spotted ray, sprat, spurdog, thornback ray, tope shark, and whiting are also present in the vicinity of the Eni Development Area (Table 3.9; Figure 3.4 to Figure 3.8) (Coull *et al*., 1998; Ellis *et al*., 2012).

A study published by Aires *et al.* (2014) provided updates to the Coull *et al.* (1998) and Ellis *et al.* (2012) datasets, by presenting spatial data on the probability of the presence of 0 group aggregations of commercial fish species around the UK. Fish in the first year of their lives are defined as 0 group fish and can provide further evidence of spawning and nursery locations. There was a low probability of the presence of 0 group aggregations of anglerfish, blue whiting, cod, haddock, mackerel, plaice, and sole in the Eni Development Area. There was a low to medium probability of the presence of 0 group aggregations of European hake, herring, horse mackerel, Norway pout, sprat, and whiting (Aires *et al.,* 2014).

A recent report by Campanella and van der Kooij (2021) presents hotspot maps for adults and juveniles of a range of forage fish species during two periods of the year (Q1 and Q4). These maps were created through a literature review and compilation of standardised survey data from 2008 to 2020. The report also presented data in the vicinity of the Eni Development Area for species that were not included in Coull *et al. (*1998), Ellis *et al. (*2012), and Aires *et al. (*2014), such as European anchovy, European sardine, and poor cod. The other species considered were cod, herring, horse mackerel, mackerel, sandeel, and whiting. Individual species accounts are presented below and summarised in Figure 3.9 to Figure 3.17.

Table 3.9: Key Species, Seasonal Spawning Periods, And Nursery And Spawning Grounds That Overlap With The Eni Development Area (Sources: Coull *et al.,* 1998; Ellis *et al.,* 2012)

Common Name	Scientific Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nursery Ground	Spawning Ground
Anglerfish	*Lophius piscatorius*														
Cod	*Gadus morhua*														
European hake*	*Merluccius merluccius*														
Haddock*	*Melanogrammus aeglefinus*														
Herring	*Clupea harengus*														
Horse mackerel*	*Trachurus trachurus*														
Lemon sole*	*Microstomus kitt*														
Ling	*Molva molva*														

Common Name	Scientific Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nursery Ground	Spawning Ground
Mackerel	*Scomber scombrus*														
Norway lobster*	*Nephrops norvegicus*														
Plaice	*Pleuronectes platessa*														
Sandeel	Ammodytidae														
Sole	*Solea solea*														
Spotted ray	*Raja montagui*														
Sprat	*Sprattus sprattus*														
Spurdog	*Squalus spp.*														
Thornback ray	*Raja clavata*														
Tope shark	*Galeorhinus galeus*														
Whiting	*Merlangius merlangus*														

Legend: Spawning Period | Peak Spawning | High Intensity | Low Intensity | Intensity not specified

*Grounds are in the vicinity of the Eni Development Area but do not directly overlap

Anglerfish

Anglerfish are distributed around all UK and Irish coasts at depths up to 550 m. They are not typically found in waters shallower than 18 m. Spawning occurs offshore at depths of around 2,000 m (Reeve, 2008). The high intensity nursery area occurs in the northern North Sea, north of Scotland and Ireland (Ellis *et al.,* 2012). The Eni Development Area overlaps with an area identified by Ellis *et al*. (2012) as being a low intensity nursery ground for anglerfish, based on the recorded number of juveniles (Figure 3.4). There was a low probability of 0 group aggregations of anglerfish in the vicinity of the Eni Development Area (Aires *et al.,* 2014).

Cod

Cod are widely distributed throughout UK and Irish waters and are found from the shoreline to depths of around 600 m. Cod have historically been subject to high levels of commercial fishing in the UK and Ireland, leading to concerns about the status of the species. Spawning occurs between January and April, with peak spawning occurring in February to March, during which time up to six million buoyant eggs are released into the pelagic environment. The eggs hatch after approximately 12 days and then juveniles have a pelagic larval phase where they feed on plankton, before moving down towards the seabed to exploit demersal prey, such as crustaceans and smaller fish (Dipper, 2001).

The Eni Development Area overlaps with an area identified by Ellis *et al*. (2012) as being a high intensity spawning and nursery area (Figure 3.4). There was a low probability of 0 group aggregations of cod in the vicinity of the Eni Development Area (Aires *et al.,* 2014). In the Campanella and van der Kooij (2021) hotspot maps, adults and juveniles were low in Q1 and low to medium in Q4 within the Eni Development Area (Figure 3.9)

European hake

European hake is demersal species, typically found between 70 m and 350 m. They have a westerly distribution around the UK and Ireland, and are present in the English Channel, Southern Ireland, the Isle of Man, and the Irish Sea (Barnes, 2008a). Within the regional fish and shellfish ecology study area, there is a low intensity nursery ground to the west of the Isle of Man (Ellis *et al.,* 2012), however none overlapping with the Eni Development Area (Figure 3.4).

European anchovy

The European anchovy is a coastal pelagic species, typically associated with the warmer waters of the Mediterranean Sea and the Bay of Biscay, with an increasing number of reports from the English Channel and Irish Sea in the 1990's (Quigley, 1997; Armstrong *et al.,* 1999). This is believed to be due to climate variability in recent years, which has led to an expansion of suitable habitats for the European anchovy's life cycle (Alheit *et al.,* 2012; Petitgas *et al.,* 2012).

They spawn in summer throughout the majority of their range, although there are no confirmed spawning areas within the regional fish and shellfish ecology study area. Campanella and van der Kooij (2021) report juveniles to be widespread in waters less than 100 m around Wales, eastern and southern Ireland, and the south-east of England. Juveniles were higher in the hotspot maps in Q4 than in Q1 in proximity to the Eni Development Area (Figure 3.10). Distributions of adults were similar to those for juveniles (Figure 3.10) and may reflect the locations of overwintering grounds, and the persistent presence of adult European anchovies in the Irish Sea (including in early autumn) may suggest possible spawning areas (Campanella and van der Kooij, 2021).

European sardine

Similar to the European anchovy, the European sardine is a small pelagic fish, but is typically distributed from below the English Channel and down to West Africa and in the Mediterranean. Spawning varies throughout its range, but in the Celtic Sea and English Channel, there are two distinct spawning peaks, in late spring and autumn (Stratoudakis *et al.,* 2007; Carpentier *et al.,* 2009; Coombs *et al.,* 2010). Within the Eni Development Area, Campanella and van der Kooij (2021) report a low hotspot index of juveniles in Q1 and Q4, which was marginally higher in Q4, and no hotspots for adults in either Q1 or Q4 (Figure 3.11).

Haddock

Haddock is widely distributed throughout UK and Irish waters at depths between 40 m to 300 m, with spawning occurring in deep water (Barnes, 2008b). Spawning occurs predominantly between February and May. Similar to cod, haddock have a pelagic larval phase feeding on plankton before juveniles move down towards the seabed where they prey on demersal species. Haddock were not included in the Ellis *et al.* (2012) or Campanella and van der Kooij (2021) reports, however there is an unspecified intensity nursery ground to the north of the Eni Development Area, but not overlapping (Coull *et al.,* 1998) (Figure 3.4). There are no haddock spawning grounds denoted within the vicinity (Coull *et al*., 1998), and there is a low probability of 0 group aggregations in the Eni Development Area (Aires *et al.,* 2014).

Herring

Herring are an important pelagic commercial species and are widely distributed throughout UK and Irish waters at depths to 200 m. Spawning times are dependent on sub-populations with both spring and autumn spawning populations occurring. During spawning, they deposit sticky eggs on a wide range of substrate types with a low proportion of fine sediment and well-oxygenated water, but preferred substrate type is gravel (Drapeau, 1973; Rogers and Stocks, 2001). These eggs adhere to the seabed and are able to form extensive beds.

Larvae have a planktonic phase and drift with the current until reaching inshore nursery grounds. After a year they migrate further offshore to join adults at feeding grounds.

The Eni Development Area overlaps with an area identified by Coull *et al.* (1998), Ellis *et al*. (2012) and Campanella and van der Kooij (2021) as being a herring nursery ground (Figure 3.5), classified by Ellis *et al.* (2012) as high intensity based on the abundance of juveniles caught in the area. The juvenile hotspot index is higher in Q4 than in Q1 in within the Eni Development Area (Campanella and van der Kooij, 2021). There is a low to medium probability of 0 group aggregations in the Eni Development Area (Aires *et al.,* 2014). The hotspot index of adults was medium in Q1 and low to medium in Q4 (Campanella and van der Kooij, 2021) (Figure 3.12).

Horse mackerel

Horse mackerel have a south-western distribution around the UK and Ireland, predominantly found throughout the English Channel, the south coast of Ireland, and within parts of the Irish Sea. They are a pelagic schooling species and may be present on continental shelves down to over 200 m depths (Barnes, 2008c). Within the regional fish and shellfish ecology study area, there is a low intensity spawning ground to the west of the Eni Development Area, but not overlapping with it (Ellis *et al.* (2012) (Figure 3.5).

Lemon sole

Lemon sole is a demersal species that is widely distributed around UK and Irish waters. They spawn from April through to September in deeper waters. They release eggs in the pelagic environment and their larvae occupy progressively deeper water as they develop (Faber Maunsel and Metoc, 2007). Within the regional fish and shellfish ecology study area, there is a nursery and spawning ground of undetermined intensity towards the north-west of the Eni Development Area, but not overlapping with it (Coull *et al.,* 1998) (Figure 3.5).

Ling

Ling are the largest the largest species within the cod family (gadoids) and has a very similar ecology and distribution to cod (described above). The Eni Development Area overlaps with a low intensity spawning ground identified by Ellis *et al*. (2012) (Figure 3.5).

Mackerel

Mackerel are one of the most prolific and well-known pelagic species in UK and Irish waters, and of considerable commercial importance. Mackerel are found around the entire coastline in large shoals, although they have been subject to commercial over-fishing. They are broadcast spawners, with eggs that float to the surface. Once hatched, larvae enter the plankton until they reach inshore nursery grounds (Campanella and van der Kooij, 2021). Nursery grounds are extensive around the coasts of UK and Ireland. The Eni Development Area overlaps with areas identified by Ellis *et al*. (2012) as being a low intensity spawning and nursery ground for this species (Figure 3.6). There hotspot index of juveniles is low to medium in Q1 and Q4, and low to medium in Q1 and medium in Q4 for adults (Figure 3.13) (Campanella and van der Kooij, 2021). The presence of 0 group aggregations was low in the vicinity of the Eni Development Area (Aires *et al.,* 2014).

Norway lobster

The Norway lobster is described in the Shellfish section above, and this information is not repeated here. Within the regional fish and shellfish ecology study area, there are spawning and nursery grounds of undetermined intensity located north of the Eni Development Area, however these do not overlap (Coull *et al.,* 1998) (Figure 3.6).

Plaice

Plaice are widely distributed demersal flatfish throughout UK and Irish waters. They are found within the intertidal region to depths of 8 m, typically on substrates of sand, gravel, and mud (Faber Maunsel and Metoc, 2007). In their first year of life, plaice live in very shallow water nurseries, after which they migrate into deeper waters (Ruiz, 2007). There are high and low intensity spawning grounds and low intensity nursery grounds which overlap with the Eni Development Area (Ellis *et al*., 2012) (Figure 3.6). There was a low probability of the presence of 0 group individuals in the vicinity of the Eni Development Area according to the Aires *et al.* (2014) report.

Poor cod

Poor cod are a small gadoid species (e.g. cod, haddock, ling, whiting), typically bentho-pelagic and found at depths between 10 m and 300 m. The spawning period is from February to March but there is limited information available on its spawning and nursery areas, likely due to the absence of any targeted fisheries for the species. Campanella and van der Kooij (2021) report juvenile and adult hotspots to be low in Q1 and Q4 within the Eni Development Area (Figure 3.14).

Sandeel

There are numerous sandeel species present in UK and Irish waters, with the most common being the Raitt's sandeel and the lesser sandeel. The three other species present in UK and Irish waters are the smooth sandeel *Gymnammodytes semisquamatus*, greater sandeel *Hyperoplus lanceolatus,* and Corbin's sandeel *H. immaculatus*. During the winter, sandeel remain buried in the sediment only emerging to spawn. Sexual maturity is reached at the age of two. The eggs are laid in clumps within sandy substrate until they hatch, after which they enter the water column. Sandeel will then metamorphose and settle in sandy sediments amongst adults (Van Deurs *et al.,* 2009). Due to this life history, there is very little movement between spawning and feeding grounds. The Eni Development Area overlaps with an area identified by Ellis *et al*. (2012) as being a high intensity spawning ground and low intensity nursery ground (Figure 3.6). These results are consistent with Campanella and van der Kooij (2021), which demonstrate a high hotspot index of adults and a low to medium hotspot index of juveniles in Q1 and Q4 within the Eni Development Area (Figure 3.15).

Sole

Sole is widely distributed throughout UK and Irish waters and found within sandy, muddy seabeds at depths between 10 m to 60 m. Adults are usually 30 to 40 cm long, however large individuals may grow to 60 cm. They mainly hunt for food at night and feed on thin shelled bivalves, bristle-worms, small crustaceans and fish. During daytime, they bury themselves in the sand with only their eyes visible. Juveniles are found during the first two to three years in coastal nurseries (typically bays and estuaries) before migrating to deeper waters (ICES, 2012; Picton and Morrow, 2016). The Eni Development Area overlaps with nursery and spawning areas identified by both Coull *et al*. (1998) and Ellis *et al*. (2012) (Figure 3.7). Both the nursery and spawning areas were determined as being high intensity in Ellis *et al*. (2012) (Figure 3.7).

Sprat

Sprat are small (<16 cm) oily fish, in the family Clupeidae, and can be found widely distributed through UK and Irish waters. Reproduction normally starts when the fish reaches its first or second year depending on growth conditions. The Eni Development Area overlaps with a spawning ground of undetermined intensity for sprat (Coull *et al*., 1998) (Figure 3.7). The hotspot maps produced by Campanella and van der Kooij (2021) demonstrate that the Eni Development Area supports medium to high intensities of juveniles and adults in Q4 (Figure 3.16). Similarly, there was a low to medium probability of the presence of 0 group individuals in the vicinity of the Eni Development Area (Aires *et al.,* 2014).

Spotted ray, thornback ray, and tope shark

These species are described in the Elasmobranch section above, and this information is not repeated here. The Eni Development Area overlaps with low intensity nursery grounds for these species (Figure 3.7 and Figure 3.8) (Ellis *et al.,* 2012).

Spurdog

The spurdog is described in the Elasmobranch section above, and this information is not repeated here. The Eni Development Area overlaps with a high intensity nursery ground for this species (Figure 3.7) (Ellis *et al.,* 2012).

Whiting

Whiting is a widely distributed demersal species, present at depths between 30 m and 100 m throughout UK and Irish waters. They have a prolonged spawning period from February to June throughout its range. Similar to other gadoids, whiting produce pelagic eggs and larva and juveniles remain pelagic until they attain a length of approximately 10 cm before adopting a demersal habitat. The nursery grounds tend to be located inshore and juveniles will remain in these areas for one or two years (Faber Maunsel and Metoc, 2007). The Eni Development Area overlaps with areas presented in Coull *et al*. (1998) and Ellis *et al*. (2012) as being a low intensity spawning ground and a high intensity nursery ground (Figure 3.8). Within the Eni Development Area, juvenile and adult intensity was higher in Q4 than in Q1 (Figure 3.17) (Campanella and van der Kooij (2021). There was a medium probability of the presence of 0 group aggregations in the Eni Development Area presented in Aires *et al.* (2014).

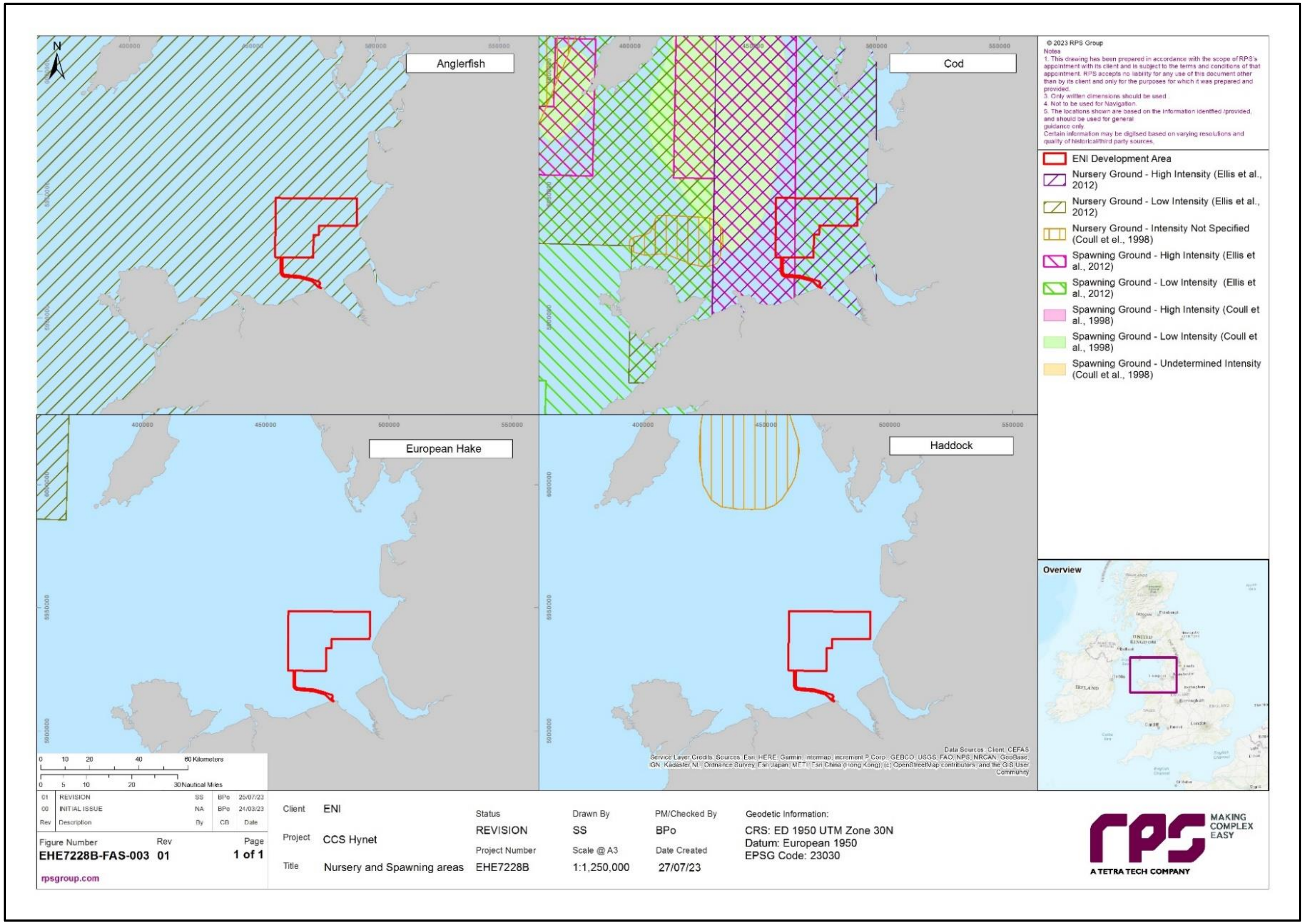

Figure 3.4: Spawning And Nursery Grounds In Proximity To The Eni Development Area For Anglerfish, Cod, European Hake, And Haddock (Source: Coull *et al.*, 1998; Ellis *et al.*, 2012)

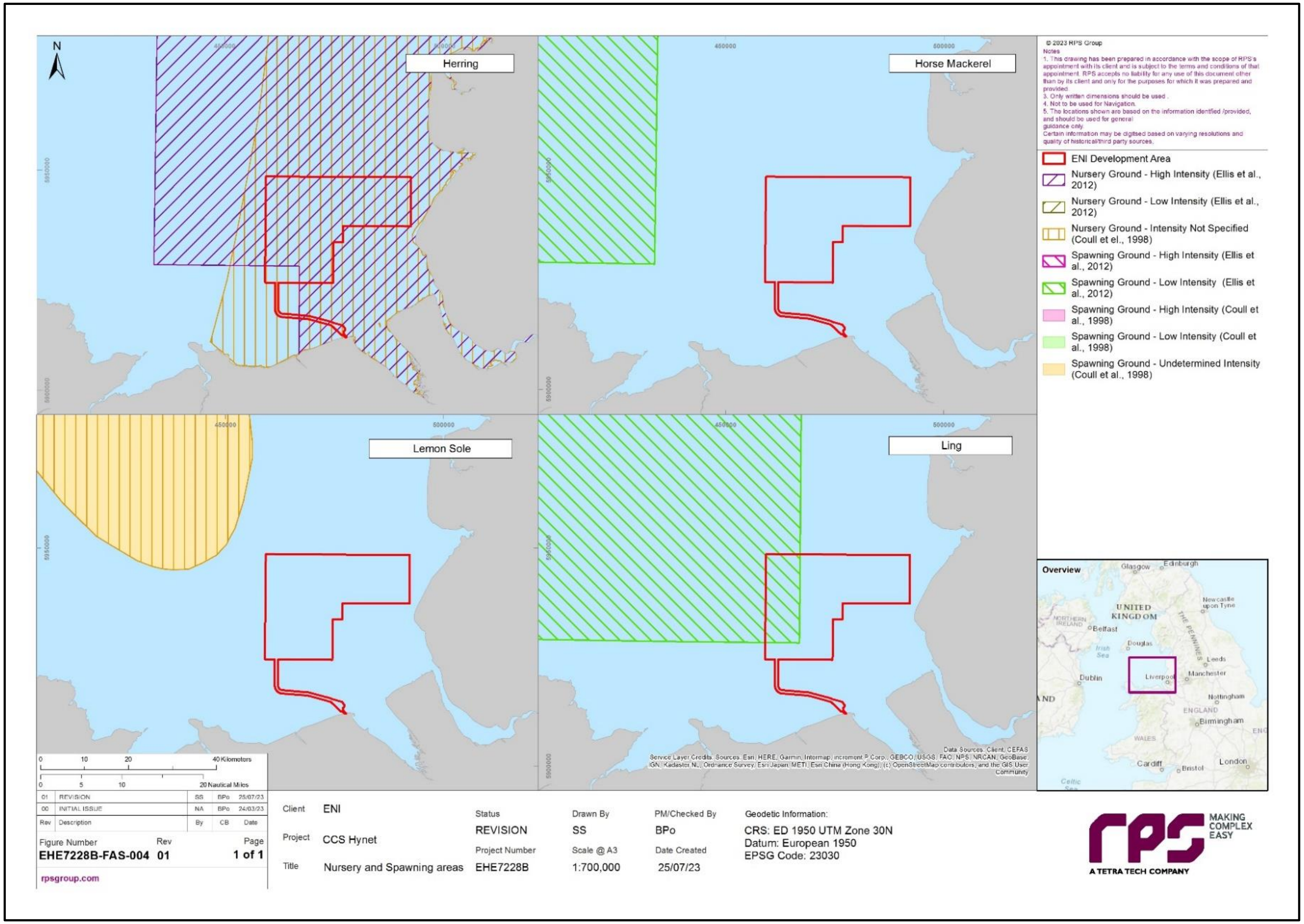

Figure 3.5: Spawning And Nursery Grounds In Proximity To The Eni Development Area For Herring, Horse Mackerel, Lemon Sole, And Ling (Source: Coull *et al.*, 1998; Ellis *et al.*, 2012)

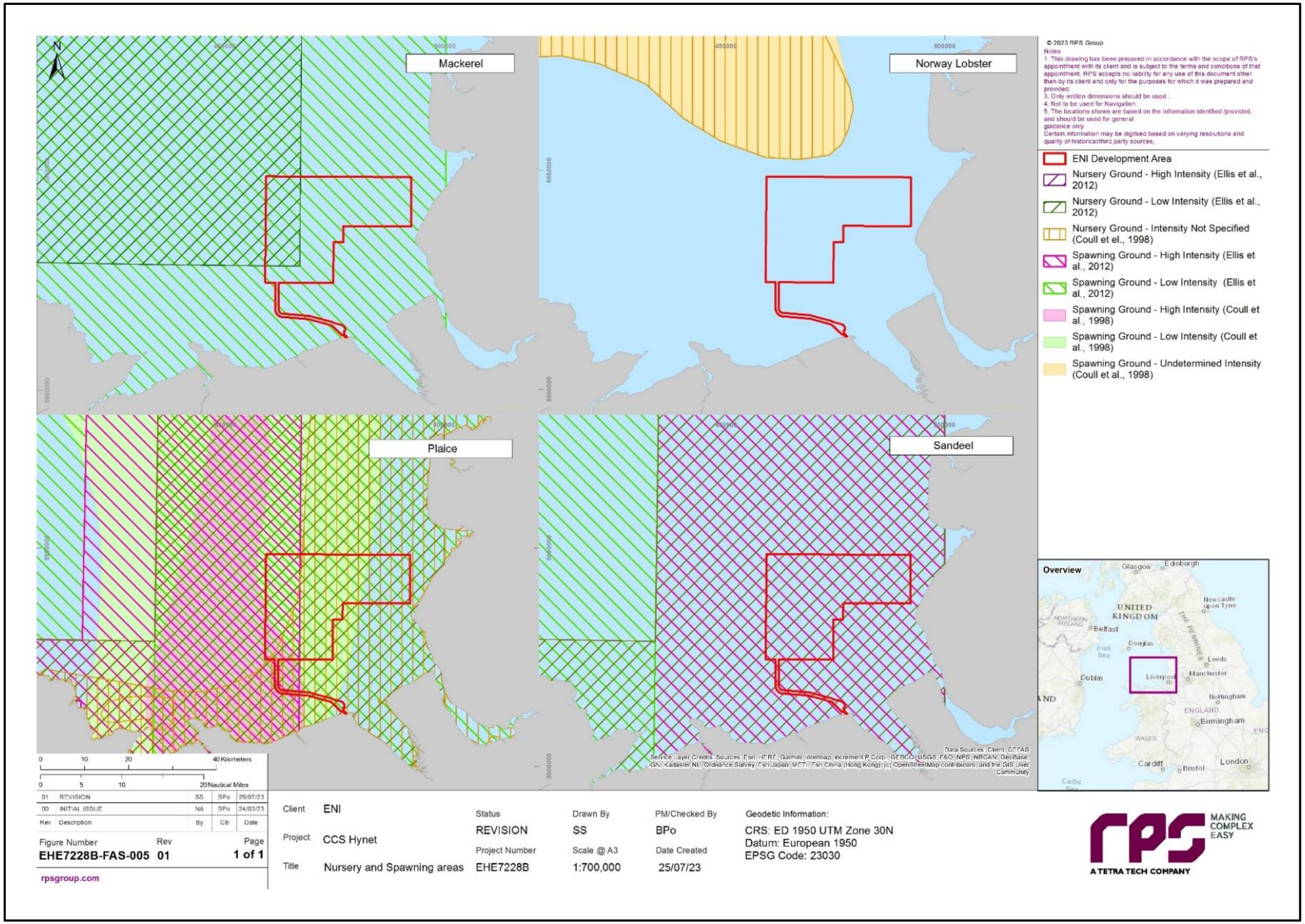

Figure 3.6: Spawning And Nursery Grounds In Proximity To The Eni Development Area For Mackerel, Norway Lobster, Plaice, And Sandeel (Source: Coull *et al.*, 1998; Ellis *et al.*, 2012)

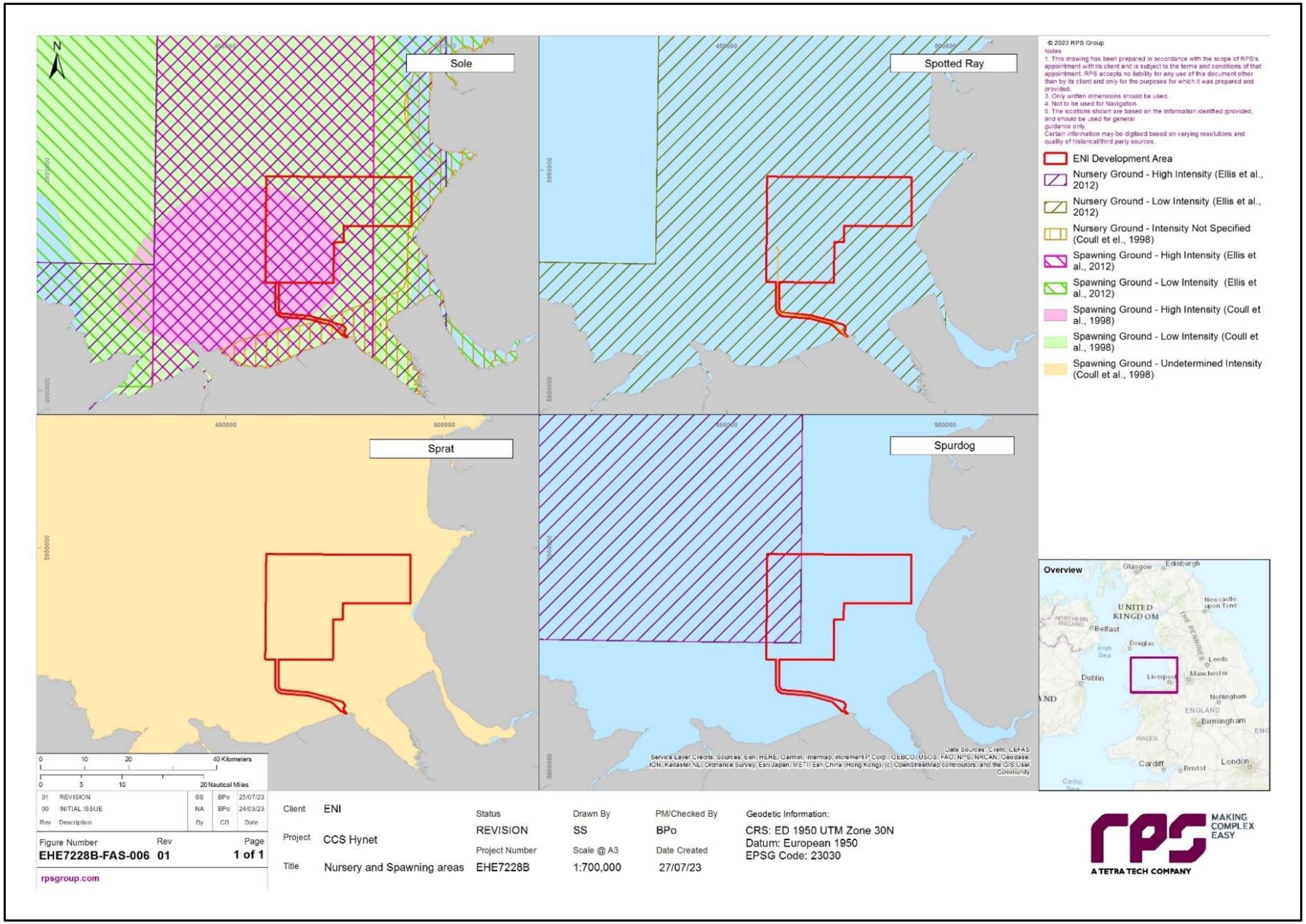

Figure 3.7: Spawning And Nursery Grounds In Proximity To The Eni Development Area For Sole, Spotted Ray, Sprat, And Spurdog (Source: Coull *et al.,* 1998; Ellis *et al.,* 2012)

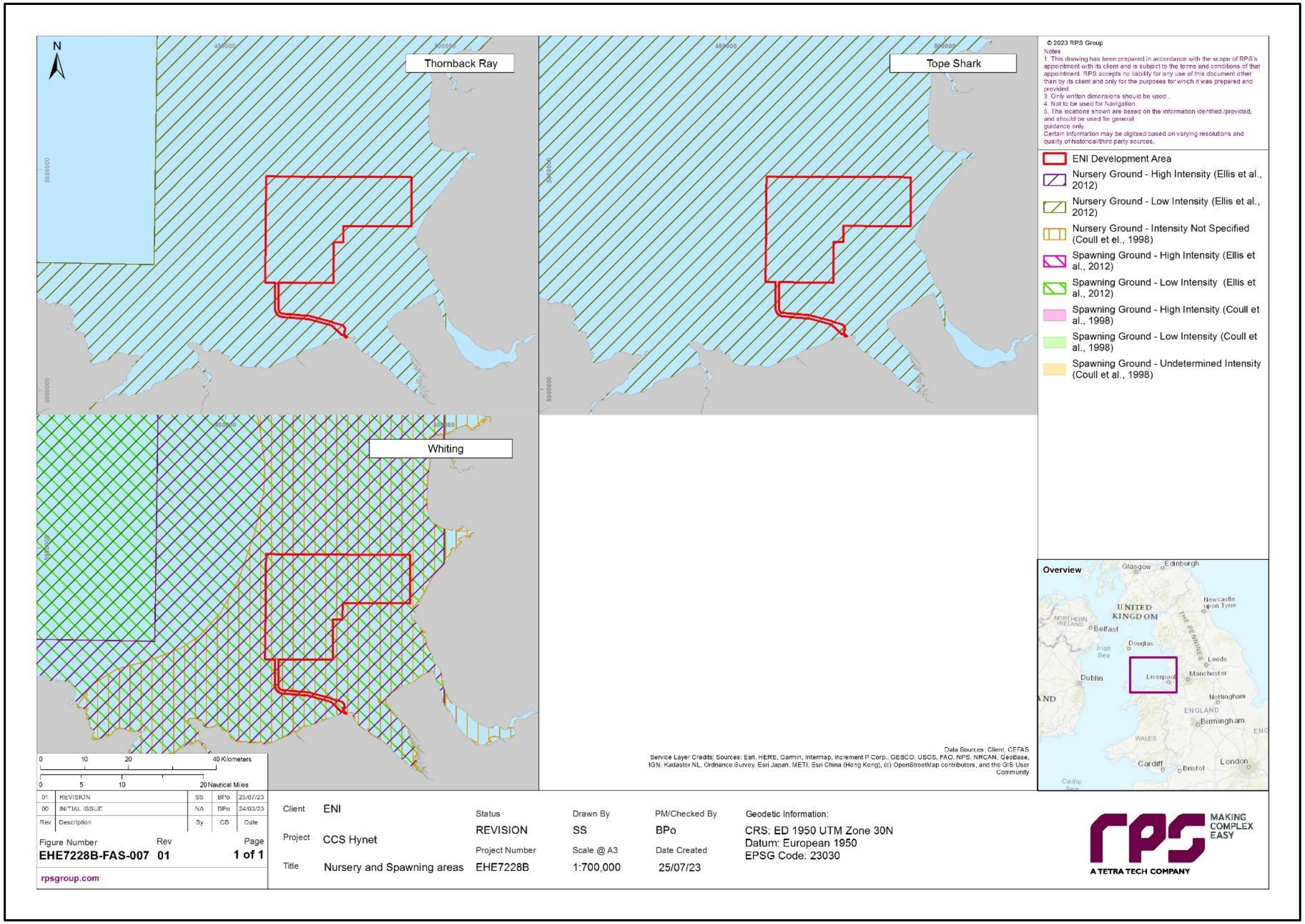

Figure 3.8: Spawning And Nursery Grounds In Proximity To The Eni Development Area For Thornback Ray, Tope, And Whiting (Source: Coull *et al.*, 1998; Ellis *et al.*, 2012)

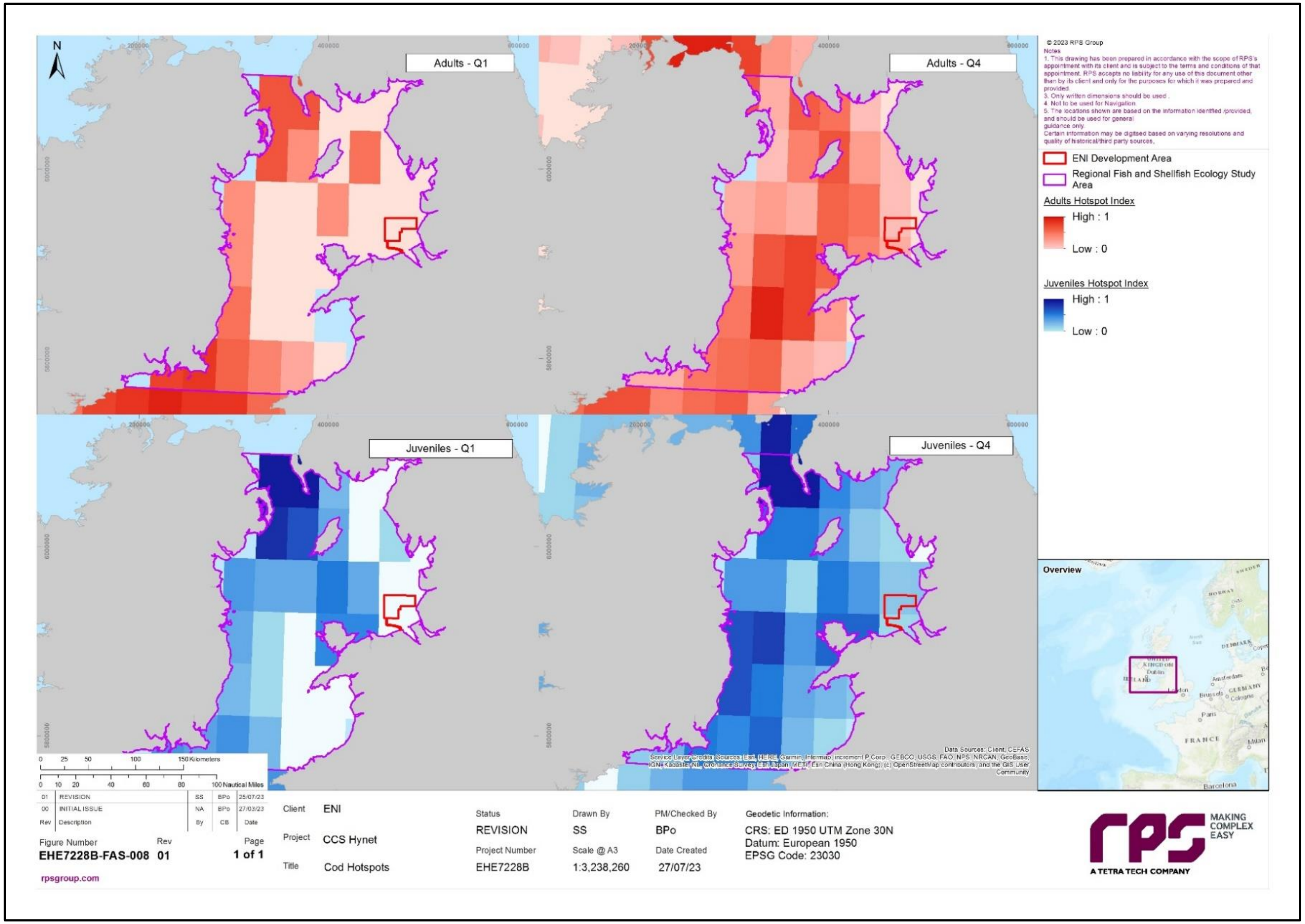

Figure 3.9: Hotspot Maps Of The Presence Of Adult And Juvenile Cod Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

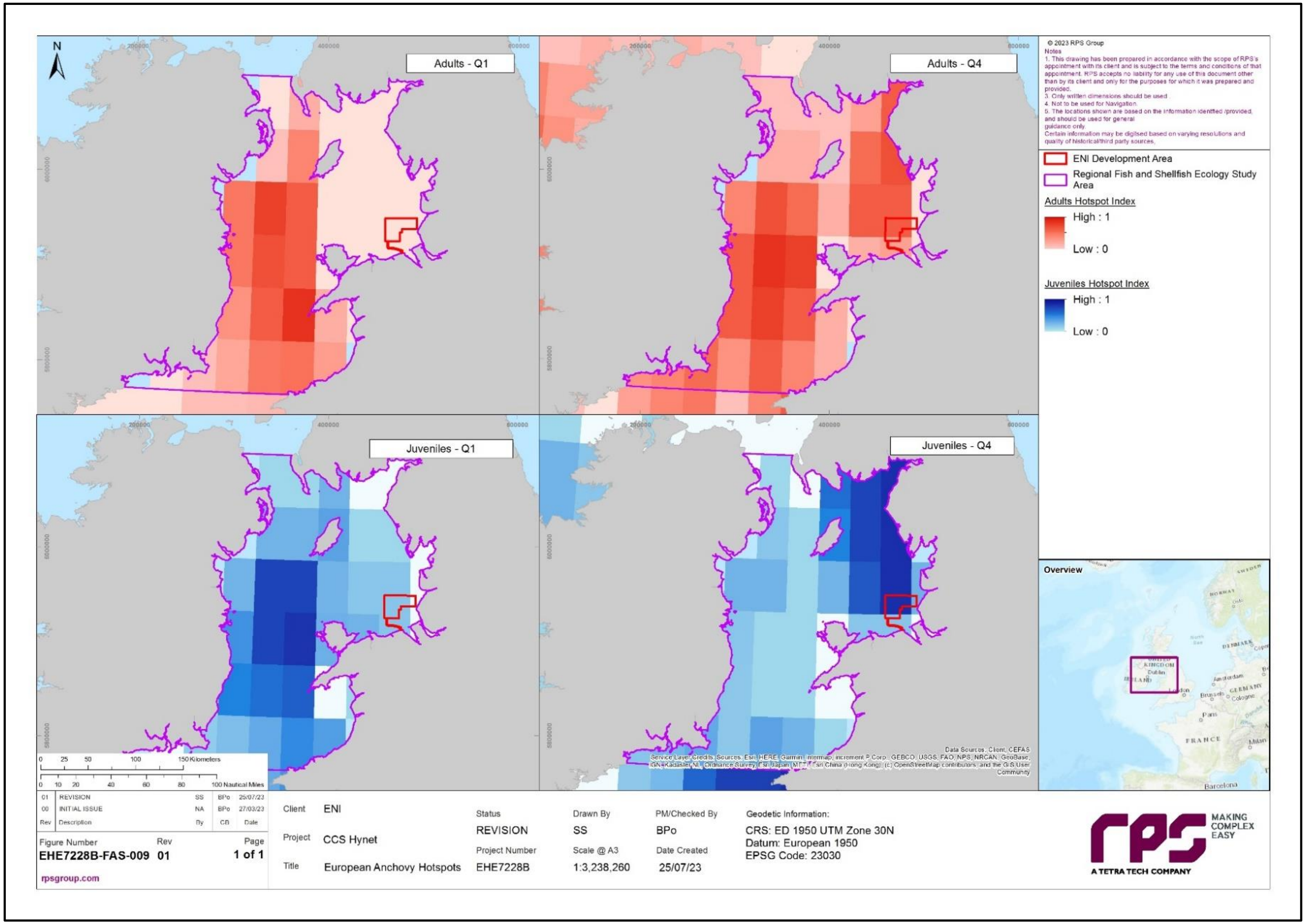

Figure 3.10: Hotspot Maps Of The Presence Of Adult And Juvenile European Anchovy Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

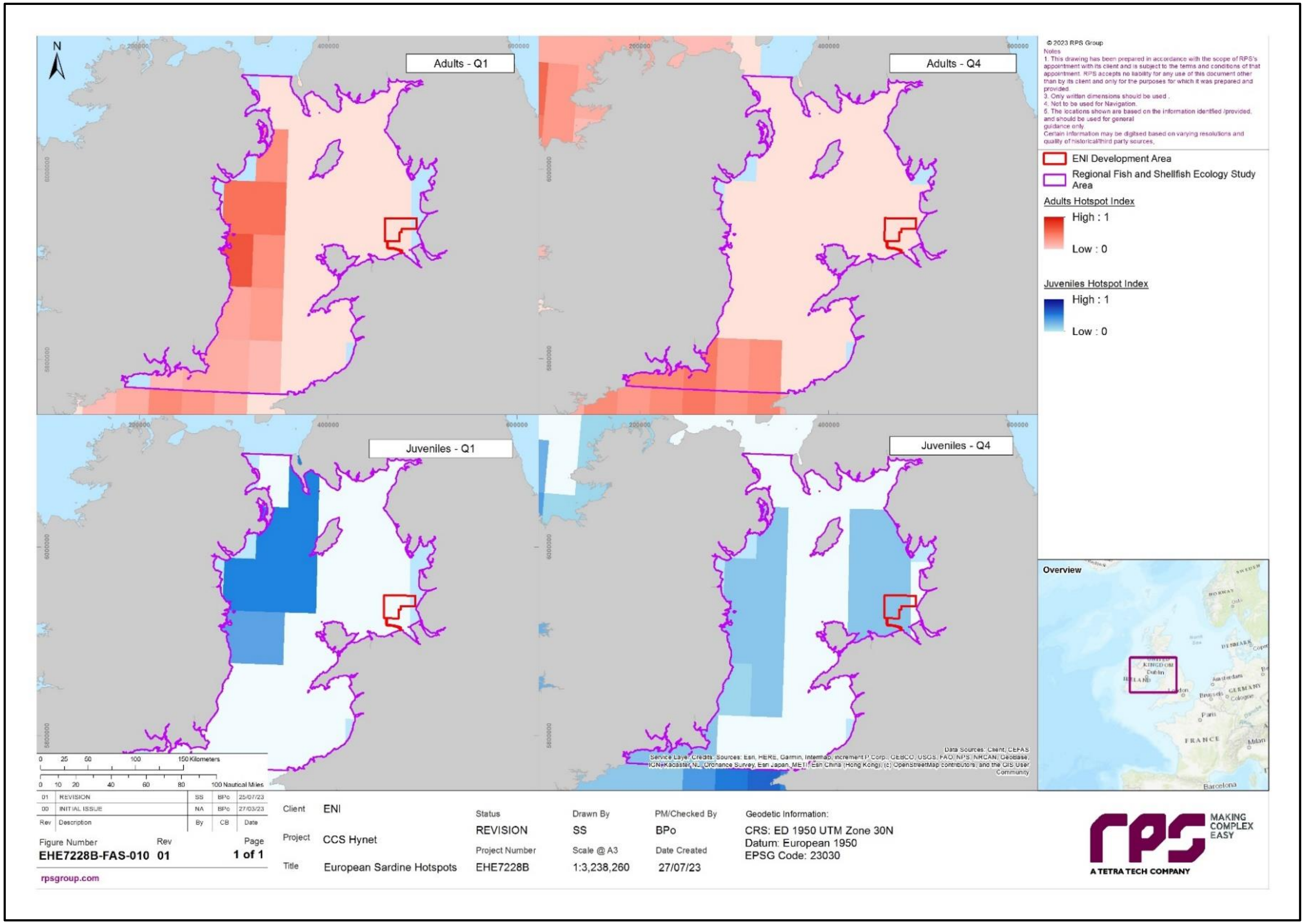

Figure 3.11: Hotspot Maps Of The Presence Of Adult And Juvenile European Sardine Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

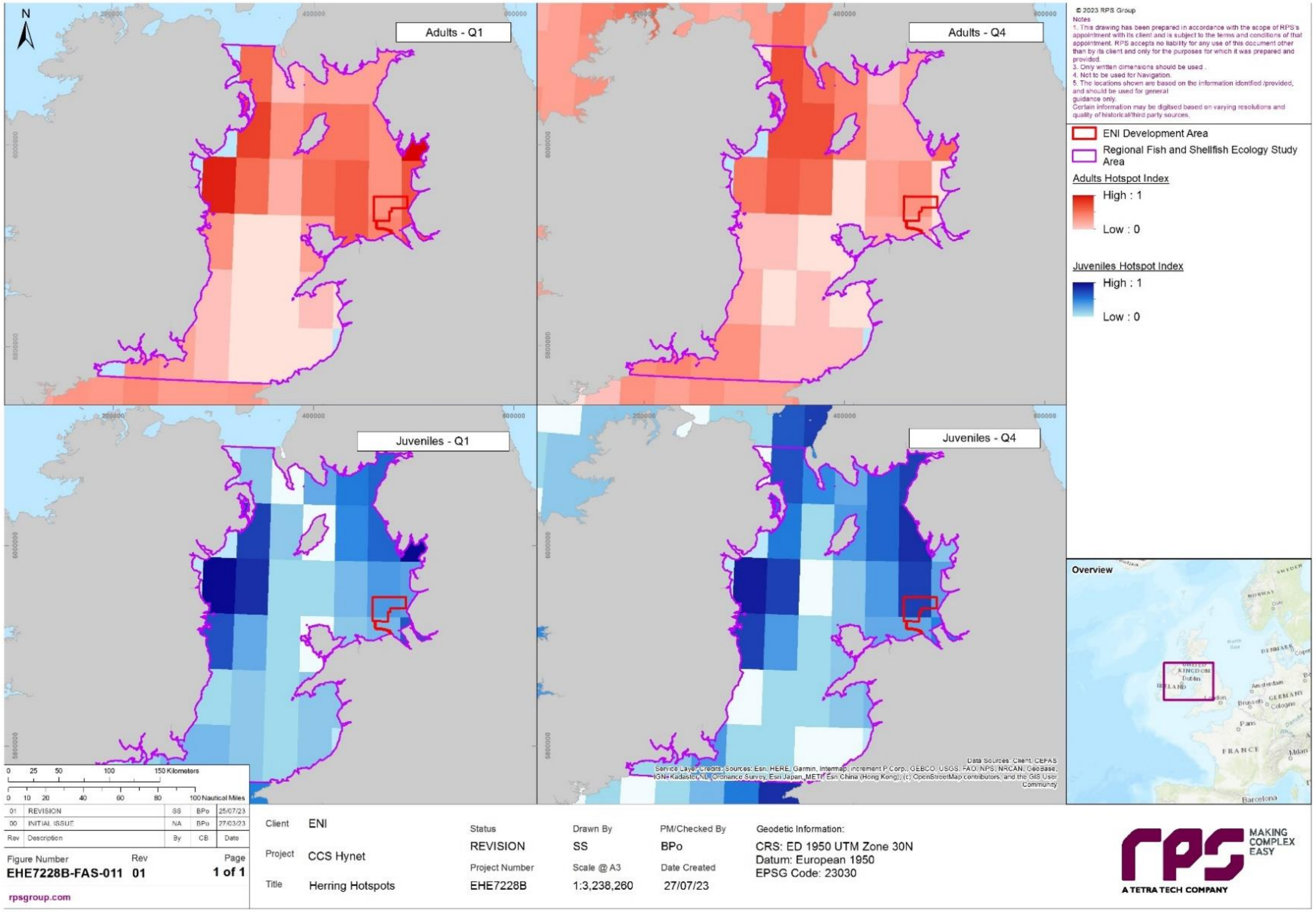

Figure 3.12: Hotspot Maps Of The Presence Of Adult And Juvenile Herring Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

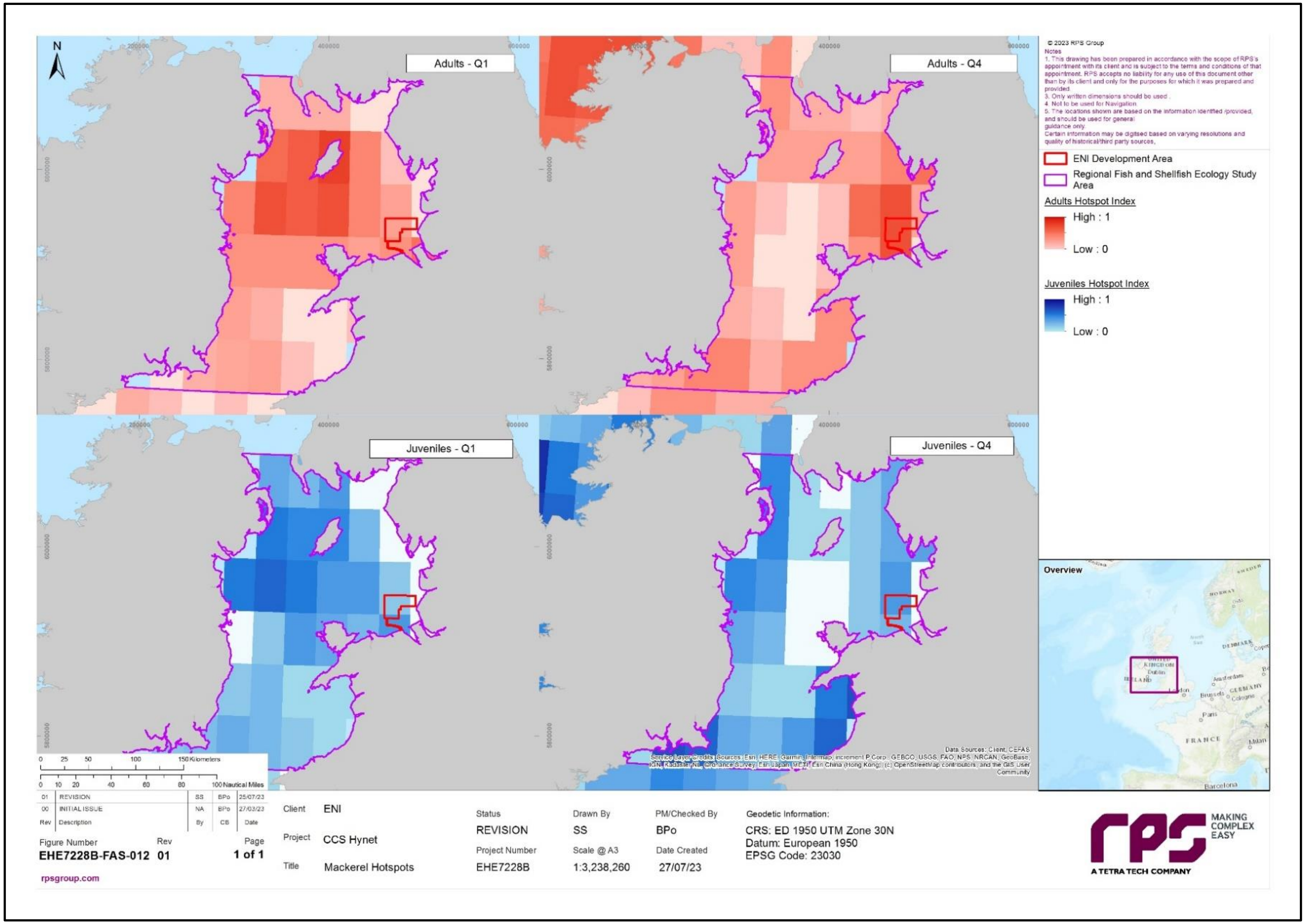

Figure 3.13: Hotspot Maps Of The Presence Of Adult And Juvenile Mackerel Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

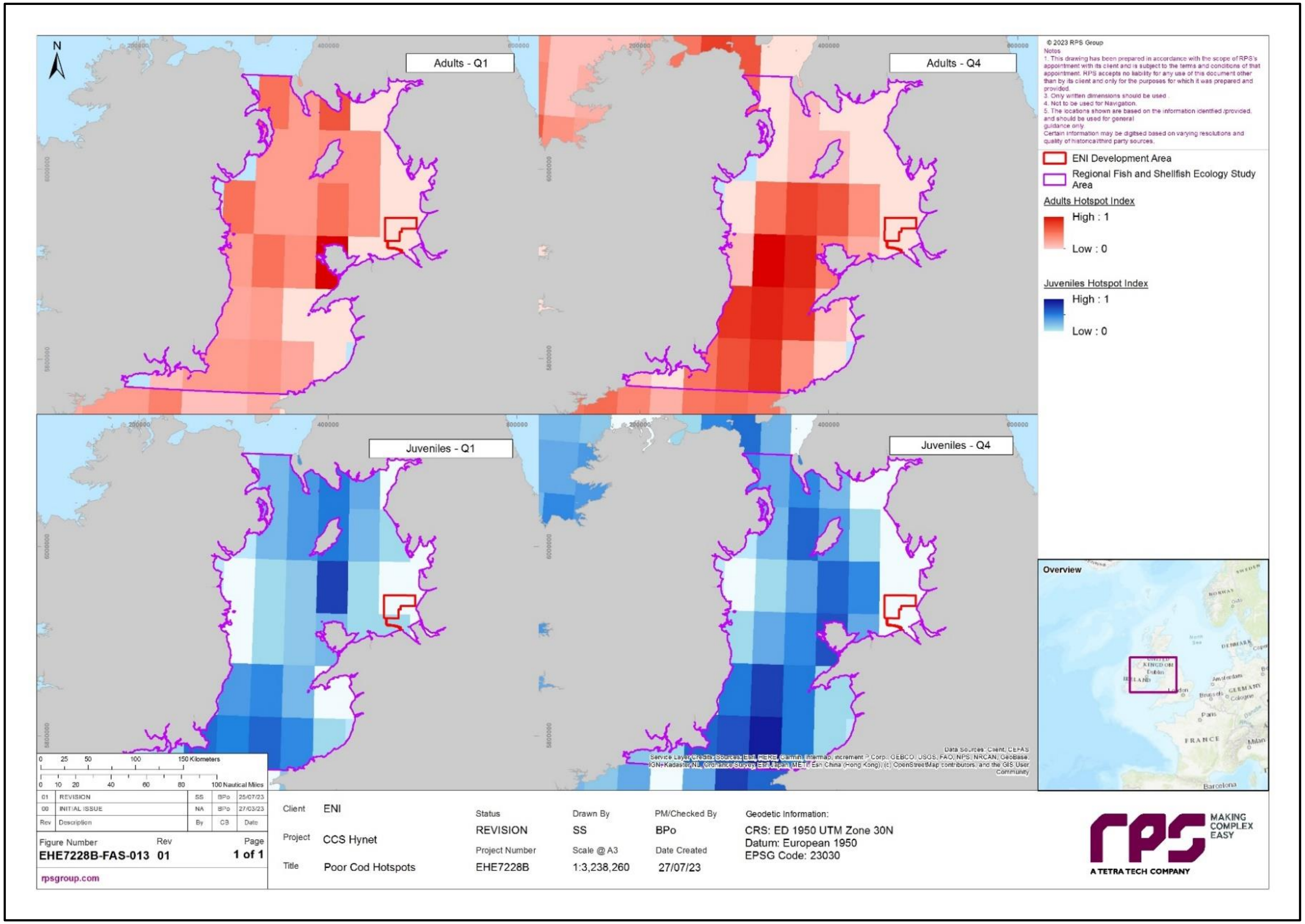

Figure 3.14: Hotspot Maps Of The Presence Of Adult And Juvenile Poor Cod Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

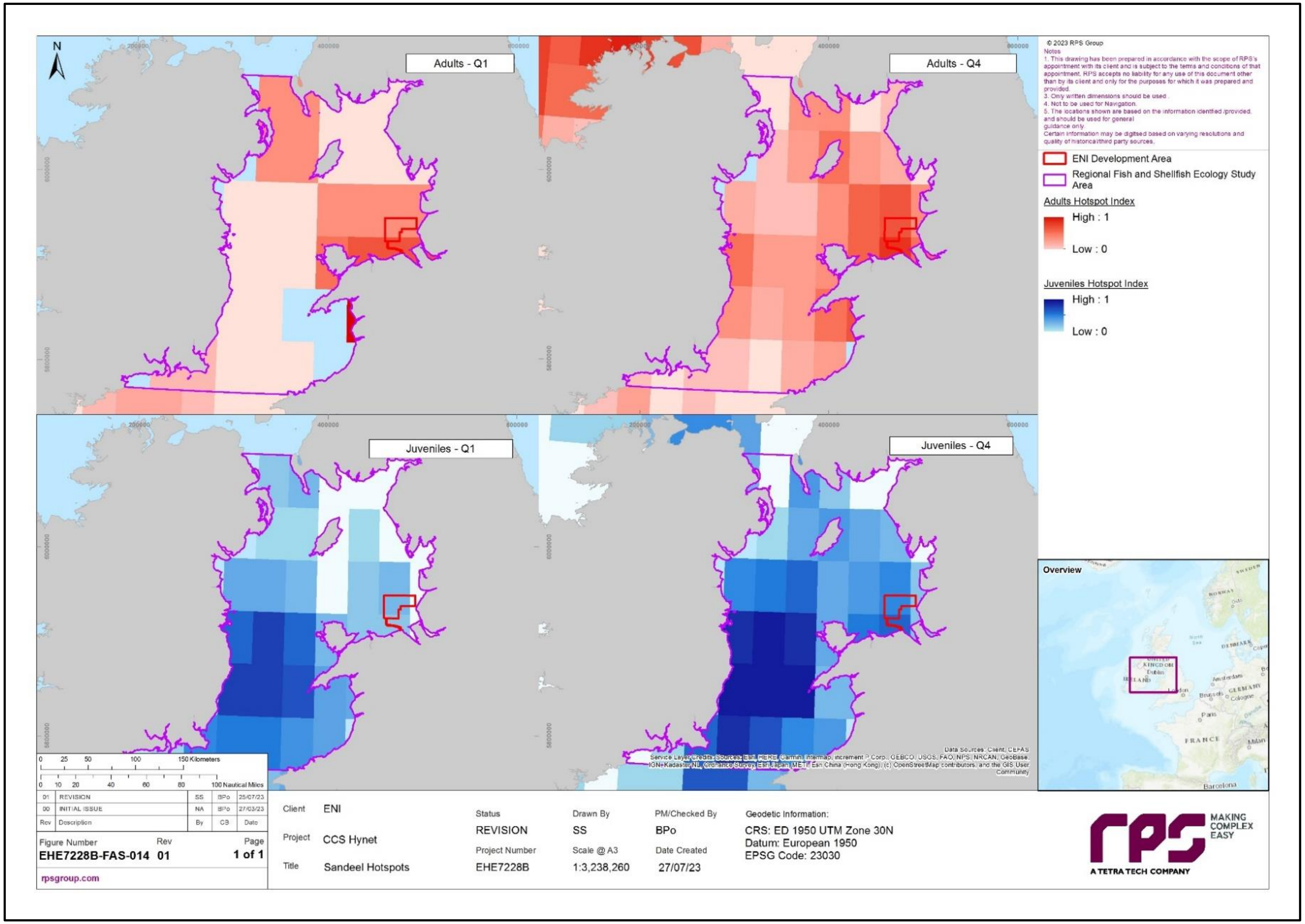

Figure 3.15: Hotspot Maps Of The Presence Of Adult And Juvenile Sandeel Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

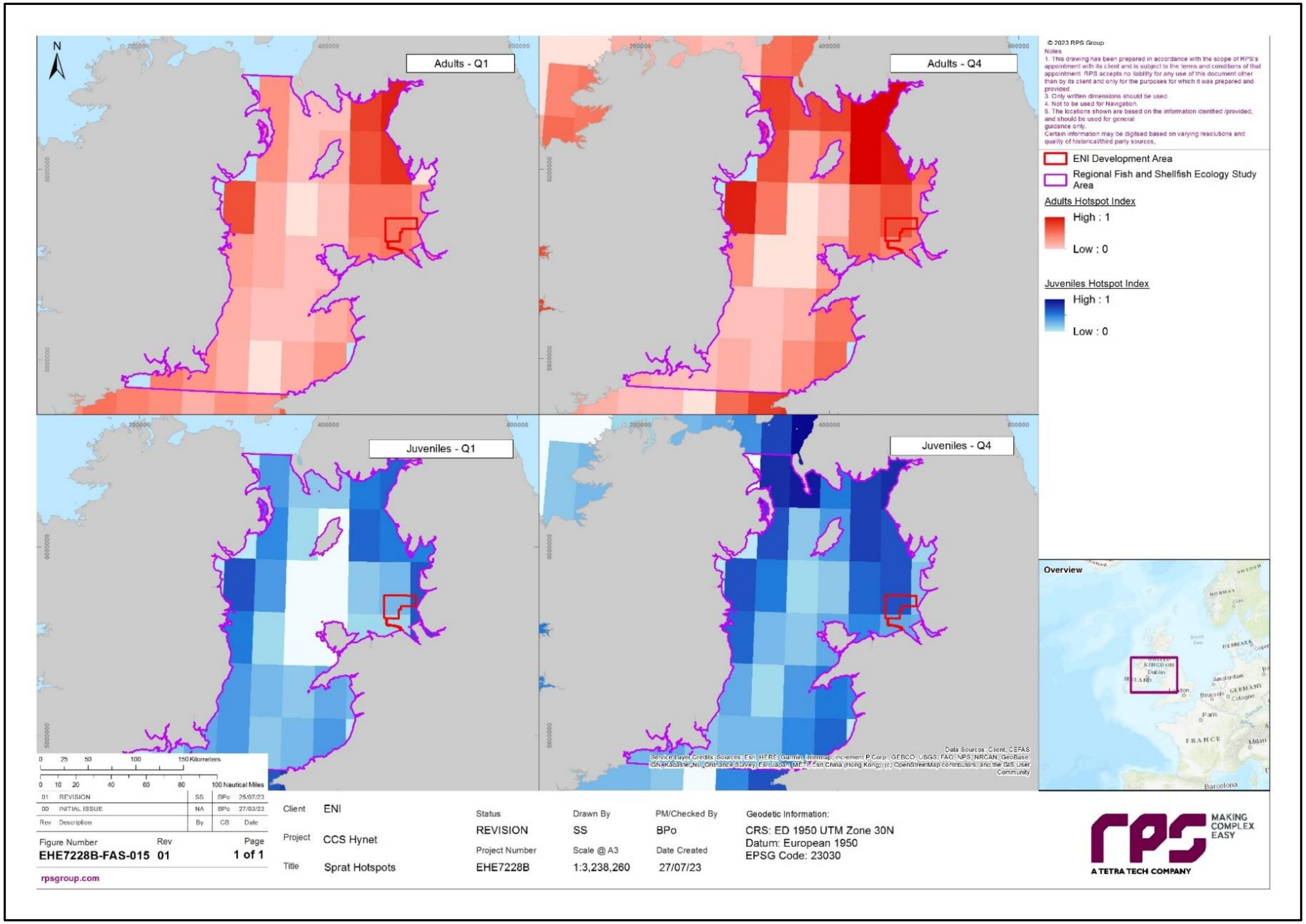

Figure 3.16: Hotspot Maps Of The Presence Of Adult And Juvenile Sprat Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

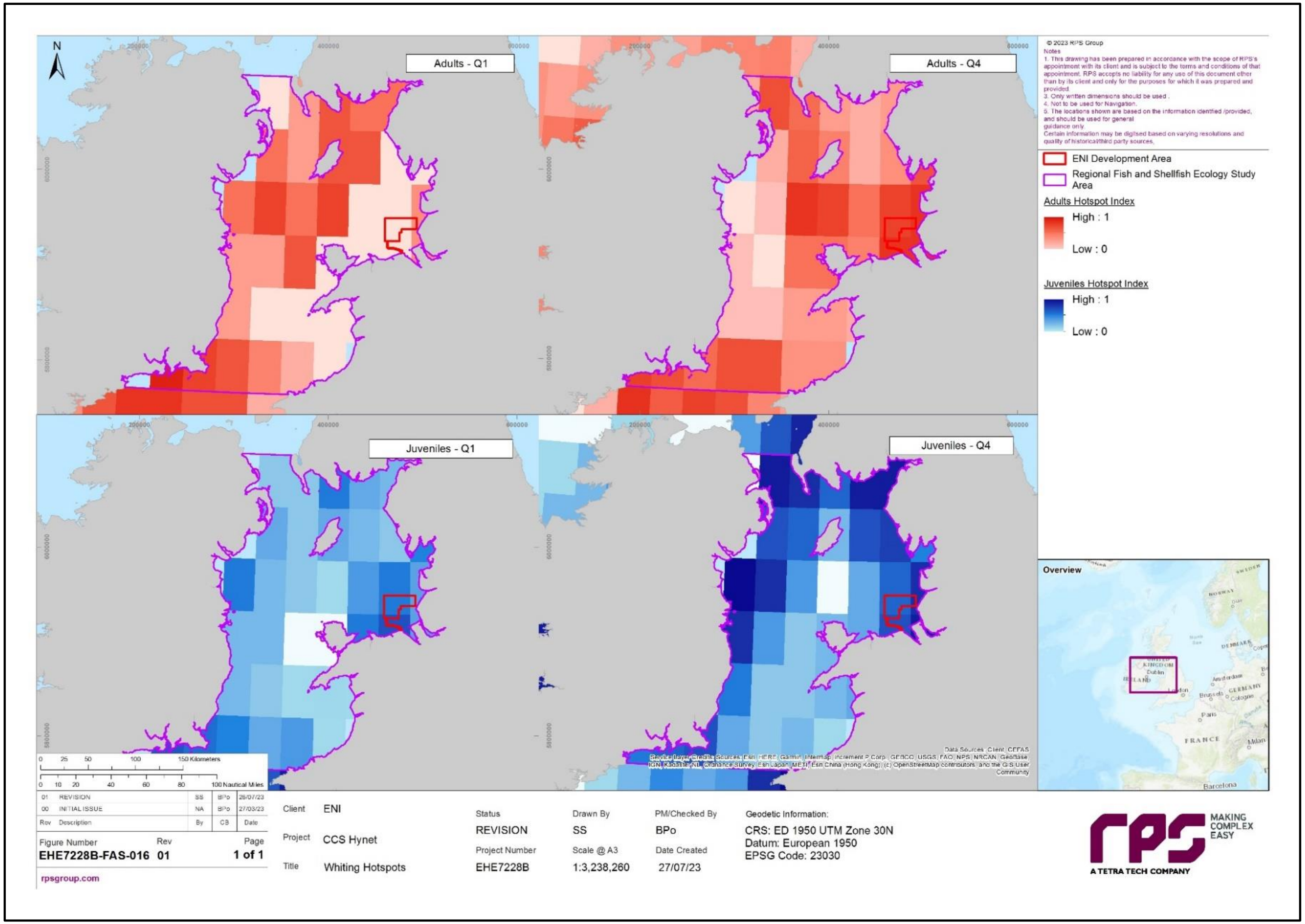

Figure 3.17: Hotspot Maps Of The Presence Of Adult And Juvenile Whiting Within The Regional Fish And Shellfish Ecology Study Area In Q1 And Q4 (Source: Campanella and van der Kooij, 2021)

3.3.1.7 Herring and sandeel spawning habitat suitability

Sandeel and herring are known to be particularly sensitive to seabed disturbance because they spawn in very specific substrates. These species are of particular importance because they play a key ecological role as principal prey items for several larger fish species, birds, and marine mammals. Therefore, spawning habitat suitability within the Eni Development Area has been assessed following the methodology presented in Latto *et al.* (2013) and Reach *et al.* (2013) (see section 3.2.5: Herring and sandeel spawning habitat suitability). Data for this assessment have been derived from PSA results of the site-specific benthic characterisation surveys (section 2.3.2).

Herring

Herring have a specific habitat preference which limits the spatial extent of their spawning grounds. Suitable herring spawning habitat comprises a seabed with a high gravel content with minimal fines and high oxygenation of sediments (Reach *et al.* 2013). Eggs adhere to the seabed and can form extensive egg beds, meaning they are particularly sensitive to seabed disturbance.

Of the 23 grab samples collected during the CCS area survey, the PSA results indicate that only one sampling station (GS19) is classified as 'suitable' habitat for herring spawning under the Reach *et al.* (2013) methodology. The remaining 22 sampling stations were classified as 'unsuitable' (Figure 3.18). Similarly, of the 53 grab samples collected within the decommissioning area, 49 were classified as 'unsuitable' and four were classified as 'sub-prime' (GS38, GS47, GS53, and GS54) (Figure 3.18). Overall, 1.31% of all sampling stations were classified as 'suitable' spawning habitat, 5.26% as 'sub-prime', and 93.42% were 'unsuitable'.

Sandeel

Sandeel hibernate in generally coarse sand or fine gravel in autumn and winter, whilst in spring and summer they exhibit diurnal movements, burying themselves in the seafloor at night and feeding on plankton in the water column above their burrows during the day (Engelhard *et al.,* 2008). A study by Holland *et al.,* (2005) showed that areas which combined a high proportion of medium and coarse sand (particle size 0.25 to 2.0 mm) with a low silt content (<4%) were preferred seabed habitats for sandeel (Holland *et al.,* 2005). Sandeel emerge from hibernation briefly between December and January to spawn. The sticky eggs are partly buried in the upper centimetres of the sediment and hatch in February to March (DECC, 2016). The PSA results from the CCS area indicate a range of sandeel spawning habitat classifications under the Latto *et al.* (2013) methodology, with 'prime', 'suitable', 'sub-prime' and 'unsuitable' habitats present (Table 3.10 and Figure 3.19). Similarly, of the 53 grab samples collected during the decommissioning area survey, all four habitat preferences were present. However, a larger proportion of sampling stations were classified as 'unsuitable' in comparison to the CCS area.

Table 3.10: Sandeel Spawning Habitat Preference (Based On Latto *et al.,* 2013) Of Grab Samples Recorded During The Benthic Subtidal Surveys Across The CCS And Decommissioning Sampling Stations In 2022

Habitat Preference	CCS Area		Decommissioning Area		Total Percentage Across all Sampling Stations (%)
	Sampling Station	Number	Sampling Station	Number	
Prime	GS20, GS21, GS22, GS84, GS85	5	GS39, GS40, GS44, GS45, GS46, GS58	6	14.47
Suitable	GS05, GS13, GS16, GS18, GS19, GS83	6	GS25, GS30, GS38, GS47, GS51, GS60,	9	19.74

Habitat Preference	CCS Area		Decommissioning Area		Total Percentage Across all Sampling Stations (%)
	Sampling Station	Number	Sampling Station	Number	
			GS63, GS75, GS76		
Sub-Prime	GS02, GS06, GS07, GS08	4	GS23, GS24, GS26, GS27, GS28, GS41, GS42, GS43, GS53, GS54, GS57, GS59, GS78	13	22.37
Unsuitable	GS03, GS04, GS09, GS10, GS11, GS14, GS15, GS17	8	GS29, GS31, GS32, GS33, GS34, GS35, GS36, GS37, GS48_A, GS49, GS50, GS52, GS55, GS61, GS64, GS66, GS67, GS68, GS69, GS70, GS72, GS73, GS77, GS79, GS81	25	43.42

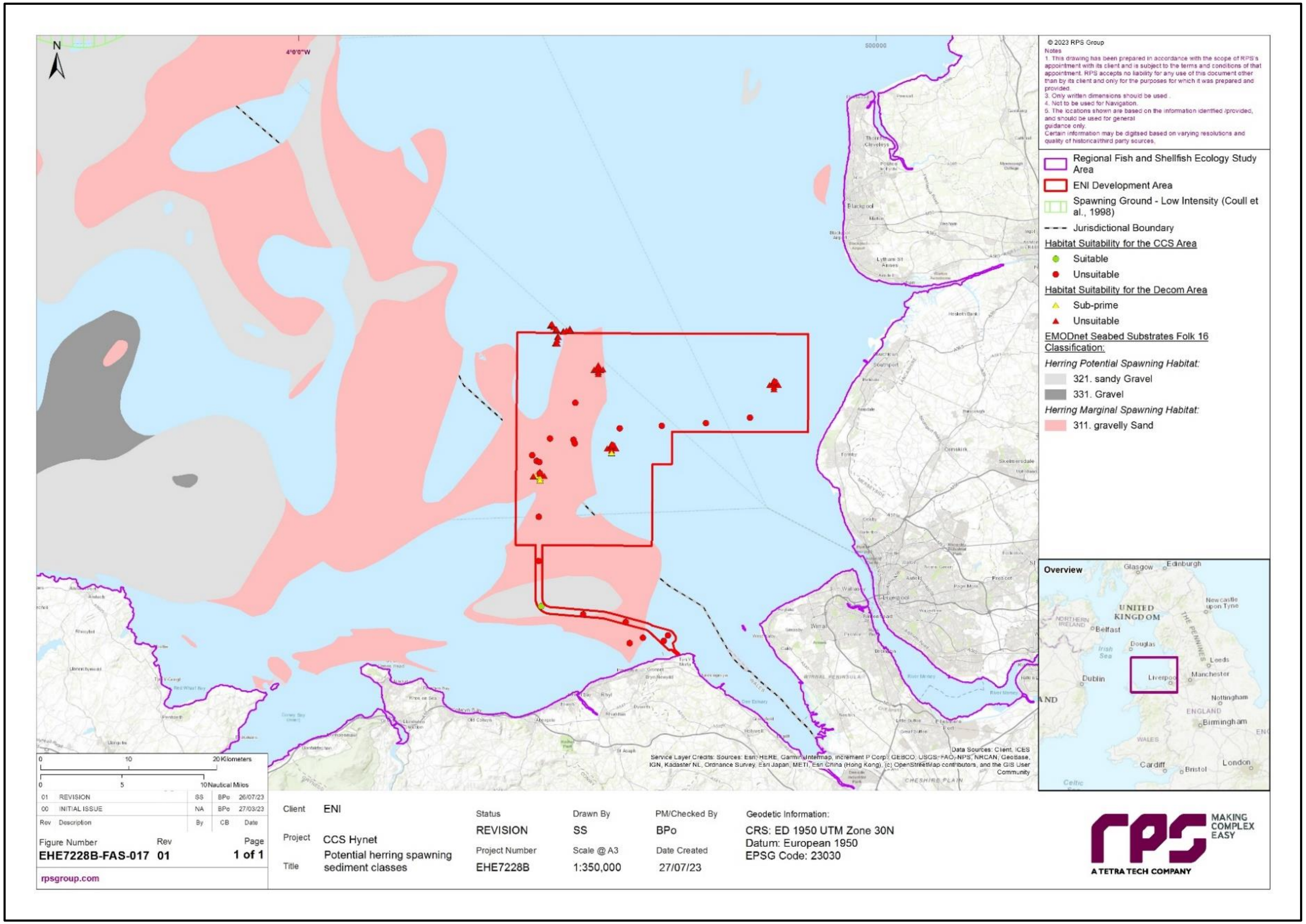

Figure 3.18: Herring Spawning Habitat Suitability Assessment Within The Eni Development Area

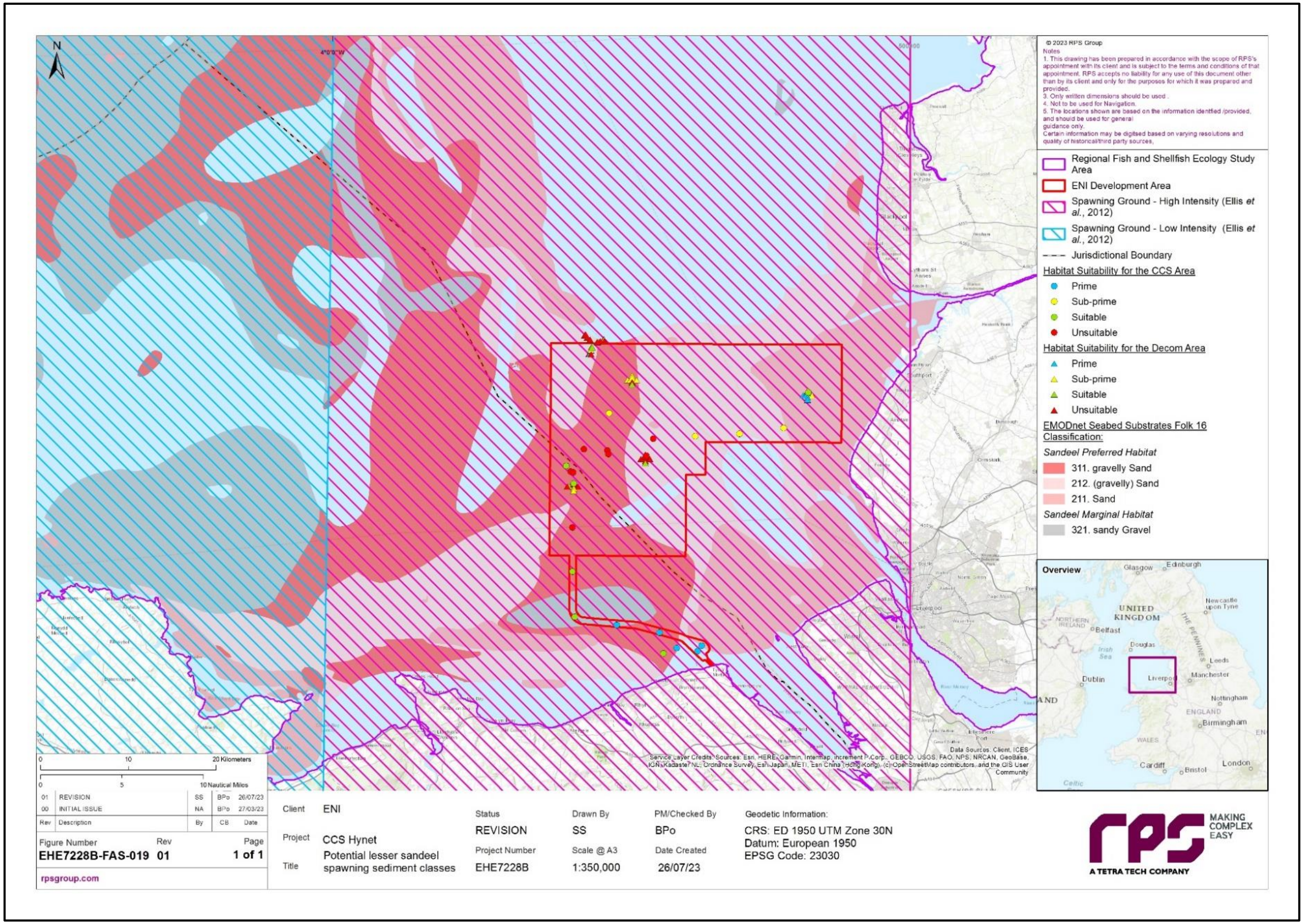

Figure 3.19: Sandeel Spawning Habitat Suitability Assessment Within The Eni Development Area

3.4 Summary

3.4.1 Regional Fish and Shellfish Ecology Study Area

Overall, a wide range fish and shellfish species are likely to occur in the regional fish and shellfish ecology study area, including demersal, pelagic, diadromous, elasmobranch, and shellfish species (Table 3.11).

Table 3.11: Fish And Shellfish Species That Are Likely To Occur In The Regional Fish And Shellfish Ecology Study Area (Based On The Information Presented Throughout This Technical Report, Namely From The Sources Outlined In Section 3.3)

Fish		Shellfish	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Demersal Fish – Benthic		**Crustaceans**	
Conger eel	*Conger conger*	Brown crab	*Cancer pagurus*
Blennies	Blenniidae	Brown shrimp	*Crangon crangon*
Brill	*Scphthalmus rhombus*	European lobster	*Homarus gammarus*
Dab	*Limanda limanda*	Green shore crab	*Carcinus maenus*
Dragonet	*Callionymus lyra*	Norway lobster	*Nephrops norvegicus*
Flounder	*Platichthys flesus*	Spiny lobster	*Palinurus elephas*
Gobies	Gobiidae	Swimming crabs	*Liocarcinus* spp.
Halibut	*Hippoglossus hippoglossus*	Velvet swimming crab	*Necora puber*
Lemon Sole	*Microstromus kitt*		
Megrim	*Lepidorhombus whiffiagonis*		
Plaice	*Pleuronectes platessa*		
Sandeel	*Ammodytidae*		
Sole	*Solea*		
Solenette	*Buglossidium leteum*		
Thickback sole	*Microchirus variegatus*		
Turbot	*Scophthalmus maximus*		
Witch	*Glyptocephalus cynoglosus*		
Demersal Fish – Benthopelagic		**Molluscs**	
Anglerfish	*Lophius piscatorius*	Blue mussel	*Mytilus edulis*
Bass	*Dicentrarchus labrax*	Cockle	*Cerastoderma edule*
Cod	*Gadus morhua*	Common octopus	*Octopus vulgaris*
European Hake	*Merluccius merluccius*	Common whelk	*Buccinum undatum*
Haddock	*Melanogrammus aeglefinus*	Curled octopus	*Eledone cirrhosa*
Ling	*Molva molva*	Cuttlefish	*Sepia* spp.
Pollock	*Pollachius pollachius*	King Scallop	*Pecten maximus*
Poor cod	*Trisopterus minutus*	Native oysters	*Ostrea edulis*
Saithe	*Pollachius virens*	Queen Scallop	*Aequipecten opercularis*

Fish		Shellfish	
Wrasses	Labridae	Razor clam	*Ensis* spp.
		Squid	*Loliginids and Ommastrephids*
Pelagic Fish			
European anchovy	*Engraulis encasicolus*		
European sardine	*Sardina pilchardus*		
Garfish	*Belone belone*		
Herring	*Clupea harengus*		
Horse mackerel	*Trachurus trachurus*		
Mackerel	*Scomber scombrus*		
Sprat	*Sprattus sprattus*		
Elasmobranchs			
Basking shark	*Cetorhinus maximus*		
Blonde ray	*Raja brachyura*		
Common smoothhound	*Mustelus mustelus*		
Cuckoo ray	*Raja naevus*		
Lesser spotted dogfish	*Scyliorhinus canicula*		
Nursehound	*Scyliorhinus stellaris*		
Thornback ray	*Raja clavata*		
Tope	*Galeorhinus galeus*		
Spotted ray	*Raja montagui*		
Spurdog	*Squalus acanthias*		
Diadromous Fish			
Atlantic salmon	*Salmo salar*		
Allis shad	*Alosa alosa*		
European eel	*Anguilla anguilla*		
River lamprey	*Lampetra fluviatilis*		
Sea lamprey	*Petromyzon marinus*		
Sea trout	*Salmo trutta*		
Smelt	*Osmerus eperlanus*		
Twaite shad	*Alosa fallax*		

3.4.2 Eni development area

There are a range of designated sites for various fish and shellfish species that either overlap with the Eni Development Area (e.g. the Dee Estuary/Aber Dyfrdwy SAC) or are in close proximity (e.g. the Ribble Estuary MCZ) (Table 3.4).

Within the Eni Development Area, spawning and/or nursery grounds are present for the following species:

- anglerfish;

- cod;
- herring;
- ling;
- mackerel;
- plaice;
- sandeel;
- sole;
- spotted ray;
- sprat;
- spurdog;
- thornback ray;
- tope; and
- whiting (Coull *et al.,* 1998; Ellis *et al.,* 2012) (Table 3.9).

While there were no site-specific surveys undertaken to characterise the fish and shellfish ecology baseline, the PSA results undertaken during the site-specific benthic characterisation survey were used to assess spawning habitat suitability within the Eni Development Area for herring and sandeel. The results of the PSA indicate that the majority of sampling stations (93.4%) within the Eni Development Area represented unsuitable spawning habitat for herring (Figure 3.18). For sandeel, 14.4% of sampling stations were assessed as prime spawning habitat, 19.7% as suitable, 22.3% as sub-prime, and 43.4% as unsuitable (Figure 3.19).

Overall, the following IEFs have been defined based on fish and shellfish species that are likely to be present within the Eni Development Area (Table 3.12). These will be taken forward as potential receptors in the ES, with further detail provided in volume 2, chapter 7.

Table 3.12: Fish And Shellfish IEFS Within The Eni Development Area

IEF	Scientific Name	Importance within the Eni Development Area	Justification
Demersal Fish (Flatfish)			
Lemon Sole	*Microstomus kitt*	Local	Undetermined and unspecified spawning and nursery grounds that do not overlap with the Eni Development Area but are within the regional fish and shellfish ecology study area.
Plaice	*Pleuronectes platessa*	National	Listed as a SPI under the UK Post-2010 Biodiversity Framework. Low and high intensity spawning, and low intensity nursery grounds overlapping with the Eni Development Area.
Sole	*Solea solea*	National	Listed as a SPI. Low and high intensity spawning, and nursery grounds overlapping with the Eni Development Area.
Other flatfish species	-	Local	Other flatfish species, including dab, flounder, halibut, Solenette, and thickback sole, are likely to occur within the regional fish and shellfish ecology study area. These species, however, have no documented spawning or nursery grounds within the regional fish and shellfish ecology study area.
Demersal Fish (Gadoids)			
Cod	*Gadus morhua*	National	Listed as a SPI, as 'vulnerable' on the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). High intensity spawning and nursery grounds overlap with the Eni Development Area. Juvenile cod are an important forage fish species, as they provide prey for a range of larger fish, birds, and marine mammals.
Ling	*Molva molva*	National	Listed as a SPI. Low intensity spawning grounds overlap with the Eni Development Area.
Whiting	*Merlangius merlangius*	National	Listed as a SPI. Low intensity spawning and high intensity nursery grounds overlap with the Eni Development Area.

IEF	Scientific Name	Importance within the Eni Development Area	Justification
			Juvenile whiting are an important forage fish species, as they provide prey for a range of larger fish, birds, and marine mammals
Demersal Fish (Others)			
Anglerfish	*Lophius piscatorius*	National	Listed as a SPI. Low intensity nursery grounds overlap with the Eni Development Area.
Sandeel species	Ammodytidae	National	Listed as a SPI. There are five sandeel species present in UK and Irish waters, with lesser sandeel *Ammodytes tobianus* and greater sandeel *Hyperoplus lanceolatus* being the most common. All sandeel species are important forage fish, as they are prey species for a wide range of larger fish, birds and marine mammals, and constitute an important component of marine food webs. High intensity spawning grounds and low intensity nursery grounds overlap with the Eni Development Area. Similarly, over 50% of the sediment samples collected within the Eni Development Area during the site-specific surveys indicated prime, suitable, and sub-prime spawning habitat preference.
Pelagic Fish			
Herring	*Clupea harengus*	National	Listed as a SPI. There are high intensity nursery grounds overlapping with the Eni Development Area. However, the majority of sediment samples collected within the Eni Development Area site-specific surveys indicated unsuitable spawning habitat preference.
Mackerel	*Scomber scombrus*	National	Listed as a SPI. Like sandeel, mackerel are an important forage fish for a range of larger fish, birds, and marine mammals and are thus, an important element of marine food webs. Low intensity spawning and nursery grounds overlap with the Eni Development Area.
Sprat	*Sprattus sprattus*	Regional	Important forage fish species for a range of larger fish, birds, and marine mammals and are thus, an important element of marine food webs.

IEF	Scientific Name	Importance within the Eni Development Area	Justification
			Undetermined spawning grounds overlap with the Eni Development Area.
Elasmobranchs			
Basking shark	*Cetorhinus maximus*	International	Listed as a SPI, under Appendix II of CITES, and under Appendix I and II of the Bonn Convention. Basking shark are also listed on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Further, the north-east Atlantic population are classed as 'Endangered' on the IUCN Red List and are protected in the UK under the Wildlife and Countryside Act 1981.
Spotted ray	*Raja montagui*	National	Listed as 'of least concern' by the IUCN Red List and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Low intensity nursery grounds identified within the Eni Development Area.
Spurdog	*Squalus acanthias*	Regional	Listed as a SPI, as 'vulnerable' on the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). High intensity nursery grounds identified within the Eni Development Area.
Thornback ray	*Raja clavata*	Regional	Low intensity nursery grounds identified within the Eni Development Area.
Tope	*Galeorhinus galeus*	Regional	Listed as a SPI, and as 'vulnerable' on the IUCN Red List. Low intensity nursery grounds identified within the Eni Development Area.
Diadromous Fish			
Atlantic salmon	*Salmo salar*	International	Listed as a SPI, as 'vulnerable' by the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Atlantic salmon are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional fish and shellfish ecology study area. Atlantic salmon are likely to migrate through the regional fish and shellfish ecology study area during their life cycle.
Allis shad	*Alosa alosa*	National	Listed as a SPI, as 'of least concern' by the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas).

IEF	Scientific Name	Importance within the Eni Development Area	Justification
			Allis shad are an Annex II species under the Habitats Directive but are not a qualifying feature of any designated sites within the regional fish and shellfish ecology study area. Allis shad may potentially migrate through the regional fish and shellfish ecology study area during their life cycle.
European eel	*Anguilla anguilla*	National	Listed as a SPI, as 'critically endangered' by the IUCN Red List, and on the OSPAR list of threatened and declining species on within OSPAR Region III (Celtic Seas). Listed as a qualifying feature of multiple MNRs within the regional fish and shellfish ecology study area. European eel are likely to migrate through the regional fish and shellfish ecology study area during their life cycle.
River lamprey	*Lampetra fluviatilis*	International	Listed as a SPI and as of 'least concern' by the IUCN Red List. River lamprey are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional fish and shellfish ecology study area. River lamprey are likely to migrate within the regional fish and shellfish ecology study area during their life cycle, although only within coastal and estuarine areas.
Sea lamprey	*Petromyzon marinus*	International	Listed as a SPI, as of 'least concern' by the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Sea lamprey are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional fish and shellfish ecology study area. Sea lamprey are likely to migrate through the regional fish and shellfish ecology study area during their life cycle
Sea trout	*Salmo trutta*	National	Listed as a SPI, as 'of least concern' by the IUCN Red List, and on the OSPAR list of threatened and declining species. Sea trout are likely to migrate through the regional fish and shellfish ecology study area during their life cycle

IEF	Scientific Name	Importance within the Eni Development Area	Justification
Smelt	*Osmerus eperlanus*	National	Listed as a SPI, as 'of least concern' by the IUCN Red List. Smelt is not an Annex II species but is listed as a qualifying feature of multiple MCZs within the regional fish and shellfish ecology study area. Smelt are likely to migrate within the regional fish and shellfish ecology study area during their life cycle, although only within coastal and estuarine areas.
Twaite shad	*Alosa fallax*	National	Listed as a SPI and as 'of least concern' by the IUCN Red List. Twaite shad are an Annex II species under the Habitats Directive but are not a qualifying feature of any designated sites within the regional fish and shellfish ecology study area. Twaite shad may potentially migrate through the regional fish and shellfish ecology study area during their life cycle
Shellfish			
Blue mussel	*Mytilus edulis*	Local	Species which is not protected under conservation legislation, and is common in UK and Irish waters, but forms a key component of the marine biodiversity within Eni Development Area.
Brown crab	*Cancer pagurus*	Local	
Common whelk	*Buccinum undatum*	Local	
European lobster	*Homarus gammarus*	Local	
Freshwater pearl mussel	*Margaritifera margaritifera*	International	Listed as a SPI and as 'endangered' by the IUCN Red List. Listed as an Annex II species under the habitats directive and is a qualifying feature of numerous designated sites within the regional fish and shellfish ecology study area.
King scallop	*Pecten maximus*	Local	Species which is not protected under conservation legislation, and is common in UK and Irish waters, but forms a key component of the marine biodiversity within Eni Development Area.
Norway lobster	*Nephrops norvegicus*	Local	Species which is not protected under conservation legislation, and is common in UK and Irish waters, but forms a key component of the marine biodiversity within Eni Development Area.

IEF	Scientific Name	Importance within the Eni Development Area	Justification
			Spawning grounds of undetermined intensity and nursery grounds of unspecified intensity identified within the regional fish and shellfish ecology study, but not overlapping with the Eni Development Area.
Queen scallop	*Aequipecten opercularis*	Local	Species which is not protected under conservation legislation, and is common in UK and Irish waters, but forms a key component of the marine biodiversity within Eni Development Area.
Spiny lobster	*Palinurus elephas*	National	Listed as a SPI and as a qualifying feature of multiple MNRs within the regional fish and shellfish ecology study area.
Velvet swimming crab	*Necora puber*	Local	Species which is not protected under conservation legislation, and is common in UK and Irish waters, but forms a key component of the marine biodiversity within Eni Development Area.
Other shellfish	-	Local	Other shellfish, such as common cockle, swimming crabs, and squid, have been identified as being likely to occur within the regional fish and shellfish ecology study area. These are species which are not protected under conservation legislation, and may be common in UK and Irish waters, but form a key component of the marine biodiversity within Eni Development Area.

4 MARINE MAMMALS AND MARINE TURTLES

4.1 Introduction

This section of the Marine Biodiversity Technical Report provides a baseline characterisation of the marine mammal and marine turtle ecology within the Proposed Development and the wider region. Data have been collated through a desktop review of relevant material within the region.

4.2 Methodology

4.2.1 Study area

Marine mammals and turtles are highly mobile and wide ranging. Therefore, two study areas have been defined:

- The Proposed Development marine mammal and marine turtle study area: This is defined as the area encompassing the Eni Development Area, (including the offshore pipeline, and associated cables in Liverpool Bay) plus a buffer of 10 km (Figure 4.1).
- The Regional marine mammal and marine turtle study area: This is defined as the area encompassing the wider Irish Sea (Figure 4.1). This area has been informed by the most recent marine mammal Management Units (MUs) (Figure 4.4; Figure 4.5) and will provide wider context for characterising the baseline. Cetacean MUs have been defined by the Inter-Agency Marine Mammal Working Group (IAMMWG, 2022), and seal MUs have been defined by the Special Committee on Seals (SCOS, 2021).

The ecology, distribution, and abundance of marine mammals and turtles within the wider area of the Irish Sea are summarised below.

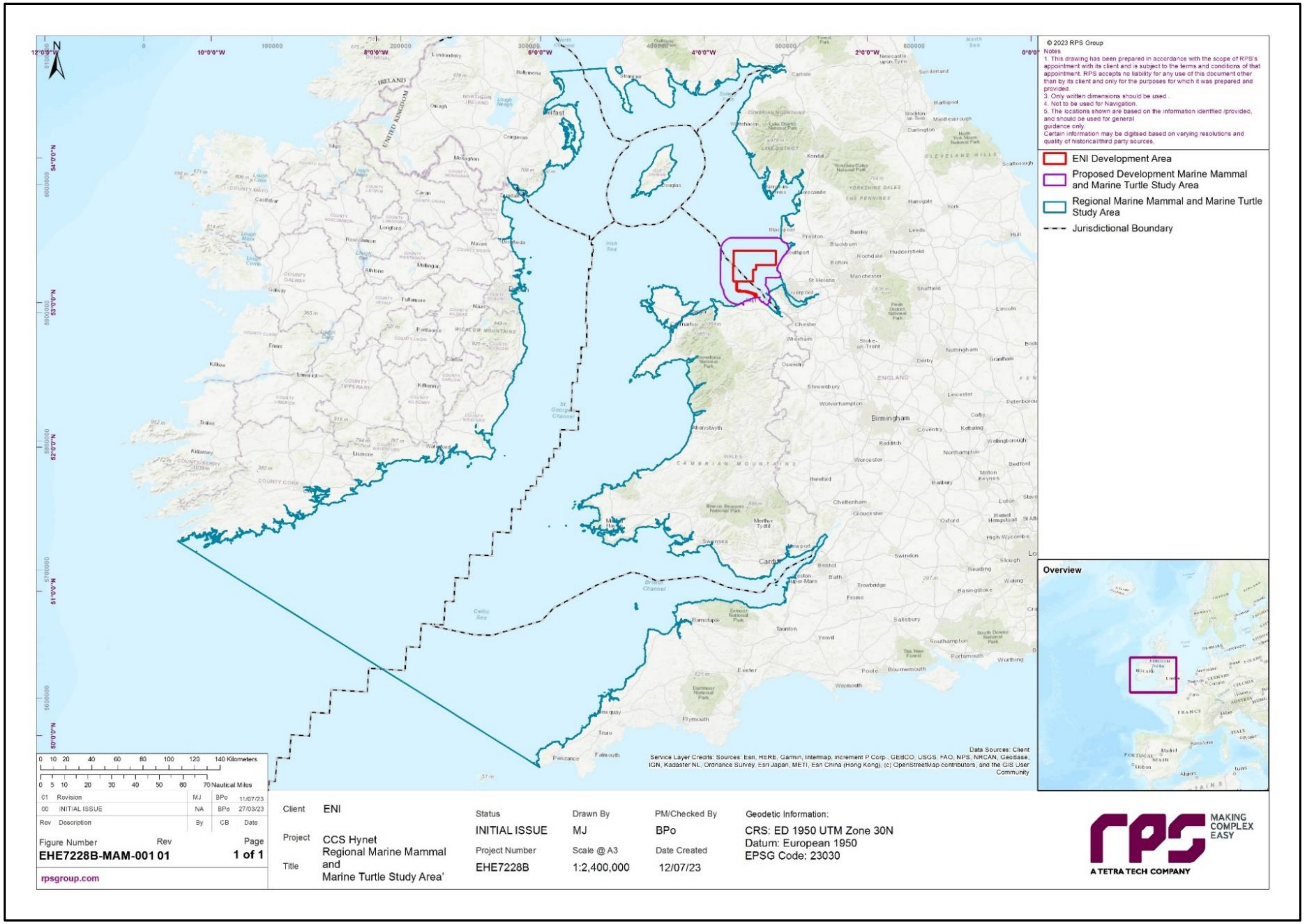

Figure 4.1: Marine Mammal Study Areas

4.2.2 Consultation

A summary of the key issues raised during consultation activities undertaken to date specific to marine mammals is presented in Table 4.1 below.

Table 4.1: Summary Of Key Consultation Issues Raised During Consultation Activities Undertaken For The Project Relevant To Marine Mammals

Date	Consultee and type of response	Issues raised
27 January 2023	OPRED Scoping Opinion response	"*The rationale of using a regional study area for scoping of SACS is not considered to be appropriate because the Annex II marine mammal SAC features are mobile and wide ranging. The Marine Mammal MUs are the appropriate scale for consideration of offsite impacts for marine mammals. Giving greater weight to the use of marine mammal MUs for assessing abundances enables consideration of marine mammal populations over a greater period of time, whereas the SCANS III data is a snapshot of one day and therefore does not account for seasonality of population trends over time*."
		"*The wider regional Marine Mammal Study Area, is not in line with Welsh Marine Mammal MUs, as outlined in NRW's position on the use of Marine Mammal MUs for screening and assessment in HRA for SACs with marine mammal features (NRW, 2022). Encompassing only the wider Irish sea habitats will not include all relevant areas for harbour porpoise Phocoena phocoena, bottlenose dolphin Tursiops truncatus, and grey seal Halichoerus grypus. The IAMMWG MUs for other cetacean species in UK waters (i.e. minke whale Balaenoptera acutorostrata, short-beaked common dolphin Dephinus dephis, Risso's dolphin Grampus griseus) should also be considered*."
		"*The Pembrokeshire Marine SAC designated for grey seal has not been included, and should be included*."

4.2.3 Desktop study

Information on marine mammals and turtles within the regional and Proposed Development marine mammal and marine turtle study area was collected through a detailed desktop review of existing studies and datasets. These are summarised at Table 4.2 below.

Table 4.2: Summary Of Key Desktop Reports For The Characterisation Of The Marine Mammal And Marine Turtle Baseline

Title	Source	Year	Author
NPWS Designations Viewer	NPWS	2023	NPWS
Sympatric seals, satellite tracking and protected areas: habitat-based distribution estimates for conservation and management	Frontiers in Marine Science.	2022	Carter *et al.*
Updated abundance estimates for cetacean management units in UK waters (Revised 2022)	JNCC	2022	IAMMWG
Review of the Irish Sea	Irish Sea Network	2022	Irish Sea Network
British and Irish Marine Turtle Strandings and Sightings. Annual Report 2021	Marine Environmental Monitoring	2022	Penrose *et al.*
Estimates of cetacean abundance in European Atlantic waters from the SCANS-III (Small Cetaceans in the European Atlantic and North Sea) aerial and shipboard surveys	Sea Mammal Research Unit (SMRU), University of St. Andrews	2021	Hammond *et al*.
Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys	Sea Mammal Research Unit (SMRU), University of St. Andrews	2023	Gilles *et al.*
NBN Atlas	NBN Atlas	2021	NBN Atlas
Awel Y Môr OWF Marine Mammal Baseline Characterisation	SMRU	2021	Sinclair, *et al.*
Scientific Advice of Matters Related to the Management of Seal Populations	SCOS and Natural Environment Research Council	2020, 2021	SCOS
JNCC MPA Mapper	JNCC	2020	JNCC
Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles	SMRU, University of St Andrews	2020	Carter *et al.*
Distribution maps of cetacean and seabird populations in the North-East Atlantic	Journal of Applied Ecology	2020	Waggitt *et al.*
Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910–2018)	Journal of the Marine Biological Association of the United Kingdom	2020	Botterell *et al.*

Title	Source	Year	Author
Aerial thermal-imaging surveys of Harbour and Grey Seals in Northern Ireland	Department of Agriculture, Environment, and Rural Affairs, Northern Ireland	2019	Duck and Morris
Bottlenose Dolphin Monitoring in Cardigan Bay, 2014 – 2016. NRW Evidence Report 191	NRW	2018	Lohrengel *et al.,*
Aerial surveys of cetaceans and seabirds in Irish waters: Occurrence, distribution and abundance in 2015-2017	Department of Communications, Climate Action, and Environment	2018	Rogan *et al.*
Gwynt y Môr OWF Post-construction Aerial Surveys 2016 to 2019	APEM Ltd.	2017 to 2019	Goddard *et al.,* 2017, 2018, Goulding *et al.,* 2019
Revised Phase III Data Analysis of Joint Cetacean Protocol (JCP) Data Resource	JNCC	2016	Paxton *et al.*
The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area	JNCC	2015	Heinänen and Skov
Atlas of the distribution and relative abundance of marine mammals in Irish offshore waters 2005 – 2011	Irish Whale and Dolphin Group	2013	Wall *et al.*
Phase II Data Analysis of JCP Data Resource	JNCC	2011	Paxton *et al.*
Burbo Bank Extension Offshore Wind Farm: Environmental Impact Assessment Scoping Report	DONG Energy	2010	Sørensen *et al.*
Cetaceans in Irish waters: A review of recent research	Royal Irish Academy.	2009	O'Brien *et al.*
Atlas of Marine Mammals of Wales	Countryside Council for Wales	2009	Baines and Evans
Modelled Distributions and Abundance of Cetaceans and Seabirds of Wales and Surrounding Waters	Natural Resources Wales	2023	Evans and Waggitt
Gwynt y Môr Offshore Wind Farm Marine Ecology Technical Report	Gwynt y Môr OWF	2005	CMACS
Background information on marine mammals for Strategic Environmental Assessment	SMRU	2005	Hammond *et al.*
Cetacean Distribution Atlas	JNCC	2003	Reid *et al.*

Title	Source	Year	Author
Cetacean distributions in the waters around the British Isles	Natural Environment Research Council	1998	Evans

4.2.4 Site-specific surveys

There were no site-specific marine mammal and marine turtle surveys undertaken for the Proposed Development.

4.2.5 Data limitations

The desktop data used are the most up to date publicly available information which can be obtained from the applicable data sources as cited. Data that have been collected are based on existing literature, consultation with stakeholders and identification of habitats to inform likely marine mammals and marine turtles.

No site-specific surveys have been carried out to inform the baseline characterisation, therefore, it is possible that marine mammals and marine turtles may have not been identified. However, given the detailed desktop study completed and the precautionary approach adopted, which has included the identification of a regional study area, it is unlikely that key species have been omitted from the baseline characterisation.

Results of site-specific surveys of other projects that partially overlap with the Eni Development Area, species records within the NBN Atlas, and spatial datasets were used to characterise these receptors on a local scale.

4.3 Baseline environment

Marine Mammals in UK and Irish waters comprise of cetaceans (porpoise, dolphins and whales), pinnipeds (seals) and the otter *Lutra lutra*. The latter do not occur near the Eni Development Area.

In addition, marine turtles have also been recorded in UK and Irish waters. These species are considered below.

4.3.1 Desktop review

4.3.1.1 Regional marine mammal and marine turtle study area

Designated sites

There are a number of designated sites with marine mammal qualifying features within the regional marine mammal and marine turtle study area. These are illustrated in Figure 4.2 and are further detailed in Table 4.3. There are no sites designated for marine turtles.

Of particular interest to marine mammal ecology, the North Anglesey Marine SAC is located approximately 39.6 km from the Eni Development Area and within the regional marine mammal and marine turtle study area. This SAC is situated in both Welsh territorial and offshore waters, with harbour porpoise being a protected feature listed as an Annex II species.

Table 4.3: Sites Designated For Relevant Marine Mammal Qualifying Features Located Within The Regional Marine Mammal And Marine Turtle Study Area

Designated Site	Minimum Distance to Eni Development Area (km)	Qualifying Features Related to Marine Mammals and Site Description
North Anglesey Marine/Gogledd Môn Forol SAC	39.68	The North Anglesey Marine SAC stretches from the northern coast of the Isle of Anglesey into the Irish Sea. **Relevant Qualifying Features**: Annex II harbour porpoise are a primary reason for site selection (JNNC, 2021c).
Isle of Man MNRs	70.06 – 91.05	As detailed in Table 2.5, there are ten MNRs around the Isle of Man, encompassing 10.8% of Manx waters (Manx Wildlife Trust, 2023). **Relevant Qualifying Features**: although it varies between individual MNRs, these sites are collectively designated for harbour seal *Phoca vitulina*, grey seal, harbour porpoise, minke whale, and Risso's dolphin (Designation of MNR Guidance Notes, undated).
L'eyn Peninsula and the Sarnau/Pen Llŷn a'r Sarnau SAC	85.70	The Lleyn Peninsula and Sarnau SAC encompasses area of sea, coast, and estuary that is known to support a wide array of marine habitat, flora and fauna. **Relevant Qualifying Features**: Annex II bottlenose dolphin and grey seal are present as qualifying features but not primary reasons for site selection (JNCC, 2023k).
West Wales Marine/ Gorllewin Cymru Forol SAC	82.99	The West Wales Marine SAC covers an area of 7,377 km^2, extending into the Irish Sea from North Wales to West Wales. The average water depth in the area ranges from 40-50 m and up to 100 m. **Relevant Qualifying Features**: Annex II harbour propose are a primary reason for site designation (JNCC, 2023l).
North Channel SAC	111.78	The North Channel SAC comprises an area of 1,604 km^2, located along the east coast of Northern Ireland and extending into the northern portion of the Irish Sea (JNCC, 2021d). **Relevant Qualifying Features**: Annex II harbour propose are a primary reason for site designation (JNCC, 2021d).
Cardigan Bay/Bae Ceredigion SAC	122.76	Cardigan Bay SAC is located between Pembrokeshire and Ceredigion, extending 20 km from the coast, and protecting an area of the sea greater than 1,000 km^2. **Relevant Qualifying Features**: Annex II bottlenose dolphin are a primary reason for site designation, while Annex II grey

Designated Site	Minimum Distance to Eni Development Area (km)	Qualifying Features Related to Marine Mammals and Site Description
		seal are present as a qualifying feature but not a primary reason for site designation (JNCC, 2023e).
Strangford Lough SAC	142.70	The main feature of the Strangford Lough SAC is the sea inlet itself, which is known to have emerged from melting ice sheets and is less than 10 m in depth, however the SAC supports a range of species and habitats (Department of the Environment, 2007). **Relevant Qualifying Features**: Annex II harbour seal are present as a qualifying feature but not a primary reason for site designation (JNCC, 2023m).
Murlough SAC	146.97	This SAC is relatively shallow (depth up to 33 m) and supports a range of coastal species and habitats. **Relevant Qualifying Features:** Annex II harbour seal are present as a qualifying feature but not a primary reason for site designation (JNCC, 2023n).
Rockabill to Dalkey Island SAC	155.10	This site includes a range of dynamic inshore and coastal waters win the Western Irish Sea and is roughly 7 km wide and 40 km long (NPWS, 2013a). **Relevant Qualifying Features:** Rockabill to Dalkey Island SAC is designated for Annex II harbour porpoise (NPWS, 2013a).
Lambay Island SAC	157.45	Lambay is the largest Irish east coast island, situated approximately 4 km off the Dublin coast dominated by igneous rock, ash, shale and limestone (NPWS, 2013b). **Relevant Qualifying Features:** Lambay Island SAC is designated in part for Annex II grey seal and harbour seal (NPWS, 2013b).
The Maidens SAC	190.72	The Maidens SAC is formed by a group of rocky reefs off the coast of Larne, Northern Ireland. **Relevant Qualifying Features**: Annex II grey seal are a primary marine feature for the designation of the SAC (Department of Agriculture, Environment and Rural Affairs (DAERA), 2023).
Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC	194.73	The Bristol Channel Approaches SAC spans the Bristol Channel between the northern coast of Cornwall and Wales.

Designated Site	Minimum Distance to Eni Development Area (km)	Qualifying Features Related to Marine Mammals and Site Description
		Relevant Qualifying Features: Annex II harbour porpoise are a primary reason for site designation (JNCC, 2021e).
Pembrokeshire Marine/Sir Benfro Forol SAC	195.44	The Pembrokeshire Marine SAC is located on the south-west coast of Wales. **Relevant Qualifying Features**: Annex II grey seal are a primary reason for site designation (JNCC, 2023o).
Slaney River Valley SAC	198.26	The Slaney River Valley SAC overlaps Raven Point Nature Reserve SAC, The Raven SPA and Wexford Harbour and Slobs SPA (NPWS, 2011). **Relevant Qualifying Features**: The Slaney River Valley SAC is designated in part for Annex II harbour seal (NPWS, 2011a).
Saltee Islands SAC	239.28	The Saltee Islands SAC is located off the coast of Wexford, Ireland, which feature sea caves and cliffs. **Relevant Qualifying Features:** Annex II grey seal are a qualifying interest feature for this site (NPWS, 2011b).
Lundy SAC	251.48	The Lundy SAC is situated within the Bristol Channel. **Relevant Qualifying Features:** Annex II grey seal are a primary reason for site designation (JNCC, 2023s).
Roaringwater Bay and Islands SAC	445.50	The Roaringwater Bay and Islands SAC is located off the coast of Cork, Ireland, at the western edge of the regional marine mammal study are. **Relevant Qualifying Features:** Annex II harbour porpoise and grey seal are a qualifying interest features for this site (NPWS, 2011c).

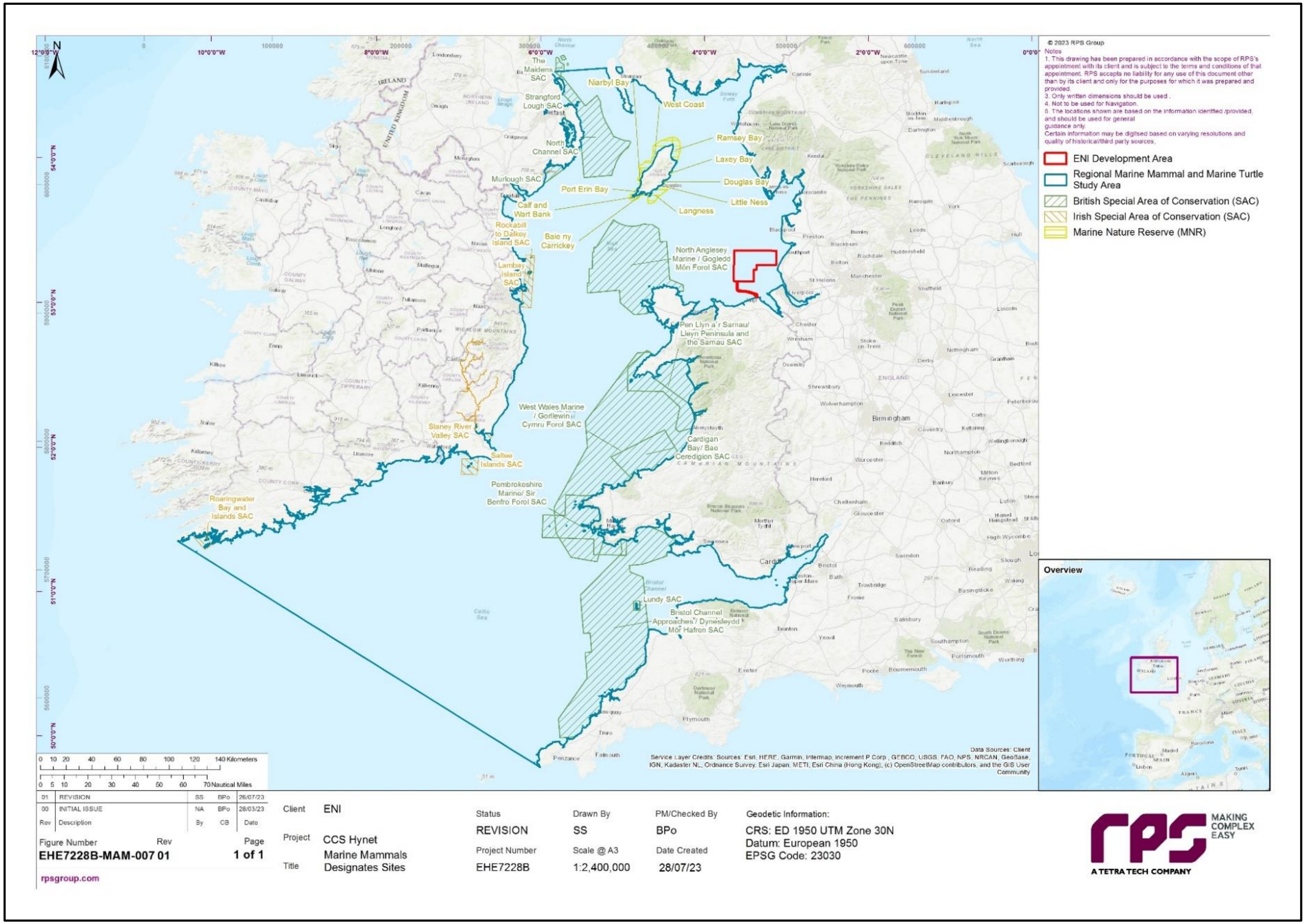

Figure 4.2: Designated Sites With Relevant Marine Mammal Qualifying Features Within The Regional Marine Mammal And Marine Turtle Study Area

Marine mammals

There are 16 marine mammal species that have been recorded within 60 km of the coastline in the eastern Irish Sea since 1975 (14 cetaceans and two pinnipeds) (Evans, 1998) and therefore, could potentially be present within the regional marine mammal and marine turtle study area (Table 4.4).

Seven of these species are known to occur regularly within the regional marine mammal and marine turtle study area:

- bottlenose dolphin;
- grey seal;
- harbour porpoise;
- harbour seal;
- minke whale;
- Risso's dolphin; and
- short-beaked common dolphin *Delphinus delphis* (hereafter 'common dolphin').

The remaining nine species of cetaceans that have been observed infrequently in the eastern Irish Sea are:

- Atlantic white-sided dolphin *Lagenorhynchus acutus;*
- fin whale *Balaenoptera. Physalus;*
- killer whale *Orcinus orca;*
- northern bottlenose whale *Hyperoodon ampullatus;*
- sei whale *Balaenoptera borealis*;
- Sowerby's beaked whale *Mesoplodon bidens;*
- sperm whale *Physeter macrocephalus;*
- striped dolphin *Stenella coeruleoalba; and*
- white-beaked dolphin *Lagenorhychus albirostris* (Table 4.4).

The waters in the regional marine mammal and marine turtle study area, and more specifically the waters of Liverpool Bay are not considered to be an important area in terms of species richness and abundance of cetacean compared to other parts of the UK (CMACS, 2005b). During the 1994 survey season, cetacean numbers in this area of the Irish Sea were so low that the SCANS project, an international assessment of cetacean abundance in UK waters, chose not to conduct surveys within the area (Hammond *et al.,* 2002).

Table 4.4: Summary Of The Abundant, Common, Occasional, And Rare Marine Mammals Within The Regional Marine Mammal And Marine Turtle Study Area (Sources: Reid *et al.* (2003); O'Brien *et al.* (2009); Baines and Evans (2012); Wall *et al.* (2013); Waggitt *et al.* (2020); Carter *et al.* (2022); Evans and Waggitt (2023); Gilles *et al*. (2023))

Species	Occurrence in the Regional Marine Mammal and Marine Turtle Study Area	Description
Toothed whales, dolphins, and porpoises (Odontoceti)		
Harbour porpoise	Abundant	Abundant and widespread throughout Irish Sea; most frequently reported cetacean in Irish waters. Highest relative abundances in the western half of the central Irish Sea. High predicted relative densities in both winter and summer in the Irish Sea.
Bottlenose dolphin	Common	A nearly global cetacean, which occurs in both eastern and western Irish Sea near the coast. There is a semi-resident population at Cardigan Bay (Wales) and off the coast of County Wexford (Ireland).
Risso's dolphin	Common	Global distribution, and typically a continental shelf species. Regularly sighted in the Irish Sea, with a relatively localised distribution, forming a wide band running south-west to north-east, that encompasses west Pembrokeshire, the western end of the Lleyn Peninsula, Anglesey, the south-east coast of Ireland, and waters around the Isle of Man.
Short-beaked common dolphin	Common	Occurs throughout the Irish Sea and second most frequently reported cetacean after harbour porpoise in Irish waters.
Atlantic white-sided dolphin	Occasional	Largely restricted to cool and temperate waters of the North Atlantic, typically in deep water along the continental shelf. Rarely recorded in the Irish Sea, with five stranding records between 1984 and 2006.
Killer whale	Occasional	Largely distributed in the north of the North Sea off the north-west of Scotland, but occasionally seen around the Isle of Man and St George's Channel. Occasionally sighted in Irish Sea (most recently 2011) but most sightings to south-west, west and north of Ireland.
Striped dolphin	Occasional	Small number of records from the Irish Sea and rarely sighted in inshore waters; largely distributed along south and west Ireland.
White-beaked dolphin	Rare	Sightings rare in all Irish waters; no sightings recorded for the Irish Sea and only one stranding record.
Sperm whale	Rare	Largely distributed off the western and along the northern coast of Ireland; single stranding record (1766) on east coast and rarely observed in the Irish Sea.
Beaked whales (Ziphiidae)		
Northern bottlenose whale	Rare	Records of strandings on east coast of Ireland although none since 1954; sightings in inshore waters very rare.
Sowerby's beaked whale	Rare	Rarely recorded in Irish Sea; records of strandings on the south-east coast of Ireland; one in 2004.

Species	Occurrence in the Regional Marine Mammal and Marine Turtle Study Area	Description
Baleen whales (Mysticeti)		
Minke whale	Common	Most frequently sighted baleen whale in Irish waters; occurs seasonally (spring/summer) in the Irish Sea.
Blue whale (*B. musculus)*	Rare	Migrates along the western seaboard of Ireland; single stranding record (early 1900) on the south-east coast of Ireland. Sightings and acoustic detections in recent years have shown they occur during the summer and autumn months offshore along the continental shelf edge, to the south-west of Ireland.
Fin whale	Rare	Occurs primarily in the south of Ireland but also along the west coast; rarely recorded in the Irish Sea.
Humpback whale (Megaptera novaeangliae)	Rare	Favours deeper waters over and along edges of continental shelfs and around oceanic islands, but sightings have occurred in the north of the Irish Sea, southern Irish Sea, Celtic Sea and Western Channel. Most sightings have been made between May and September, which is when small numbers have also been seen off the continental shelf west and north of Scotland.
Sei whale	Rare	Prefers deep, offshore waters and are known to be far ranging animals that infrequently visit UK shores. Some sightings between southern Ireland and south-west England, although minimal.
Pinnipeds		
Grey seal	Abundant	Restricted to the North Atlantic but distributed all around the UK and Ireland, with breeding populations around the coast of the Irish Sea. High counts along east of Northern Ireland, south-west of Isle of Man, and north coast of Wales and River Dee. Seal usage at sea maps show high density areas in the south-east of the Irish Sea, and along the east coast of Ireland and west Isle of Man (Carter *et al*., 2022).
Harbour seal	Abundant	Harbour seals haul out on coasts of Scotland and Northern Ireland, with high haul-out counts on the east of Northern Ireland. Seal usage at sea maps show high density areas on the east coast of Northern Ireland (Carter *et al*., 2022).

Marine turtles

Six species of marine turtles have been documented within UK and Irish waters (Botterell *et al.,* 2020):

- green turtle *Chelonia mydas*;
- hawksbill turtle *Eretmochelys imbricata*;
- Kemp’s ridley turtle *Lepidochelys kempii*;
- leatherback turtle *Dermochelys coriacea*;

- loggerhead turtle *Caretta caretta*; and
- olive ridley turtle *L. olivacea*

Due to the relative paucity of information surrounding the ecology, distribution, and abundance of these six species within UK and Irish waters in comparison to that available for marine mammals, they have been grouped together as 'marine turtles' for the purposes of this assessment.

SCANS-III survey

The SCANS III survey is the third in an ongoing series of large scale surveys for cetaceans in European Atlantic waters, with the first instalment undertaken in 1994 (Hammond *et al.,* 2002) and SCANS II in 2005 (Hammond *et al.,* 2013). The SCANS III survey was conducted in the summer of 2016, with results published in Hammond *et al.* (2021). Survey effort was divided into blocks Figure 4.3. The Proposed Development marine mammal and marine turtle study area is located within SCANS-III block F, while blocks E and F are within the regional marine mammal and marine turtle study area. SCANS-III block D also overlaps partly with the regional marine mammal and marine turtle study area (Figure 4.3). The estimated density and abundance values of harbour porpoise, bottlenose dolphin, common dolphin, Risso's dolphin, and minke whale from blocks D, E, and F are presented in Table 4.5. Harbour porpoise was the only species observed in block F, while common dolphin and Risso's dolphin were only observed in blocks D and E, respectively.

Table 4.5: Cetacean Abundance (Number Of Animals) And Density (Animals Per km^2) Estimates Within The SCANS-III Blocks Which Overlap With The Regional Marine Mammal And Marine Turtle Study Area (Source: Hammond *et al.,* 2021)

Species	Survey Block	Abundance	Density
Harbour porpoise	D	5,734	0.118
	E	8,320	0.239
	F	1,056	0.086
Bottlenose dolphin	D	2,938	0.0605
	E	288	0.0082
	F	-	-
Common dolphin	D	18,187	0.3743
	E	-	-
	F	-	-
Risso's dolphin	D	-	-
	E	1,090	0.0313
	F	-	-
Minke whale	D	543	0.0112
	E	603	0.0173
	F	-	-

SCANS-IV survey

The SCANS-IV survey is the fourth of the SCANS surveys, with the primary aim of providing large-scale estimates of cetacean abundance to inform the upcoming Marine Strategy Framework Directive assessment of Good Environmental Status in European Atlantic waters in 2024. The SCANS-IV survey was conducted between June and October of 2022, with results published in Giles *et al.* (2023). The Proposed Development marine mammal and marine turtle study area is located within SCANS-IV block CS-E, while blocks CS-C and CS-D are within the regional marine mammal and marine turtle study area (Figure 4.3). SCANS-IV blocks CS-

D and CS-E cover a similar area to the SCANS-III blocks E and F, respectively. However, SCANS-IV block CS-C does not cover the same area as SCANS-III block D, as shown in Figure 4.3. Therefore, the density values presented for the SCANS-III survey and the SCANS-IV survey are not always directly comparable. The estimated density and abundance values of harbour porpoise, bottlenose dolphin, common dolphin, Risso's dolphin, and minke whale from blocks CS-C, CS-D, and CS-E are presented in Table 4.6. Harbour porpoise, bottlenose dolphin and minke whale were observed in survey blocks CS-C, CS-D and CS-E, while common dolphin and Risso's dolphin were observed in blocks CS-C and CS-D only.

Table 4.6: Cetacean Abundance (Number Of Animals) And Density (Animals Per km^2) Estimates Within The SCANS-IV Blocks Which Overlap With The Regional Marine Mammal And Marine Turtle Study Area (Source: Giles, *et al.,* 2023)

Species	Survey Block	Abundance	Density
Harbour porpoise	CS-C	564	0.0157
	CS-D	9,773	0.2803
	CS-E	6,325	0.5153
Bottlenose dolphin	CS-C	15,117	0.4195
	CS-D	8,199	0.2352
	CS-E	127	0.0104
Common dolphin	CS-C	30,301	0.8410
	CS-D	949	0.0272
	CS-E	-	-
Risso's dolphin	CS-C	205	0.0057
	CS-D	75	0.0022
	CS-E	-	-
Minke whale	CS-C	284	0.0079
	CS-D	477	0.0137
	CS-E	108	0.0088

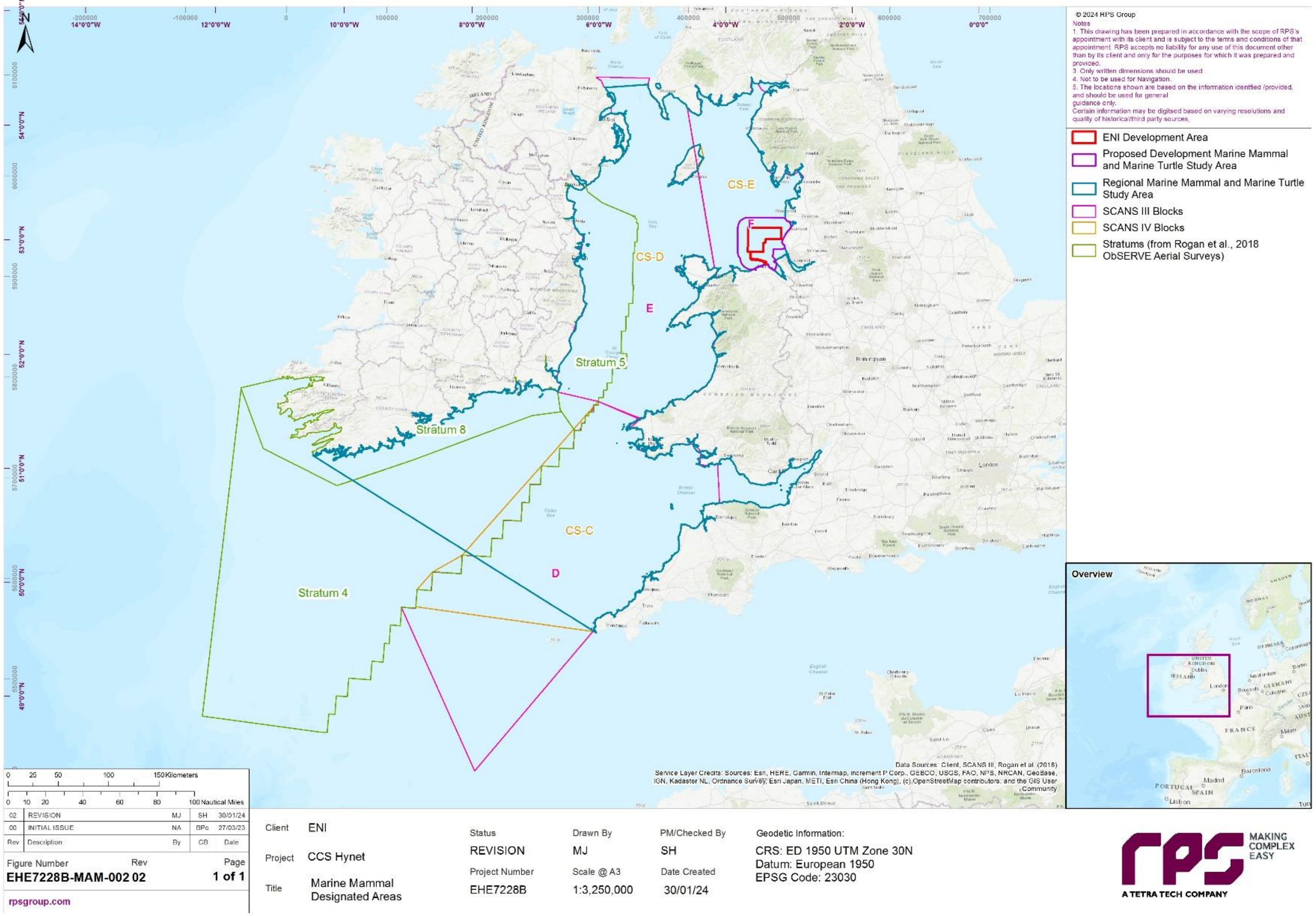

Figure 4.3: SCANS-III, SCANS-IV And ObSERVE Aerial Survey Blocks Within The Regional Marine Mammal And Marine Turtle Study Area (Sources: Rogan *et al.,* 2018; Hammond *et al.,* 2021; Gilles *et al.,* 2023)

ObSERVE surveys

Aerial surveys were conducted between 2015 and 2017 by Rogan *et al.* (2018) in Irish waters, with the aim to investigate key marine species. These waters were divided into strata in order to conduct the surveys, which were composed of line transects with observers monitoring approximately 500 m either side of the aeroplane. Stratum 5 lies within the regional marine mammal and marine turtle study area in the western Irish Sea, while strata 4 and 8 partially overlap it (Figure 4.3). Strata 4 and 5 were surveyed in summer and winter in both 2015 and 2016, while stratum 8 was only surveyed in 2016. Pinnipeds were observed, but not recorded to species level and abundances and densities were not presented. Within the regional marine mammal and marine turtle study area, pinnipeds were recorded in Stratum 5. Leatherback was the only species of turtle recorded during the ObSERVE surveys, at the south-western edge of stratum 4 thus outwith the regional marine mammal and marine turtle study area.

The abundances and densities of the species recorded in strata 4, 5, and 8 between 2015 to 2017 are presented in Table 4.7.

Table 4.7: Estimates Of Abundance (Number Of Animals) And Density (Animals Per km^2) Of Cetaceans And Turtles Within The ObSERVE Survey Strata 4,5, And 8 (Source: Rogan *et al.,* 2018)

Species	Season	Stratum	Abundance	Density
Harbour porpoise	Summer 2015	4	14,190	0.227
		5	7,734	0.696
	Winter 2015/16	4	3,752	0.060
		5	9,636	0.867
	Summer 2016	4	14,196	0.227
		5	11,625	1.046
		8	1,977	0.208
	Winter 2016/17	4	-	-
		5	-	-
		8	568	0.060
Bottlenose dolphin	Summer 2015	4	3,885	0.062
		5	-	-
	Winter 2015/16	4	6,217	0.098
		5	-	-
	Summer 2016	4	5,549	0.088
		5	-	-
		8	11,266	1.161
	Winter 2016/17	4	58,647	0.929
		5	401	0.036
		8	3,322	0.342
Common dolphin	Summer 2015	4	2,760	0.018
		5	-	-
	Winter 2015/16	4	39,899	0.262
		5	-	-
	Summer 2016	4	-	-
		5	-	-
		8	819	0.035
	Winter 2016/17	4	-	-
		5	-	-

Species	Season	Stratum	Abundance	Density
		8	-	-
Risso's dolphin	Summer 2015	4	-	-
		5	35	0.0001
	Winter 2015/16	4	40	0.0006
		5	-	-
	Summer 2016	4	809	0.0128
		5	-	-
		8	549	0.0565
	Winter 2016/17	4	-	-
		5	-	-
		8	-	-
Minke whale	Summer 2015	4	836	0.004
		5	495	0.014
	Winter 2015/16	4	751	0.004
		5	-	-
	Summer 2016	4	761	0.004
		5	180	0.005
		8	2,242	0.070
	Winter 2016/17	4	-	-
		5	-	-
		8	-	-
Leatherback turtle	Summer 2015	4	1	-
	Summer 2016	4	2	-

JCP Phase III analysis

The JCP Phase III analysis included 38 data sources, with data from at least 542 distinct survey platforms (ships and aircraft). This analysis was conducted to estimate spatial and temporal patterns of abundance of seven species of cetacean between 1994 to 2010 (Paxton *et al.,* 2016). The species of cetaceans included in the study were harbour porpoise, minke whale, bottlenose dolphin, common dolphin, Risso's dolphin, white-beaked dolphin and Atlantic white-sided dolphin.

The survey covered the region from 48° N to c. 64° N and from the continental shelf edge west of Ireland to the Kattegat in the east. The Eni Development Area is situated within the "Irish Sea" area of special commercial interest, covering the area of 8,227 km^2. Density surface models were used to predict species density over a fine scale grid of 25 km^2 resolution for one day in each season in each survey year. The data were divided into regions and seasonal estimates of abundance given for winter (January to March), spring (April to June), summer (July to September) and autumn (October to December).

Management units

Cetaceans

The IAMMWG have defined MUs for a range of cetacean species in the UK and calculated abundance estimates for each MU. In relation to the regional marine mammal and marine turtle study area, common dolphin, Risso's dolphin, and minke whale are all part of the Celtic and Greater North Seas MU, harbour porpoise within the Celtic and Irish Sea MU, and bottlenose dolphin are within the Irish Sea MU and the Offshore Channel, Celtic Sea and South West England MU (Figure 4.4) (IAMMWG, 2022). The results of aerial surveys conducted by Rogan *et al.* (2018) and of the SCANS-III survey were used to generate estimates of localised abundances and densities of the key cetacean species within their respective MUs (Table 4.8) (IAMMWG, 2022).

Table 4.8: Cetacean Abundance Estimates Within Their Respective MUs (Sources: Rogan *et al.,* 2018; Hammond *et al.,* 2021; IAMMWG, 2022)

Species	Management Unit (MU)	Abundance of animals in MU (CV= Coefficient of Variation)	95% Confidence Interval
Harbour porpoise	Celtic and Irish Sea	62,517 (CV = 0.13)	48,324 to 80,877
Bottlenose dolphin	Irish Sea	293 (CV = 0.54)	108 to 793
	Offshore Channel, Celtic Sea and South West England	10,947 (0.25)	6,727 to 17,814
Common dolphin	Celtic and Greater North Seas	102,656 (CV = 0.29)	58,932 to 178,822
Risso's dolphin		12,262 (CV = 0.46)	5,227 to 28,764
Minke whale		20,118 (CV = 0.18)	14,061 to 28,786

Pinnipeds

SCOS have defined MUs for grey and harbour seal in UK waters. The regional marine mammal and marine turtle study area fully encompasses the Wales MU and the North West (NW) England MU, and partially overlaps with the Northern Ireland MU, the South West (SW) Scotland MU, and the SW England MU (Figure 4.5) (SCOS, 2021). Population dynamics within these MUs are discussed in greater detail in each seal species' account below.

Marine turtles

There are no MUs defined for any marine turtles within UK and Irish waters, however sightings and strandings are monitored and reported annually by Marine Environmental Monitoring (Penrose *et al.,* 2022), where they are then published on the NBN Atlas.

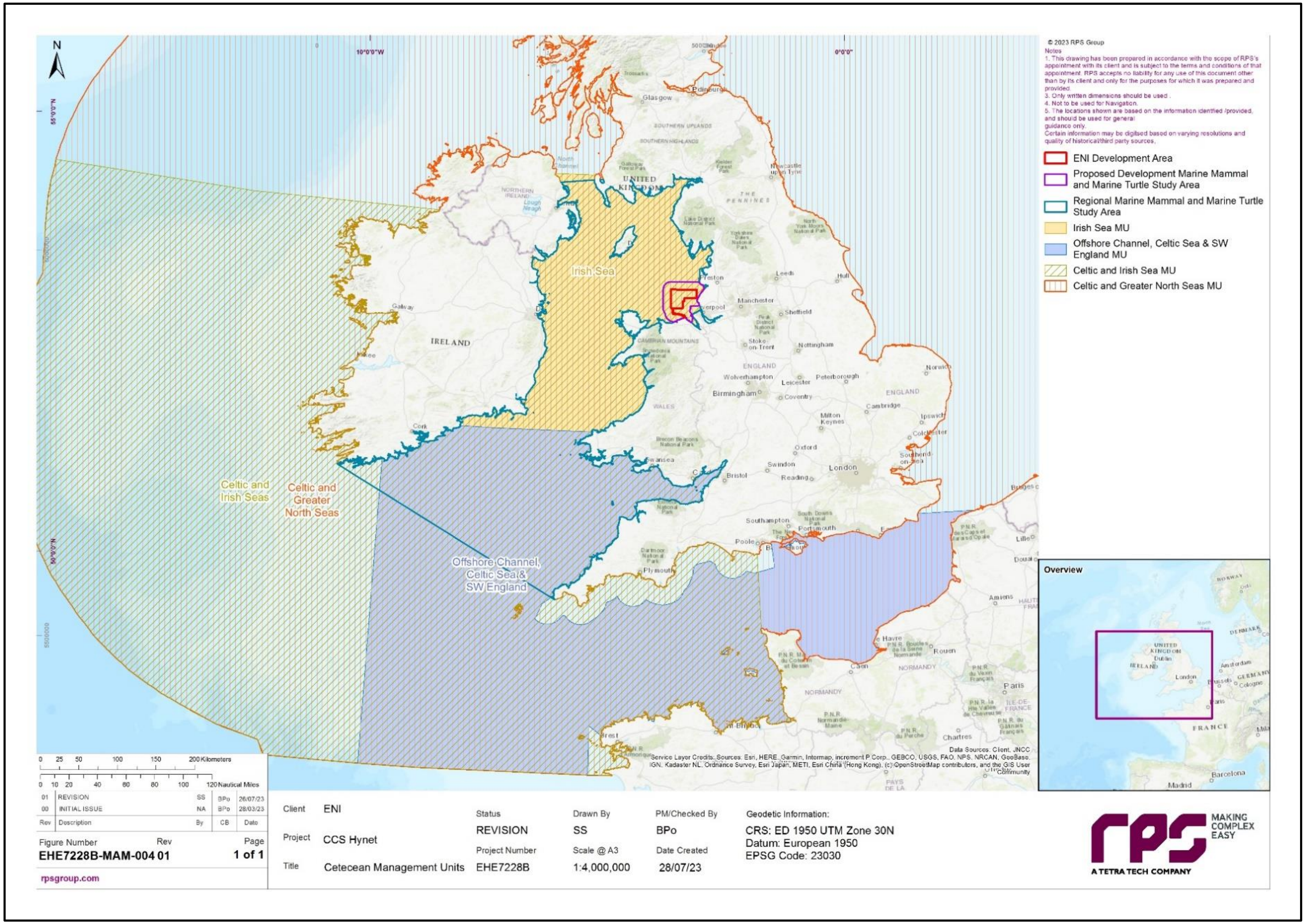

Figure 4.4: Cetacean Management Units (Source: IAMMWG, 2022)

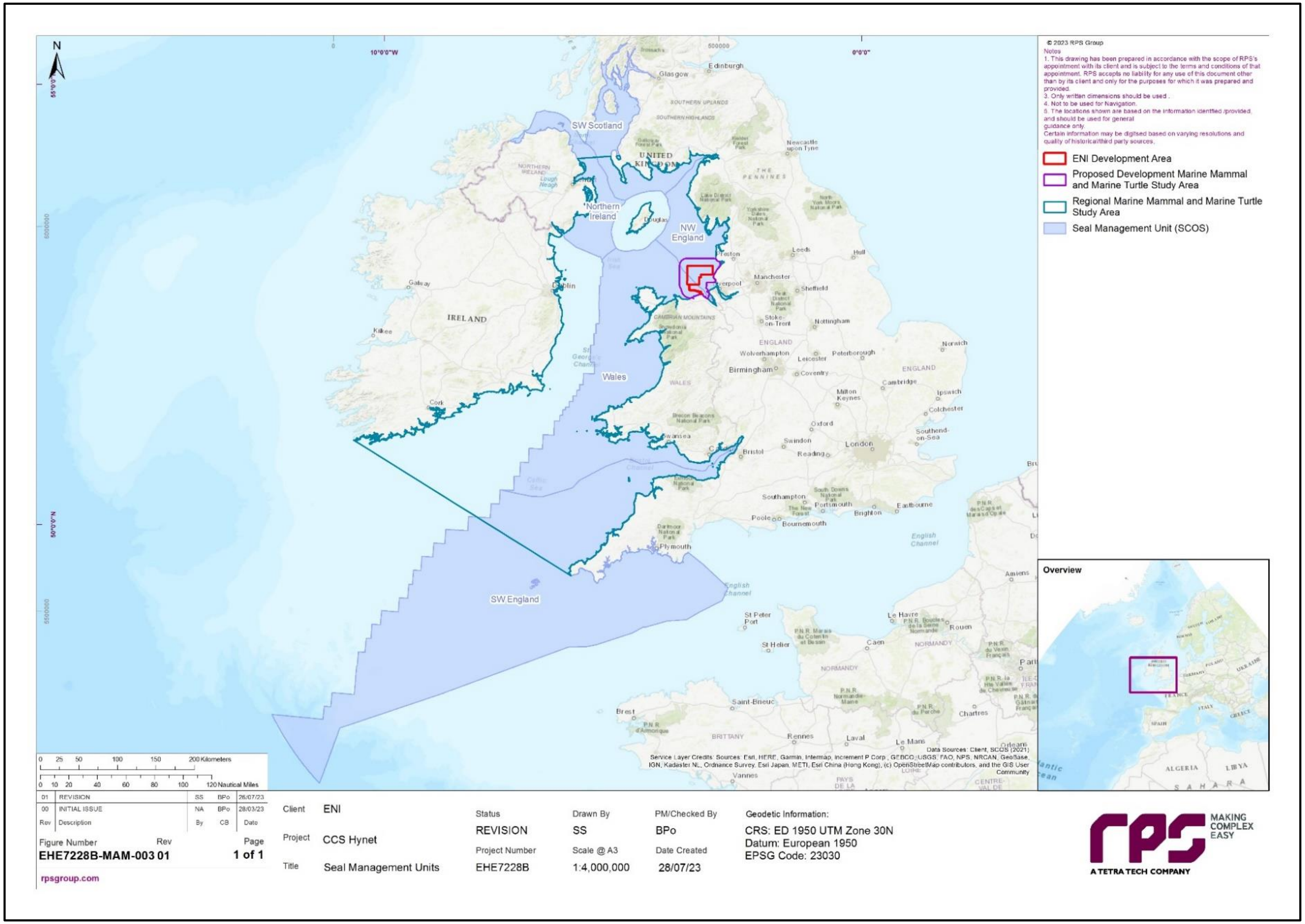

Figure 4.5: Seal Management Units (Source: SCOS, 2021)

4.3.1.2 Proposed Development Marine Mammal and Marine Turtle Study Area

Although no site-specific surveys were carried out for the Proposed Development, information obtained from surveys undertaken for OWFs within the Eni Development Area can be used for the characterisation of the marine mammal and turtle baseline on a local scale. It should be noted that these data are limited, and, in the case of the first Gwynt y Môr OWF survey, now quite dated (CMACs, 2005b). For example, site-specific surveys conducted for the Gwynt y Môr OWF EIA recorded harbour porpoise, and grey seal throughout the year (CMACS, 2005b). Bottlenose dolphin, common dolphin, and minke whale were recorded irregularly, and these species were considered transient or occasional visitors (Table 4.9) (CMACS, 2005b). The results of the post-construction monitoring at Gwynt y Môr OWF recorded 43 unidentifiable marine mammals, 63 grey seal, and four harbour porpoise (Goddard *et al.,* 2017, 2018; Goulding *et al.,* 2019). Most recently, site-specific surveys conducted for Awel y Môr OWF reported harbour porpoise, seals, and dolphins (Sinclair *et al.,* 2021). There were no marine turtles recorded in any of these surveys. A summary of these surveys for Gwynt y Môr OWF and Awel y Môr OWF is presented in Table 4.9.

Table 4.9: Summary Of Marine Mammals Recorded During Relevant Site-Specific Surveys For Projects Within The Regional Marine Mammal And Marine Turtle Study Area

Project	Minimum Distance to Eni Development Area (km)	Survey Years	Marine Mammals Recorded	Reference
Awel y Môr OWF EIA site-specific surveys	0.00	2019 to 2021	152 marine mammal sightings comprised of 74 dolphin/porpoise, 38 unidentifiable seals, 27 harbour porpoise, 7 unidentifiable marine mammals, and 6 unidentifiable dolphins	Sinclair *et al.,* 2021
Gwynt y Môr OWF post construction site-specific surveys	0.00	2016 to 2019	110 sightings, including 63 grey seal, 22 unidentifiable seals, 20 dolphin/porpoise, 4 harbour porpoise, and 1 unidentifiable marine mammal	Goddard *et al.*, 2017, 2018; Goulding *et al.*, 2019
Gwynt y Môr OWF site-specific surveys for the EIA	0.00	2003 to 2005	84 harbour porpoise and 68 grey seals sighted during boat based transects, while harbour porpoise and potentially bottlenose dolphin were recorded by hydrophones. There were also irregular sightings of bottlenose dolphins, common dolphins, and one minke whale throughout the surveys.	CMACS, 2005b

Where available, species records within the Proposed Development marine mammal and marine turtle study area from the NBN Atlas (2021) are presented in the individual species accounts below. These records were identified by using the 'user defined polygon' search tool to approximately trace the Proposed Development marine mammal and marine turtle study area in the NBN Atlas map feature (2021). Given the nature of the NBN Atlas, it was not possible to provide detailed descriptions of any records, but they are included to provide additional site-specific context to the marine mammal and marine turtle baseline characterisation.

4.3.1.3 Species accounts

Based on the information presented above, the following species are considered likely to occur within the regional marine mammal and marine turtle study area and Proposed Development marine mammal and marine turtle study area:

- bottlenose dolphin;
- common dolphin;
- grey seal;
- harbour porpoise;
- harbour seal;
- marine turtles;
- minke whale; and
- Risso's dolphin.

Individual accounts for each of these key species are presented below, informed by the most recent evidence.

Harbour porpoise

Ecology and distribution

Harbour porpoise are widespread around UK and Irish waters, where they feed on a range of fish (mainly small shoaling pelagic or demersal species) (Santos and Pierce, 2003; Aarfjord, 1995). They are by far the most common cetacean in the regional marine mammal and marine turtle study area (Reid *et al*., 2003; Hammond *et al*., 2005; Baines and Evans, 2012; Wall *et al.,* 2013; Evans and Waggitt, 2023).

Wide-scale historical data from 1990 to 2009 presented in the Welsh Marine Atlas confirms regular widespread sightings of harbour porpoise across the Irish Sea, with hotspots off North and West Anglesey, the south-west coast of the Lleyn Peninsula, southern Cardigan Bay, and in the Bristol Channel of the south coast of Wales (Baines and Evans 2012). These broadscale data, however, have limitations such as age of the data and inadequate survey coverage.

The Modelled Distributions and Abundances of Cetaceans of Wales and Surrounding Waters presented in Evans and Waggitt (2023) supersedes Baines and Evans (2012) and presents over 440,000 km of cetacean survey effort conducted between 1990 and 2020 using a combination of vessel, aerial visual and aerial digital observation platforms. The main aim was to produce distribution maps of cetacean species to update the maps formed for the earlier Marine Mammal Atlas by Baines and Evans (2012). The dataset presented in the updated Welsh Marine Atlas indicates the main areas of high density of harbour porpoise are between north Anglesey and the Isle of Man, the outer part of Cardigan Bay, and west Pembrokeshire in Wales, and in eastern Ireland, the coastal area particularly from Co. Dublin south to Co. Waterford. The quarterly modelled density maps for harbour porpoise, measured as the mean density per cell across months within a season, are shown in Figure 4.6 (Evans and Waggitt 2023).

SCANS-III, SCANS-IV and ObSERVE data showed widespread sightings across the Irish Sea between 2015 and 2022 (Rogan *et al.,* 2018; Hammond *et al.*, 2021; Gilles *et al*., 2023), as shown in Table 4.5, Table 4.7, and Table 4.8 above, The observed distribution of harbour porpoise from SCANS-III and from Rogan *et al*. (2018), was similar to that observed in SCANS-II in 2005 (Hammond *et al.*, 2013). There was an increase in the observed distribution of harbour porpoise in SCANS-IV survey block CS-E compared to the equivalent survey block in SCANS-III (block F), and the observed distribution of harbour porpoise in the SCANS-IV survey block CS-D was similar to that observed in the equivalent SCANS-III survey block (block E). Since SCANS-IV survey block CS-C does not cover the same area as any survey block from the SCANS-III surveys (see Figure 4.3), these distributions cannot be compared directly; however abundance and distributions of harbour porpoise for this block are presented in Table 4.6 (Gilles *et al*., 2023). Finally, sightings data from the Manx

Whale and Dolphin Watch (MWDW) indicated that harbour porpoise are widespread in the waters around the Isle of Man, extending out towards the Eni Development Area and up towards the coast of Northern Ireland (MWDW, 2022).

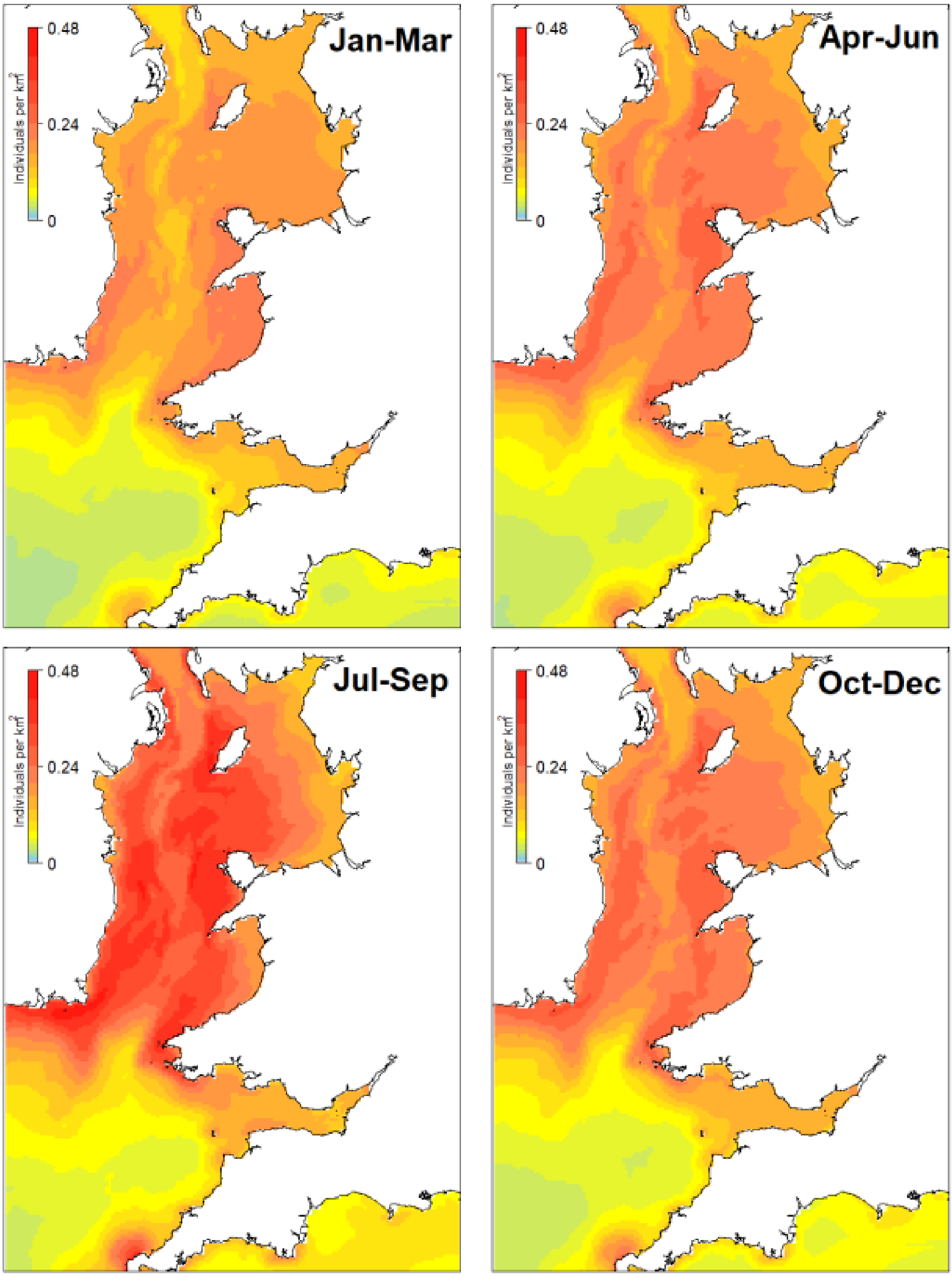

Figure 4.6: Harbour porpoise modelled densities by quarter (measured as the mean density per cell across months within a season; taken from Evans and Waggitt (2023)

Abundance within the Regional Marine Mammal and Marine Turtle Study Area

Abundance estimates for harbour porpoise vary considerably depending on the dataset and spatial scale. Harbour porpoise abundance is estimated as 62,517 animals (CV = 0.13, 95% CI = 48,324 to 80,877) within the relevant harbour porpoise MU (Celtic and Irish Seas MU) (Table 4.8) (IAMMWG, 2022).

The Eni Development Area is situated within block F for the 2016 SCANS-III surveys which had an estimated 1,056 animals (95% CI = 342 to 2,010) (Table 4.5) (Hammond *et al*., 2021). Harbour porpoises were also recorded in the adjacent block E, however, with an estimated abundance of 8,320 animals (95% CI = 4,643 to 14,354) (Table 4.5) (Hammond *et al.,* 2021).

The Eni Development Area is situated within the SCANS-IV survey block CS-E, which had an estimated 6,325 animals (95% CI = 3,663 to 10,162) (Table 4.6) (Gilles *et al*., 2023). Harbour porpoises were also recorded in the adjacent block CS-D, with an estimated abundance of 9,773 animals (95% CI = 4764 to 18,125) (Table 4.6) (Gilles *et al*., 2023).

Abundance estimates within strata 4, 5, and 8 of the ObSERVE surveys ranged from 568 animals in stratum 8 in winter 2016/17 to 14,196 animals in stratum 4 in summer 2016 (Table 4.7) (Rogan *et al.,* 2018). The JCP Phase III analysis gave predicted abundances for the Irish sea by season; spring was 2,300 animals, summer was 3,200 animals, autumn had 2,000 animals, and winter was 4,600 animals (Paxton *et al.,* 2016).

Density within the Regional Marine Mammal and Marine Turtle Study Area

As presented in Table 4.5, harbour porpoise density is estimated to be 0.118 animals per km^2 in SCANS-III block D, 0.239 animals per km^2 in block E and 0.086 animals per km^2 in block F (Hammond *et al.,* 2021). From the observations recorded during SCANS-IV surveys, as presented in Table 4.6, harbour porpoise density is estimated to be 0.2803 animals per km^2 in block CS-D and 0.5153 animals per km^2 in block CS-E (Gilles *et al*., 2023). However, as these densities are based on surveys conducted in the summer, they may vary throughout the year. Density surface modelling in the JCP III analysis (which aimed at providing estimates of both abundance and changes in abundance for common cetacean species in UK waters), gave a mean density of 0.8738 animals per km^2 across the entire JCP Phase III study region, with areas of relative higher density for harbour porpoise in the Irish and Celtic Sea (Paxton *et al.* 2016).

The aerial surveys conducted by Rogan *et al.* (2018) intersected with the regional marine mammal and marine turtle study area during strata 4, 5, and 8. These surveys were conducted in the summer and winter in 2015 and 2016, with densities of harbour porpoise ranging from 0.060 animals per km^2 in winter 2015/16 to 1.046 animals per km^2 in summer 2016 (Table 4.7) (Rogan *et al.,* 2018). A recent study by Waggitt *et al*. (2020) collated diverse survey data to generate predicted distribution maps at 10 km resolution for a range of cetaceans. The study confirmed harbour porpoise to be abundant year-round in the Irish Sea with higher densities towards the east of the Irish Sea.

Heinänen and Skov (2015) demonstrated that water depth, surface sediments, current speed, and eddy potential all influence the distribution of harbour porpoise in the Celtic and Irish Sea MU. In winter, water depth and current speed were the major determinants of distribution with some influence from surface salinity. An increased probability of occurrence was associated with increasing current speed, yet a tendency for lower probability of occurrence was observed at very high current speeds of greater than 0.7 m/s. The authors also concluded that high densities of harbour porpoise are associated with depth and season. Using spatio-temporal modelling of species and environmental data, they illustrated that the shallowest areas (< 40 m) and winter months supported high densities (Heinänen and Skov, 2015).

During summer, harbour porpoise were associated with areas of high eddy activity, with the coarseness of sediments also playing an important role (Heinänen and Skov, 2015). Peak densities were associated with sandy-gravelly sediments, with lower densities in muddy areas. In summer, current speed and eddy potential were important, with similar increasing probabilities of occurrence with increasing current speed up to 0.4 m/s and increasing eddy activity. Harbour porpoise are often found in areas of high shipping traffic, however, this study found that densities of porpoise decreased with increasing levels of traffic. Density of ships was a static predictor variable, given as the mean number of ships per year in each cell (Heinänen and Skov, 2015).

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There are approximately 237 records of harbour porpoise within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021). These records date from 1864 – 2022.

Bottlenose dolphin

Ecology and distribution

Bottlenose dolphins are found worldwide in temperate and tropical waters. They have a broad diet, and a study of bottlenose dolphins in the Irish Sea found that the main prey species were gadoid fish (pollock, haddock, blue whiting, whiting, and saithe *Pollachius virens*) (Hernandez-Milian *et al.,* 2015). Coastal populations are frequently observed in pods which may be larger in offshore populations but very little is known about their distribution (Rogan *et al.,* 2018). Studies on bottlenose dolphins from Cardigan Bay and Anglesey suggest that distance from the coast had a significant effect on encounter rates, with the population favouring habitat as close as 5 km from the coast and shallow waters of 5 to 10 m deep (Pesante *et al.,* 2008; Feingold and Evans, 2013). The species occurs particularly along the north coast of the north coast of the Llŷn Peninsula, around Anglesey, the coast of mainland North Wales east to Liverpool Bay, around the Isle of Man and probably elsewhere in the Irish Sea. In those locations, particularly in winter, groups rarely remain for extended periods in any one locality, instead ranging around and often occurring more offshore, as revealed from casual sightings (Evans and Waggitt, 2023). The quarterly modelled density maps for bottlenose dolphin, measured as the mean density per cell across months within a season, are shown in Figure 4.7 (Evans and Waggitt, 2023).

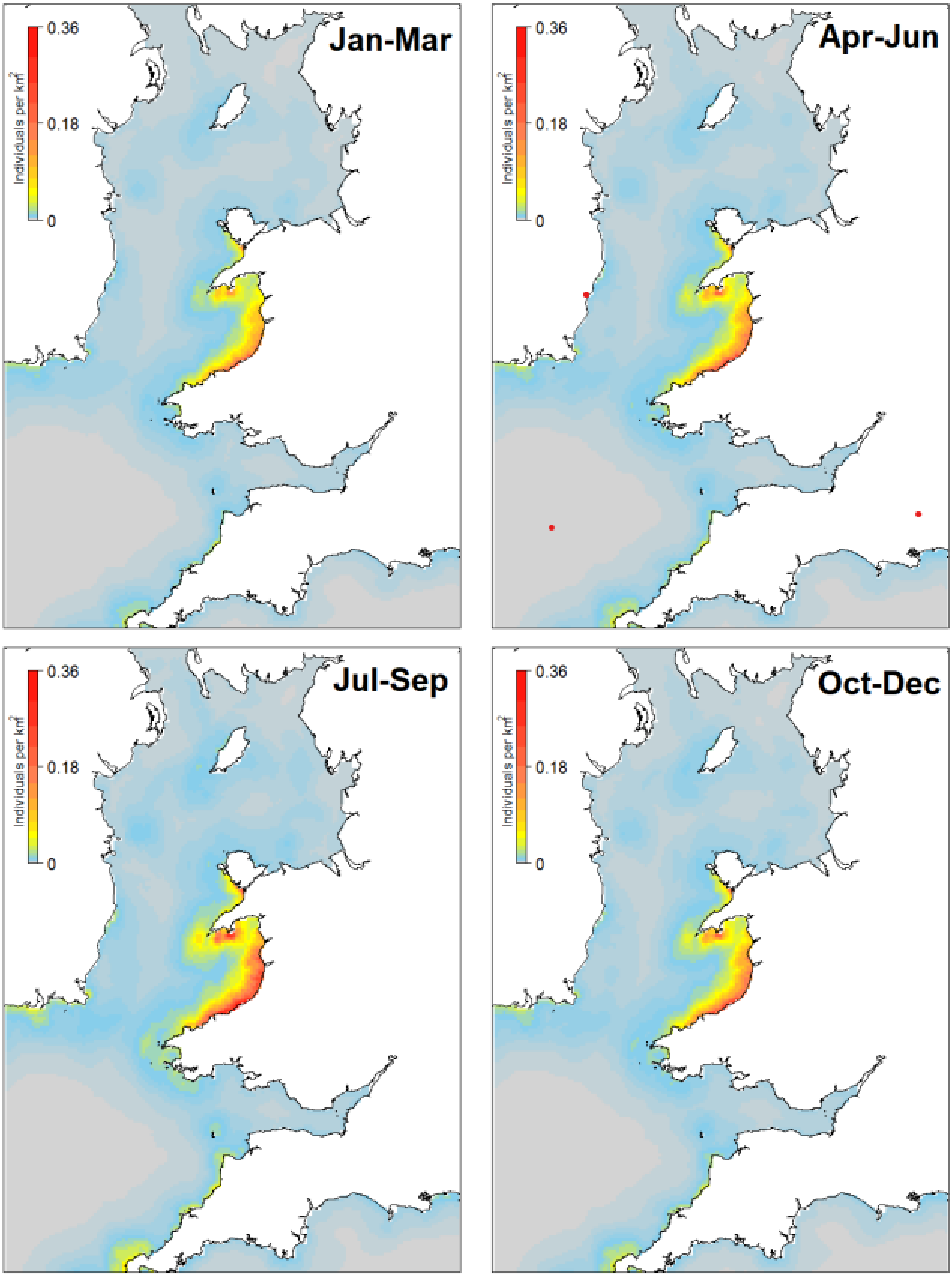

Figure 4.7: Bottlenose dolphin modelled densities by quarter (taken from Evans and Waggitt, 2023)

There are two semi-resident groups of bottlenose dolphin in UK waters, one in Cardigan Bay and on in the Moray Firth (Wilson *et al.,* 1997). These two areas have therefore been designated as SACs due to the presence of Annex II bottlenose dolphins. The Cardigan Bay/Bae Ceredigion SAC is within the regional marine mammal and marine turtle study area (Table 4.3). Bottlenose dolphin from Cardigan Bay are likely to interact with animals in waters of south-west UK and southern Ireland and there is probably exchange with more distant populations (Pesante *et al*., 2008), as the range extends north to the Isle of Man (Duckett, 2018). Estimates in recent years from across Cardigan Bay have been amongst the lowest recorded, and the robust design models indicate some permanent emigration from the Bay (Lohrengel *et al.* 2018).

Abundance within the Regional Marine Mammal and Marine Turtle Study Area

Broad scale abundance estimates are available for bottlenose dolphin within the regional marine mammal and marine turtle study area, which includes the Irish Sea MU and the Offshore Channel, Celtic Sea and South West England MU (Table 4.8) (IAMMWG, 2022). The most recent abundance estimate of bottlenose dolphin in these MUs are 293 animals (CV = 0.54, 95% CI = 108 to 793) and 10,947 animals (CV = 0.25, 95% CI = 6,727 to 17,814), respectively (Table 4.8) (IAMMWG, 2022).

The Eni Development Area is situated within block F for the 2016 SCANS-III surveys but no bottlenose dolphin were sighted within the block. They were recorded in the adjacent Block E, however, with an estimated abundance of 288 animals (95% CI = 0 to 664) and mean group size of 1.50 (CV = 0.192) (Table 4.5) (Hammond *et al.,* 2021). They were also recorded in block D, which partially overlaps with the regional marine mammal and marine turtle study area, with an estimated abundance of 2,938 animals (95% CI = 914 to 5,867) and mean group size of 2.6 (CV = 0.224) (Table 4.5) (Hammond *et al.,* 2021).

Bottlenose dolphin were however observed within block CS-E for the SCANS-IV surveys conducted in summer 2022, which overlaps with the Eni Development Area, which had an estimated 127 animals (95% CI = 3 to 353) and mean group size of 1.50 (CV = 406) (Table 4.6) (Gilles *et al*., 2023). Bottlenose dolphin were also recorded in the adjacent block CS-D, with an estimated abundance of 8,199 (95% CI = 3,595 to 15,158) and mean group size of 2.74 (CV = 0.353) (Table 4.6) (Gilles *et al*., 2023), which is a marked increase from an estimate of 288 animals during the previous SCANS survey campaign (Table 4.5; Hammond *et al.,* 2021). This increase may be driven, in part by a response to interannual spatial variation in prey availability across the wider range, reflected as differences in distribution and abundance estimates between SCANS survey campaigns (Gilles *et al*., 2023).

Bottlenose dolphin were not observed in all surveys within the ObSERVE survey strata 4, 5, and 8 (which overlap with the regional marine mammal and marine turtle study area). Abundance estimates ranged from 401 animals in stratum 5 in the winter 2016/17 survey to 58,647 in stratum 5 in the same survey (Table 4.7) (Rogan *et al.*, 2018). In the JCP Phase III analysis, estimated predicted abundances in 2010 were given per season for the Irish Sea, with 30 animals in both spring and summer and ten animals in both autumn and winter (Paxton *et al.* 2016).

Lohrengel *et al.* (2018) summarised distance sampling surveys between Cardigan Bay SAC and the wider Cardigan Bay to provide abundance estimates for bottlenose dolphin. These abundance estimates were used by Sinclair *et al.* (2021) to calculate densities for these areas. Within the Cardigan Bay SAC, density estimates were 0.088 dolphins per km^2 (based upon abundance estimates of 85 dolphins in 2016, 95% CI = 44 to 160; Lohrengel *et al.,* 2018) and SAC area of 958.58 km^2 (Sinclair *et al.,* 2021). For the wider Cardigan Bay area (4,986.86 km^2), a density of 0.035 dolphins per km^2 has been predicted (Sinclair *et al.,* 2021). This was based upon abundance estimates of 174 dolphins in 2016 (95% CI = 150 to 246) in a closed population Capture, Mark and Recapture (CMR) model (Lohrengel *et al.,* 2018). This does, however, assume uniform density of animals throughout the areas and the study did not extend into North Wales, thus not covering the Eni Development Area.

Density within the Regional Marine Mammal and Marine Turtle Study Area

Within the regional marine mammal and marine turtle study area, bottlenose dolphin are sighted regularly across the Irish Sea, with high counts observed in Cardigan Bay and Anglesey (Figure 4.7) (Baines and Evans, 2012; Evans and Waggitt, 2023). There is a semi-resident bottlenose dolphin in Cardigan Bay, which has two SACs designated for the species (Cardigan Bay SAC and Pen llyn a'r Sarnau SAC) (Table 4.3). The JCP Phase III data demonstrate that bottlenose dolphin are largely coastal, with consistently high density in Cardigan Bay (Paxton *et al.,* 2016). These data also suggest densities of up to two bottlenose dolphins per km^2 in the Irish Sea, driven by high densities in Cardigan Bay (Paxton *et al.,* 2016). Rogan *et al.* (2018) estimated peak density in stratum 8 as 1.161 animals per km^2 during summer 2016 (Table 4.7). Most recently, Waggitt *et al.* (2020) demonstrated bottlenose dolphin densities to be fairly consistent all year round. Low density areas of bottlenose were predicted in the Irish Sea year-round but do not appear to reflect the known localised higher densities around Cardigan Bay, as small and isolated sub-populations would have little influence on broad scale models (Waggit *et al.,* 2020).

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There are 24 records of bottlenose dolphin within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021). These records date from 1942 – 2016.

Common dolphin

Ecology and distribution

Common dolphins are found worldwide in temperate and tropical waters and are widely distributed throughout Europe. Within the UK and Ireland, they are common in the western approaches to the English Channel and the southern Irish Sea. Common dolphin are often found in large groups, ranging from small schools to large concentrations of up to 5,000 individuals. The average group size recorded in Reid *et al.* (2003) was 14 individuals. They are opportunistic feeders, with small pelagic schooling fish and squid likely to be the main prey items in the Irish Sea (Hammond *et al.,* 2005).

Densities within the Irish Sea appear to have increased across the decades. Numbers of recorded common dolphin are greatest in summer although the species is recorded in all months of the year and may be under-recorded in winter when offshore survey effort is much lower (Evans and Waggitt, 2023). Numbers can also vary greatly between years (see, for example, Rogan *et al.* 2018, Hammond *et al*. 2021). The quarterly modelled density maps presented in the updated Welsh Marine Atlas (Evans and Waggitt 2023), measured as the mean density per cell across months within a season, are shown in Figure 4.8.

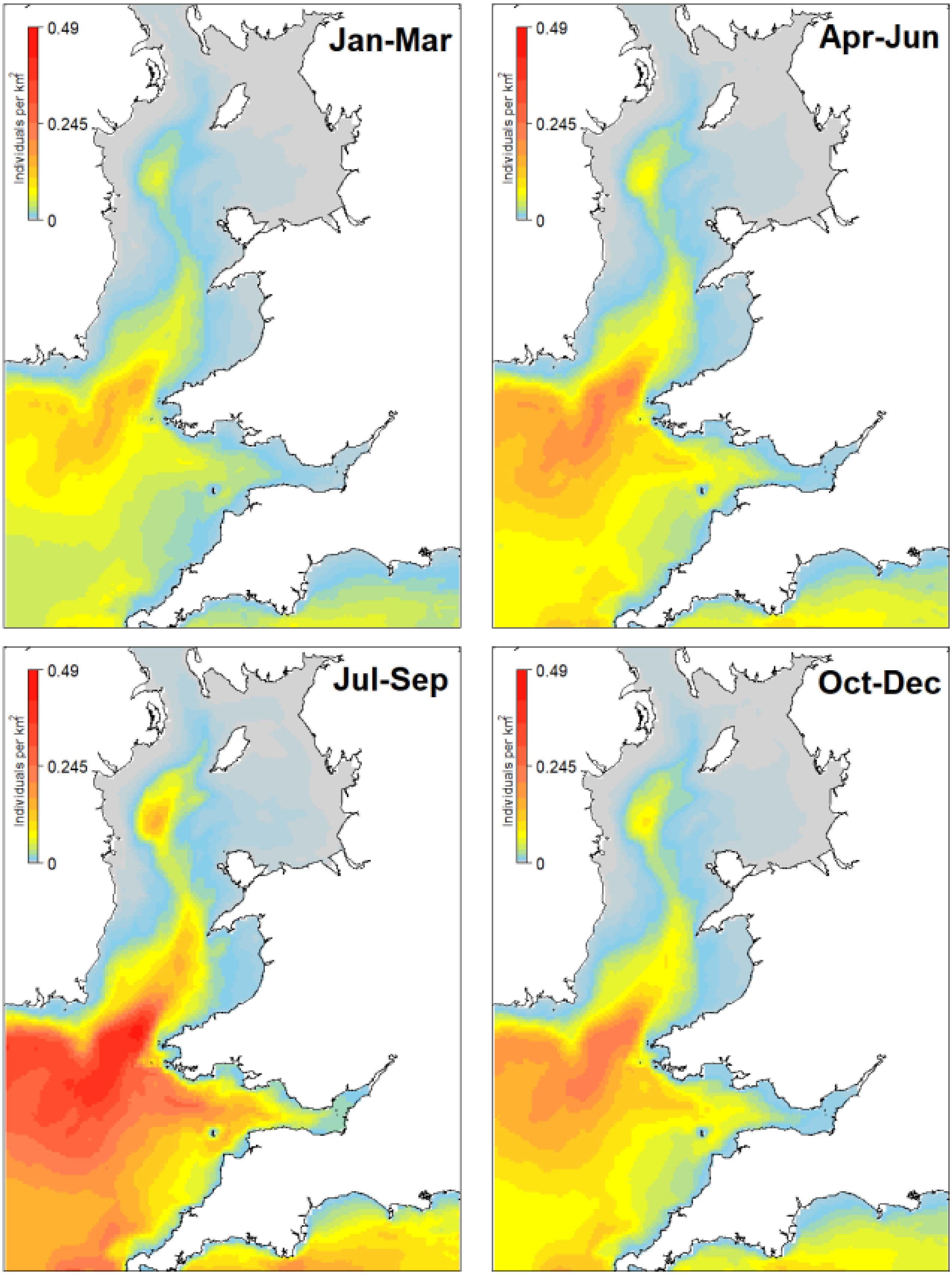

Figure 4.8: Common dolphin modelled densities by quarter (taken from Evans and Waggitt, 2023)

Abundance within the Regional Marine Mammal and Marine Turtle Study Area

Broad scale abundance estimates are available for common dolphin, with all UK waters considered to be part of the Celtic and Greater North Seas MU (Table 4.8). The most recent abundance estimate of common dolphin in this MU is 102,656 animals (CV = 0.29, 95% CI = 58,932 to 178,822; IAMMWG, 2022).

The Eni Development Area is situated within block F for the 2016 SCANS-III surveys, while the block E sits within the regional marine mammal and marine turtle study area, and block D overlaps with it. There was an estimated abundance of 18,187 animals within block D (CV = 0.413, 95% CI = 4,394 to 33,077) and mean group size of 10.06 animals (CV = 0.170), but no sightings within block E or F (Table 4.5) (Hammond *et al.,* 2021).

The Eni Development Area is situated within the SCANS-IV survey block CS-E, which did not record any common dolphin during these surveys. Common dolphin were however recorded within the adjacent survey block CS-D, with an estimated abundance of 949 animals (95% CI = 32 to 2,990) (Table 4.6) (Gilles *et al*., 2023). Common dolphin were also recorded in the SCANS-IV survey block CS-C, which overlaps partially with the Proposed Development marine mammal and marine turtle study area (Figure 4.3), which has an estimated abundance of 30,301 animals (95% CI = 17,888 to 51,902) (Table 4.6) (Gilles *et al*., 2023).

The JCP Phase III analysis gave estimated predicted abundances for the Irish sea during 2010 by season. Spring abundance was 50 animals (95% CL = 20 – 160), summer was 80 animals (95% CL = 30 – 260), autumn had 310 animals (95% CL = 110– 860), and winter was ten animals (95% CL = 0 – 50) (Paxton *et al*., 2016). Summer and autumn therefore had the highest abundances. Common dolphin were recorded from strata 4 and 8 of the ObSERVE survey, with a maximum abundance estimate of 39,899 animals in stratum 4 in winter 2015/16 (Table 4.7) (Rogan *et al.,* 2018).

Density within the Regional Marine Mammal and Marine Turtle Study Area

Sightings data from MWDW shows that common dolphin are widespread in the waters around the Isle of Man, extending towards the Eni Development Area (MWDW, 2022). Predicted density values using the SCANS-III data showed common dolphin densities were low (0 to 0.07 animals per km^2) in the Irish Sea but increased towards the Celtic Sea (BEIS, 2022). From the observations recorded during SCANS-IV surveys, as presented in Table 4.6, common dolphin density is estimated to be 0.0272 animals per km^2 in block CS-D and 0.8410 animals per km^2 in block CS-C (Gilles *et al*., 2023). In the ObSERVE survey, densities ranged from 0.018 to 0.262 animals per km^2 in strata 4 and 8 (Table 4.7) (Rogan *et al.,* 2018).

The Atlas of the Marine Mammals of Wales (Baines and Evans, 2012) and updated Welsh Marine Atlas (Evans and Waggitt 2023) confirms regular sightings of common dolphin across the Irish Sea with higher numbers of sightings towards the south (Figure 4.8). However, these maps need careful interpretation because survey effort is patchy and greater in the southern Irish Sea than elsewhere. Although the modelled density map (Figure 4.8) does attempt to overcome potential biases including variation in effort, where effort is minimal, there is greater uncertainty. Casual sightings of common dolphins occur in the Bristol Channel, off the North Wales coast and around the Isle of Man. Nevertheless, the largest groups (sometimes numbering hundreds of animals) have only been recorded in the deeper areas (exceeding 50m) of the Irish Sea. Common dolphin were recorded in all months of the year, with high densities in the southern approaches to the Irish Sea in the spring and summer (Wall *et al.,* 2013). The JCP Phase III data presents mean predicted densities in the east Irish Sea of 0.05 individuals per km^2 (Paxton *et al.,* 2016). Similarly, Waggitt *et al.* (2020) and Gilles *et al.* (2023) showed low densities year-round in the Irish Sea, particularly in the east (and thus in the vicinity of the Eni Development Area).

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There are seven records of common dolphin within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021). These records date from 1925, 1975, 1987, 1996 (three records), and 2009.

Risso's dolphin

Ecology and distribution

Risso's dolphins are widely distributed in tropical and temperate seas, with a preference for steep, shelf-edge habitats (Baird, 2009). Risso's dolphins feed almost exclusively on squid and octopus but may also eat cuttlefish and fish (Clarke and Pascoe, 1985; Santos *et al.*, 1994). In the UK and Ireland, the majority of sightings have been reported around the Hebrides, western English Channel, the Celtic Sea and the Irish Sea, where they are typically encountered in groups of up to 20 animals (Reid *et al.,* 2003). Risso's dolphin are not particularly common, but are regularly sighted in the southern Irish Sea, off the Co. Wexford coast in south-east Ireland, west of Pembrokeshire, off the western end of the Llŷn Peninsula around Bardsey Island and beyond, off north-west and north Anglesey, and around the Isle of Man (Reid *et al.,* 2003; de Boer *et al.,* 2002; Stevens, 2014; MWDW, 2022). The modelled distributions presented in the updated Welsh Marine Atlas suggest that the major part of the population occurs in the southern Irish Sea (Evans and Waggitt, 2023). The quarterly modelled density maps for Risso's dolphin, measured as the mean density per cell across months within a season, are shown in Figure 4.9 (Evans and Waggitt, 2023).

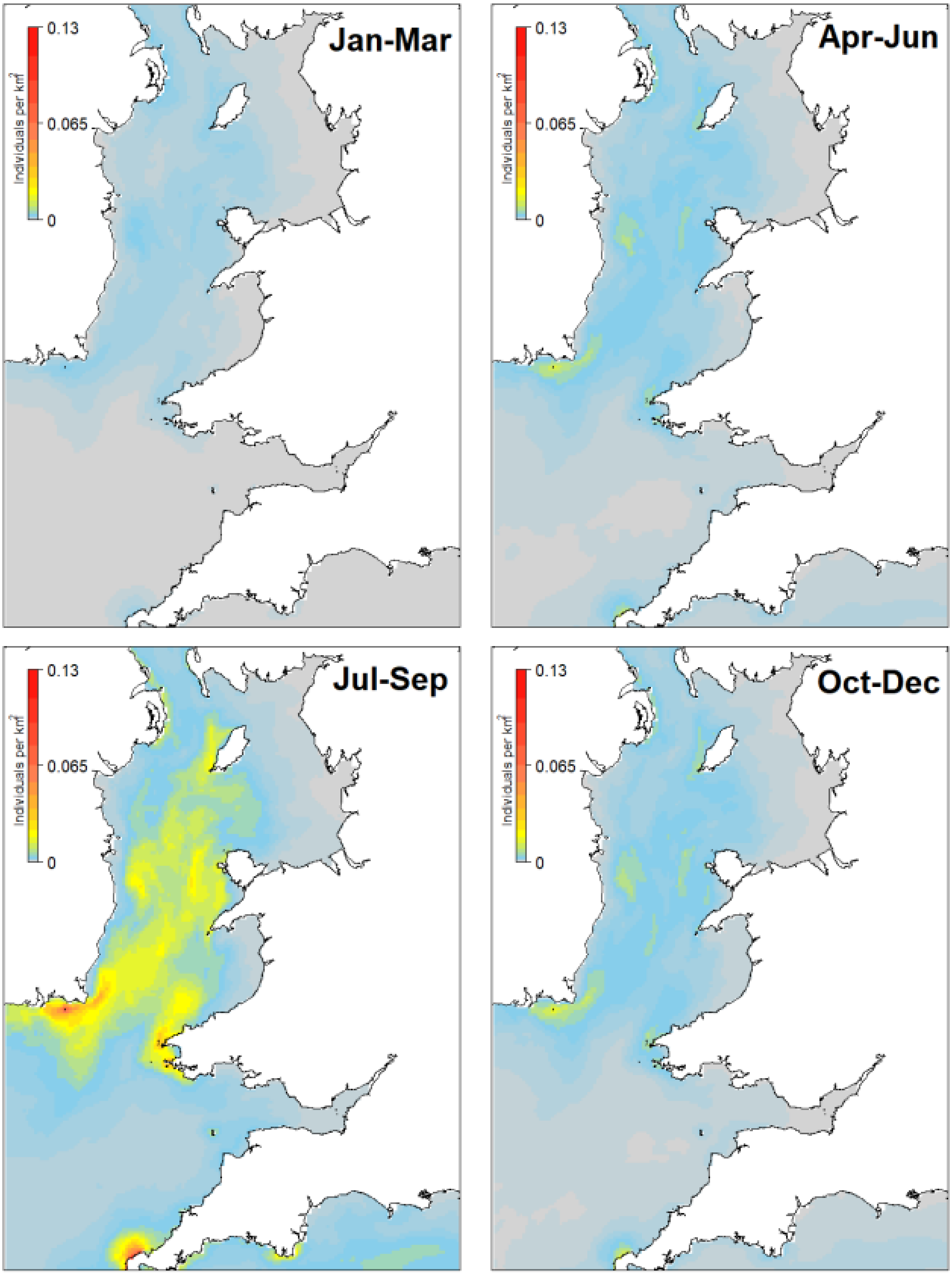

Figure 4.9: Risso's Dolphin modelled densities by quarter (taken from Evans and Waggitt, 2023)

Abundance within the Regional Marine Mammal and Marine Turtle Study Area

Broad scale abundance estimates are available for Risso's dolphin, with all UK waters considered to be part of the Celtic and Greater North Seas MU (Table 4.8). The most recent abundance estimate of Risso's dolphin in this MU is 12,262 animals (CV = 0.46, 95% CI = 5,227 to 28,764; IAMMWG, 2022).

The Eni Development Area is situated within block F for the 2016 SCANS-III surveys but no Risso's dolphin were sighted within the block. They were recorded in the adjacent Block E, however, with an estimated abundance of 1,090 animals (95% CI = 0 to 2,843) and mean group size of 7.50 (CV = 0.200) (Table 4.5) (Hammond *et al.,* 2021). There were also no Risso's dolphin recorded in block D, which partially overlaps with the regional marine mammal and marine turtle study area. Abundance estimates in the ObSERVE surveys ranged from 35 animals in stratum 5 during summer 2015 to 809 animals in stratum 4 during summer 2016 (Table 4.7) (Rogan *et al.,* 2018). The JCP Phase III analysis estimated predicted abundances in the Irish Sea per season during 2010, with 70 animals in spring, 30 in summer, and zero in autumn and winter (Paxton *et al.,* 2016).

No Risso's dolphins were sighted in the SCANS-IV block CS-E, which overlaps with the Eni Development Area. They were recorded in the adjacent block CS-D, with an estimated abundance of 75 (95% CI = 2 to 259) (Table 4.6) (Gilles *et al*., 2023). Risso's dolphin were also recorded in the SCANS-IV survey block CS-C, which overlaps partially with the Proposed Development marine mammal and marine turtle study area (Figure 4.3), which has an estimated abundance of 205 animals (95% CI = 3 to 721) (Table 4.6) (Gilles *et al*., 2023).

Density within the Regional Marine Mammal and Marine Turtle Study Area

The distribution of Risso's dolphin in the Irish Sea appears to be localised, with a wide band running from south-west to north-east, encompassing Pembrokeshire, the western end of the Lleyn Peninsula and Anglesey, the south-east coast of Ireland, and around the Isle of Man (Baines and Evans, 2012; Evans and Waggitt, 2023) (; Figure 4.9). Sightings data from MWDW indicate that Risso's dolphin are widespread in the waters around the Isle of Man, extending out towards the Eni Development Area (MWDW, 2022). Risso's dolphin is also the most commonly sighted dolphin in Manx territorial waters (Felce, 2014), although this publication does not provide abundances or density estimates. Seasonal and long-term site fidelity in the waters off Bardsey Island in Cardigan Bay has been demonstrated through photo-identification studies (de Boer *et al.,* 2013; Eisfeld-Pierantonio and James, 2018).

The JCP Phase III modelling predicted mean densities of 0.004 animals per km^2 across the entire UK and North Sea waters, with some areas of high density around the Isle of Man and the West of Anglesey (Paxton, *et al.,* 2016). During the ObSERVE survey, estimates of Risso's dolphins in the strata that overlapped with the regional marine mammal and marine turtle study area ranged from 0.0001 to 0.565 animals per km^2 (Table 4.7) (Rogan *et al.* (2018). Most recently, Waggitt *et al.* (2020) demonstrated densities in the Irish Sea to be higher in the summer months between June and September than any other time of the year. Finally, from the observations recorded during SCANS-IV surveys, as presented in Table 4.6, Risso's dolphin density is estimated to be 0.0022 animals per km^2 in block CS-D and 0.0057 animals per km^2 in block CS-C (Gilles *et al*., 2023).

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There is one Risso's dolphin record within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021) from the Merseyside BioBank in 2017.

Minke whale

Ecology and distribution

The minke whale is a small mysticete (baleen) whale that is regularly sighted around the UK and Ireland. Minke whales typically occur in depths of less than 200 m. They tend to be observed alone, in pairs or threes but have been observed in groups of up to 15 animals in areas of high prey density (Reid *et al.,* 2003; Anderwald *et al.,* 2007). Most sightings are of single individuals but aggregations of minke whale may occur when feeding conditions are good, for example 19 were seen over a small area south of the Isle of Man in June 2021 (Evans and Waggitt, 2023). They are known to display low energy foraging by exploiting prey resources that other species have herded. Sandeel, shad, sprat, and herring are key prey items (Robinson and Tetley, 2007). Within the Irish Sea, there are two known herring stocks, and it has been suggested that minke whale distribution mirrors these stocks throughout the year (Bowers, 1980). In addition, dedicated surveys collated in the updated Welsh Marine Atlas show the greatest number of minke whale sightings to occur in the St George's Channel westwards from Pembrokeshire across the Celtic Deep to Co. Wexford, and from Co. Dublin north-eastwards to around the Isle of Man (Evans and Waggitt, 2023). They also display a strong seasonality in sightings with most recorded during April to September, a few recorded in and around the Celtic Deep in October to December, and virtually none recorded between January and March. These seasonal differences are reflected in the modelled distribution maps by quarter shown in Figure 4.10.

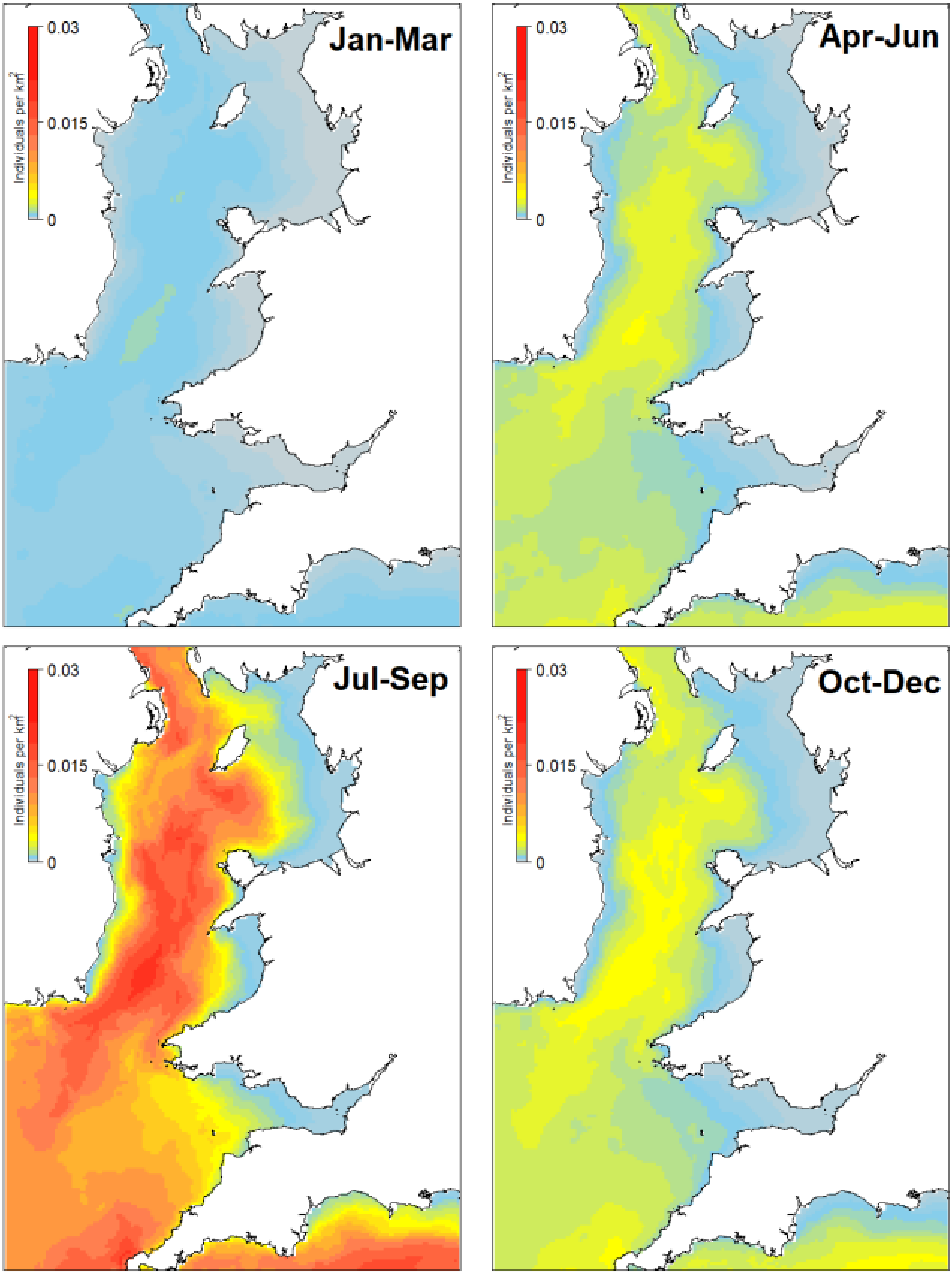

Figure 4.10: Minke whale modelled densities by quarter (taken from Evans and Waggitt, 2023)

Abundance within the Regional Marine Mammal and Marine Turtle Study Area

Broad scale abundance estimates are available for minke whale, with all UK waters considered to be part of the Celtic and Greater North Seas MU (Table 4.8). The most recent abundance estimate of minke whale in this MU is 20,118 animals (CV = 0.18, 95% CI = 14,061 to 28,786; IAMMWG, 2022).

The Eni Development Area is situated within block F for the 2016 SCANS-III surveys, but no minke whale were recorded in this block. However, the regional marine mammal and marine turtle study area also encompasses block E, which had an abundance of 603 animals was estimated for this block (CV = 0.618, 95% CI = 134 to 1,753) and a mean group size of one individual (Table 4.5) (Hammond *et al.,* 2021). The regional marine mammal and marine turtle study area also overlaps with block D, which had an estimated abundance of 543 animals (CV = 0.755, 95% CI = 0 to 1,559) and a mean group size of one individual (Table 4.5) (Hammond *et al.,* 2021).

Minke whale were however observed within block CS-E for the SCANS-IV surveys conducted in summer 2022, which overlaps with the Eni Development Area, which had an estimated 108 animals (95% CI = 1 to 491) (Table 4.6) (Gilles *et al*., 2023). Minke whale were also recorded in the adjacent block CS-D, with an estimated abundance of 477 (95% CI = 85 to 1,425) (Table 4.6) (Gilles *et al*., 2023).

The JCP Phase III analysis presented abundance estimates in the Irish Sea for each season in 2010, with 40 animals in spring, 190 in summer, 20 in autumn, and ten in winter (Paxton *et al.,* 2016). Rogan *et al.* (2018) presented abundance estimates ranging from 180 individuals in stratum 5 to 2,242 individuals in stratum 8, both during summer 2016 (Table 4.7).

Density within the Regional Marine Mammal and Marine Turtle Study Area

Within the Irish Sea, minke whales mainly occur in the south and west of the area (Hammond *et al*., 2005), and are present from late April to early August (Wall *et al.,* 2013). This is confirmed by a high degree of seasonality to the waters around the Isle of Man, with presence between June and November (Howe, 2018b; Evans and Waggitt, 2023) (; Figure 4.10). A clear spatial aspect to the distribution of Minke whale sightings is evident in Manx waters, with the majority of summer sightings on the west coast of the island, whereas in the autumn most sightings are on the east coast which may reflect the different spawning periods of the two Irish Sea herring stocks (Howe, 2018b).

Sighting data from MWDW confirm minke whales are widespread in waters around the Isle of Man, with some sightings to the north and north-west of the Eni Development Area and towards the coast of Northern Ireland (MWDW, 2022). High minke whale density of 0.027 to 0.036 animals per km^2 around the Isle of Man, and moderate densities across the entire Irish Sea (0.012 to 0.02 animals per km^2) have been extrapolated from the SCANS-III data (BEIS, 2022). The JCP Phase III analysis presented mean densities of 0.022 animals per km^2 across the entire UK, with some areas of relative high density around the Isle of Man (0.1 animals per km^2 in summer 2010) (Paxton *et al.,* 2016). Estimated densities based on the ObSERVE surveys ranged from 0.004 to 0.070 animals per km^2 (Table 4.7) (Rogan *et al.,* 2018).

Most recently, Waggitt *et al.* (2020) showed areas of low minke whale density in the Irish Sea compared to areas in north-west Scotland, with higher densities from June to October. In comparison to UK and Irish waters as a whole, densities were found to be low in the east Irish Sea region, with the highest predicted densities in August with 0.0409 animals per km^2. Densities were estimated to be higher in the mid channel and west side of the Irish Sea, particularly around the Isle of Man from July to November, and towards the west of the Irish Sea (Waggitt *et al.,* 2020). From the observations recorded during SCANS-IV surveys, as presented in Table 4.6, Minke whale density is estimated to be 0.0088 animals per km^2 in block CS-E and 0.0137 animals per km^2 in block CS-D (Gilles *et al.,* 2023).

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There are 13 records of minke whale within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021). These records date from 1948 – 2013.

Grey seal

Ecology

Grey seal are the larger of the two seal species that breed in UK and Irish waters, with males weighing up to 300 kg and females up to 200 kg (SCOS, 2021). Around the UK and Ireland, grey seals gather in colonies on land at haul-outs to rest, breed, moult, and engage in social activity. Grey seal breeding occurs between September to December, with moulting occurring between November to April (Harwood and Wylie, 1987). They exhibit site fidelity, and females tend to return to their natal haul out in order to give birth. In the UK, pups tend to be born between August and November (SCOS, 2021). In UK waters, the majority of pups are born in Scotland (84%), however, within the regional marine mammal and marine turtle study area, there are smaller colonies including Lundy, islands off Pembrokeshire and the Lleyn Peninsula, and east Northern Ireland.

Grey seal are generalist feeders, mainly foraging on the seabed at depths of up to 100 m for a wide variety of species. They display regional and temporal differences in diet, with individuals in shallow waters showing a preference for benthic prey such as flatfish and cephalopods, and individuals in deeper waters targeting pelagic and benthopelagic fish such as blue whiting and sandeel (Gosch, 2017). Grey seals tend to forage in open sea and return to land regularly to haul out. Although they can undertake wide-ranging foraging trips which last anywhere between 1 to 30 days. Most foraging is likely to occur within 100 km of haul outs (SCOS, 2021).

Pup production, population estimates, and abundances

Grey seal population size estimates around the UK are derived from pup production surveys and the total breeding population at the start of the season (before pups are born). The most recent estimates are presented in Table 4.10. The largest breeding population in the Irish Sea and south-west UK is in Pembrokeshire, accounting for 4% of the UK breeding population (Strong and Morris 2010, Stringell *et al*. 2014). Most of this pup production is located around Yyns Dewi/Ramsey Island and the north Pembrokeshire mainland coast between St David's Head and the Teifi Estuary (Morgan *et al.,* 2018). In north Wales, smaller breeding populations can be found on the west coast of Anglesey and the Lleyn Peninsula (Figure 4.11).

Grey seal pup production in the regional marine mammal and marine turtle study area is comparatively low compared to other parts of the UK, such as Scotland and the east coast of England (Figure 4.11) (SCOS, 2021). The most recent estimate of total pup production in the UK was 67,850 in 2019 (see Table 4.10), with an estimated population size of 157,300 in 2020 (SCOS, 2021). The majority of this, however, is attributed to Scotland and the north-east of England (Figure 4.11). Colonies within the regional marine mammal and marine turtle study area are surveyed less frequently than those in Scotland and on the east coast of England, however 7,200 pups were estimated to have been born in Wales and at less frequently surveyed colonies in south-west England, Northern Ireland, Shetland, and at scattered locations around Scotland (SCOS, 2021).

Table 4.10: Grey Seal Pup Production by country (based on 2019 pup production estimates) and Total Population Estimates at the start of the 2020 breeding season. (Source: SCOS, 2021)

Location	Pup Production in 2019	2020 Population Estimate
Scotland	54,050	120,800
England and Isle of Man*	11,300	30,700
Wales	2,250	5,200
Northern Ireland	250	600
Total	67,850	157,300

Pup production numbers rounded to nearest 50 pups and total population rounded to nearest 100.

There are two main grey seal haul-outs in the NW England MU: one in the Dee Estuary on the Welsh-English border (Hilbre Island), and one in South Walney. The August count at Walney Island was 248 in 2019 and 300 adults in 2020. It has been a pupping site since 2015 and numbers are currently still low (2-10 pups produced per year), however data suggest grey seal abundance is steadily increasing (SCOS, 2020). Data are not available for the Dee Estuary haul-out(SCOS, 2020). In north Wales, grey seals mainly haul-out around the coast of Anglesey (including the Skerries), near Llandudno (Angel Bay) and the Dee Estuary (Hilbre North and West Hoyle Sandbank). There were 236 unique individuals identified at the Dee Estuary haul-out by the Irish and Celtic Sea Database for Grey Seal (EIRPHOT) Photo-ID data showed connectivity between the Dee Estuary and the Skerries, with some connectivity with Cardigan Bay and Skomer (Langley *et al.,* 2018).

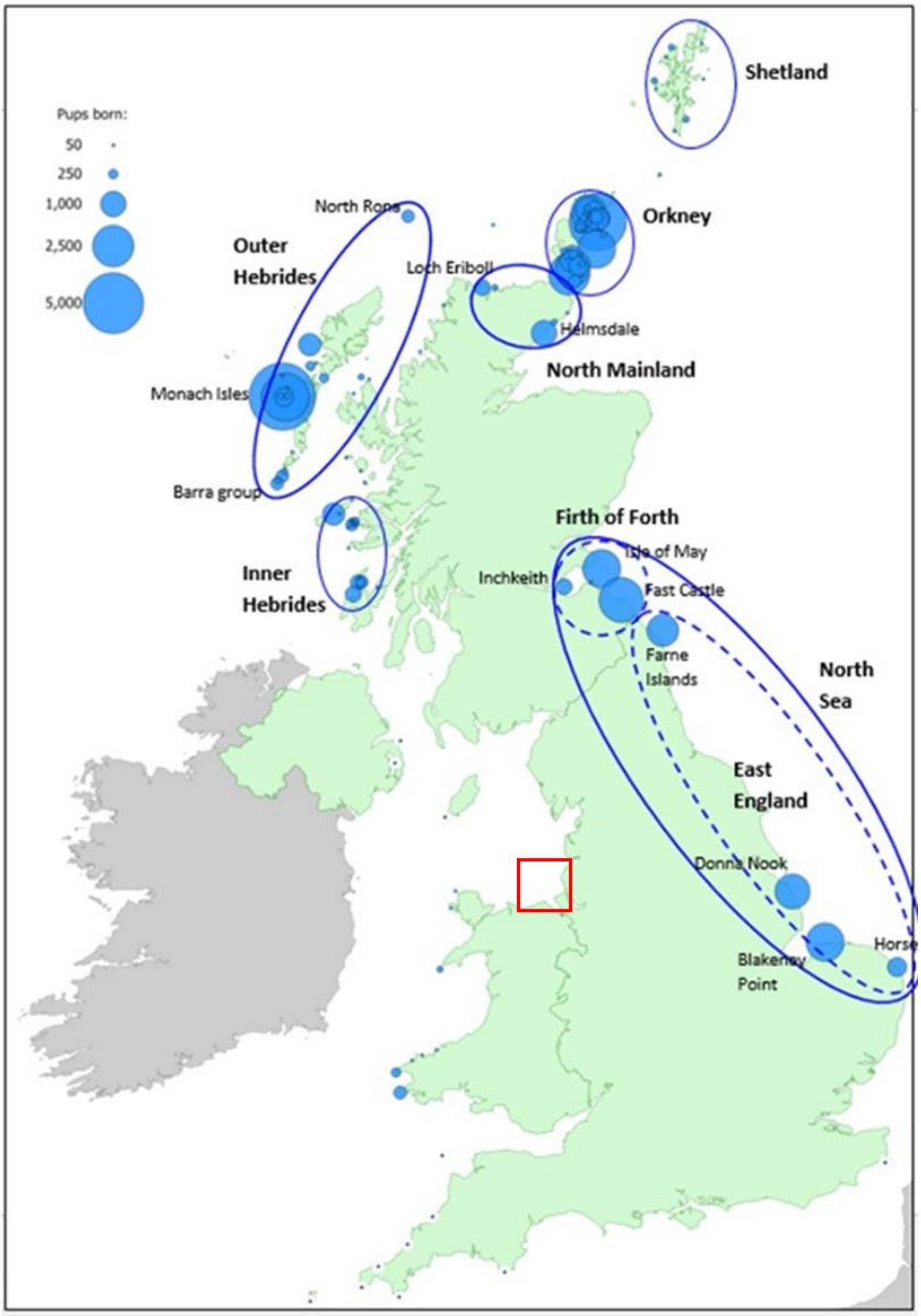

Figure 4.11: Distribution And Estimated Pup Production Of The Main Grey Seal Breeding Colonies In The UK And Isle Of Man. (Solid Blue Ovals = Groups Of Regularly Monitored Colonies Within Each

Region, Dashed Ovals = Sites Routinely Monitored By Aerial Survey, Red Square = Location Of The Proposed Development Marine Mammal And Marine Turtle Study Area) (Source: SCOS, 2021)

There are limited data available on three of the five MUs within the regional marine mammal and marine turtle study area (Wales, NW England, and SW England), and numbers should be regarded as rough estimates. The most recent August haul out counts of grey seal in the Wales MU, NW England MU, and SW England MU were 900, 250, and 500, respectively (SCOS, 2020). In the SW Scotland MU, grey seal August haul-out counts have seen a steady increase from 75 in the 1997 period to 517 in the 2016-2019 period (SCOS, 2020). The value of 517 can be scaled to account for the proportion of the population at sea at the time of the survey, resulting in a population estimate of 2,163 grey seal in the South-west Scotland MU in the 2016 – 2020 period (SCOS, 2020). In the Northern Ireland MU, August haul-out counts have increased from 272 in the 2000-2006 period to 505 in the 2016-2019 period, resulting in the most recent population estimate of 2,113 grey seal in the Northern Ireland MU (SCOS, 2020). There is an indication of a growing population in these areas, however due to the lack of dedicated surveys a population trend cannot be estimated (SCOS 2021). The August haul out counts in these five MUs is low in comparison to those elsewhere in the UK, such as North East England, South East England, East Scotland, and the Western Isles (Figure 4.12) (SCOS, 2020).

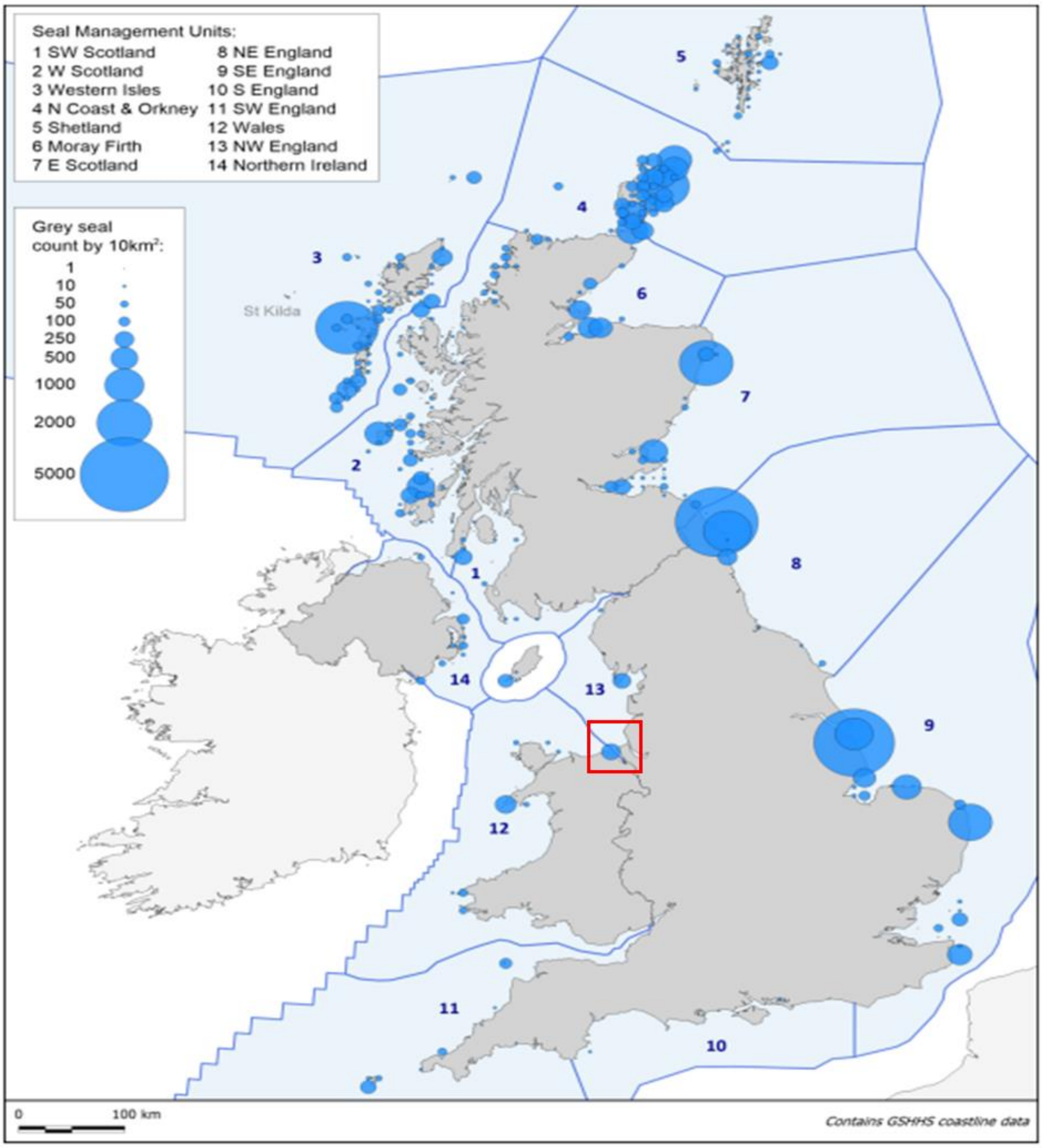

Figure 4.12: August Distribution Of Grey Seal Around The UK (Red Square = Location Of The Proposed Development Marine Mammal And Marine Turtle Study Area) (Source: SCOS, 2020)

The Manx Marine Environmental Assessment presents an estimated 350 to 400 individual grey seal on the Isle of Man (Howe, 2018b) and monthly counts on the island have ranged from 135 to 405 individuals (Sharpe, 2007). At the south end of the Isle of Man, there is a resident population estimated at 50 seals, which is included in the total population estimate given above.

Duck and Morris (2019) provide counts of grey seals in Northern Ireland. In the most recent survey (2017/2019) 418 grey seal were recorded in the East region, and 556 grey in the south -east. Using population scalars from Russell *et al.* (2016), this leads to population estimates of 1,749 grey seal for the East region and 2,326 for the south-east Region.

Density within the Proposed Development Marine Mammal and Marine Turtle Study Area

Carter *et al.* (2022) present at-sea distribution of grey seal around the UK and Ireland (Figure 4.13). They demonstrated areas of high at-sea usage for grey seals around Liverpool Bay, the east coast of Ireland, and to the north-west of the Isle of Man (Figure 4.13). Distribution and predicted number of grey seal in the Proposed Development marine mammal and marine turtle study area are illustrated in Figure 4.14, which shows areas of high seal at-sea density in the inshore areas of Liverpool Bay, with a peak of more than 100 animals per 25 km^2 around East Hoyle Spit and moderate densities (>5 to 10 animals per 25 km^2) further out from Liverpool Bay and to the south-west of the Isle of Man (Carter *et al.,* 2022). These at-sea distribution maps improve on those in Carter *et al.* (2020) and have increased potential for ecological insights at regional and population wide scales. Carter *et al.* (2020) identified finer scale seasonal movements, with seals transitioning between sites within the Irish Sea, but not leaving Wales.

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There are approximately 599 records of grey seal within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021). These records date from 1905 – 2022.

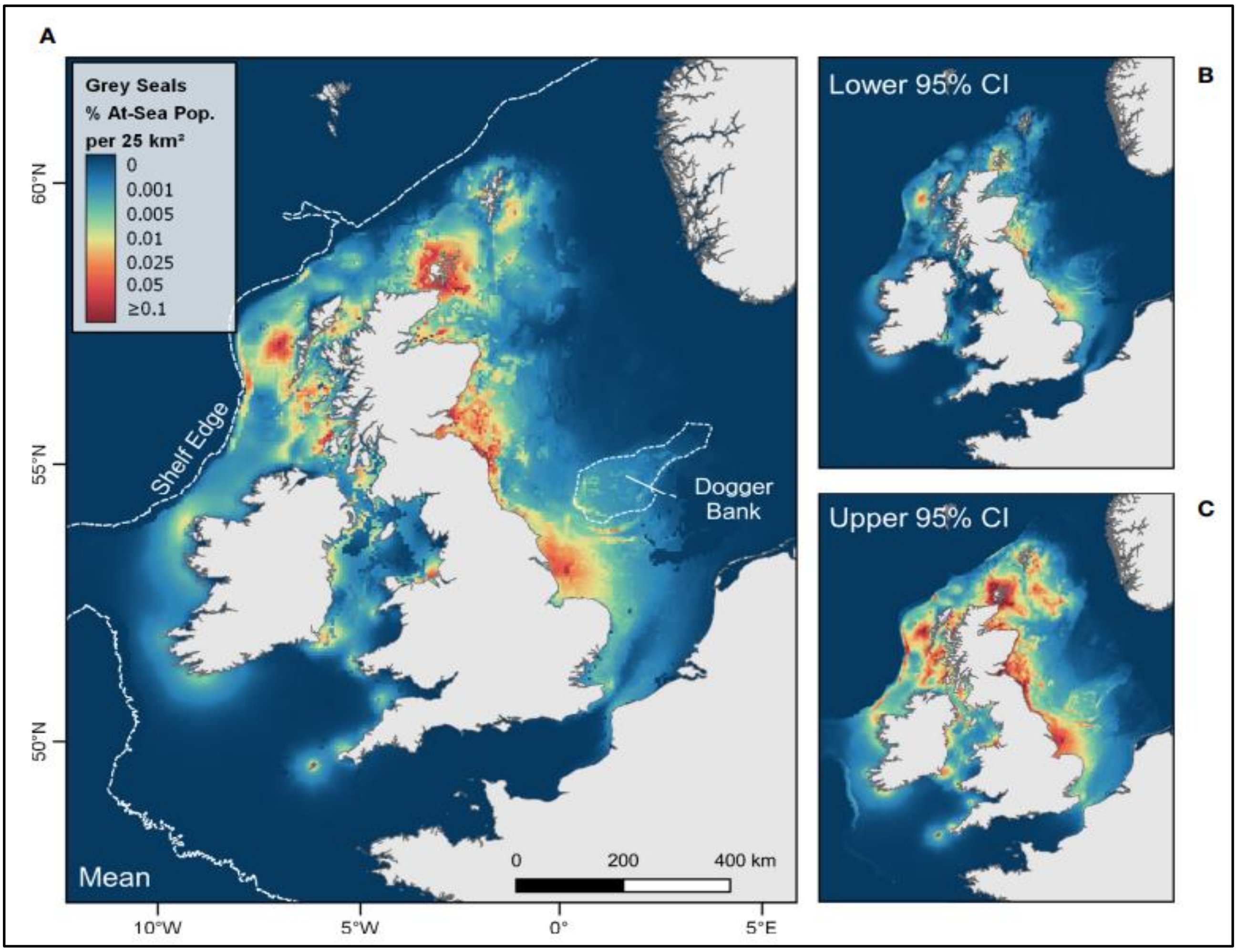

Figure 4.13: Grey Seal At-Sea Distribution (Source: Carter *et al.,* 2022)

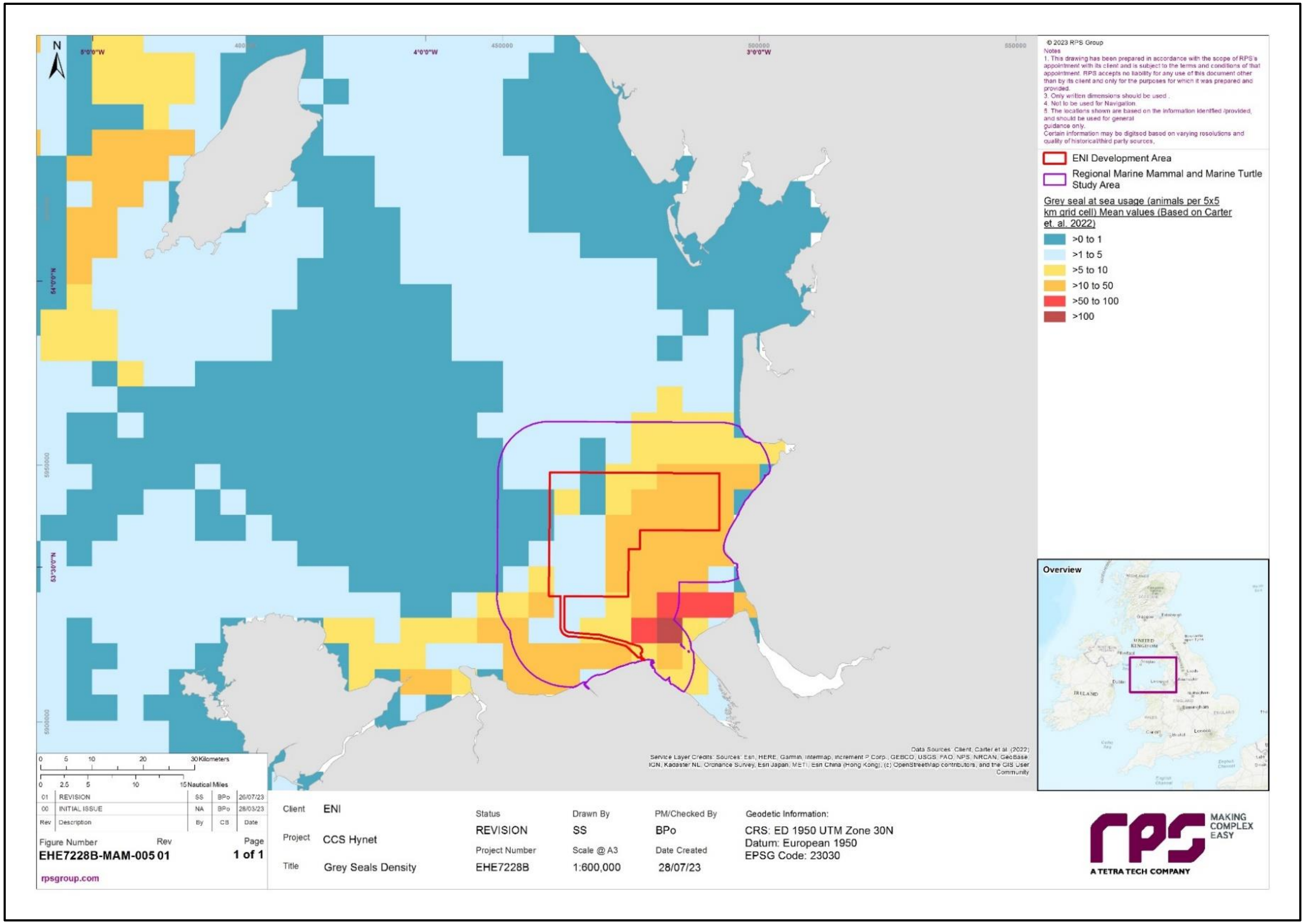

Figure 4.14: Grey Seal Usage At Sea In The Vicinity Of The Eni Development Area (Carter *et al*, 2022)

Harbour seal

Ecology and distribution

The harbour seal is the smaller of the two species of seal that breed around the British Isles, typically weighing between 80 to 100 kg (SCOS, 2021). Breeding and moulting take place between June and August (Carter *et al,* 2022). Pups are born in June and July and can swim within a few hours of birth (Burns, 2002). It is thought that different sex and age classes haul out at different times during the moulting season with juvenile harbour seals moulting earliest and adult males latest (Thompson and Rothery, 1987; Daniel *et al*., 2003; Cronin *et al.,* 2014). Moulting seasons have been shown to differ between Ireland, Scotland and the Wadden Sea (Cronin *et al*., 2014) and it has also been suggested the timing of the moult also varies throughout the UK.

Harbour seals disperse from their haul outs in order to forage at sea and are likely to travel directly to areas of previous foraging success (Bailey *et al.,* 2014). They are opportunistic generalist feeders, consuming a wide range of prey, such as sandeels, herring, sprat, cephalopods, flatfish, and gadoids (Kavanagh *et al.,* 2010; Wilson and Hammond, 2019). They typically forage within 50 km of the coast (SCOS, 2021) though females forage during lactation and therefore may foraging over smaller distances as they need to regularly return to their pups (Thompson *et al.,* 1994). Carter *et al.* (2022) found that distance to haul-out was the primary factor determining harbour seal distribution in all regions. Harbour seals may be particularly vulnerable to changes in prey abundance or disturbance events from human activities due to this constraint on their foraging range, particularly during the breeding season (Bailey *et al.,* 2014).

Pup production, population estimates, and abundances

The UK and Ireland harbour seal population accounts for approximately 36% of the Eastern Atlantic pup production (SCOS, 2020). Carter *et al.* (2022) identified large congregations in Shetland, The Wash (in south-east England) and west Scotland, with adjacent high density at-sea areas. The most recent harbour seal counts show highest numbers in west Scotland, Shetland, and south-east England (Figure 4.15) (SCOS, 2021).

Combining the most recent counts (2016-2019) at all sites in Scotland and 2021 counts in South-east England, approximately 31,500 harbour seals were counted in the UK, with the vast majority in Scotland (Table 4.11) (SCOS, 2021). Including the 4,000 seals counted in Ireland, there is therefore an estimated 35,500 harbour seal in the British Isles (SCOS, 2021).

Table 4.11: UK Harbour Seal Population Estimates, Based On Counts During The Moulting Season, Rounded To The Nearest 100 (Source: SCOS, 2021)

Location	Most Recent Count (2016-2021)	Total Population Estimate (with 95% CI)
Scotland	26,800	37,200 (30,400 – 49,600)
England	3,600	5,000 (4,100 – 6,700)
Northern Ireland	1,000	1,400 (1,100 – 1,900)
Wales*	<10	<15
Total UK	31,500	43,750 (38,500 – 58,300)

*There are no systematic surveys for harbour seal in Wales

Harbour seal surveys are conducted in the summer and early autumn and consist of counts of breeding and moulting seals. Breeding seals are surveyed annually, in June and July annually in a small number of key areas (such as the Moray Firth and, in recent years, in Lincolnshire and Norfolk). The main harbour seal population surveys are conducted during the moulting season in the first three weeks of August when the greatest and most consistent numbers of harbour seal are hauled-out during for their annual moult. The frequency of the moulting surveys differs, with annual moult surveys carried out in key areas such as Lincolnshire and Norfolk, the Moray Firth, and the Firth of Tay, with the remainder of the UK surveyed approximately every four to five years, although there is considerable variation between areas.

There are five seal MUs within the regional marine mammal and marine turtle study area, however there are limited data available for three of them: the Wales MU, NW England MU, and SW England MU, with the most recent August haul-out counts of ten, five, and zero, respectively (SCOS, 2021). Based on the proportion of the population estimated to be hauled out during the survey window, these counts provide rough population estimates of 13 individuals in the Wales MU (95% CI = 11-18) and six in the NW England MU (95% CI = 5-9) (SCOS, 2021). Harbour seal counts in these three MUs are low in comparison to the total counts for the UK and Ireland presented in Table 4.11. In the period between 2016 and 2021, there were 1,709 harbour seals counted in the SW Scotland MU and 1,012 in the Northern Ireland MU (Figure 4.15) (SCOS, 2021). Based on these counts, the estimated population size of harbour seal in the SW Scotland MU was 2,373 (95% CI = 1,942-3,164) and 1,405 (95% CI = 1,150-1,874) in the Northern Ireland MU (SCOS, 2021).

The Manx Marine Environmental Assessment reports that harbour seals are rare in the waters around the Isle of Man, but are observed in small numbers throughout the year around the Sound and Maughold Head areas, more commonly during summer (Howe, 2018b).

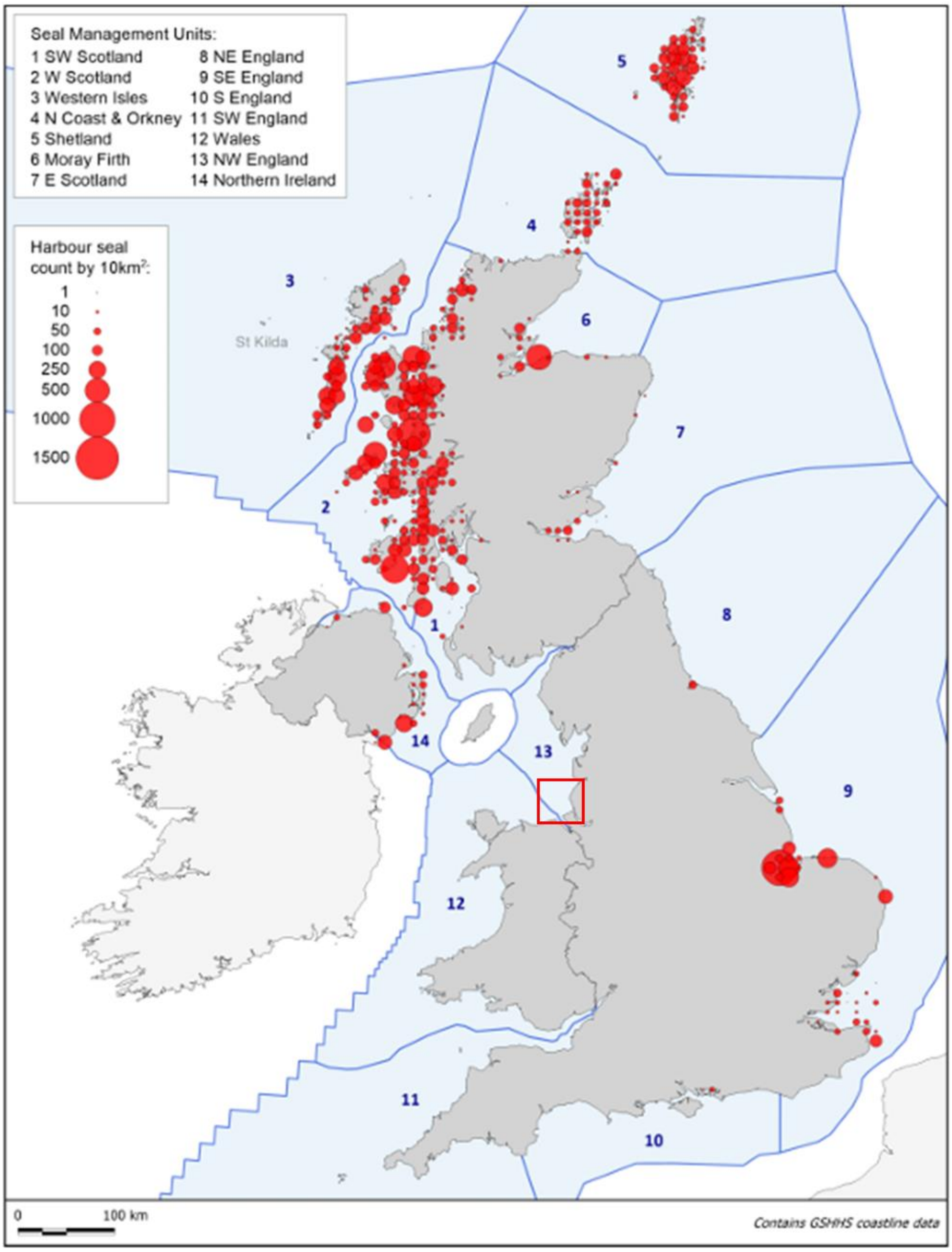

Figure 4.15: August Distribution Of Harbour Seal Around The UK. There Were Limited Data Available For MUs 10 – 13 (Red square = Location Of The Proposed Development Marine Mammal And Marine Turtle Study Area) (Source: SCOS, 2021)

Density within the Proposed Development Marine Mammal and Marine Turtle Study Area

Carter *et al.* (2022) present at-sea distribution of harbour seal around the UK and Ireland (Figure 4.16). They demonstrated areas of low at-sea density around Liverpool Bay, the east coast of Ireland, and to the north-west of the Isle of Man (Figure 4.17). Mean harbour seal at-sea density is low in the Proposed Development marine mammal and marine turtle study area (Carter *et al.*, 2022), with the highest concentration in the regional marine mammal and marine turtle study area along the east coast of Northern Ireland (Figure 4.16). Within the Proposed Development marine mammal and marine turtle study area, the average density of harbour seals at sea was estimated at 0 to 1 animals per 25 km², with a small area near the Dee Estuary of 1 to 5 animals per 25 km² (Figure 4.17).

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There are approximately 128 records of harbour seal within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021). These records date from 1907 – 2021.

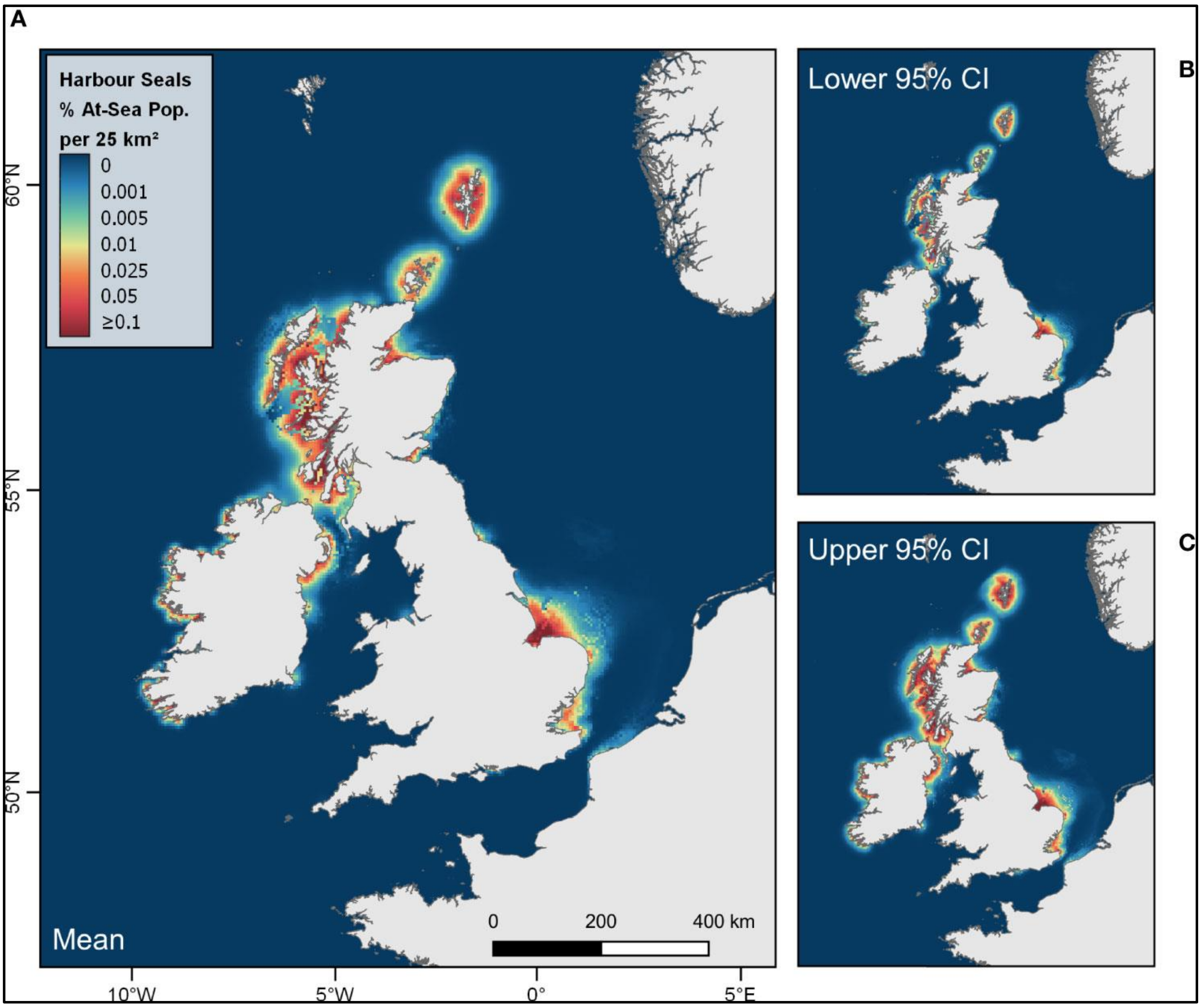

Figure 4.16: Harbour Seal At-Sea Distribution (Source: Carter *et al.,* 2022)

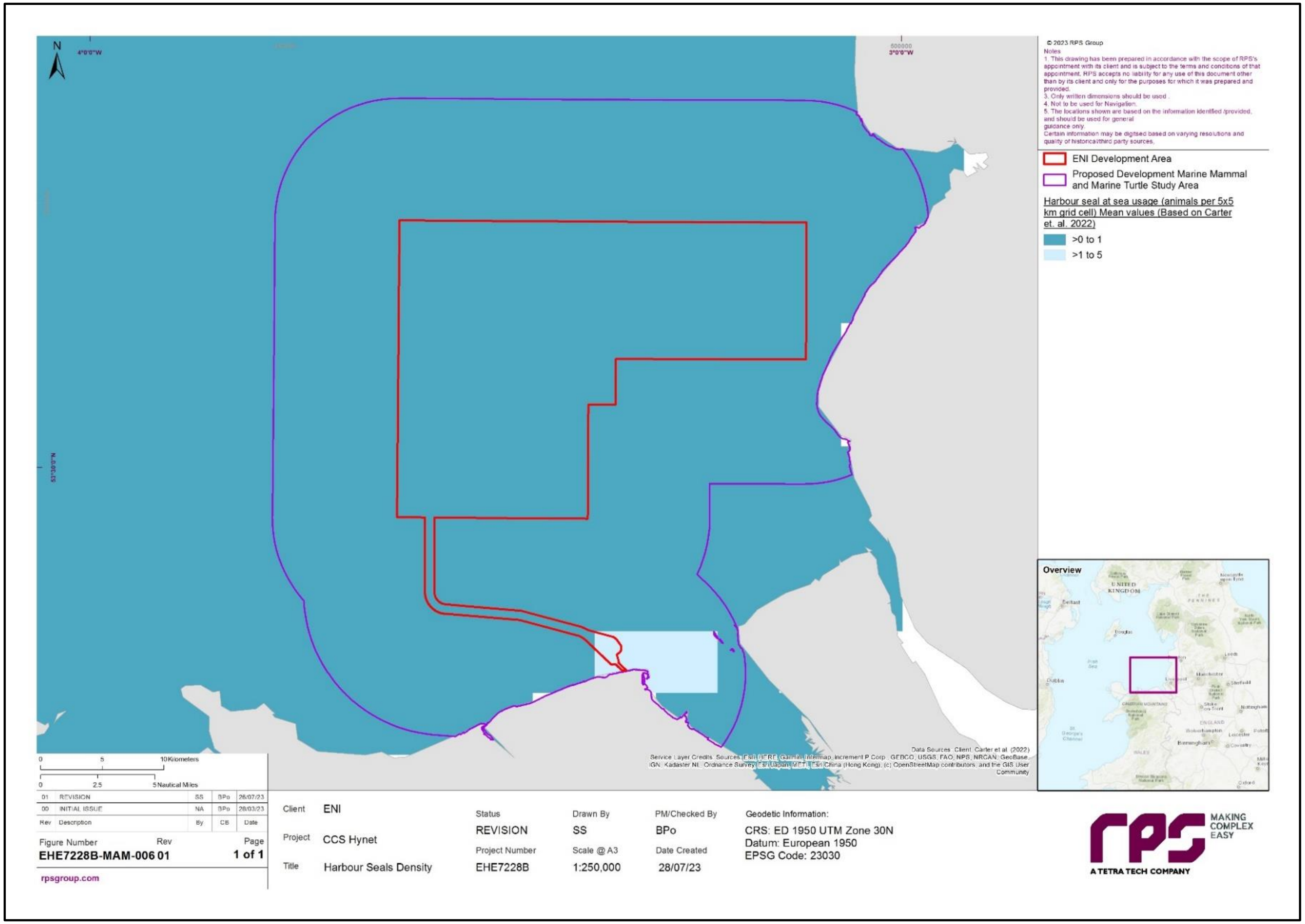

Figure 4.17: Harbour Seal Usage At Sea In The Vicinity Of The Eni Development Area (Carter *et al*, 2022)

Marine turtles

Ecology and distribution

Six marine turtle species have been recorded around the British Isles, where they are at the northern limit of their distribution.

Juvenile marine turtles migrate into offshore oceanic habitats to grow and develop (Mansfield *et al.,* 2014; Putman and Mansfield, 2015). They use oceanic currents during their juvenile phase, with the North Atlantic Subtropical Gyre, the Azores Current and the North Atlantic Current likely facilitating their dispersal from tropical and subtropical latitude's to the European continental shelf (Carr, 1987; Collard and Ogren, 1990; Bolten, 2003; Witt *et al.,* 2007a).

Marine turtles are most commonly recorded on the west coast of the UK and around Ireland. The total sightings and strandings of all species between 2011 to 2021 are presented in Figure 4.18. Overall, a total of 2,882 marine turtles have been recorded between 1748 to 2021, with the majority identified as leatherback turtle (n = 2,172), followed by unidentified species (n = 394), loggerhead turtle (n = 268), Kemp's ridley turtle (n = 76), green turtle (n = 15), hawksbill turtle (n = 1), and olive ridley turtle (n = 1) (Penrose *et al.,* 2022). The majority pf these records are derived from Ireland (Table 4.12).

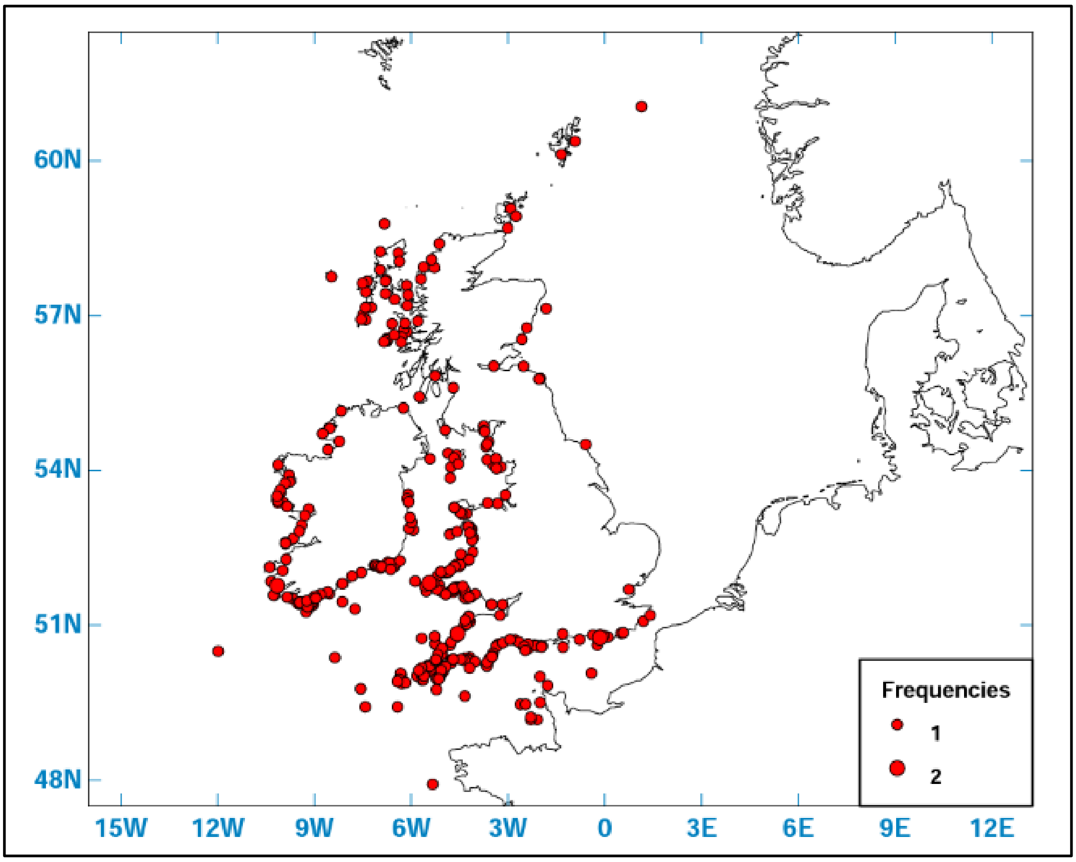

Figure 4.18: Total Sightings And Strandings Of All Marine Turtles Recorded Around The UK And Ireland Between 2011 To 2021 (Penrose *et al.,* 2022)

Table 4.12: Number Of Sightings And Strandings Of All Marine Turtles Between 1748 And 2021 By Country (Penrose *et al.,* 2022)

Country	Number of Sightings and Strandings of all Marine Turtle Species	
	2021	1748 to 2021
Ireland	6	1,358
England	7	699
Scotland	11	425
Wales	5	292
Northern Ireland	0	41
Isle of Man	1	37
Channel Islands	0	17
Offshore waters	0	13
Total	**30**	**2,882**

Seasonality

Marine turtles tend to occur seasonally in UK and Irish waters, with leatherback turtles commonly present in the summer and autumn where they feed on jellyfish and salps (Godley *et al.,* 1998; Hays *et al.,* 2006; Houghton *et al,* 2006; King and Berrow, 2009; Witt *et al.,* 2007a, 2007b). In contrast, hard-shell species, such as loggerhead and Kemp's ridley turtles, are more common in the autumn and winter months, when waters are coolest (Witt *et al.,* 2007a; Botterell *et al.,* 2020).

Abundance and density

Calculating abundance and density estimates of marine turtles in UK and Irish waters is difficult and likely to be inaccurate for several reasons. Primarily, there are no designated MUs and regular monitoring programmes In contrast to marine mammals, with most of the information on marine turtles derived from strandings and incidental sightings. Although these records provide some insight into the general distribution of different species, unquantifiable survey effort, mistakes in identification, and oceanographic and biological factors (such as currents and decomposition rates) lead to inaccuracies in the data. As such, there are currently no abundance and density estimates available for marine turtles within the regional marine mammal and marine turtle study area or Proposed Development marine mammal and marine turtle study area, including OSPAR Status Assessments for leatherback turtle and loggerhead turtle (OSPAR Assessment Portal, 2023a, 2023b).

Records within the Proposed Development Marine Mammal and Marine Turtle Study Area

There were a total of eight marine turtles recorded within the Proposed Development marine mammal and marine turtle study area on the NBN Atlas (2021) (Table 4.13).

Table 4.13: Marine Turtle Records Within The Proposed Development Marine Mammal And Marine Turtle Study Area (Source: NBN Atlas, 2021)

Species	Scientific Name	Number of Records	Date(s)
Green turtle	Chelonia mydas	0	N/a
Hawksbill turtle	Eretmochelys imbricata	0	N/a

Species	Scientific Name	Number of Records	Date(s)
Kemp's ridley turtle	Lepidochelys kempii	4	2014
Leatherback turtle	Dermochelys coriacea	3	1948, 1998, 2004
Loggerhead turtle	Caretta	1	1960
Olive ridley turtle	Lepidochelys olivacea	0	N/a

4.4 Summary

4.4.1 Regional Marine Mammal and Marine Turtle Study Area

Overall, seven marine mammal species are likely to occur within the regional marine mammal and marine turtle study area. Similarly, six marine turtle species may occasionally occur, which have been grouped together as 'marine turtles'.

The occurrence of cetaceans is often unpredictable due to their highly mobile nature and their distribution in the regional marine mammal and marine turtle study area, particularly within the east Irish Sea, is patchy. Harbour porpoise is the most frequently sighted species, and is recorded throughout the area, whilst Risso's dolphin and common dolphin are sighted more regularly towards the south of the Irish sea. Bottlenose dolphin sightings are highest in the Cardigan Bay SAC compared to the rest of the Irish Sea and regional marine mammal and marine turtle study area.

Harbour seal are concentrated along the coast of Northern Ireland and in the Firth of Clyde, whilst grey seals extensively use areas of the southern Irish Sea, the north of St George's Channel, and Liverpool Bay (Hammond *et al.,* 2005). Harbour seal haul out along the north-east coast of Ireland, with lower presence within Liverpool Bay.

Marine turtles have been recorded more frequently on the west coast of the UK and all around Ireland, thus within the regional marine mammal and marine turtle study area. The most frequently recorded species is the leatherback turtle, which is believed to migrate to the north Atlantic in the summer months to feed on gelatinous prey (such as jellyfish and salps).

4.4.2 Proposed Development Marine Mammal and Marine Turtle Study Area

Localised data within the Proposed Development marine mammal and marine turtle study area are scarce due to the lack of site-specific surveys and the broadscale nature of other marine mammal surveys (e.g. SCANS-III, SCANS-IV, ObSERVE, and SCOS surveys). Nonetheless, the results of site-specific surveys of projects overlapping with the Proposed Development marine mammal and marine turtle study area (e.g. Gwynt y Môr OWF and Awel y Môr OWF) have provided more localised information to characterise the marine mammal baseline (Table 4.9). Harbour porpoise and grey seal were the most common species in these surveys, with bottlenose dolphin, common dolphin, minke whale also recorded (Table 4.9).

The NBN Atlas (2021) also provided marine mammal and marine turtle records within the Proposed Development marine mammal and marine turtle study area. Overall, there were records of 599 grey seal, 237 harbour porpoise, 128 harbour seal, 24 bottlenose dolphin, 13 minke whale, eight marine turtles, seven common dolphin, and one Risso's dolphin.

Overall, the following IEFs have been defined based on the marine mammal and marine turtle species that are likely to be present within the Proposed Development marine mammal and marine turtle study area (Table 4.14). These will be taken forward to the ES, with further detail provided in volume 2, chapter 7.

Table 4.14: Marine Mammal And Marine Turtle IEFs Within The Proposed Development Marine Mammal And Marine Turtle Study Area

IEF	Scientific Name	Importance	Justification
Bottlenose dolphin	*Tursiops truncatus*	International	Listed as a SPI, EPS, and in Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Bottlenose dolphin are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Bottlenose dolphin is also listed in Annex II of the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal and marine turtle study area.
Common dolphin	*Delphinus delphis*	International	Listed as a SPI, EPS, and in Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Common dolphin are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990.
Grey seal	*Halichoerus grypus*	International	Listed as a EPS, and in Appendix I and II of the Bonn Convention, Appendix III of the Bern Convention, and Appendix II of CITES. Grey seal are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Grey seal are also listed in Annex II of the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal and marine turtle study area.
Harbour porpoise	*Phocoena*	International	Listed as a SPI, EPS, and in Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. They are included in the OSPAR list of threatened and declining species within OSAPR Region III (Celtic Seas). Harbour porpoise are also protected in UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Harbour porpoise is also listed in Annex II of the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal and marine turtle study area.

IEF	Scientific Name	Importance	Justification
Harbour seal	*Phoca vitulina*	International	Listed as a SPI, EPS, and in Appendix I and II of the Bonn Convention, Appendix III of the Bern Convention, and Appendix II of CITES. Harbour seal are also protected in UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Harbour seal is also listed in Annex II of the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal and marine turtle study area.
Marine turtles	Green turtle *Chelonia mydas*; hawksbill *Eretmochelys imbricata;* Kemp's ridley *Lepidochelys kempii;* leatherback *Dermochelys coriacea;* loggerhead *Caretta; and* olive ridley *Lepiodchelys olivacea.*	International	Leatherback turtle is included in the OSPAR List of threatened and declining species within OSPAR Region III (Celtic Seas). Loggerhead turtle is also on the OSPAR list, but not within OSPAR Region III (Celtic Seas). Both species are also listed as SPIs. Leatherback, loggerhead, green, hawksbill, and Kemp's ridley turtle are all classed as EPSs. All marine turtles are protected under CITES, and in UK waters under the Wildlife and Countryside Act 1981. Olive ridley turtles are only protected under section 9 (as amended) of the Wildlife and Countryside Act 1981.
Minke whale	*Balaenoptera acutorostrata*	International	Listed as a SPI, EPS, and in Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Minke whales are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990.
Risso's dolphin	*Grampus griseus*	International	Listed as a SPI, EPS, and in Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Risso's dolphin is also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990.

The marine mammal population densities and population estimates that will be taken forward to the assessment in the ES are presented in Table 4.15. As this information is not available for marine turtles, population-based assessment will only be included for marine mammals.

Table 4.15: Summary Of Marine Mammal Densities That Will Be Taken Forward To The Assessment

Species	Density (animals per km²)	Management Unit (MU)[5]	Population Estimate in MU
Harbour porpoise	0.086[1]	Celtic and Irish Sea	62,517
Bottlenose dolphin	0.0082 to 0.035[2]	Irish Sea	293
Short-beaked common dolphin	0.018[3]	Celtic and Greater North Seas	102,656
Risso's dolphin	0.0313[2]	Celtic and Greater North Seas	12,262
Minke whale	0.0173[2]	Celtic and Greater North Seas	20,118
Grey seal	0.467 to 4.06[4]	Wales	3,766
		NW England	1,046
		Northern Ireland	2,113
		SW Scotland	2,163
		Isle of Man estimate	400
		East of Ireland South-east of Ireland	1,749[6] 2,326[6]
		OSPAR Region III	60,780
Harbour seal	0.0049 to 0.593[4]	Wales	14
		NW England	7
		Northern Ireland	1,406
		Isle of Man	No estimate available

[1] SCANS-III (Hammond *et al*., 2021) Block F
[2] SCANS-III (Hammond *et al.,* 2021) for adjacent Block E, as none observed for Block F and high-density coastal area density in outer Cardigan Bay from Lohrengel *et al*. (2018)
[3] SCANS-II (Hammond *et al*., 2013) Block O, as no values for SCANS-III for this species
[4] Carter *et al.* (2022) – average and maximum densities calculated to per km² using absolute mean values for cells overlapping with the Proposed Development marine mammal and marine turtle study area.
[5] All population estimates include the Isle of Man unless population estimate is given separately.
[6] Population estimates based upon counts from Duck and Morris (2019), using scalars from Lonergan *et al.* (2013) for harbour seal and Russell *et al.* (2016) for grey seal

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