MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

Environmental Statement

Volume 2, Annex 3.1: Fish and shellfish ecology technical report

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Prepared by:	Prepared for:
RPS	**Morgan Offshore Wind Limited, Morecambe Offshore Windfarm Ltd**

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Glossary

Term	Meaning
Anadromous fish	Species that regularly migrate from sea to fresh water to spawn.
Applicants	Morgan Offshore Wind Limited (Morgan OWL) and Morecambe Offshore Windfarm Ltd (Morecambe OWL).
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 usually float in the water column just above the sea floor and can occupy either shallow coastal waters or deep waters offshore. Examples of benthopelagic species in Irish waters include dogfish, cod, haddock, whiting, monkfish and saithe.
Berried	Egg bearing individual whereby eggs are attached to its tail or some other exterior part.
Demersal fish	Fish species that live close to the sea floor and are bottom feeders. There are two types: benthic fish which rest on the sea floor (e.g., flatfish, dragonets, skates and rays) or benthopelagic fish (see above). Some demersal fish are demersal spawning species, which deposit eggs onto the seabed during spawning.
Design envelope	A description of the range of possible elements and parameters that make up the Transmission Assets options under consideration, as set out in detail in Volume 1, Chapter 3: Project Description. This envelope is used to define the Transmission Assets for EIA purposes when the exact engineering parameters are not yet known. This is also referred to as the Maximum Design Scenario or Rochdale Envelope approach.
Diadromous fish	Fish species that regularly migrate between sea and freshwater systems.
Effect	The term used to express the consequence of an impact. The significance of effect is determined by correlating magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
EIA Scoping Report	A report setting out the proposed scope of the Environmental Impact Assessment process. The Transmission Assets Scoping Report was submitted to The Planning Inspectorate (on behalf of the Secretary of State) for the Morgan and Morecambe Offshore Windfarms Transmission Assets in October 2022.
Environmental Impact Assessment	The process of identifying and assessing the significant effects likely to arise from a project. This requires consideration of the likely changes to the environment, where these arise as a consequence of a project, through comparison with the existing and projected future baseline conditions.
Environmental Statement	The document presenting the results of the Environmental Impact Assessment process.
Elasmobranchs	Elasmobranchs like sharks, rays and skates have a skeleton composed entirely of cartilage.

Term	Meaning
European sites	Designated nature conservation sites which include the National Site Network (designated within the UK) and Natura 2000 sites (designated in any European Union country). This includes Sites of Community Importance, Special Areas of Conservation and Special Protection Areas.
Export cable corridor	The specific corridor of seabed (seaward of Mean High Water Springs and land (landward of Mean High Water Springs) from the Generation Assets to the National Grid Penwortham substation.
Fecundity	The potential for reproduction of an organism measured by number of gametes (eggs), seed set or asexual propagules.
Fishery	A group of vessel voyages which target the same species or use the same gear.
Generation Assets	The generation assets associated with the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm include the offshore wind turbines, inter-array cables, offshore substation platforms and platform link (interconnector) cables to connect offshore substations.
Important Ecological Features	Habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Morgan and Morecambe Offshore Wind Farms: Transmission Assets.
Impact	Change that is caused by an action/proposed development, e.g., land clearing (action) during construction which results in habitat loss (impact).
International Council for the Exploration of the Sea rectangles	Defined areas, 1 degree longitude x 0.5 degree latitude equalling approximately 30 x 30 nm used for fisheries statistics.
Intertidal Infrastructure Area	The temporary and permanent areas between Mean High Water Springs and Mean Low Water Springs.
Landfall	The area in which the offshore export cables make landfall (come on shore) and the transitional area between the offshore cabling and the onshore cabling. This term applies to the entire landfall area at Lytham St. Annes between Mean Low Water Springs and the transition joint bays inclusive of all construction works, including the offshore and onshore cable routes, intertidal working area and landfall compound(s).
Marine Conservation Zone	Marine Conservation Zones are a type of marine protected area that can be designated in English, Welsh and Northern Irish territorial and offshore waters.
Mean High Water Springs	The height of mean high water during spring tides in a year.
Morecambe Offshore Windfarm Transmission Assets	The offshore export cables, landfall and onshore infrastructure required to connect the Morecambe Offshore Windfarm to the National Grid.
Morecambe Offshore Windfarm: Generation Assets	The offshore generation assets and associated activities for the Morecambe Offshore Windfarm.
Morecambe OWL	Morecambe Offshore Windfarm Limited is a joint venture between Zero-E Offshore Wind S.L.U. (Spain) (a Cobra group company) and Flotation Energy Ltd

Term	Meaning
Morgan and Morecambe Offshore Wind Farms: Transmission Assets	The offshore export cables, landfall and onshore infrastructure for the Morgan Offshore Wind Project and the Morecambe Offshore Windfarm. This includes the offshore export cables, landfall site, onshore export cables, onshore substations, 400 kV grid connection cables and associated grid connection infrastructure such as circuit breaker compounds. Also referred to in this report as the Transmission Assets, for ease of reading.
Morgan Offshore Wind Project Transmission Assets	The offshore export cables, landfall and onshore infrastructure required to connect the Morgan Offshore Wind Project to the National Grid.
Morgan Offshore Wind Project: Generation Assets	The offshore generation assets and associated activities for the Morgan Offshore Wind Project.
Morgan OWL	Morgan Offshore Wind Limited is a joint venture between bp Alternative Energy Investments Ltd and Energie Baden-Württemberg AG (EnBW).
Nursery habitat	A habitat where juveniles of a species regularly occur as a population.
Offshore export cable corridor	The corridor within which the offshore export cables will be located.
Offshore Order Limits	See Transmission Assets Order Limits: Offshore (below).
OSPAR	The Convention for the Protection of the Marine Environment of the north east Atlantic or OSPAR Convention regulates international cooperation on environmental protection in the North East Atlantic.
Oviparous	A mode of reproduction in which eggs laid with little or no other embryonic development within the mother. This is the reproductive method of most fish, amphibians, reptiles and birds.
Ovoviviparity	A mode of reproduction in sharks (and other animals) in which embryos develop inside eggs that are retained within the mother's body until they are ready to hatch.
Pelagic fish	Pelagic fish are species which live and feed within the water column.
Planning Inspectorate	The agency responsible for operating the planning process for applications for development consent under the Planning Act 2008.
Preliminary Environmental Information Report	A report that provides preliminary environmental information in accordance with the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. This is information that enables consultees to understand the likely significant environmental effects of a project and which helps to inform consultation responses.
Protected species	A species of animal or plant which it is forbidden by law to harm or destroy.
Renewable energy	Energy from a source that is not depleted when used, such as wind or solar power.
Scoping Opinion	Sets out the Planning Inspectorate's response (on behalf of the Secretary of State) to the Scoping Report prepared by the Applicants. The Scoping Opinion contains the range of issues that the Planning Inspectorate, in consultation with statutory stakeholders, has identified should be considered within the Environmental Impact Assessment process.

Term	Meaning
Shellfish	For the purposes of this assessment, shellfish is considered a generic term to define molluscs and crustaceans.
Site of Special Scientific Interest	A Site of Special Scientific Interest is a formal conservation designation. Usually, it describes an area of particular interest to science due to the rare species of fauna or flora it contains - or even important geological or physiological features that may lie in its boundaries.
Spawning grounds	Spawning grounds are the areas of water or seabed where fish/shellfish spawn or produce their eggs.
Special Areas of Conservation	A site designation specified in the Conservation of Habitats and Species Regulations 2017. Each site is designated for one or more of the habitats and species listed in the Regulations. The legislation requires a management plan to be prepared and implemented for each Special Areas of Conservation to ensure the favourable conservation status of the habitats or species for which it was designated. In combination with Special Protection Areas and Ramsar sites, these sites contribute to the national site network.
Study area	This is an area which is defined for each environmental topic which includes the Transmission Assets Order Limits as well as potential spatial and temporal considerations of the impacts on relevant receptors. The study area for each topic is intended to cover the area within which an impact can be reasonably expected.
Survey area	The area within which each survey has been undertaken. This may differ from the Study Area as a Survey Area will be based on species or survey-specific guidance on the extent of survey required, which may be limited by, for example, habitat conditions, or be defined in terms of buffer areas around an area of potential impact.
Transmission Assets	See Morgan and Morecambe Offshore Wind Farms: Transmission Assets (above).
Transmission Assets Order Limits	The area within which all components of the Transmission Assets will be located, including areas required on a temporary basis during construction and/or decommissioning (such as construction compounds).
Transmission Offshore Order Limits: Offshore	The area within which all components of the Transmission Assets seaward of Mean Low Water Springs will be located, including areas required on a temporary basis during construction and/or decommissioning. Also referred to in this report as the Offshore Order Limits, for ease of reading.
Vessel Monitoring System	A system used in commercial fishing to allow environmental and fisheries regulatory organizations to monitor, minimally, the position, time at a position, and course and speed of vessels.

Acronyms

Acronym	Meaning
AFBI	Agri-Food Biosciences Institute
BGS	British Geological Survey
Cefas	Centre for Environment Fisheries and Aquaculture Science
CIEEM	Chartered Institute of Ecology and Environmental Management
CMACS	Centre for Marine and Coastal Studies
CPUE	Catch Per Unit Effort
CSTP	Celtic Sea Trout Project
DDV	Drop Down Video
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
ES	Environmental Statement
FAO	Food and Agriculture Organisation
IBTS	International Bottom Trawl Survey
ICES	International Council for Exploration of the Sea
IEF	Important Ecological Feature
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MarLIN	Marine Life Information Network
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MNR	Marine Nature Reserve
NBN	National Biodiversity Network
NIGFS	Northern Irish Ground Fish Trawl Survey
NINEL	Northern Irish Herring Larvae Survey
NRW	Natural Resources Wales
NW-IFCA	North Western Inshore Fisheries and Conservation Authority
OSPAR	Oslo and Paris Convention
PEIR	Preliminary Environmental Information Report
PSA	Particle Size Analysis
SAC	Special Area of Conservation
SEA6	Strategic Environmental Assessment 6
SSSI	Site of Special Scientific Interest

Acronym	Meaning
SPI	Species of Principal Importance
UK	United Kingdom
UKOOA	United Kingdom Offshore Operators Association
VMS	Vessel Monitoring System
ZOI	Zone of Influence

Units

Unit	Description
%	Percentage
°C	Degrees Celsius
kg	Kilogram
km^2	Square kilometres
km	Kilometres (distance)
m	Metre (distance)
mm	Millimetre
m^2	Square Metre
nm	Nautical mile
t	Tonnes

1 Fish and shellfish ecology technical report

1.1 Introduction

1.1.1.1 This document forms Annex 3.1 of the Environmental Statement (ES) prepared for the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (hereafter referred to as the Transmission Assets). The ES presents the findings of the Environmental Impact Assessment (EIA) process for the Transmission Assets.

1.1.1.2 This document provides a detailed baseline characterisation of the fish and shellfish ecology (e.g., species, communities and habitats) associated with the Transmission Assets.

1.1.1.3 The Transmission Assets will be located within the Transmission Assets Order Limits: Offshore, in the east Irish Sea (**Figure 1.1**), hereafter referred to as the Offshore Order Limits for ease of reference. The Transmission Assets will provide the connection between the Morgan Offshore Wind Project: Generation Assets and Morecambe Offshore Windfarm: Generation Assets (collectively referred to as the Generation Assets) and the National Grid. The Generation Assets will be located south east of the Isle of Man in the east Irish Sea.

1.1.1.4 Data were collated through a detailed desktop study of the fish and shellfish species, habitats, and communities within a defined study area within the east Irish Sea (see **section 1.2.2**), incorporating site-specific survey data and data from third party organisations.

1.1.1.5 The aim of this technical report is to provide a robust baseline characterisation of the fish and shellfish receptors within the Offshore Order Limits and defined study area (see **section 1.2.2**) against which the potential impacts associated with the construction, operation and decommissioning of the Transmission Assets can be assessed. To support the impact assessment undertaken as part of the EIA process, the ecological information presented in this technical report was used to identify a number of Important Ecological Features (IEFs). IEFs were determined based on the conservation, ecological and commercial importance of each identified feature within the Offshore Order Limits and within the wider study area, in line with published Ecological Impact Assessment guidelines (Chartered Institute of Ecology and Environmental Management (CIEEM), 2022).

1.1.1.6 This technical report is structured as follows.

- **Section 1.2**: Methodology – overview of desktop reports and data and site-specific survey used to inform the baseline.
  - **Section 1.2.1**: Sources of information – overview of the sources of information used in this report.
  - **Section 1.2.2**: Study area – overview of the study area that is relevant to the report.

  - **Section 1.2.3**: Consultation – key comments raised during consultation activities undertaken to date specific to fish and shellfish ecology.
  - **Section 1.2.4**: Baseline methodology – Overview of the methodology to characterise the fish and shellfish ecology baseline.
  - **Section 1.2.5**: Desktop study – Overview of literature and datasets used to inform the baseline characterisation.
  - **Section 1.2.6**: Site-specific survey – Overview of the site-specific survey undertaken to inform the baseline characterisation.
- **Section 1.3**: Baseline characterisation – details the results of the desktop study and site-specific survey.
  - **Section 1.3.2**: Broad overview and description of the fish and shellfish assemblages within the east Irish Sea.
  - **Section 1.3.3**: Fish spawning and nursery grounds – spawning and nursery grounds are described for key species.
  - **Section 1.3.4**: Herring – a description of herring habitats and ecology (focussing on spawning).
  - **section 1.3.5**: Sandeel – a description of sandeel habitats and ecology.
  - **Section 1.3.6**: Elasmobranchs – a description of elasmobranch fish ecology.
  - **Section 1.3.7**: Diadromous fish – a description of diadromous fish ecology and designated sites associated with them.
  - **Section 1.3.8**: Shellfish – a description of shellfish habitats and ecology.
  - **Section 1.3.9**: Designated sites – a description of designated sites within the east Irish Sea which may be affected by the Transmission Assets.
- **Section 1.4**: Summary – a summary of the information provided in the report.
  - **Section 1.4.2**: Baseline – a summary of the fish and shellfish ecology baseline characterisation.
  - **Section 1.4.3**: Important Ecological Features – a description of the IEFs to be considered within the EIA.

1.2 Methodology

1.2.1 Sources of information – Generation Assets

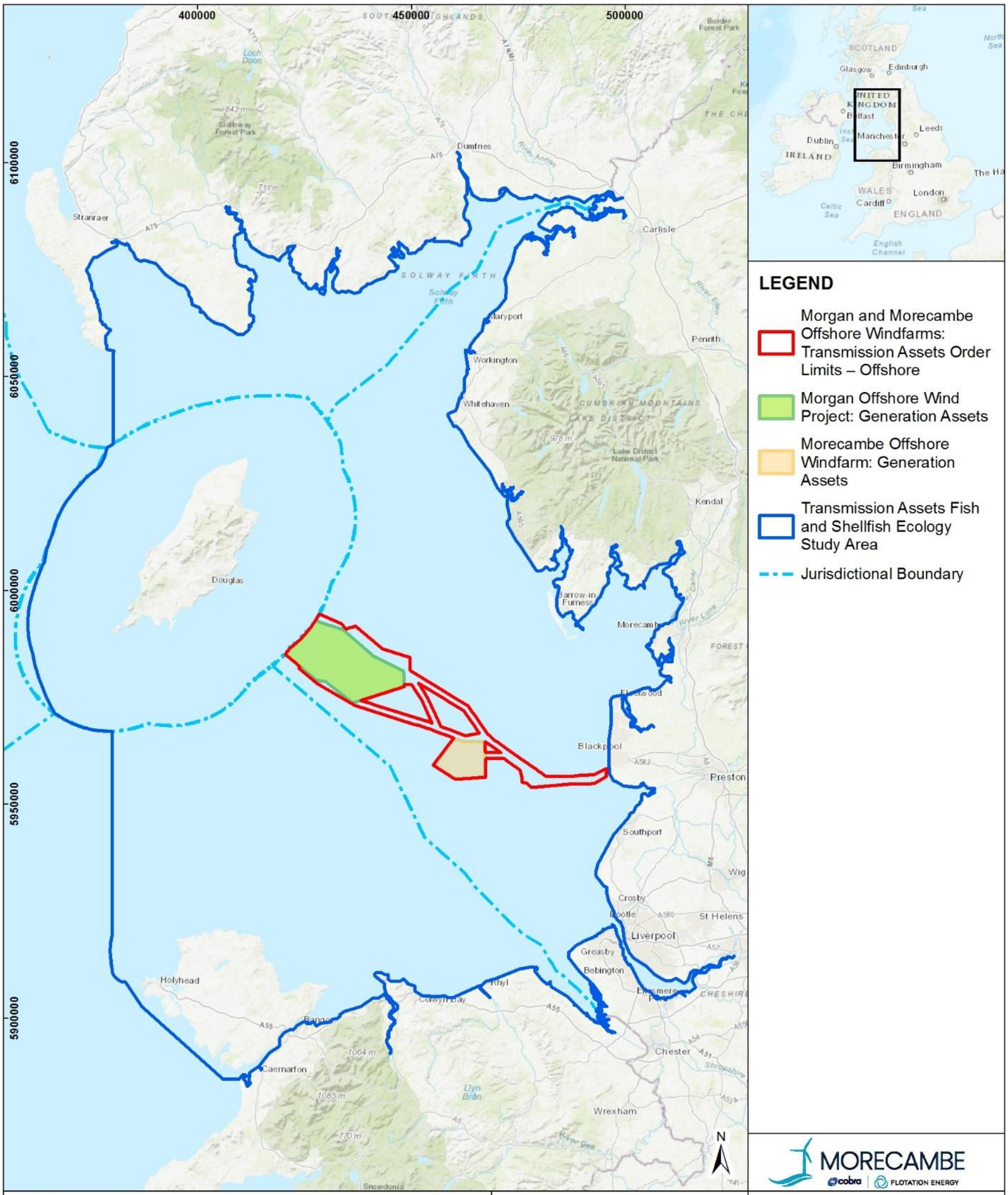
1.2.1.1 This baseline characterisation has included data from the fish and shellfish ecology technical report for the Morgan Offshore Wind Project: Generation Assets (Morgan Offshore Wind Limited, 2024a) and the baseline section of the fish and shellfish ecology ES chapter for the Morecambe Offshore Windfarm: Generation Assets (Volume 5, Chapter 10, Morecambe Offshore Windfarm Ltd, 2024). Both reports are presented in full in **Appendix A** and **Appendix B**. Baseline desktop data reported for both projects has been referred to along with the results of relevant site-specific surveys (**section 1.2.6**) to fully and robustly characterise the fish and shellfish assemblages present within the study area. A list of key desktop reports used to inform the baseline characterisation is included in **Table 1.1**.

1.2.2 Study area

1.2.2.1 Fish and shellfish species, habitats and communities are spatially and temporally variable, therefore for the purpose of the fish and shellfish ecology baseline characterisation, a broad study area has been defined. The Transmission Assets fish and shellfish ecology study area (hereafter referred to as the ‘study area’) is presented in **Figure 1.1**.

1.2.2.2 The study area for the Transmission Assets covers the east Irish Sea, extending from Mean High Water Springs west from the Mull of Galloway in Scotland to the west tip of Anglesey, following the 12 nautical miles (nm) limit (territorial waters) of the Isle of Man.

1.2.2.3 The study area matches the fish and shellfish ecology study area used in for the Morgan Offshore Wind Project: Generation Assets and also encompasses the large majority of the study areas defined for fish and shellfish ecology for the Morecambe Offshore Windfarm: Generation Assets (see **section 1.3.2**). This study area has been selected to account for the spatial and temporal variability of fish and shellfish populations, including fish migration and the intertidal area when relevant for fish and shellfish ecology. This area was considered appropriate as it will ensure the characterisation of all fish and shellfish IEFs within the east Irish Sea and is therefore large enough to consider all direct (e.g., habitat loss/disturbance within project boundaries) and indirect impacts (e.g., underwater sound over a wider area) associated with the Transmission Assets on the identified IEFs.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T001-04

Drawing Title:
STUDY AREA EXTENDING ACROSS THE EAST IRISH SEA, INCLUDING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

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Figure 1.1: Study area extending across the east Irish Sea, including the Offshore Order Limits

1.2.3 Consultation

1.2.3.1 A summary of the key comments raised during consultation activities undertaken to date specific to fish and shellfish ecology is presented in Table 3.4 of Volume 2, Chapter 3: Fish and shellfish ecology of the ES, and in the Consultation Report (document reference E1).

1.2.4 Baseline methodology

1.2.4.1 A desktop review has been undertaken to inform the baseline for fish and shellfish ecology, including a review of a number of peer-reviewed publications and reports from surveys undertaken to support other project consents. These provide context to the site-specific survey undertaken for the Transmission Assets in 2022 which are described in **section 1.2.6**.

1.2.4.2 Detailed methodologies for all site-specific survey and analyses are presented in **section 1.2.6**.

1.2.5 Desktop study

1.2.5.1 Information on fish and shellfish ecology within the study area was collected through a detailed desktop review of existing studies and datasets. Additionally, information collected as part of the commercial fisheries baseline characterisation (including landings data and consultation with fisheries organisations) has been incorporated into this baseline (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information), with regard given to the best practice advice for offshore wind assessments recently published by Natural England (2022). These sources are summarised in **Table 1.1.**

Table 1.1: Summary of key desktop reports

Title	Source	Year	Author
Manx Basking Shark Watch	Manx Whale and Dolphin Watch	1987 – 2022	Manx Whale and Dolphin Watch
Annual scallop surveys	Agri-Food Biosciences Institute (AFBI)	1992 to 2022	AFBI
Isle of Man scallop surveys	Bangor University – Sustainable Fisheries Isle of Man	1992 to 2022	Bangor University Sustainable Fisheries and Aquaculture Group
Herring larvae surveys of the northern Irish Sea 1993-2021	AFBI	1993 to 2021	AFBI
Fisheries Sensitivity Maps in British Waters	United Kingdom Offshore Operators Association (UKOOA) Ltd.	1998	Coull *et al.*
Rhyl Flats Offshore Wind Farm, Fish and Fisheries Baseline Study	Marine Data Exchange	2002 to 2006	Coastal Fisheries Conservation and Management

Title	Source	Year	Author
Walney and West of Duddon Sands Offshore Wind Farms, Baseline Benthic Survey – Epifaunal Beam Trawl Results	Marine Data Exchange	2005	Titan Environmental Surveys Ltd.
Effects of climate variability on basking shark abundance off southwest Britain	Fisheries Oceanography	2005	Cotton *et al*.
Burbo Bank Offshore Wind Farm, Pre-construction Commercial Fish Survey (2 m Beam Trawl)	Marine Data Exchange	2006	Centre for Marine and Coastal Studies Ltd. (CMACS)
Burbo Bank Offshore Wind Farm, Post-construction Commercial Fish Survey	Marine Data Exchange	2008	CMACS
Walney Offshore Wind Farm Pre-Construction Fish Survey	Marine Data Exchange	2009	Brown and May Marine Ltd.
Ormonde Offshore Wind Farm Pre-Construction Juvenile & Adult Fish Survey	Marine Data Exchange	2009	Brown and May Marine Ltd.
Burbo Bank Offshore Wind Farm, Post-construction (Year 3) Commercial Fish Survey	Marine Data Exchange	2010	CMACS
Ormonde Offshore Wind Farm, Construction (Year 1) Environmental Monitoring	Marine Data Exchange	2010	RPS Energy
Rhiannon Wind Farm Round 3 Autumn Fish Trawl Surveys	Marine Data Exchange	2010, 2013	CMACS
Burbo Bank Extension Offshore wind farm: Adult and Juvenile Fish Characterisation Survey	Marine Data Exchange	2011	Brown and May Marine Ltd.
Gwynt y Môr Offshore Wind Farm, Pre-construction Baseline Beam Trawl Data	Marine Data Exchange	2011	CMACS
Ormonde Offshore Wind Farm, Adult and Juvenile Fish and Epi-benthic Post-construction Survey	Marine Data Exchange	2012 to 2014	Brown and May Marine Ltd.
West of Duddon Sands Offshore Wind Farm, Adult and Juvenile Fish and Epibenthic Pre-Construction Surveys	Marine Data Exchange	2012	Brown and May Marine Ltd.
Mapping the Spawning and Nursery Grounds of Selected Fish for Spatial Planning	Centre for Environment Fisheries and Aquaculture Science (Cefas)	2012	Ellis *et al.*

Title	Source	Year	Author
Northern Irish Ground Fish Trawl Survey (NIGFS)	International Council for the Exploration of the Sea (ICES)	2013	ICES
Walney Offshore Wind Farm, Year 2 Post-construction Monitoring Fish and Epibenthic Survey	Marine Data Exchange	2013	Brown and May Marine Ltd.
Welsh waters scallop survey – Cardigan Bay to Liverpool Bay July-August 2013	Bangor University	2013	Lambert *et al.*
Celtic Array - Rhiannon Wind Farm preliminary environmental information chapter 10: fish and shellfish ecology	Marine Data Exchange	2014	Celtic Array Ltd.
Updating Fisheries Sensitivity Maps in British Waters	Scottish Marine and Freshwater Science Report	2014	Aires *et al.*
Marine Life Information Network (MarLIN)	MarLIN	2018	Tyler-Walters *et al*.
Manx Marine Environmental Assessment	Isle of Man Government – Fisheries Division	2018	Howe *et al*.; Duncan and Emmerson
National Biodiversity Network (NBN) Atlas	NBN Atlas	2019	NBN Atlas
Welsh Waters Scallop Surveys and Stock Assessment	Bangor University	2019	Delargy *et al*.
Joint Nature Conservation Committee (JNCC) Marine Protected Area Mapper	JNCC	2019	JNCC
ICES scallop assessment working group	ICES	2019	ICES
Marine Recorder Public UK Snapshot	JNCC	2020	JNCC
Annual Fisheries Science Report	Bangor University Sustainable Fisheries and Aquaculture Group	2020	Jenkins *et al.*
Bass and Ray Ecology in Liverpool Bay	Bangor University Sustainable Fisheries and Aquaculture Group.	2020	Moore *et al.*
United Kingdom (UK) Sea Fisheries Annual Statistics Report	Marine Management Organisation (MMO)	2020	MMO

Title	Source	Year	Author
Spawning and nursery grounds of forage fish in Welsh and surrounding waters	Cefas	2021	Campanella and van der Kooij
ICES working group on surveys on ichthyoplankton in the North Sea and adjacent seas	ICES	2021	ICES
Awel y Môr Offshore Wind Farm. Category 6: Environmental Statement	Awel y Môr Offshore Wind Farm Ltd.	2022	RWE Renewables UK
Fisheries and Conservation Science Group	Bangor University	2022	Bangor University
Marine Recorder Public UK Snapshot	JNCC	2022	JNCC
SeaLifeBase	https://www.sealifebase.ca/	2022	Palomares and Pauly
Cefas OneBenthic Tool	Cefas	2023	Cefas
Morecambe Offshore Windfarm: Generation Assets Preliminary Environmental Impact Report (PEIR) Volume 1 Chapter 10: Fish and shellfish ecology.	Morecambe Offshore Windfarm Ltd	2023	Morecambe Offshore Windfarm Ltd
Morecambe Offshore Windfarm: Generation Assets Environmental Statement Volume 5, Chapter 10: Fish and Shellfish Ecology.	Morecambe Offshore Windfarm Ltd	2024	Morecambe Offshore Windfarm Ltd
Mona Offshore Wind Project. Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement	Mona Offshore Wind Ltd	2024	Mona Offshore Wind Ltd
Morgan Offshore Wind Project: Generation Assets. Volume 4, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement	Morgan Offshore Wind Ltd	2024b	Morgan Offshore Wind Ltd
Fish and shellfish survey results for the east Irish Sea	Environment Agency	Various	Environment Agency
Cefas Pelagic ecosystem in the western English Channel and eastern Celtic Sea surveys	Cefas	Various	Cefas
Fish and shellfish sensitivity reports	https://www.marlin.ac.uk/activity/pressures_report	Various	Various

Title	Source	Year	Author
The novel use of pop-off satellite tags (PSATs) to investigate the migratory behaviour of European sea bass *Dicentrarchus labrax* (L., 1758) in the Celtic Sea area.	Journal of Fish Biology	2018	O'Neill, *et al.*

1.2.6 Site-specific survey

1.2.6.1 A summary of the site-specific benthic subtidal survey that has informed the fish and shellfish ecology baseline characterisation is outlined in **Table 1.2.** The locations where site-specific sampling has been undertaken are presented in **Figure 1.2**. The benthic subtidal survey for the Transmission Assets was undertaken between April and August 2022 covering the area of the Offshore Order Limits (see **Figure 1.1**); this survey included additional sampling associated with the Morgan Offshore Wind Project: Generation Assets with stations located within and adjacent to the Offshore Order Limits. Additional survey data from the Morgan Offshore Wind Project: Generation Assets and Morecambe Offshore Windfarm: Generation Assets has been reviewed and incorporated as desktop data (see **section 1.3**) to inform the overall Offshore Order Limits baseline characterisation. For completeness, sampling locations from the Transmission Assets site specific benthic survey (including those stations within Morgan Offshore Wind Project: Generation Assets) and the Generation Assets benthic surveys are shown in **Figure 1.2**, to demonstrate the data coverage available in the area of the Offshore Order Limits.

1.2.6.2 Given the wide ranging and comprehensive desktop information and data sources available to characterise the fish and shellfish ecology baseline, site-specific surveys specifically targeting fish and shellfish IEFs were not proposed in order to inform the EIA for the Transmission Assets. However, the results from site-specific survey, primarily designed to inform the benthic subtidal and intertidal ecology baseline characterisation (see Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the ES for comprehensive details of the benthic survey) which can include records of demersal fish and shellfish species, have been used to inform the baseline characterisation for fish and shellfish ecology alongside existing data sources.

1.2.6.3 Site-specific subtidal benthic surveys were undertaken across the Offshore Order Limits in 2022 (within the offshore cable corridor and the Morgan Offshore Wind Project: Generation Assets), to characterise the benthic habitats within the area. The sampling strategy was designed to adequately sample the area to provide data for baseline characterisation and encompassed the Offshore Order Limits along with the Morgan Offshore Wind Project: Generation Assets and the associated Zone of Influence (ZOI). The benthic subtidal survey was undertaken by Gardline Limited (Gardline) between April and August 2022 onboard the Motor Vessels *Ocean Resolution* (offshore) and *Titan Endeavour* (nearshore).

1.2.6.4 Combined grab and Drop-Down Video (DDV) sampling were undertaken across 103 sampling stations, of which 77 were within the Offshore Order Limits (the remaining were 26 within Morgan Offshore Wind Project: Generation Assets and the ZOI; **Figure 1.2**), with Particle Size Analysis (PSA) data obtained from grabs used to inform habitat characterisation for sandeel and potential spawning grounds of Atlantic herring. Further, species presence/absence records were also recorded from both grab samples and DDV transects, although these should be noted as purely opportunistic incidental data as surveys were not specifically designed to target fish and shellfish species.

1.2.6.5 Herring spawning habitat characterisation was undertaken using results of the PSA to determine the sediment composition at each grab location. Samples were categorised into preferred, marginal and unsuitable based on their suitability as herring spawning habitat, using classifications derived from Reach *et al*. (2013) defined by the relative proportions of gravel and mud in the grab samples. Data from the Northern Irish Herring Larvae Survey (NINEL) were also utilised to show potential herring spawning habitats in line with guidelines published by Boyle and New (2018). The abundances of larvae ≤10 mm per m^2 were plotted as density maps for the years 2012 to 2021. These maps, combined with the PSA data from site-specific grab sampling, were used to determine where key spawning habitats were located within and in the vicinity of the Offshore Order Limits (see **section 1.3.4**).

1.2.6.6 Sandeel habitat characterisation was also completed using a similar method as above, where samples were categorised into preferred, marginal and unsuitable, based on their suitability as sandeel habitat. Classifications were derived from Latto *et al.* (2013) based on the proportion of sand and mud in the grab samples. Incidental sandeel observations were collated from the benthic surveys to inform presence/absence of individuals caught within grab samples. These data were plotted into maps and reviewed alongside additional desktop data sources to further characterise sandeel habitats within and in the vicinity of the Offshore Order Limits (see **section 1.3.5**).

1.2.6.7 Norway lobster *Nephrops norvegicus* (hereafter referred to as *Nephrops*) presence within the vicinity of the Offshore Order Limits was assessed through presence/absence data derived from DDV sampling (taken at grab sample sites and specific DDV transects). These data were plotted alongside favourable *Nephrops* habitat as identified in a benthic biotope map as shown in Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the ES (see **section 1.3.8**).

Table 1.2: Summary of survey undertaken to inform the fish and shellfish ecology baseline characterisation

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Benthic Subtidal Survey	Offshore Order Limits and Morgan Offshore Wind Project: Generation Assets and associated ZOI	Grab samples, Visual survey outputs (DDV sampling) and laboratory testing	Gardline Limited	2022	Gardline Limited, 2023

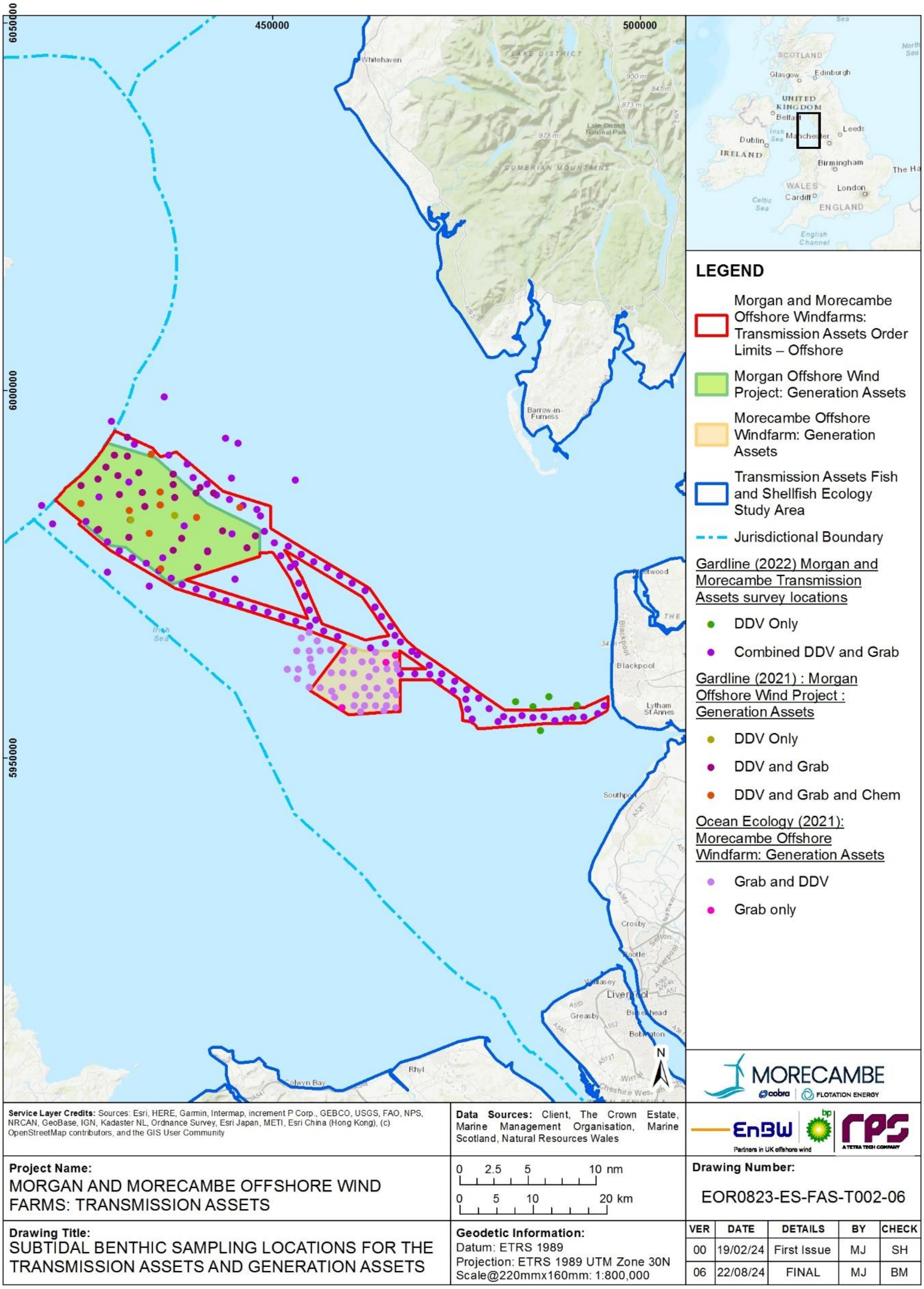


Figure 1.2: Subtidal benthic sampling locations for the Transmission Assets and Generation Assets

1.3 Baseline characterisation

1.3.1 Introduction

1.3.1.1 The baseline characterisation presented in this section summarises the fish and shellfish assemblages and communities within the study area based upon regional datasets. This desk study considers fish and shellfish assemblages, fish and shellfish spawning and nursery grounds, fish and shellfish ecology, and the location and characterisation of nearby designated sites.

1.3.1.2 Results from the site-specific survey were also used to complement the baseline characterisation in the relevant sections.

1.3.2 East Irish Sea

1.3.2.1 This section provides an overview of the fish and shellfish assemblages in the study area through a comprehensive desktop review. This review primarily covers fish species and communities from regional datasets including other offshore developments within the area, with some additional information on shellfish species and communities. A more detailed characterisation of key shellfish species in the study area, including species of commercial importance, is presented in **section 1.3.8**.

1.3.2.2 The study area is additionally classified as comprising the Strategic Environmental Assessment 6 (SEA6) area and ICES Region VIIa according to the UK Government. SEA6 corresponds to the east half of the St. George’s Channel and Irish Sea, comprising a major portion of the ICES division VIIa, generally used for fisheries assessment purposes (UK Government, 2022).

1.3.2.3 The east Irish Sea supports valuable fisheries assemblages, including demersal, pelagic and shellfish species. Historically, several of these species were known to be targeted by international fleets (Cefas, 2005). Important commercial species include flatfish, gadoids and elasmobranchs, as these species are typically caught by beam and otter trawls, which are frequently used gear types in the area (Cefas, 2005). The east Irish Sea is also known to be an important spawning ground and nursery area for several species (further discussed in **section 1.3.3**), subsequently making it a focal point of seasonal fisheries. Pelagic species are less targeted commercial species than demersal species, whilst shellfish species are highly targeted and of high commercial value within the east Irish Sea; particularly king scallop *Pecten maximus*, queen scallop *Aequipecten opercularis* and *Nephrops* (ICES, 2021a).

1.3.2.4 The sediments of the Irish Sea can be subdivided into three broad regions: two ‘mudbelts’ comprising of soft muds which occupy the east and west inshore areas separated by a central ‘gravel belt’ which comprises coarser sediment and hard substrate (Mellet *et al*., 2015). The east and west areas of the Irish Sea in particular are known for their muddy sediments (clay and silt) that support one of the most valuable fisheries for *Nephrops* (Lundy *et al*., 2019; Parker-Humphreys, 2004). In the Isle of Man territorial waters within the 12 nm limit, the sediment is a split between mixed sands to the north and mixed gravel to the west (Howe *et al*., 2018).

1.3.2.5 The distribution of fish and shellfish species is determined by a range of factors including abiotic parameters such as water temperature, salinity, depth, local scale habitat features, substrate type and biotic parameters such as predator prey interactions, competition and anthropogenic factors such as infrastructure and commercial fishing intensity. Specific population sizes and habitat ranges within the Irish Sea tend to be limited largely by fishing activity, with increasing pressure from the renewable energy and aggregate extraction industries acting alongside broader pressures such as climate change, sound, and marine litter (van der Kooij *et al*., 2021).

1.3.2.6 The fish assemblages likely to be observed within the study area include demersal species: European plaice *Pleuronectes platessa*, common dab *Limanda limanda*, solenette *Buglossidium luteum*, Dover sole *Solea solea*, whiting *Merlangius merlangus*, lesser-spotted dogfish *Scyliorhinus canicula* and cod, with pelagic species including herring, European seabass *Dicentrarchus labrax* and Atlantic mackerel *Scomber scombrus*. European seabass and thornback ray *Raja clavata* have been recorded in Liverpool Bay, the Dee estuary and Morecambe Bay within the fish and shellfish ecology study area.

1.3.2.7 Dominant shellfish species in the Irish Sea include blue mussel *Mytilus edulis*, European lobster *Homarus gammarus*, *Nephrops*, common whelk *Buccinum undatum*, great/king scallop, queen scallop, edible crab *Cancer pagurus*, brown/common shrimp *Crangon crangon*, loliginid squid Loliginidae *spp.* and ommastrephid squid Ommastrephidae *spp*. As key components of the shellfish community, these species are also commercially valuable within this region (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information).

1.3.2.8 Ellis *et al.* (2000) described the macro-invertebrate and demersal fish assemblages within the Irish Sea from 101 beam trawl survey stations and found that fine substrates in inshore waters of the east and west portions of the Irish Sea are typically dominated by flatfish including plaice, common dab and Dover sole. In coarse substrates further offshore, abundant species include thickback sole *Microchirus variegatus* whilst muddy sediments are characterised by *Nephrops* and witch flounder *Glyptocephalus cynoglossus* (Ellis *et al.,* 2000). Additionally, from samples collected within inshore waters, Ellis *et al*. (2000) described an *Alcyonium* assemblage in which dab and velvet swimming crab *Necora puber* were typical of the fish and shellfish features.

1.3.2.9 The International Bottom Trawl Survey (IBTS) is a historical time series of bottom and pelagic fish trawl surveys undertaken in the north east Atlantic and Baltic Seas regions. The study area sits within the IBTS S5, S6 and S7 survey zones. These areas, in addition to IBTS zones S1-S4 and S8-S10 have been utilised to gain a better understanding of the fish assemblages present within the Irish Sea (ICES, 2021b).

1.3.2.10 Bottom trawl surveys conducted by the IBTS in the Irish Sea were conducted during March 2020 and undertaken with a Rockhopper trawl fitted with a

20 mm cod-end liner towed between one and three nautical miles in the Irish Sea and St George's Channel (ICES, 2021b). Of the 58 trawls that were successfully undertaken within the area, a total of 128 species were recorded (ICES, 2021b). Groundfish surveys in the area were predominantly comprised of the following species in order of abundance; whiting, haddock *Melanogrammus aeglefinus*, European plaice, red gurnard *Chelidonichthys cuculus*, cod, lemon sole *Microstomus kitt*, thornback ray, spotted ray *Raja montagui*, European hake *Merluccius merluccius*, spurdog *Squalus acanthias*, brill *Scophthalmus rhombus*, John Dory *Zeus faber*, megrim *Lepidorhombus whiffiagonis* and European pollock *Pollachius pollachius* (ICES, 2021b).

1.3.2.11 More recent trawl surveys have been undertaken throughout the Irish Sea, and particularly in the east Irish Sea, as part of the NIGFS (under the IBTS) with data reviewed from between 2012 and 2022. The distributions and abundances recorded for all species remained stable across the years with similar proportions of catches per species. Plaice, lesser-spotted dogfish, whiting, herring, common dab, common dragonet *Callionymus lyra*, thornback ray, *Nephrops*, haddock and grey gurnard *Eutrigla gurnardus* were the most commonly caught species in the trawls. The fish and shellfish assemblages recorded in NIGFS align with the other data sources, which have historically surveyed the same area and corroborate the presence and long-term stability of these communities within the study area and around the Offshore Order Limits, as supported by Campanella and van der Kooij (2021). This indicates that older datasets detailing fish and shellfish distribution and spawning (Coull *et al*., 1998; Ellis *et al*., 2012), along with those collected from historic project-specific fish and shellfish surveys also remain broadly relevant to the current baseline conditions of the east Irish Sea and can be used to support characterisation of projects within this area.

1.3.2.12 Despite not being recorded in 2012 and 2022, queen scallop were recorded in large number (i.e., more abundant than *Nephrops* between 2013 and 2021) across the study area with limited observations in inshore waters (i.e., within the 12 nm limit). Herring records were also distributed across the study area with only few inshore locations with herring catches (ICES, 2021b; 2022b).

1.3.2.13 The IBTS scientific catch data, including NIGFS data, has been relatively consistent over the last 10 years with similar fish and shellfish assemblages and similar abundances observed over the years. In addition, the species in the IBTS data align with the data from surveys at other offshore wind farms located in the study area which recorded similar species with comparable relative abundances (see **paragraphs 1.3.2.27** to **1.3.2.69**).

1.3.2.14 Several species of both commercial and ecological importance are known to be present within the east Irish Sea. These species include European plaice, dab, Dover sole, whiting, cod, European seabass, spurdog, spotted ray, herring, mackerel, sprat, ling *Molva molva* and sandeel. As previously stated, the east Irish Sea hosts important and valuable populations of shellfish species including king scallop, queen scallop, European lobster, edible crab, velvet swimming crab and *Nephrops* (ICES, 2021a).

1.3.2.15 Beam trawl surveys undertaken throughout the Irish Sea from 1993 to 2001 found that plaice accounted for the largest proportion of the catches by biomass, resulting in 24.44% of the total (Parker-Humphreys, 2004). Plaice is a widespread and common species throughout European waters and in the east Irish Sea, showing a preference for sandy sediments throughout its lifespan. This species spawns in offshore areas where eggs and larvae are then transported on currents to coastal nurseries. Tagging studies show that individuals have strong site fidelity, returning to the same location to spawn and feed (Hunter *et al.,* 2003). Plaice make use of tidal currents in various life stages. For example, plaice have been evidenced moving downstream with the tide in mid-water during seasonal migrations between spawning and feeding grounds. Their diet tends to be polychaete worms, small crustaceans, siphons of bivalve molluscs and in some areas, brittle stars (Rijnsdorp and Vingerhoed, 2001).

1.3.2.16 Common dab was the most abundant species recorded during demersal beam trawl surveys of the Irish Sea accounting for 28.04% of the catch by number and 17.40% by biomass (Parker-Humphreys, 2004). Adult common dab live mainly on sandy substrates from depths of a few metres to 100 m and feed on crustaceans and small fish (Braber and Groot, 1973). Ellis *et al.* (2000) described the inshore waters of the east Irish Sea as plaice-dab assemblages, with plaice, common dab and Dover sole dominating the fish component of the assemblage. Dover sole is widespread and abundant in European waters and lives buried in both sandy and muddy sediments. Juveniles spend the first year in shallow coastal waters and estuaries, migrating to deeper offshore waters following this period, although they are largely restricted to depths of <50 m. From the months of March to May, sole return to inshore waters to spawn, with spawning migrations occurring at night (Kruuk, 1963). Sole is a nocturnal and olfactorial feeder, making use of sensory organs to detect prey. They are known to feed on polychaete worms, small echinoderms and sea urchins (Braber and Groot, 1973).

1.3.2.17 Atlantic herring, European hake, whiting, blue whiting *Micromesistius poutassou*, Atlantic mackerel and cod are predominantly found in deeper waters in the benthopelagic or pelagic zone and have been observed throughout the east Irish Sea. Their core range includes St. George’s Channel (at the south boundary of the Irish Sea); however, they have additionally been found to be present around the south and west coast of Ireland and north coast of Northern Ireland.

1.3.2.18 European hake is focused within the north east Atlantic as one population and is distributed across the Irish Sea, Celtic Sea, English Channel and the North Sea. They are a relatively fast-growing species, with males maturing at around 35 cm and females at 50 cm within 3-5 years for both sexes (FishBase, 2020a). Adult hake live close to the seabed during the day but move up from the seabed at night for opportunistic feeding within the water column (Riccioni *et al*., 2018). The ICES 2019 stock assessment which included the Celtic Sea, suggests a relatively stable population of this species since 1978 (ICES, 2019a).

1.3.2.19 Whiting is abundant throughout the north east Atlantic, Mediterranean and European seas. They are most commonly found in depths of 10 m to 100 m, predominantly on mud and gravel bottoms, but also on sand and rock. Year one, fish feed primarily on crustaceans such as shrimps and crabs and on small fish and molluscs. After the first year, whiting have been evidenced to move further offshore in search of prey (FishBase, 2020b).

1.3.2.20 Blue whiting is distributed throughout the north Atlantic and found on continental shelves at depths of 300 m to 400 m but have been found at depths exceeding 1,000 m. This species is known to make daily migrations from the surface waters at night to the seabed during the day where they feed on small crustaceans, small fish and cephalopods (FishBase, 2020c).

1.3.2.21 Atlantic mackerel is abundant and widespread in the cold and temperate shelf areas of the east Irish Sea. This species overwinters in deeper waters but moves closer inshore during spring when water temperatures increase. Atlantic mackerel within the Irish Sea are part of the British Isles (west) stock (the other being the North Sea (east) stock). They are generally a pelagic species, forming large schools near the surface, but their habitat preferences are poorly understood (FishBase, 2020d).

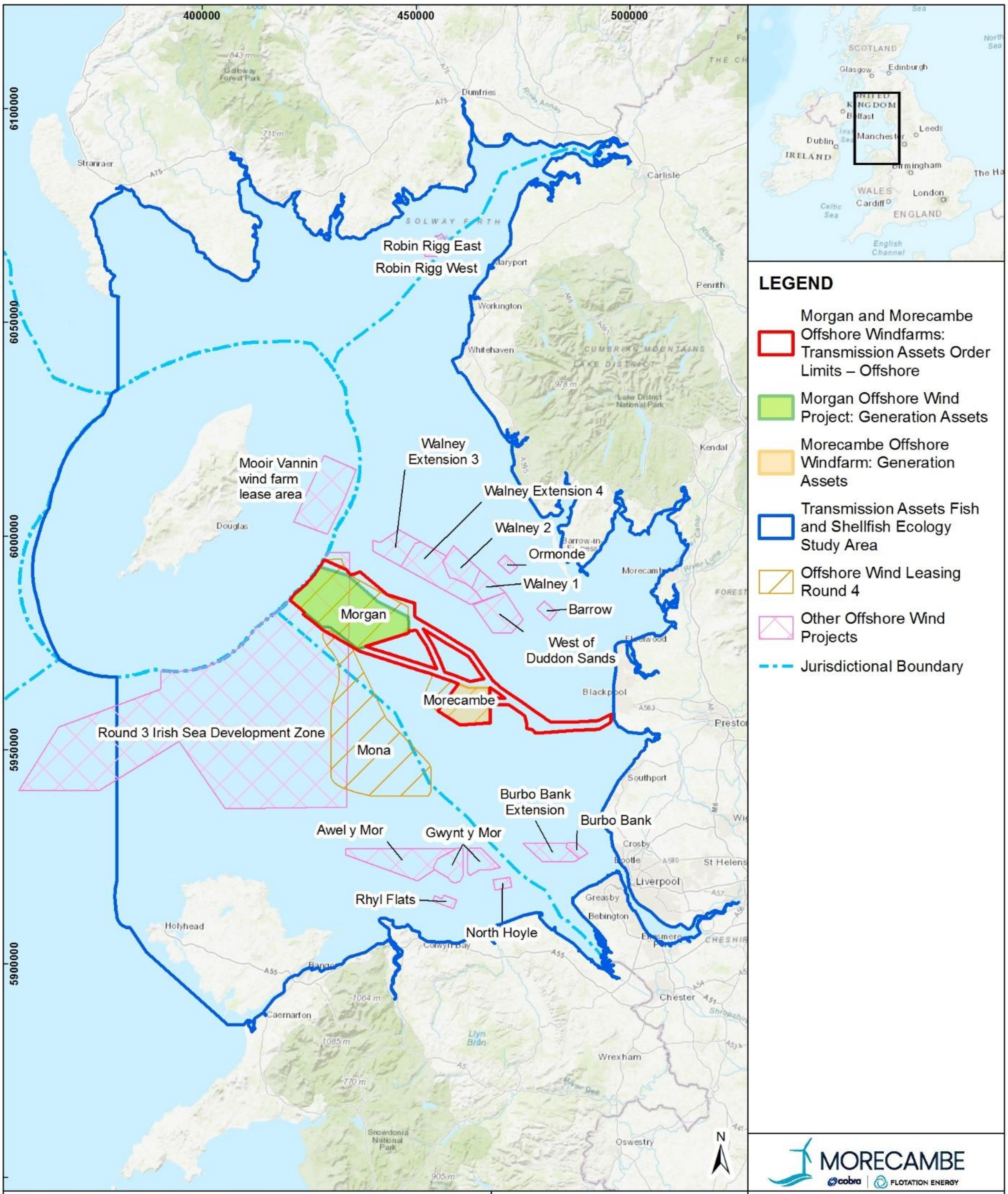
1.3.2.22 Atlantic cod is widely distributed in a variety of habitats. Juveniles typically inhabit shallow sublittoral waters with seagrass or coarse substrate (gravel, rocks or boulders). Adults are associated with deeper, colder waters; during the day they form large schools which swim just above the seabed, whilst at night they disperse to feed. Cod migrate between spawning, feeding and overwintering areas within the boundaries of their stock. Spawning occurs between winter and start of spring when they congregate in large numbers to spawn, utilising vocalisations during courtship and spawning behaviour (Finstad and Nordeide, 2004). Spawning sites are usually in offshore waters, at or near the bottom at depths of 50 m to 200 m (FishBase, 2020e). An omnivorous species, cod feed on invertebrates and fish, including young cod.

1.3.2.23 European seabass is known to support an important commercial and recreational fishery within the UK (Moore *et al*., 2021). Seabass caught within the Irish Sea fisheries consistently showed a significant bias (79.8% of catches) towards females, findings which were supported by data collected from North Wales, suggesting potential localised spawning within the area (Moore *et al*., 2021). Monthly landings data between 2019 and 2020 illustrated that the seabass fishery within Liverpool Bay is highly seasonal, with the majority of spawning occurring before May and peak landings reported between July and November (Moore *et al*., 2021). Within the Irish Sea, at least two broad spawning grounds are predicted: the central Irish Sea and the south Irish Sea/Celtic Sea (Lincoln *et al*., 2024), with further evidence collated for spawning in the area of Liverpool Bay collated by Moore *et al.* (2021). Migratory behaviour is reported for European seabass, with an annual trend of inshore feeding in summer, and offshore migration during winter and spring for spawning, with some individuals reported to show site fidelity for both spawning and feeding (Pawson *et al.*, 2007; de Pontual *et al.*, 2023). O'Neill *et al.* (2018) undertook a tagging study of European seabass in the Celtic Sea which also demonstrated periods of offshore migration corresponding to spawning movements described above, although the specific movements undertaken by the individual fish tagged were variable and based upon a small sample size. This study reported one tagged specimen moving between the south coast of Ireland in the Celtic Sea into the east Irish Sea and back again between the period of February and June (O'Neill *et al.,* 2018). European seabass are known to form spatio-temporally restricted annual spawning aggregations with temperature and the hours of daylight/darkness reported to be key triggers for spawning activity (de Pontual *et al.*, 2019; Lincoln *et al.*, 2024). During spawning, pelagic eggs are released into the water column, with eggs and larvae dispersing into coastal nursery grounds (e.g. estuaries or salt marsh areas; Jennings and Pawson, 1992; Food and Agriculture Organisation (FAO), 2009; Lincoln *et al.*, 2024).

1.3.2.24 It is worth noting that the International Union for Conservation of Nature (IUCN) Red List of Threatened Species indicates that whilst European seabass is common throughout much of Europe and is assessed to be of Least Concern within this region (except the Mediterranean, where is it defined as Near Threatened), the population trend is decreasing, with a decline in the numbers of mature individuals (IUCN, 2015). Fisheries management measures have been introduced, such as North Western Inshore Fisheries and Conservation Authority (NW-IFCA) Byelaw 5 – Heysham Bass Nursery Area Prohibition of Fishing, seasonal catch limits and minimum conservation reference sizes. Key factors affecting seabass recruitment and growth are reported to relate to seawater temperature, and therefore climate is considered likely to affect seabass lifecycles with implications to natural stocks and the interconnectivity between lifecycle stages, including larval migration to inshore/estuarine areas (Pinto *et al.*, 2021; de Pontual *et al.*, 2023).

1.3.2.25 Many of these aforementioned fish species have high ecological value as prey species for marine mammals, seabirds and other fish (e.g., sandeel, herring, mackerel, whiting and sprat) as well as being of high importance to commercial fisheries (see **sections 1.3.4** and **1.3.5** for further details on herring and sandeel and in Volume 2, Annex 6.1: Commercial fisheries technical report of the ES).

1.3.2.26 Additional offshore wind farm developments, either in the construction or planning stages, are present within the study area (**Figure 1.3**). Data collected through site-specific surveys undertaken for additional offshore renewable energy developments can therefore be utilised to help better characterise the fish and shellfish assemblages in the vicinity of the Offshore Order Limits and within study area.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales

EnBW bp Partners in UK offshore wind rps A TETRA TECH COMPANY

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T003-04

Drawing Title:
LOCATIONS OF OTHER OFFSHORE WIND PROJECTS IN THE STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

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00	19/02/24	First Issue	MJ	SH
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Figure 1.3 : Locations of other offshore wind projects in the study area

Other offshore wind projects

Irish Sea Round 3 Development Zone

1.3.2.27 Beam trawl surveys were undertaken in the autumn of both 2010 and 2011 across the Irish Sea Round 3 Development Zone which overlaps the west portion of the Offshore Order Limits. The Irish Sea Round 3 Development Zone is located within the south west corner of the study area (**Figure 1.3**).

1.3.2.28 The surveys conducted within the Irish Sea Round 3 Development Zone reported that the most dominant fish species present were poor cod *Trisopterus minutus* and the lesser-spotted dogfish. The next most common species were common dragonet, grey gurnard and red gurnard. The most common commercially valuable fish species was plaice, followed by thickback sole and lemon sole (CMACS, 2010; Celtic Array Ltd., 2013).

1.3.2.29 Furthermore, seven elasmobranch species were recorded, including lesser-spotted dogfish, cuckoo ray *Leucoraja naevus*, spotted ray, thornback ray, nursehound *Scyliorhinus stellaris*, starry smooth-hound *Mustelus asterias* and starry ray *Amblyraja radiata*. Basking shark were also recorded in surveys undertaken in July 2011 for the Rhiannon Wind Farm located within the Irish Sea Round 3 Development Zone (Celtic Array Ltd., 2011). No other observations of rare or endangered fish species were reported from the survey (CMACS, 2010; Celtic Array Ltd., 2011; 2013).

Gwynt y Môr offshore wind project

1.3.2.30 The Gwynt y Môr offshore wind project is located approximately 28.9 km south east of the Offshore Order Limits (**Figure 1.3**). Pre-construction beam trawl and benthic grab surveys were undertaken in autumn 2010 to monitor the status of organisms and seabed sediments.

1.3.2.31 Across the Gwynt y Môr offshore wind project, 472 individual fish from 23 species were recorded at 30 trawl stations. The highest number of individuals encountered were consistently observed from inshore, shallow waters compared to those further offshore in water depths ranging from 20 m to 30 m (CMACS, 2011).

1.3.2.32 Utilising beam trawl, benthic grab and DDV data, the general sediments within the site were described as coarse sands and gravels with flatfish such as plaice, dab and solenette being the predominant fish species present. During the survey, relatively few elasmobranch species were encountered (CMACS, 2011).

1.3.2.33 Similar to findings evidenced from the Irish Sea Round 3 Development Zone, plaice was found to be the most commonly recorded fish species during the surveys and was found in 15 of 30 (50%) sampling sites. The second most abundant species was solenette, recorded in 14 of 30 (47%) sites and sand goby *Pomatoschistus minutus*, recorded in 15 of 30 (50%) sites. The only elasmobranch species that were recorded within the Gwynt y Môr offshore wind project were lesser-spotted dogfish, thornback ray and blonde ray *Raja brachyura*. Other teleost species recorded infrequently and in low numbers include grey, red and tub gurnard *Chelidonichthys lucerna*, John Dory, thickback sole and whiting (CMACS, 2011).

1.3.2.34 Five commercially valuable shellfish species were recorded from within and surrounding the Gwynt y Môr offshore wind project. These species include whelk, edible crab, blue mussel, brown shrimp and pink shrimp *Pandalus montagui*. With the exception of whelk, none of these species were known to be commercially targeted within the Gwynt y Môr offshore wind project or wider surrounding area at the time of survey reporting (CMACS, 2011).

1.3.2.35 Although the sand goby, which was commonly encountered during the beam trawl surveys is a scheduled species in the Bern Convention and protected for its important contribution to the marine trophic level, the species is not subject to any UK conservation measures and is known to be abundant in shallow, sandy habitats (CMACS, 2011).

West of Duddon Sands offshore wind project

1.3.2.36 Baseline otter and beam trawl surveys were conducted in May and September 2012 for the West of Duddon Sands offshore wind project, located approximately 6.5 km east of the Offshore Order Limits in inshore waters (**Figure 1.3**).

1.3.2.37 The West of Duddon Sands offshore wind project found that plaice, dab and lesser-spotted dogfish were the most abundant species encountered during both surveys and the total catch rates (catch per unit of effort; CPUE) per station were highest to the south east of the array (Brown and May Marine Ltd., 2012a, 2012b). Although the surveys recorded a total of 35 species in the May survey and 32 species in September, plaice and dab were found to represent the majority of the catch at most of the 23 otter trawl sampling stations in both surveys.

1.3.2.38 Otter trawl catch rates within the West of Duddon Sands offshore wind project were as high as 4,331 and 4,063 individuals per hour from sampling within the wind farm and along the export cable corridor, respectively, with the highest CPUE in both areas recorded during the spring survey. Between the wind farm and export cable corridor, plaice, dab, lesser-spotted dogfish, whiting, grey gurnard, tub gurnard, thornback ray, Dover sole, sprat, starry smooth-hound, common dragonet, nursehound, poor cod, cod, lemon sole, herring, tope shark *Galeorhinus galeus*, anglerfish *Lophius piscatorius*, bib *Trisopterus luscus*, mackerel, scaldfish *Arnoglossus laterna*, lesser weaver *Echiichthys vipera*, flounder *Platichthys flesus*, pogge *Agonus cataphractus*, sea trout, streaked gurnard *Chelidonichthys lastoviza* and brill were the fish species observed across the two surveys. The shellfish species recorded in these areas included edible crab, whelk, squid Alloteuthis *spp*. Velvet swimming crab, European lobster, spiny spider crab *Maja brachydactyla* and *Nephrops* (Brown and May Marine Ltd., 2012a, 2012b).

1.3.2.39 Beam trawl surveys found a total of 13 species of fish in the May 2012 survey and 14 in the September 2012 survey. Overall, solenette was the most abundant species caught during both surveys, followed by scaldfish in the spring and dab in the autumn. Beam trawl catch rates illustrated abundances as high as 423 individuals per hour from within the windfarm boundary and 387 individuals per hour from along the export cable corridor, with the highest total CPUE in the wind farm found in the autumn, and along the export cable corridor in the spring. Fish species captured during the two surveys included solenette, dab, goby Gobiidae *spp*., scaldfish, sand goby, plaice, whiting, Dover sole, common dragonet, pogge, lesser spotted dogfish, poor cod, lesser pipefish *Syngnathus rostellatus*, thornback ray, four bearded rockling *Enchelyopus cimbrius*, Norway pout *Trisopterus esmarkii* and grey gurnard (Brown and May Marine Ltd., 2012a, 2012b).

Walney offshore wind project

1.3.2.40 Beam and otter trawl surveys were undertaken for the Walney offshore wind project (Walney 1 and Walney 2) from May 2009 (pre-construction surveys) to June 2013 (year 2 post-construction surveys), with surveys typically conducted in the spring and summer of each survey year. The Walney offshore wind project is located approximately 11.4 km north east of the Offshore Order Limits (**Figure 1.3**). Walney 1 is located to the east of Walney 2, in inshore waters. The key species of commercial importance that were observed during these surveys were *Nephrops*, Dover sole and cod (Brown and May Marine Ltd., 2009a; 2013a).

1.3.2.41 Collectively, between Walney 1 and Walney 2, plaice, dab, solenette, whiting and lesser-spotted dogfish were the most abundant fish species observed during the surveys, while *Nephrops* was the most abundant shellfish species encountered. *Nephrops* grounds are known to occur within the Walney offshore wind project area and were identified during the pre-construction and post-construction monitoring surveys (Brown and May Marine Ltd., 2013a).

1.3.2.42 Walney 1 pre- and post- construction surveys found that Dover sole abundances were slightly increased in most post-construction surveys, but overall, there were no significant changes observed between the pre- and post-construction survey results (Brown and May Marine Ltd., 2013a). *Nephrops* were highly varied in the Walney 1 surveys and higher yields were consistently recorded in the summer months of May and June, illustrating a degree of seasonal variability in population patterns (Brown and May Marine Ltd., 2013a), with the caveat that further studies in different seasons would provide a more rounded view of the post-construction population characteristics. Otter trawl catch rates for Walney 1 evidenced abundances as high as 3,900 *Nephrops* individuals per hour trawled.

1.3.2.43 Walney 2 catch rates for fish and shellfish species illustrated that the overall number of species caught slightly increased during post-construction surveys, suggesting that the Walney offshore wind project may have had a positive effect on the localised fish and shellfish populations, although it’s important to note that these surveys provide only a snapshot of highly mobile species at the time of sampling (Brown and May Marine Ltd., 2013a). Otter trawl catch rates during the survey recorded abundances as high as 1,700 individuals per hour trawled.

1.3.2.44 Infrequent numbers of cod, herring, dragonet, grey gurnard, lesser spotted dogfish, tub gurnard and scaldfish were recorded within the Walney 1 and Walney 2 otter trawl surveys (Brown and May Marine Ltd., 2013a). Higher catch rates were recorded in April for whiting and herring, whereas the highest catch rates pertaining to *Nephrops*, lesser-spotted dogfish, dragonet, scaldfish, grey gurnard and tub gurnard were recorded in June, suggesting some degree of seasonality among these species (Brown and May Marine Ltd., 2013a).

1.3.2.45 Beam trawl surveys undertaken at Walney 1 evidenced abundances as high as 369 individuals per hour trawled, while Walney 2 illustrated a slightly lower number of individuals caught per hour at 293 (Brown and May Marine Ltd., 2013a). Solenette was found to be the most abundant species encountered within both of these survey areas during the months of April and June. Amongst the survey stations with the highest total catch rates in Walney 1 and Walney 2, solenette represented more than 50% of the catch repeatedly (Brown and May Marine Ltd., 2013a).

Awel y Môr offshore wind project

1.3.2.46 The Awel y Môr offshore wind project is located approximately 28.9 km to the south of the Offshore Order Limits (**Figure 1.3**). The Awel y Môr offshore wind project utilised findings from Gwynt y Môr, Burbo Bank Extension, North Hoyle, Rhyl Flats and the Rhiannon to better inform and undertake their 2021 PEIR. Data assessed from other offshore wind projects in the region illustrated similar patterns as discussed above regarding the dominant species that would be expected within this part of the Irish Sea.

1.3.2.47 Based on the data sources described above and findings presented within the Awel y Môr PEIR (RWE Renewables UK, 2022), it was found that a wide range of fish and shellfish species were expected to inhabit the project area, which may also be present within the Offshore Order Limits. These species include Atlantic salmon *Salmo salar*, cod, whiting, plaice, Dover sole, herring, mackerel, lesser sandeel *Ammodytes tobianus*, spotted and thornback ray (MacNab and Nimmo, 2021).

1.3.2.48 Additionally, the Awel y Môr offshore wind project analysed long-term time series data across the whole of the Irish Sea, including findings from the Northern Irish Ground Fish Trawl Survey (NIGFS). Otter trawls conducted across the Irish Sea from 2005 to 2018 were found to be dominated by whiting, haddock, lesser-spotted dogfish, plaice and herring, similar results to those illustrated within the IBTS survey zones overlapping the Offshore Order Limits (ICES, 2010; MacNab and Nimmo, 2021).

Burbo Bank and Burbo Bank Extension offshore wind projects

1.3.2.49 Beam trawl surveys were undertaken for the Burbo Bank and Burbo Bank Extension offshore wind projects between 2005 and 2010 and in May and September 2011 respectively (CMACS, 2006a; 2006b; Brown and May Marine Ltd., 2011a, 2011b; Dong Energy Burbo Extension Ltd., 2013). The Burbo Bank offshore wind project is located 26.2 km south east of the Offshore Order Limits (**Figure 1.3**). Burbo Bank Extension is located to the west of Burbo Bank, 25.8 km from the Offshore Order Limits.

1.3.2.50 Pre-construction surveys at Burbo Bank in 2005 and 2006 were undertaken using a 2-metre beam trawl and 4-metre beam trawl, respectively (CMACS, 2006a; 2006b). In addition, the 2-metre beam trawl survey reports from 2007 and 2009 Burbo Bank post-construction surveys and the 4-metre beam trawl survey report from 2010 were available for review (SeaScape, 2008, 2011a, 2011b). A total of 22 species of fish were recorded from both the 2006 and 2010 4-metre beam trawl surveys at Burbo Bank. The fish species composition remained similar during all pre- and post-construction fish surveys with dab, plaice, solenette and whiting being the most commonly recorded species.

1.3.2.51 Three species of elasmobranchs were caught during the pre-construction 4-metre beam trawl survey: thornback ray, lesser spotted dogfish and starry smooth-hound and four species were reported from the 2010 post-construction survey, encompassing the above three species plus the spotted ray. Thornback ray were abundant during both pre- and post-construction surveys and were largely identified as juvenile, with approximately equal proportions of males and females present; the area was considered important for juvenile ray species. One juvenile sea trout was captured during the 2006 4-metre beam trawl survey which was surmised to be present in the area for feeding.

1.3.2.52 Baseline otter trawl surveys within the Burbo Bank Extension area in 2011 found dab, plaice and flounder to be most abundant in catches in the spring survey, with the addition of herring to this group of species in the autumn survey (Brown and May Marine Ltd., 2011a, 2011b; Dong Energy Burbo Extension Ltd., 2013). During 2-metre beam trawl sampling, dab and sandeel were the most abundant species caught in May whereas in September, whiting and dab were most commonly captured. The overall composition was broadly consistent with that reported from the Burbo Bank pre- and post-construction surveys between 2005 and 2010. Thornback ray and lesser-spotted dogfish were the most abundant elasmobranch species during both 2011 otter trawl surveys. Other elasmobranch species recorded using the two techniques were starry smooth-hound, spotted ray, blond ray and nursehound. Herring and sprat were among the most abundant pelagic teleost species caught during both otter trawl surveys with higher catches for herring in September and sprat in May. Other fish species of interest, such as Dover sole, sandeel, horse mackerel *Trachurus trachurus*, cod, river lamprey *Lampetra fluviatilis* and seabass were caught in relatively low numbers.

Ormonde offshore wind project

1.3.2.53 The Ormonde offshore wind project is located approximately 20.1 km north east of the Offshore Order Limits (**Figure 1.3**). Pre-construction otter and beam trawl surveys were undertaken in April and October 2009 and post-construction surveys were undertaken in 2012 to 2014 (Brown and May Marine Ltd., 2009b; 2009c; 2013b; 2013c; 2013d; 2014).

1.3.2.54 The Ormonde offshore wind project otter trawl surveys found that dab and plaice were the most abundant species encountered during all surveys. The 2-metre beam trawl samples generally reflected highest abundances of solenette and dab from all surveys. The total number of fish and shellfish species captured during otter trawling ranged from 14 in the spring pre-construction survey to 38 in the October 2012 and 2013 post-construction surveys. During beam trawl sampling, the total number of fish species captured ranged from 13 in October 2009 to 28 in October 2013. Elasmobranch species recorded during the otter trawl sampling included lesser spotted dogfish, thornback ray, nursehound, starry smooth-hound, blonde ray and cuckoo ray. Shellfish species captured with the otter trawl included edible crab, *Nephrops*, European lobster, long-finned squid *Loligo forbesii* and velvet crab. Beam trawl surveys also recorded a similar array of species, with the addition of razor clam *Ensis ensis*.

Mona Offshore Wind Project

1.3.2.55 The fish and shellfish ecology baseline characterisation for the Mona Offshore Wind Project was based upon a combination of desktop information sources, findings from previous targeted fish and shellfish surveys undertaken for wind farm projects within the east Irish Sea and relevant site-specific benthic survey results from the Mona Array Area in 2021, and along the Mona Offshore Cable Corridor and ZOI in 2022 (Mona Offshore Wind Ltd., 2024). Imagery data from digital aerial surveys were examined for presence of basking shark, however none were identified within the survey area at the time of surveying.

1.3.2.56 Site-specific benthic subtidal survey results supported the assessment for habitat suitability for herring spawning and sandeel and provided a number of opportunistic observations of fish and shellfish species of interest. Data from the Mona Offshore Wind Project benthic surveys illustrated similar patterns as would be expected within this part of the Irish Sea. Specifically, observations of queen and king scallop, *Nephrops*, other bivalves including *Ensis magnus*, common dab, lemon sole, plaice, thickback sole, haddock, sandeel, blonde ray, thornback ray, cuckoo ray and lesser spotted dogfish were recorded during the benthic subtidal surveys (Mona Offshore Wind Ltd., 2024).

Morgan Offshore Wind Project: Generation Assets

1.3.2.57 The study area defined for Morgan Offshore Wind Project: Generation Assets matches the fish and shellfish ecology study area used for the Transmission Assets (**Figure 1.1**).

1.3.2.58 The fish and shellfish ecology baseline characterisation for Morgan Offshore Wind Project: Generation Assets was based upon a combination of desktop information sources, findings from previous targeted fish and shellfish surveys undertaken (as outlined above) for wind farm projects within the east Irish Sea and relevant results from the 2021 and 2022 subtidal benthic site-specific surveys (Morgan Offshore Wind Ltd., 2023). These surveys include records of small demersal fish and shellfish species which have been used to inform the baseline characterisation. Digital aerial surveys were also undertaken for the Morgan Offshore Wind Project: Generation Assets to inform the marine mammals and ornithological assessments. Imagery data were reviewed for the presence of basking shark; however, none were identified from the surveys. The full benthic subtidal survey data for the Morgan Offshore Wind Project: Generation Assets is referenced within Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the ES and is used here as desktop data.

1.3.2.59 Site-specific benthic subtidal survey results supported the assessment for habitat suitability for herring spawning and sandeel (results are presented in **sections 1.3.4** and **1.3.5** as the station locations fall within the Offshore Order Limits) and provided opportunistic observations of fish and shellfish species (**Figure 1.2**). Data from the Morgan Offshore Wind Project: Generation Assets illustrated similar patterns as discussed above regarding the dominant species that would be expected within this part of the Irish Sea.

1.3.2.60 Observations of razor clam, queen scallop, *Nephrops*, Dover sole, solenette, common topknot *Zeugopterus punctatus*, common dab, lemon sole, plaice, thickback sole, haddock, common dragonet, gurnards Triglidae *spp*., gadoids Gadidae *spp*., gobies, sandeel, blonde ray, thornback ray, cuckoo ray and lesser spotted dogfish were recorded during the benthic subtidal surveys (Gardline, 2022).

Morecambe Offshore Windfarm: Generation Assets

1.3.2.61 For the Morecambe Offshore Windfarm: Generation Assets, two study areas were defined, from which the baseline characterisation was characterised.

- The Morecambe Offshore Windfarm: Generation Assets fish and shellfish ecology study area encompassed a 15 km ZOI identified for direct and indirect effects (namely increased suspended sediments and subsequent deposition) on fish and shellfish ecology and provided a regional context on baseline fish and shellfish populations.
- In consideration of potential impacts associated with underwater sound and migratory species of conservation importance, such as diadromous fish and basking shark *Cetorhinus maximus*, consideration of an additional 'wider fish and shellfish ecology study area' was deemed appropriate. The Morecambe Offshore Windfarm: Generation Assets wider study area encompassed a circular area with a 100 km radius around the windfarm site (noting

underwater sound impacts are encompassed with a 50 km ZOI based on site specific modelling). This is to capture the maximum distances for potential impacts associated with underwater sound and to allow for the fact that migratory species could pass through the windfarm site. At distances over 100 km, given the coastal orientation, migratory movements and the level of dispersal expected beyond this range would be such that effects at a detectable level would be unlikely.

1.3.2.62 As part of the baseline characterisation for fish and shellfish assemblages within the Morecambe Offshore Windfarm: Generation Assets, no surveys targeting specifically fish or shellfish species were undertaken (Morecambe Offshore Windfarm Ltd., 2024). However, benthic subtidal surveys and digital aerial surveys have been used to inform the baseline characterisation for fish and shellfish ecology, notably for habitat suitability for herring spawning and sandeel (results presented in **sections 1.3.4** and **1.3.5** as the sampling locations fall within the Offshore Order Limits), opportunistic observations of fish and shellfish species (**Figure 1.2**) and the aerial imagery to determine the presence of basking shark. The full benthic subtidal survey data for the Morecambe Offshore Wind Project: Generation Assets is referenced within Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report to the ES and is used here as desktop data.

1.3.2.63 The baseline characterisation focussed principally on available data sources such as findings from other wind farm project fish and shellfish surveys (Barrow, Ormonde, West of Duddon Sands, Rhiannon, Walney and Awel y Môr). Data presented in the Morecambe Offshore Windfarm: Generation Assets fish and shellfish ecology ES chapter (Morecambe Offshore Windfarm Limited 2024) illustrated similar patterns as discussed above regarding the dominant species and species composition expected within this part of the Irish Sea.

1.3.2.64 Observations of razor clam, prickly cockle *Acanthocardia echinata* and unspecified fish were recorded during the benthic subtidal surveys at Morecambe Offshore Wind Project: Generation Assets (Ocean Ecology, 2022).

1.3.2.65 No basking shark were sighted during the aerial surveys undertaken over the period March 2021 to February 2023 to inform the ornithology and marine mammal assessments across the Morecambe Offshore Windfarm: Generation Assets study area (Morecambe Offshore Windfarm Limited 2024).

Transmission Assets

1.3.2.66 The 2022 site-specific survey results from grab/DDV samples have provided incidental data on the presence of fish species within the Offshore Order Limits, including commercially important species, such as observations of solenette, common dragonet, red gurnard, common dab, haddock, lemon sole, plaice, Dover sole, other flatfish, spotted ray, lesser spotted dogfish and greater pipefish *Syngnathus acus*. However, it should be noted that this data collection method does not target fish species specifically, therefore these results should be regarded as opportunistic and considered in the context of these largely highly mobile species.

1.3.2.67 Prickly cockle, common cockle *Cerastoderma edule* and pod razor *Ensis siliqua* were identified during an intertidal survey within the Offshore Order Limits (see Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the ES for additional details).

1.3.2.68 A wide range of fish and shellfish species, including elasmobranchs, are expected to inhabit or migrate through the study area. Fish and shellfish communities described and recorded in the surrounding offshore wind projects described above are likely to be present within the Offshore Order Limits.

1.3.2.69 Characterising species recorded within site-specific fish and shellfish surveys for various local offshore wind projects (Gwynt y Môr, Burbo Bank Extension, North Hoyle, Rhyl Flats, Rhiannon, Walney and West of Duddon Sands) within the vicinity of the Offshore Order Limits and inside the defined fish and shellfish ecology study area, are consistent with those species recorded in regional scientific surveys (such as IBTS), further suggesting that monitoring data are not only consistent within the area, but remains relevant, as the temporal span of these surveys covers the last decade (MacNab and Nimmo, 2021). Observations within the Transmission Assets Order Limits: Offshore support the fish and shellfish assemblages and findings in the wider region.

1.3.3 Spawning and nursery grounds

1.3.3.1 A number of fish species are known to have spawning and nursery grounds within the study area. Data from Cefas (Ellis *et al*., 2012; Coull *et al*., 1998) provides spatially explicit maps of the spawning and nursery areas of multiple key species. It is worth noting that Coull *et al*. (1998) data may lack accuracy due to the age of the study and for this reason, it has only been used where no other data from Ellis *et al*. (2012) are available.

1.3.3.2 Potential nursery and spawning areas in the Irish Sea for a range of species were identified by Coull *et al*. (1998), based on larvae, egg and benthic habitat data. Ellis *et al*. (2012) reviewed these data for several finfish species in the Irish Sea, including cod, whiting and herring, providing an updated understanding of areas of low and high intensity nursery and spawning grounds. Further information regarding nursery areas is provided in Aires *et al*. (2014). The study assessed evidence of aggregations of ‘0 group fish’ (fish in the first year of their lives) around the UK coastline. These data were ascertained from species distribution modelling, combining observations of species occurrence or abundance with environmental data (Aires *et al*., 2014). The outputs of this process have been suggested to be used as a guide for the most likely locations of aggregations of 0 group fish. Recent modelling based on collated survey data in Welsh waters and the surrounding shelf sea waters, including the Irish Sea, provides up-to-date evidence to support the distribution of previously identified spawning and nursery grounds for a range of foraging species, with any slight changes in mapped species distribution likely being due to natural interannual variation (Campanella and van der Kooij, 2021). Broadly, these studies all describe the same patterns of spawning and nursery habitat within the study area and thus the maps available from Coull *et al*. (1998) and Ellis *et al*. (2012) data can be considered reliable.

1.3.3.3 Based on the above data sources, spawning areas for several species overlap the Offshore Order Limits, including high intensity spawning areas for cod, herring, plaice, Dover sole and sandeel. Species with known spawning periods and nursery habitats identified within the Offshore Order Limits have been summarised in **Table 1.3, Table 1.4** and **Figure 1.4** to **Figure 1.22**.

1.3.3.4 Spawning and nursery habitats are often influenced by the seabed sediments and substrates. As such, site-specific information on sediments can be useful to characterise spawning and nursery habitats within the Offshore Order Limits and have been utilised to characterise herring and sandeel habitats in later sections of this technical report (**section 1.3.4** and **section 1.3.5**).

1.3.3.5 Subtidal benthic sediments across the Offshore Order Limits, exclusive of the Morgan Offshore Wind Project: Generation Assets and ZOI, were found to range from gravelly muddy sand to slightly gravelly sand, with 42% of the samples classified as muddy sand. Of the other samples, 26% were classified as sand and 10% were classified as gravelly sand, representing the three most common sediment types throughout the entirety of the Offshore Order Limits. With increasing distance offshore, the sediments graded into gravelly muddy sand in the west. According to the simplified Folk Classification (Long, 2006), most stations were classified as sand and muddy sand (46%), with areas of mud and sandy mud (36%), mixed sediment (11%) and coarse sediment (8%) (see Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the ES for comprehensive details of the benthic survey).

1.3.3.6 Areas important for supporting juvenile fish (i.e., that provide adequate food resources and shelter) are known as nursery areas. Nursery areas for several species, including herring, mackerel, lemon sole, Dover sole, anglerfish, haddock, cod, whiting and *Nephrops* are found within the Irish Sea (**Figure 1.4** to **Figure 1.22**). These species are further discussed in Volume 2, Annex 6.1: Commercial fisheries technical report of the ES. A large proportion of the east Irish Sea, including the environment around the Offshore Order Limits, has been mapped as a nursery habitat for cod and whiting.

1.3.3.7 Anglerfish were found to have low intensity nursery grounds across the Irish Sea and therefore coincide with the Offshore Order Limits (**Figure 1.4**). Anglerfish are thought to spawn in deep waters during winter and spring months, however there is insufficient data to properly identify spawning grounds (Ellis *et al*., 2012). They are considered unlikely to overlap with the Offshore Order Limits. The presence of anglerfish nursery grounds within the Irish Sea is supported by outputs from Aires *et al*. (2014).

1.3.3.8 Cod are commonly found throughout the east Irish Sea and have high intensity nursery grounds overlapping the majority of the Offshore Order Limits (**Figure 1.5**; Ellis *et al*., 2012). The presence of cod nursery grounds is supported by Aires *et al*. (2014). In addition to nursery grounds, cod have high intensity spawning grounds in areas further offshore overlapping with the Offshore Order Limits and low intensity spawning grounds overlapping with the eastern section of the Offshore Order Limits, with spawning occurring between January and April and peaking in February and March (**Figure 1.5**; Ellis *et al*., 2012). Spawning behaviour involves courtship in demersal environments typically consisting of sandy sediments and boulders (Grabowski *et al*., 2012), followed by release of buoyant eggs into the water column (Hutchings *et al*., 1999).

1.3.3.9 Dover sole spawning and nursery grounds are similar to those presented above for plaice, with spawning occurring between February and April and peaking in March (**Table 1.4**) with evidence of spawning behaviour up to the end of June in some places (Savina *et al*., 2010). Spawning grounds for Dover sole were found to coincide with the Offshore Order Limits, with high intensity grounds across the middle section (i.e. east sections of the Morgan Offshore Wind Project: Generation Assets), with low intensity grounds also overlapping the Offshore Order Limits, specifically in the coastal waters and the west portion of the Morgan Offshore Wind Project: Generation Assets. High intensity nursery grounds for Dover sole are concentrated across the majority of the Offshore Order Limits, with low intensity grounds also overlapping with the Offshore Order Limits (specifically located to the west of the Morgan Offshore Wind Project: Generation Assets) (**Figure 1.6**). These findings are further supported by outputs illustrating the presence of 0 group aggregations in inshore waters south of the Offshore Order Limits from Aires *et al*. (2014).

1.3.3.10 European hake low intensity nursery grounds were identified to marginally overlap the study area west of the Isle of Man. The presence of nursery grounds in this area are strongly supported by Aires *et al*. (2014). Similarly, low intensity spawning grounds of European hake are found in the central Irish Sea and overlapping the west portion of the study area. No nursery or spawning grounds for the European hake coincide with the Offshore Order Limits (**Figure 1.7**).

1.3.3.11 Haddock spawning occurs predominantly between February and May. Similar to both cod and whiting, haddock have a demersal courting period followed by pelagic egg release and larval phases (Casaretto and Hawkins, 2012), feeding on plankton before juveniles move down towards the seabed to exploit demersal prey resources, including small crustaceans and small fish. There is an unspecified intensity nursery ground which marginally overlaps with the most north portion of the Offshore Order Limits (**Figure 1.8**) The extent of haddock nursery grounds is supported by outputs from Aires *et al*. (2014).

1.3.3.12 Herring have high intensity nursery grounds over the majority of the Offshore Order Limits, with both high and low intensity spawning grounds bordering the Offshore Order Limits near the Isle of Man

(**Figure 1.9**; Ellis *et al*., 2012; Coull *et al*., 1998). Spawning times for herring are dependent on sub-populations, with both spring and autumn spawning populations occurring in the study area. The Manx herring stock (which includes the Douglas Bank spawning population) spawn over a period of three to four weeks from late September, which is reported to have remained consistent since the 1940s (Dickey-Collas *et al*., 2001). Herring fishing in Manx waters has recently commenced again following a new agreement between the Isle of Man and UK governments which allows Manx boats to catch up to 100 tonnes of herring in 2023, and which may increase over the coming years. This agreement was part of the negotiations in the wake of the UK's departure from the EU, which resulted in increases to the British share of quotas that are applied to EU and British fishing fleets (Isle of Man Government, 2023).

1.3.3.13 Herring deposit sticky eggs, preferably on gravel substrate, and the eggs adhere to the seabed forming extensive beds which can be several layers thick (Drapeau, 1973; Rogers and Stocks, 2001). After hatching the larvae enter the plankton and drift with the current until reaching inshore nursery grounds. A year later they migrate further offshore to join adults at feeding grounds. The presence of nursery grounds for herring in the study area is supported by outputs from Aires *et al*. (2014), with predicted aggregations of zero group herring found inshore and near the Isle of Man. A further review of herring spawning has been included in **section 1.3.4**. The AFBI in Northern Ireland has undertaken herring larval surveys of the north Irish Sea in November every year since 1993. The 2019 survey results recorded the majority of herring larvae in the east Irish Sea in the vicinity of the Douglas Bank spawning ground and to the north of the Isle of Man (ICES, 2021a).

1.3.3.14 The Offshore Order Limits overlap marginally with low intensity spawning grounds of horse mackerel (**Figure 1.10**; Ellis *et al*. 2012). Outputs from Aires *et al*. (2014) suggest that nursery grounds for horse mackerel are present in the east Irish Sea coinciding with the Offshore Order Limits; however, it's worth noting that Ellis *et al.* (2012) reported that catches of juvenile horse mackerel were widespread around the UK in various scientific surveys. Horse mackerel spawning occurs between March and August, with peak spawning in May and June (**Table 1.3**; **Table 1.4**).

1.3.3.15 Lemon sole are found throughout the study area but have unspecified intensity nursery grounds and undetermined intensity spawning grounds over the west portion of the Offshore Order Limits, specifically between the Isle of Man and the west border of the Morecambe Offshore Windfarm: Generation Assets (**Figure 1.11**; Coull *et al*., 1998). These findings are supported by Aires *et al.* (2014). Lemon sole are known to spawn primarily between March and May, peaking in April (**Table 1.4**) with spawning in some places known to occur until September (Smith, 2014). Evidence also exists of spawning in October to November dependent on the stock and location (Geffen *et al*., 2021), with lemon sole utilising their preferred benthic habitats when exhibiting spawning behaviour (Hinz *et al*., 2006). Specific spawning grounds for lemon sole are not well-defined and lemon sole are believed to spawn widely throughout their range without specific conditions required. Large batches of eggs are released at the sea floor but rapidly become pelagic in the water column until hatching (Rae, 1965).

1.3.3.16 Ling were found to have a low intensity spawning ground located overlapping the west section of the Offshore Order Limits, extending north towards the Solway Firth and west to Ireland (**Figure 1.12;** Ellis *et al*., 2012). Ling are known to primarily spawn from February to May (**Table 1.4**) with spawning in some places known to occur until July (Cohen *et al*., 1990) and pelagic eggs are released into the water column (Cohen *et al*., 1990; Wheeler, 1992).

1.3.3.17 Mackerel have low intensity spawning grounds which coincide with the entirety of the Offshore Order Limits and low intensity nursery grounds overlapping the west section of the Offshore Order Limits (**Figure 1.13**; Ellis *et al*., 2012). The presence of mackerel nursery grounds is not supported by outputs from Aries *et al*. (2014), with no modelled observations of 0 group fish within the study area. Mackerel spawn over the spring and summer months from March to July (**Table 1.4**) with peak spawning occurring during the months of May and June. Spawning behaviour involves the release of eggs into the water column, where fertilisation also occurs (Walsh and Johnstone, 2006), indicating a low level of reliance on sedimentary habitats for spawning.

1.3.3.18 *Nephrops* are opportunistic predators that leave their burrows at dawn and dusk to forage. They reach sexual maturity after two to three years and have an annual reproductive cycle. When spawning, once eggs are fertilised, females carry them on their abdomen for eight to nine months. Females tend to remain in their burrows during this period (Farmer, 1975) and once the eggs hatch, larvae is released between April and June (Farmer, 1974). Larvae are dispersed by local hydrodynamics (e.g., the gyre that forms in the Irish Sea during spring and summer) (Hillis, 1968). However, larvae are not transported over long distances and are retained in the vicinity of the parent population rather than being carried away into unsuitable habitats (Hill *et al.,* 1996, 1997). *Nephrops* spawning and nursery grounds (unspecified intensity) coincide with the west section of the Offshore Order Limits (**Figure 1.14**, Coull *et al*., 1998). Further details on *Nephrops* are provided in **section 1.3.8**.

1.3.3.19 Plaice spawn between December and March, with peak spawning occurring in January and February (**Table 1.4**) and each female producing up to half a million eggs which drift passively in the plankton. Once the larvae reach a suitable size for settlement, they metamorphose into the asymmetric body shape. As juveniles, they inhabit mostly shallow water including tidal pools. In their second year they move into deeper water and are mostly found in a depth range of 10 m to 50 m. Plaice have high intensity spawning grounds overlapping the west section of the Offshore Order Limits and low intensity spawning grounds over the east portion of the Offshore Order Limits (i.e., the offshore export cable corridor; **Figure 1.15**; Ellis *et al*., 2012). Low intensity nursery grounds occur over the majority of the Offshore

Order Limits, excluding the far west of the Morgan Offshore Wind Project: Generation Assets (**Figure 1.15**; Ellis *et al*., 2012).

1.3.3.20 During the winter months sandeel remain in the sediment, only emerging to spawn. 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). A review of spawning and nursery grounds suggests that there is an overlap of the Offshore Order Limits with both sandeel spawning and nursery grounds (**Figure 1.16**. Low intensity nursery grounds are present across the majority of the Offshore Order Limits. Both high and low intensity spawning grounds are denoted as being present across the Offshore Order Limits and the whole of the wider Irish Sea (**Figure 1.16**; Ellis *et al*., 2012).

1.3.3.21 Sprat spawning grounds (unspecified intensity) coincide with the Offshore Order Limits and the whole of the east Irish Sea (**Figure 1.17**). Sprat nursery grounds have been identified throughout the study area with higher abundances of juvenile sprat during the last quarter of the year when compared to the first quarter (Campanella and van der Kooij, 2021). The presence of sprat nursery grounds is supported by outputs from Aires *et al*. (2014), with aggregations of 0 group fish occurring throughout the study area, and a spawning period of May to August, with peak spawning in May and June (**Table 1.3**; **Table 1.4**).

1.3.3.22 Whiting are common in the Irish Sea and spawning occurs between February and June (**Table 1.4**). The Irish Sea provides ideal conditions for whiting spawning, with sandy substrates and fast movement of water for release of eggs into the water column. After the eggs hatch, the larvae drift in surface waters for a year and then move closer to the seabed as juveniles. The majority of the Offshore Order Limits coincides with low intensity spawning and high intensity nursery grounds for whiting (**Figure 1.18**).

1.3.3.23 There are several low intensity nursery grounds for elasmobranch species within or in close proximity to the Offshore Order Limits including for spotted ray, thornback ray and tope shark (**Figure 1.19, Figure 1.21** and **Figure 1.22**, respectively). Additionally, the offshore area of the Offshore Order Limits, which comprises the Generation Assets, has been classified as a high intensity nursery ground for spurdog (**Figure 1.20**; Ellis *et al*., 2012). These classifications are in line with desktop data sourced from other offshore wind projects in the area and data related to commercial fisheries landings.

1.3.3.24 Of the shellfish species within the study area and more specifically, in proximity to and overlapping the Offshore Order Limits, queen scallop are known to spawn in the region. Vessel Monitoring System (VMS) data and feedback from commercial fisheries stakeholders indicated that an area overlapping with the Offshore Order Limits, in the eastern portion of the Morgan Offshore Wind Project: Generation Assets is known to be an important queen scallop spawning area (Morgan Offshore Wind Limited, 2023; Morgan Offshore Wind Limited, 2024a). Other shellfish species are likely to spawn within the study area across the year as outlined within **Table 1.5** and further discussed in **section 1.3.8**.

Table 1.3: Key species with spawning and nursery grounds overlapping the Offshore Order Limits (Coull *et al*., 1998 and Ellis *et al*., 2012)

Common name	Species name	Spawning	Nursery
Teleost fish			
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*	✓	
Mackerel	*Scomber scombrus*	✓	✓
Plaice	*Pleuronectes platessa*	✓	✓
Sandeel	Ammodytidae spp.	✓	✓
Dover sole	*Solea solea*	✓	✓
Sprat	*Sprattus sprattus*	✓	
Whiting	*Merlangius merlangus*	✓	✓
Elasmobranchs			
Spotted ray	*Raja montagui*		✓
Spurdog	*Squalus acanthias*		✓
Thornback ray	*Raja clavata*		✓
Tope shark	*Galeorhinus galeus*		✓
Shellfish			
Nephrops	*Nephrops norvegicus*	✓	✓

Table 1.4: Periods of spawning activity for key species in the study area (Adapted from Coull *et al*., 1998; Ellis *et al*., 2012)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Teleost fish												
Anglerfish	🟦	🟦	🟦	🟦	🟦	🟦	🟦					
Cod	🟦	■	■	🟦								
Dover sole		🟦	■	🟦								

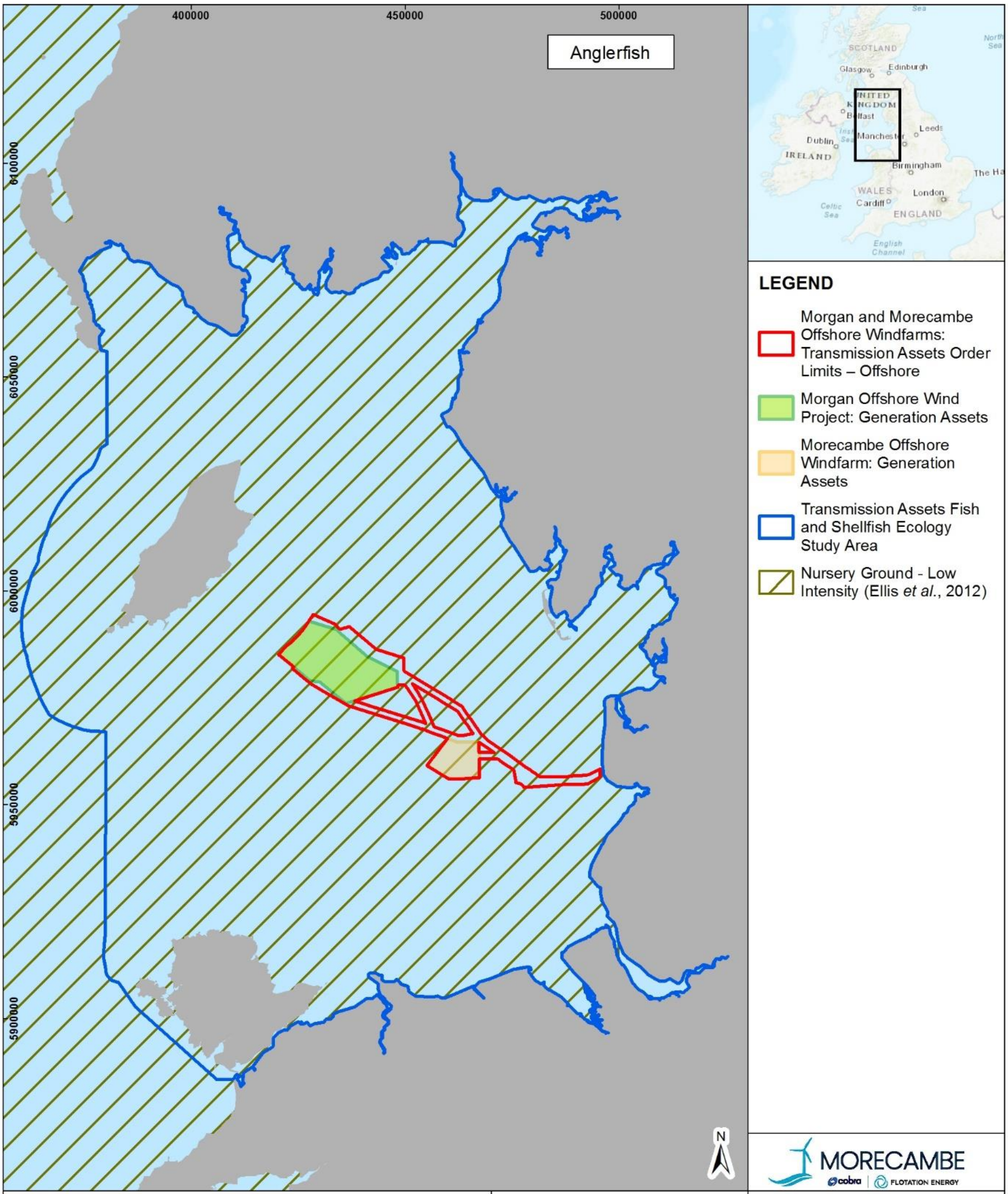
Species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
European hake	▨	■	■	▨	▨	▨						
Haddock		■	■	■	▨							
Herring*									▨	▨		
Horse mackerel			▨	▨	■	■	▨	▨				
Lemon sole			▨	■	▨							
Ling		▨	▨	▨	▨							
Mackerel			▨	▨	■	■	▨					
Plaice	■	■	▨									▨
Sandeel	▨	▨									▨	▨
Sprat					■	■	▨	▨				
Whiting		▨	▨	▨	▨	▨						
Elasmobranchs												
Spotted ray					■	■	■					
Spurdog	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Thornback ray		▨	▨	■	■	■	■	■	▨			
Tope shark	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Shellfish												
Nephrops	▨	▨	▨	■	■	■	▨	▨	▨	▨	▨	▨

Spawning periods are highlighted in light blue, peak spawning periods are marked dark blue.

*Refers to the Manx Stock which are reported to spawn consistently from late September for 3-4 weeks (Dickey-Collas *et al*. 2001).

Table 1.5: Period and type of reproduction for key shellfish species in the study area (adapted from MarLIN, 2022)

Common Name	**Reproductive period**	**Reproductive type**
Edible crab	November to February	Annual episodic
European lobster	Summer	-
King scallop	April to September	Annual protracted
Nephrops	Summer-autumn	Annual episodic



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T005-04

Drawing Title:
ANGLERFISH NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.4: Anglerfish nursery grounds within the study area and overlapping the Offshore Order Limits

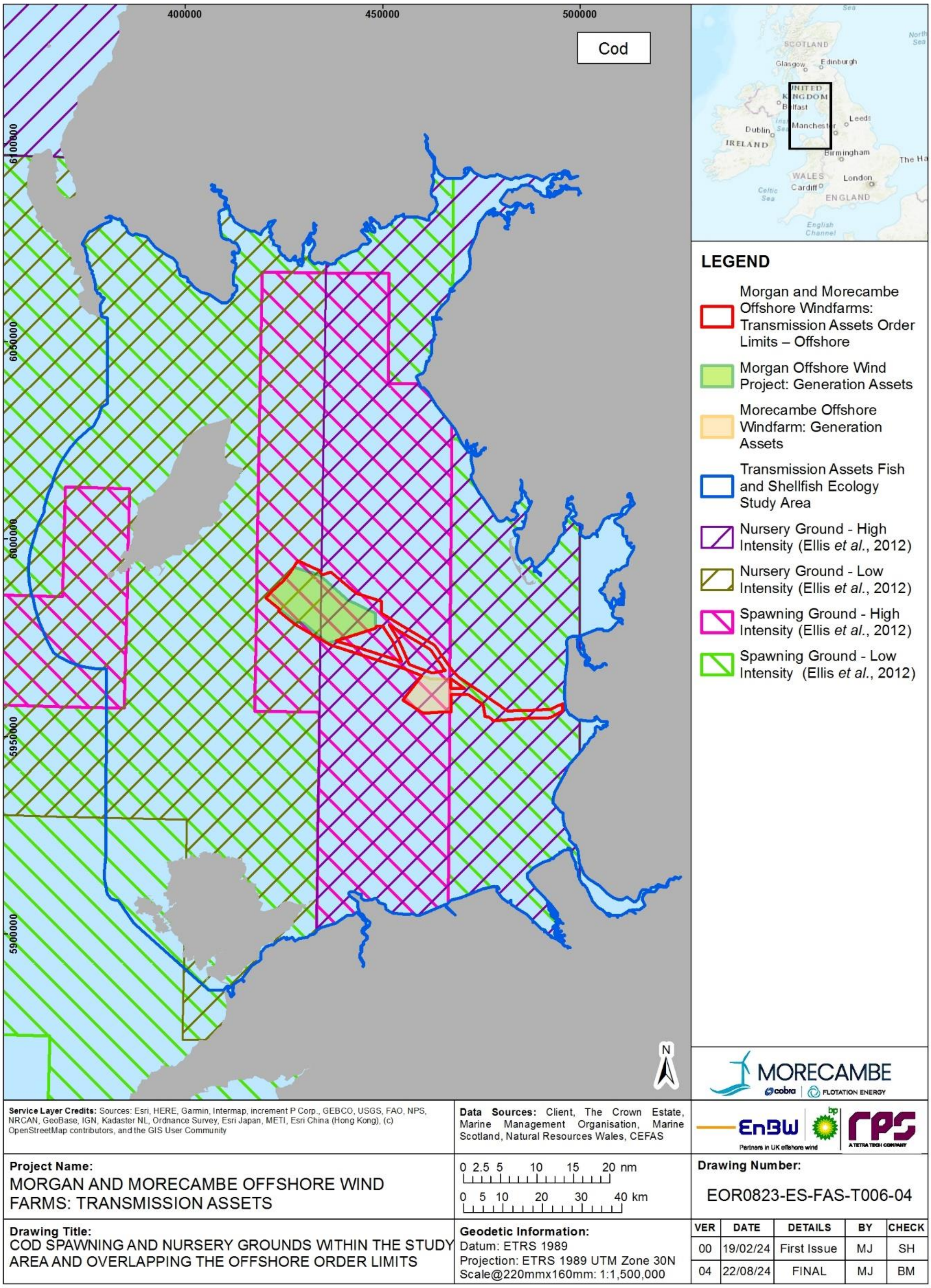
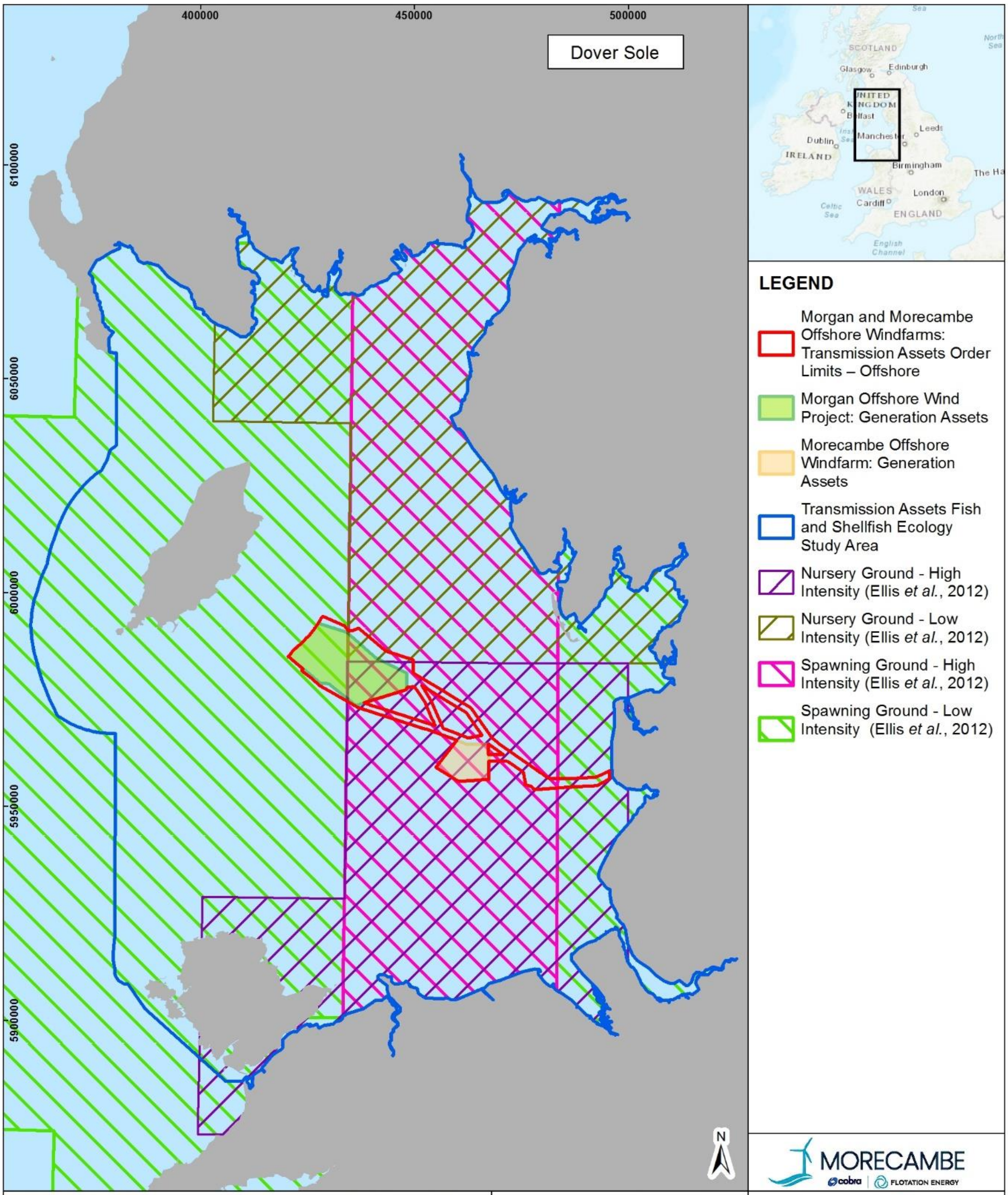


Figure 1.5: Cod spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T017-06

Drawing Title:
DOVER SOLE SPAWNING AND NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
06	22/08/24	FINAL	MJ	BM

Figure 1.6: Dover sole spawning and nursery grounds within the study area and overlapping the Offshore Order Limits

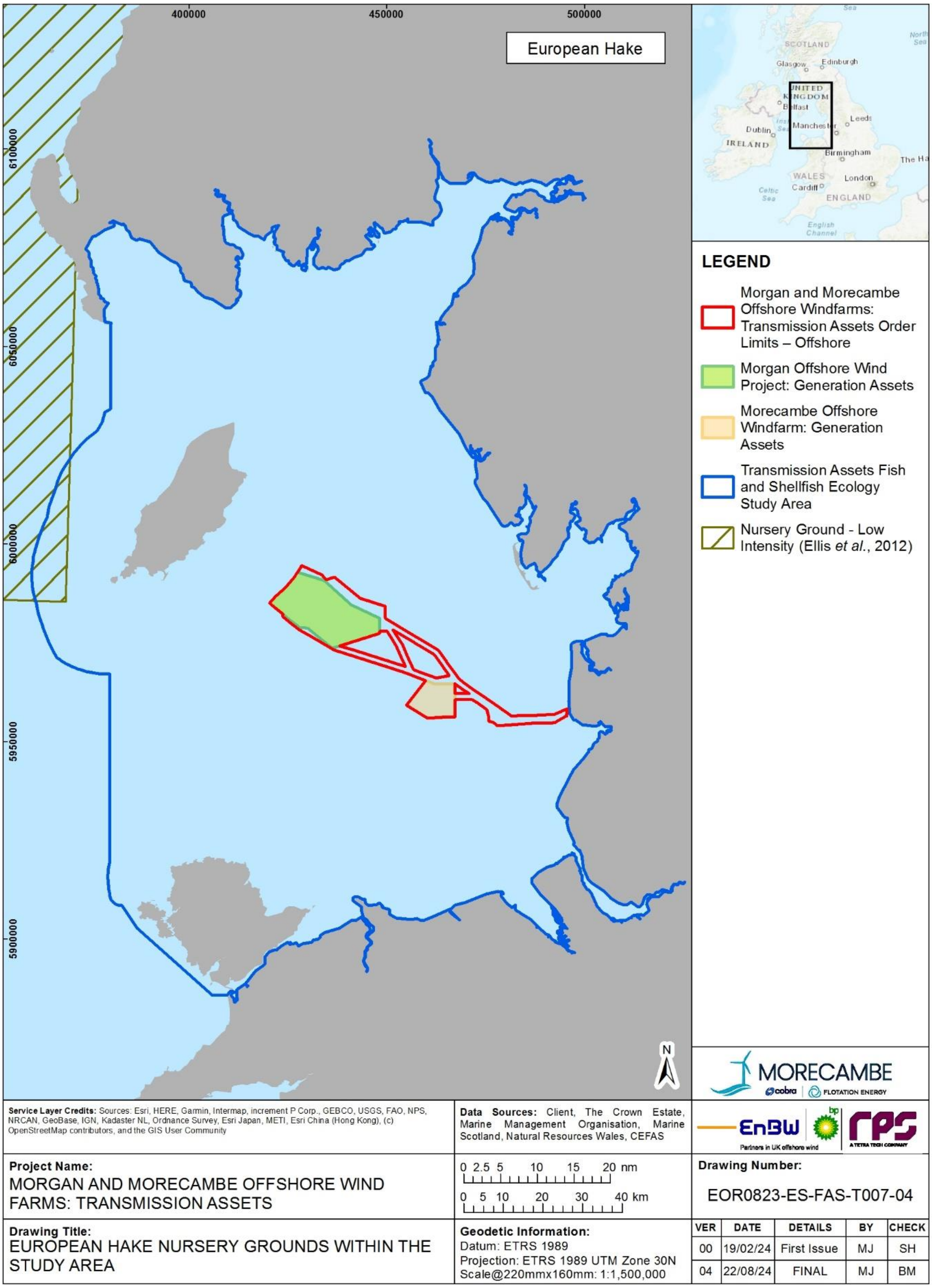
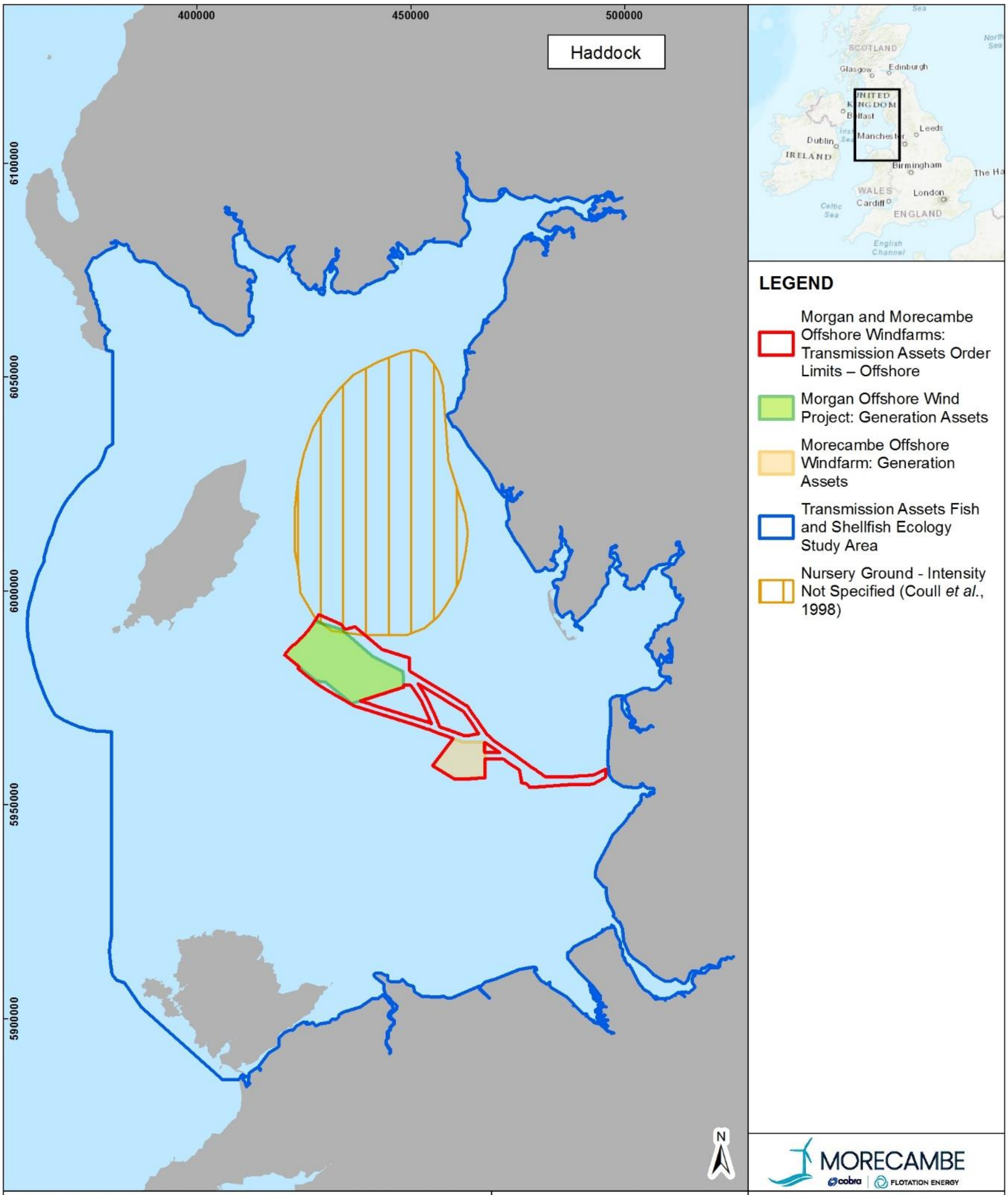


Figure 1.7: European hake nursery grounds within the study area



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

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Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T008-04

Drawing Title:
HADDOCK NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.8: Haddock nursery grounds within the study area and overlapping the Offshore Order Limits

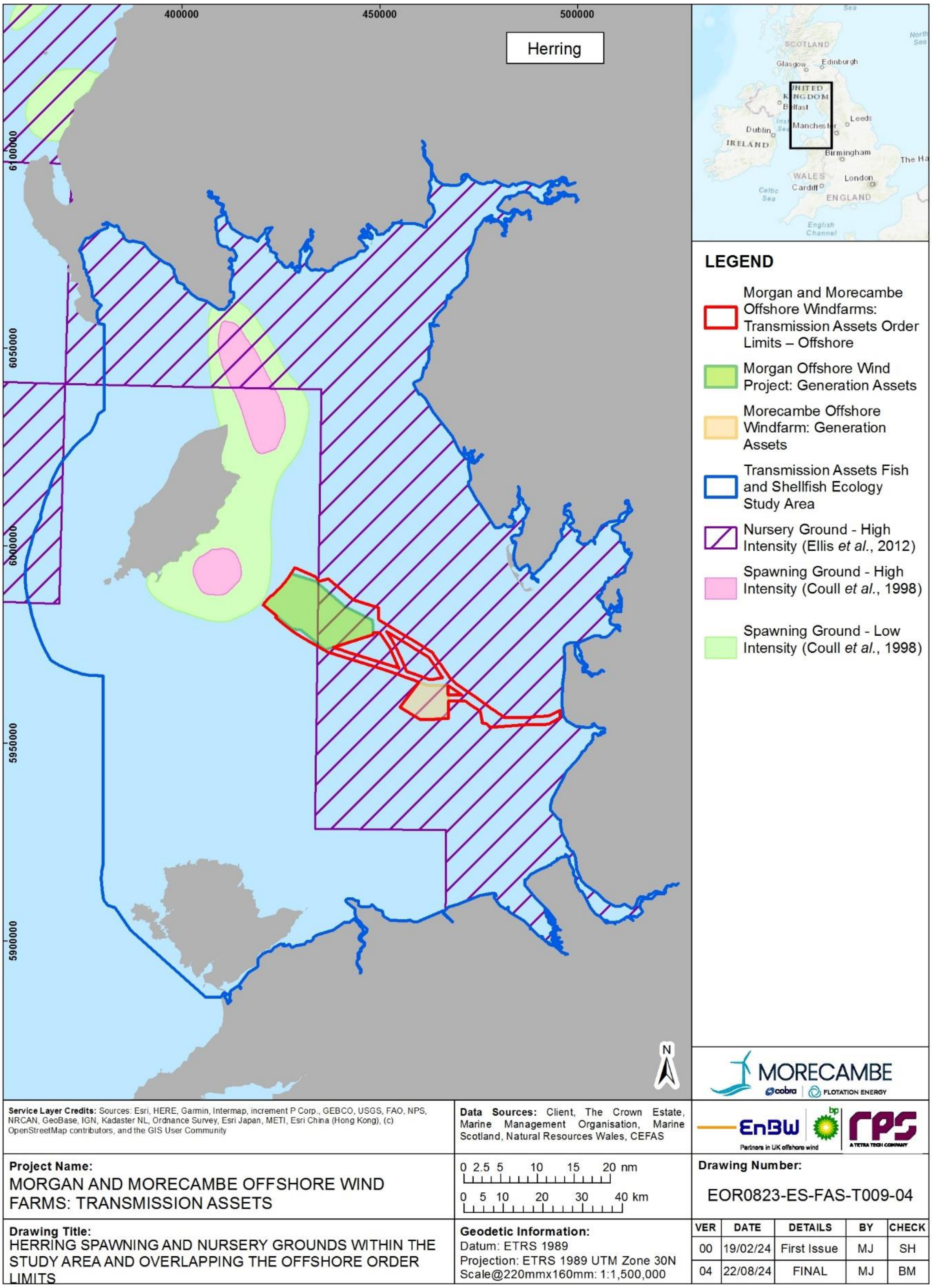
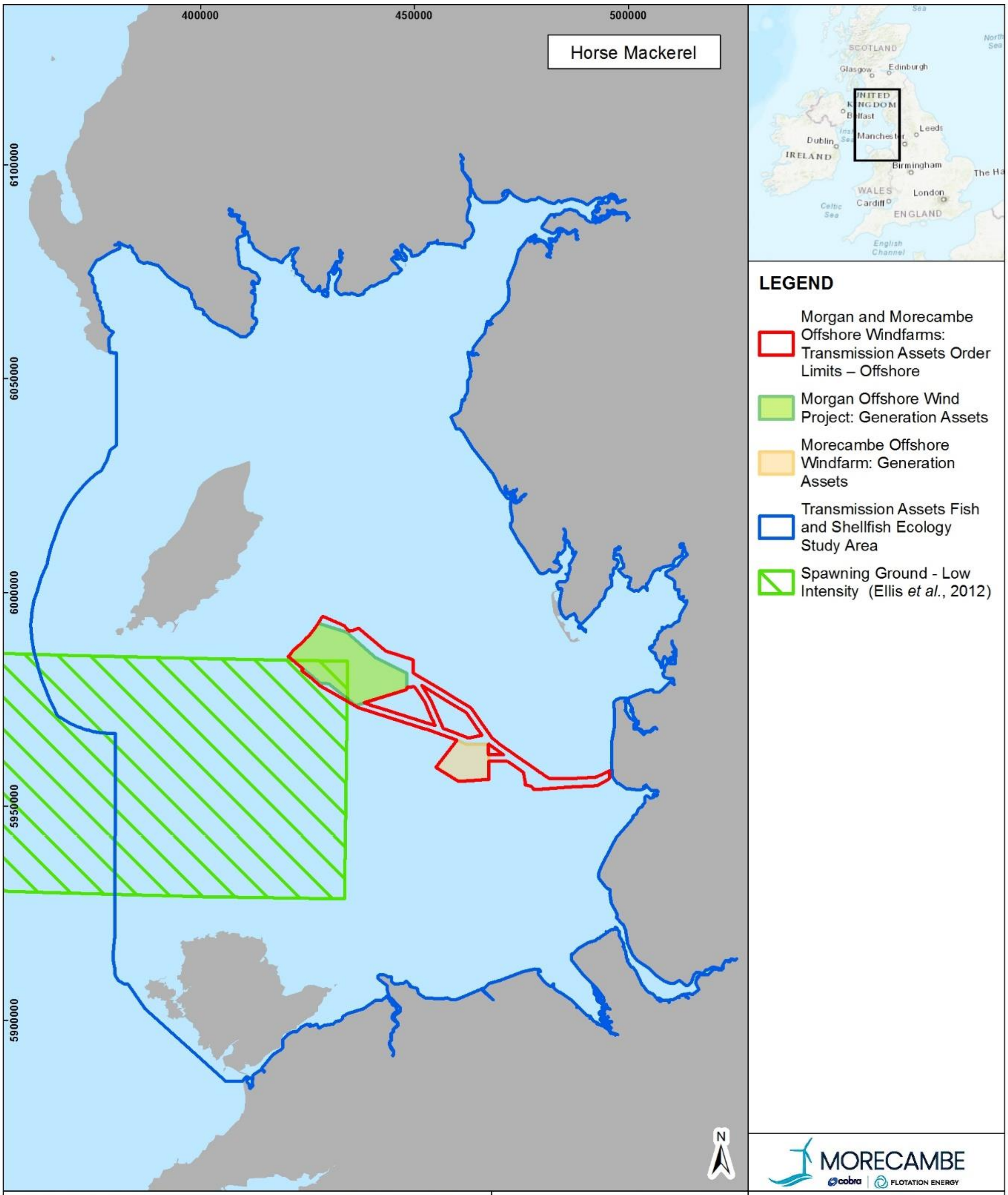


Figure 1.9: Herring spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T010-04

Drawing Title:
HORSE MACKEREL SPAWNING GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.10: Horse mackerel spawning grounds within the study area and overlapping the Offshore Order Limits

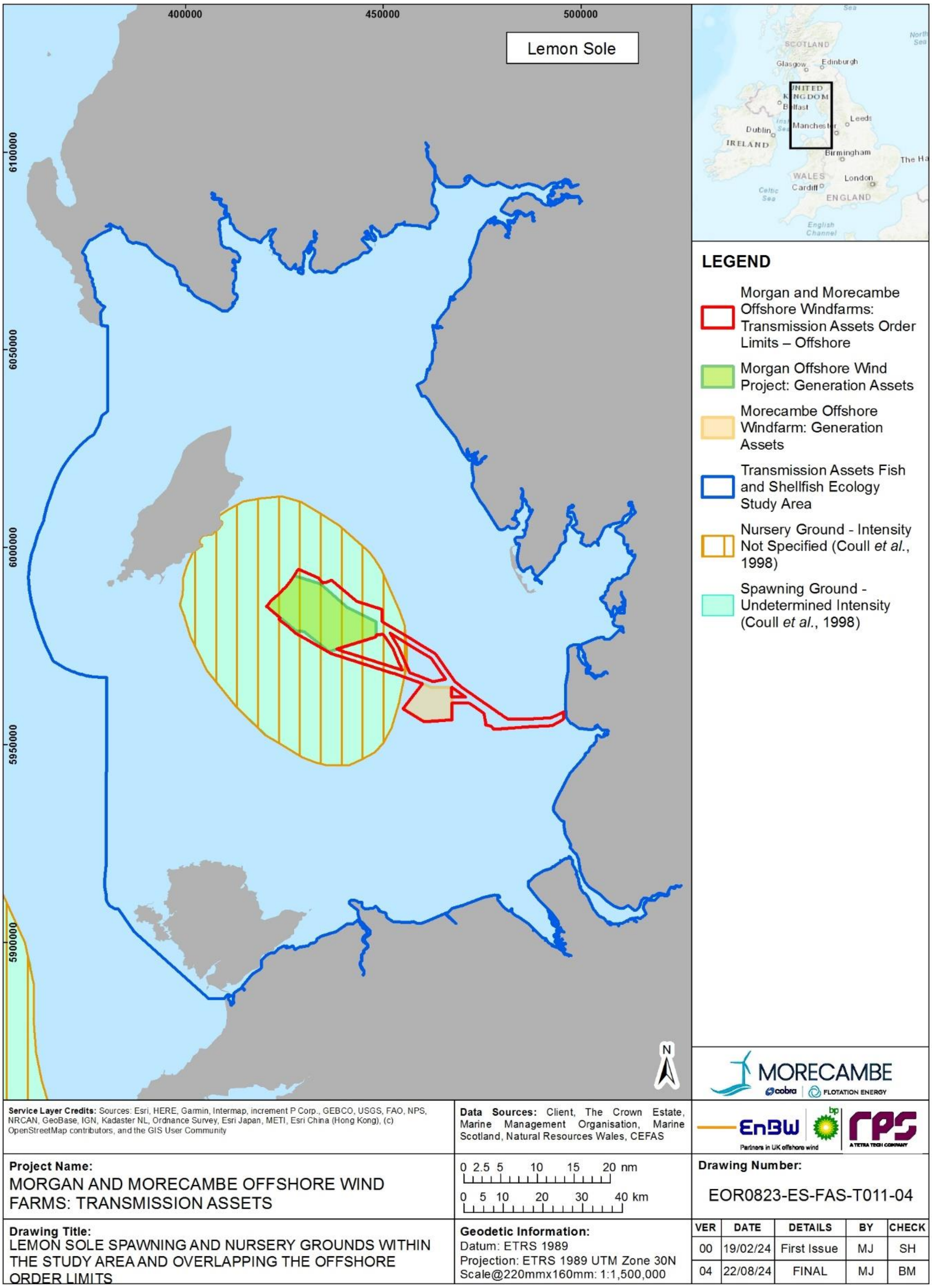
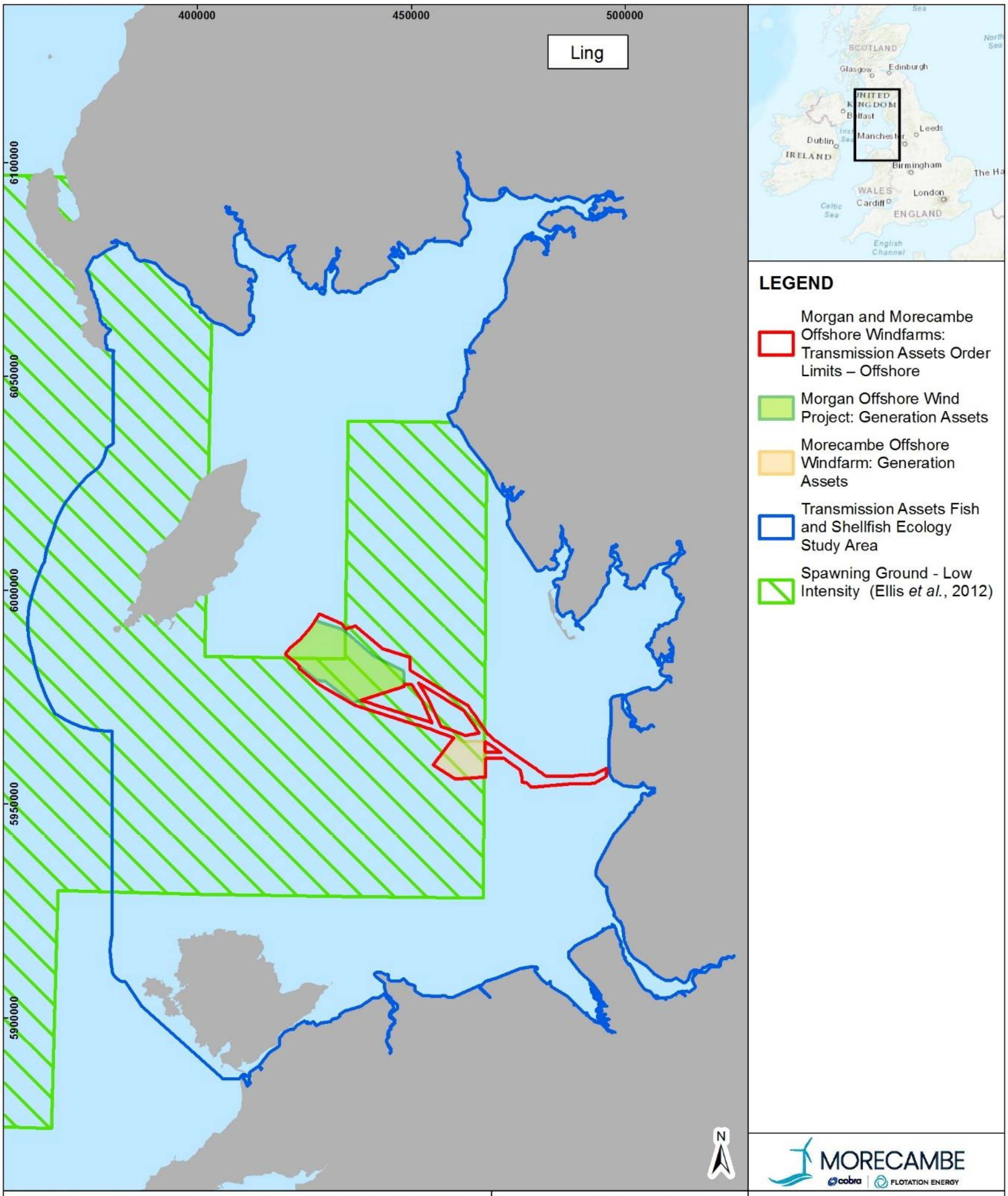


Figure 1.11: Lemon sole spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm

0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T012-04

Drawing Title:
LING SPAWNING GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.12: Ling spawning grounds within the study area and overlapping the Offshore Order Limits

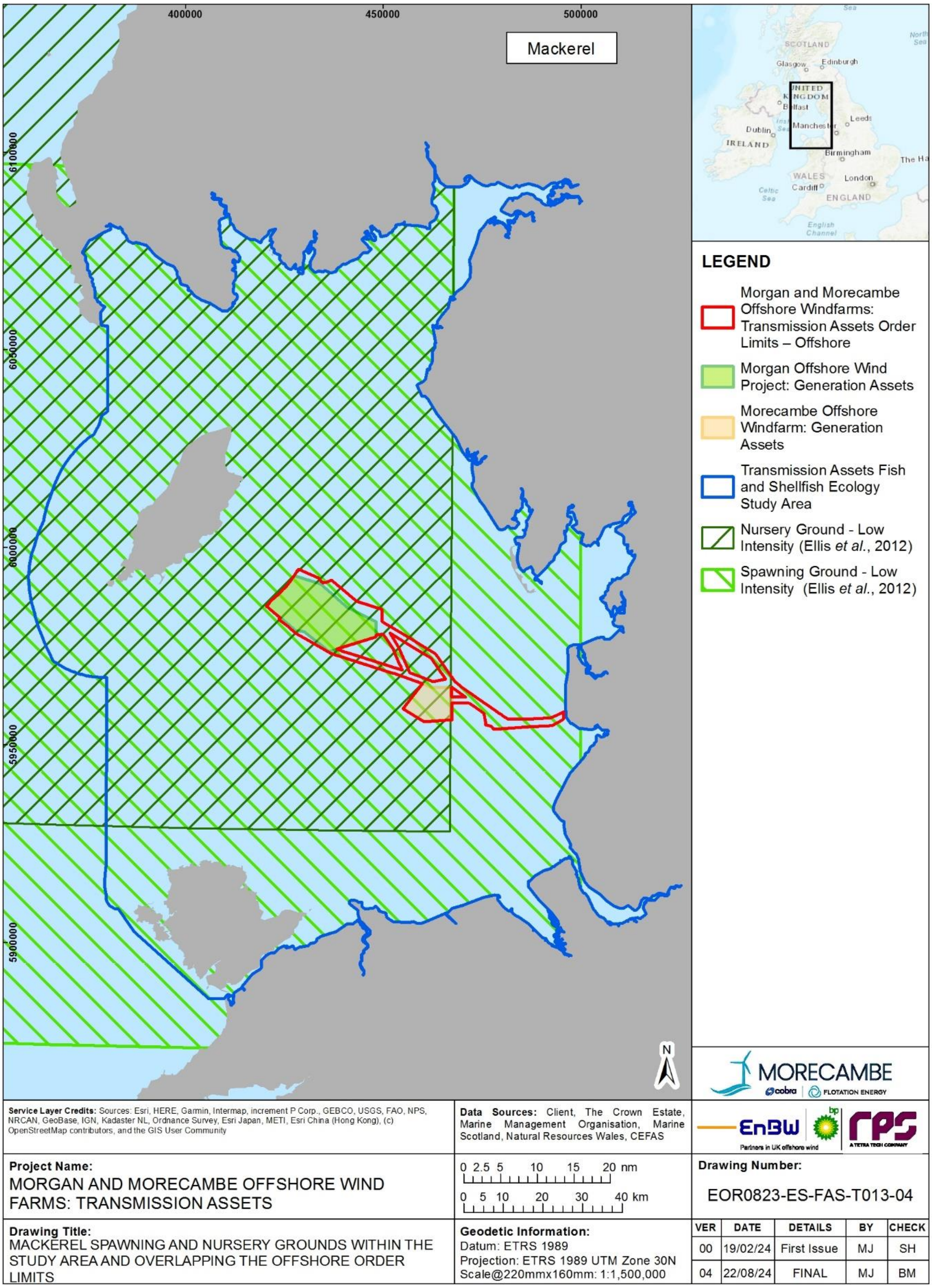
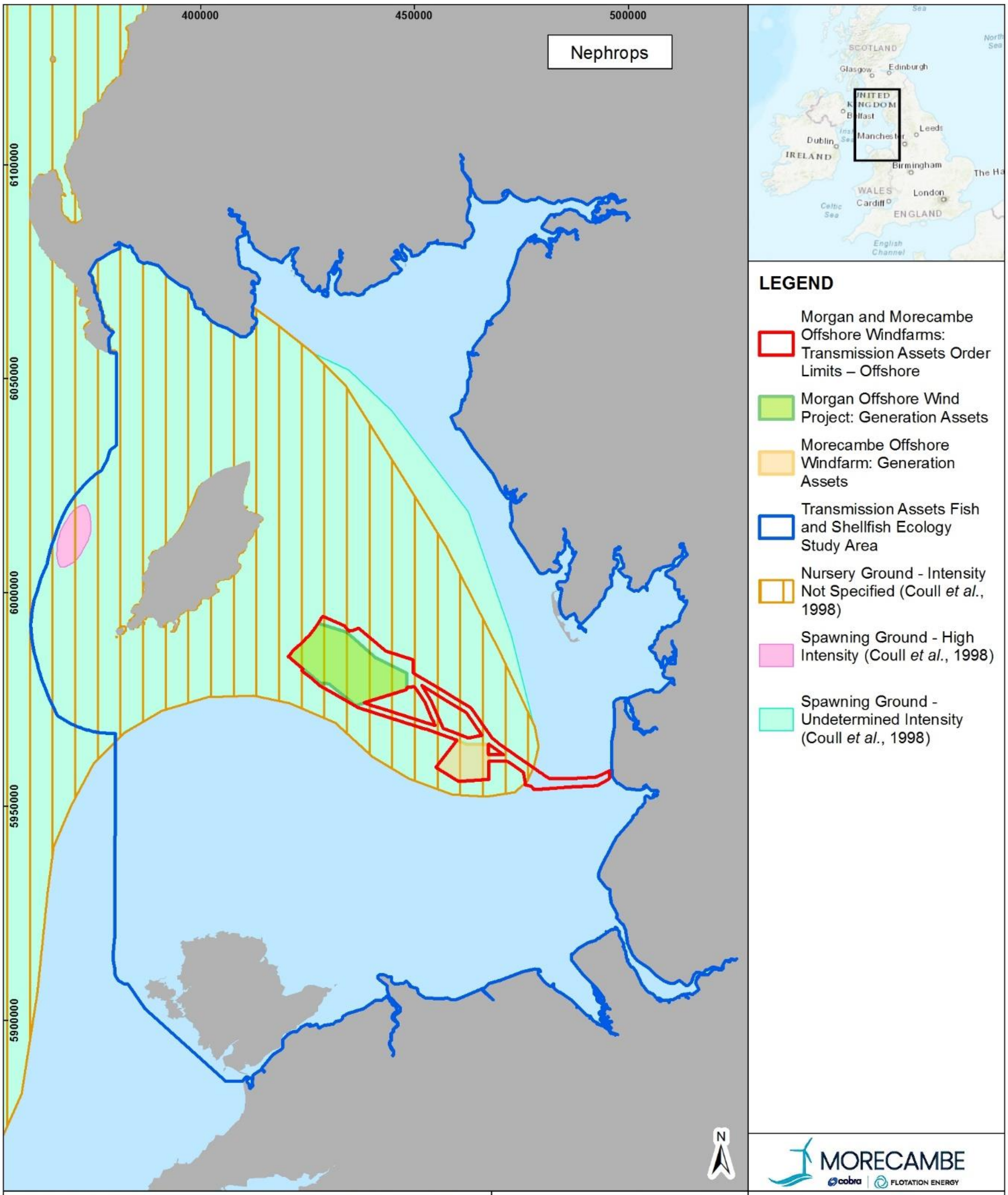


Figure 1.13: Mackerel spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm

0 5 10 20 30 40 km

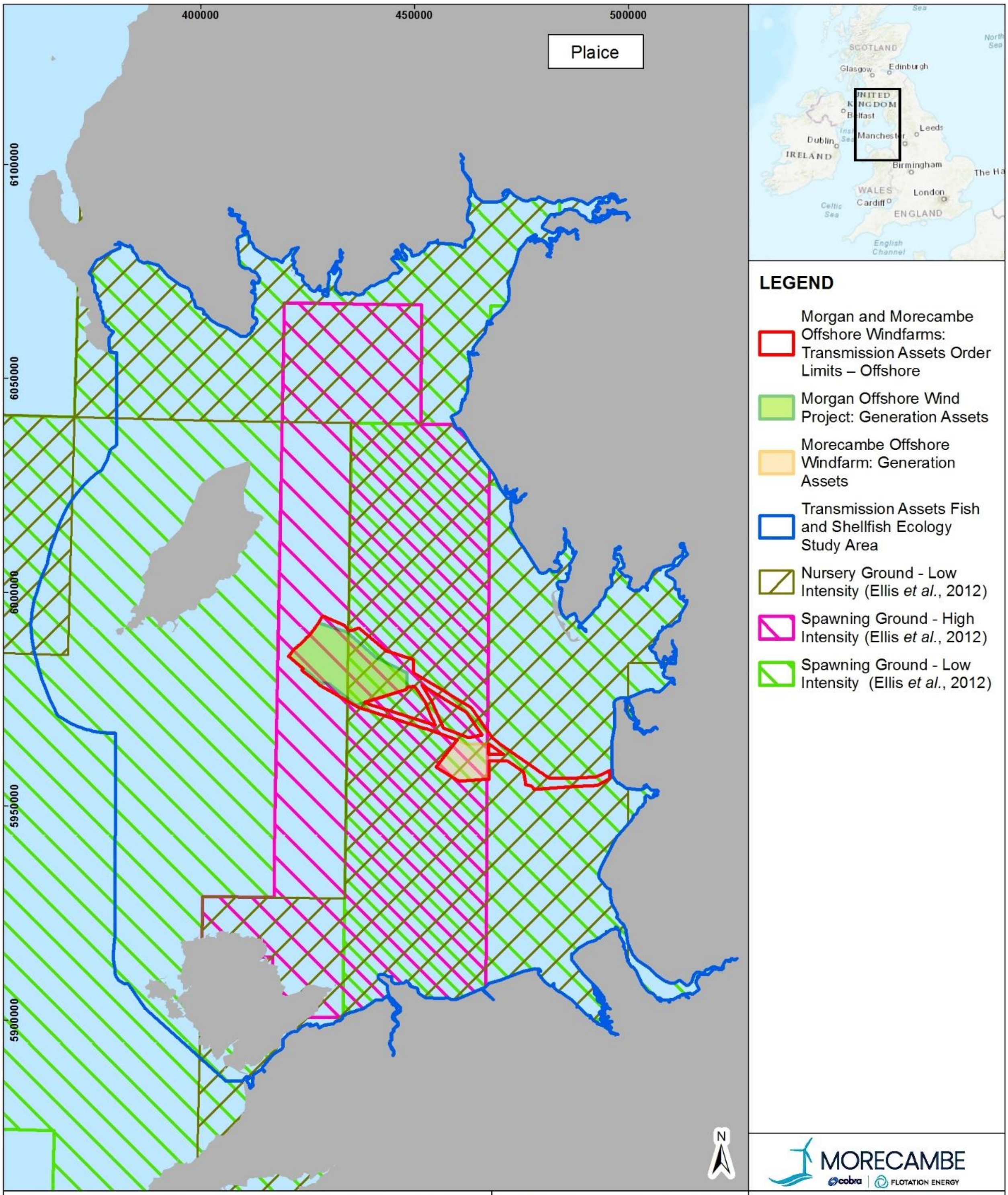
Drawing Number:
EOR0823-ES-FAS-T014-04

Drawing Title:
NEPHROPS SPAWNING AND NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.14: Nephrops spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

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0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

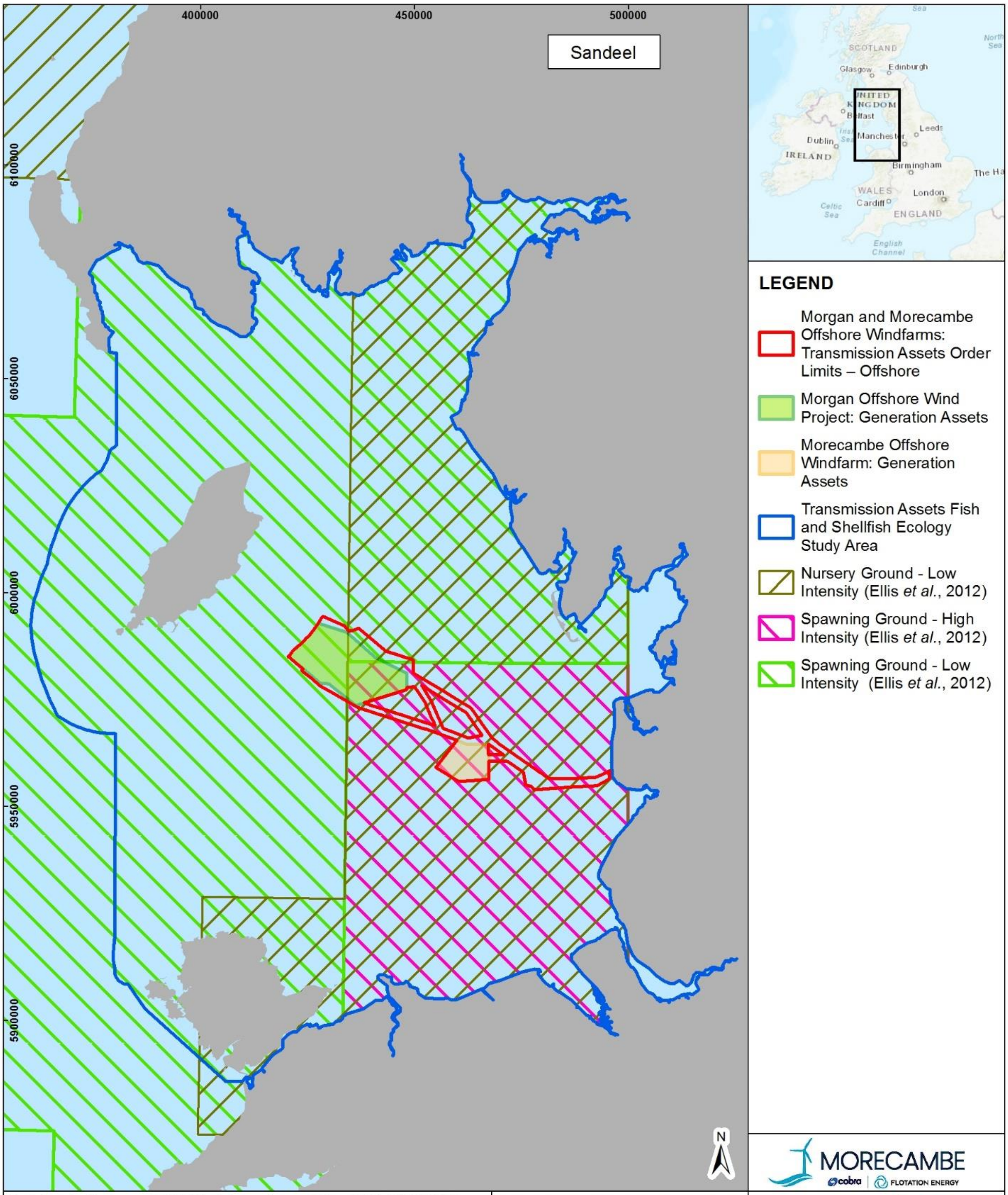
Drawing Number:
EOR0823-ES-FAS-T015-04

Drawing Title:
PLAICE SPAWNING AND NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.15: Plaice spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

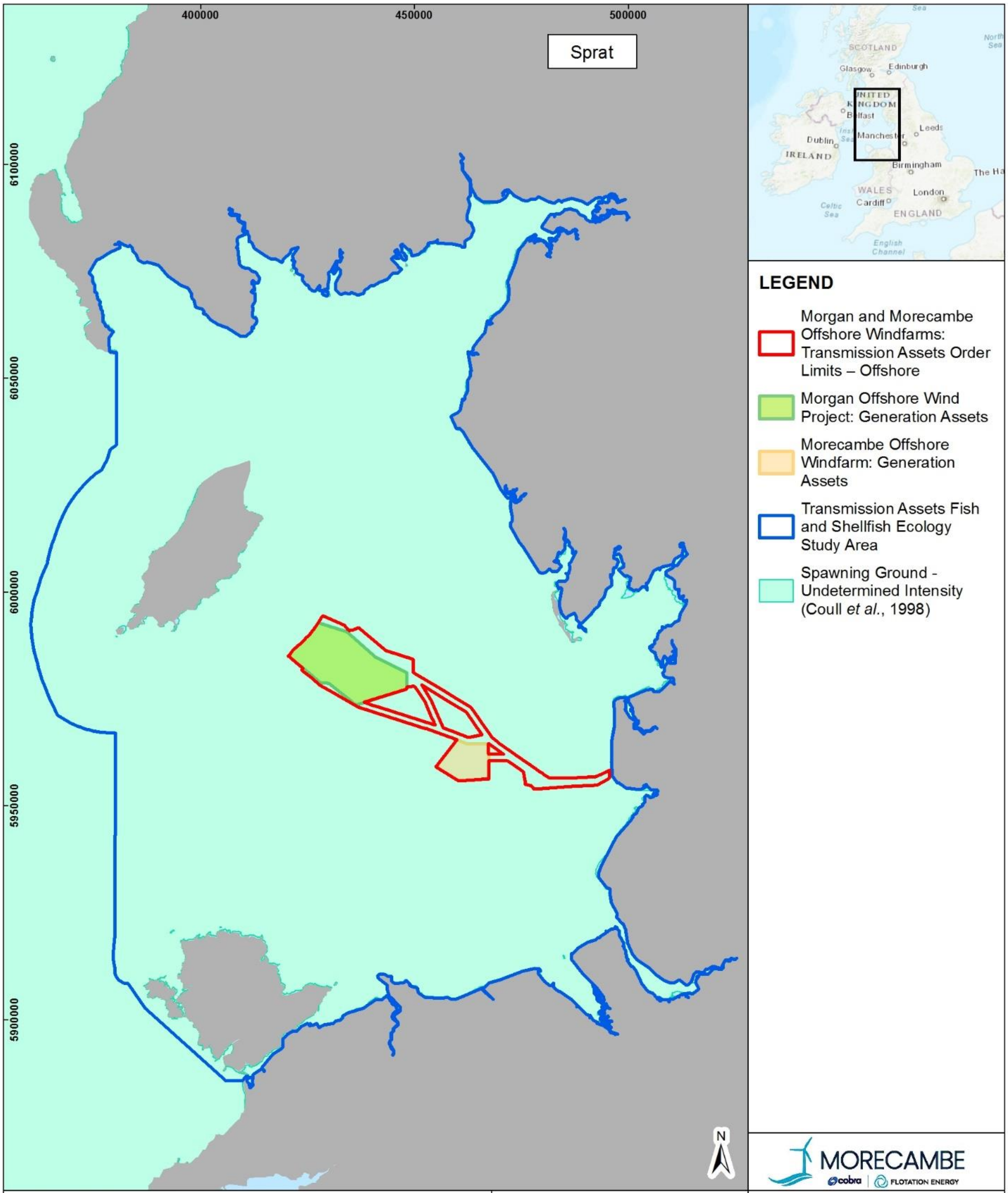
Drawing Number:
EOR0823-ES-FAS-T016-04

Drawing Title:
SANDEEL SPAWNING AND NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.16: Sandeel spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

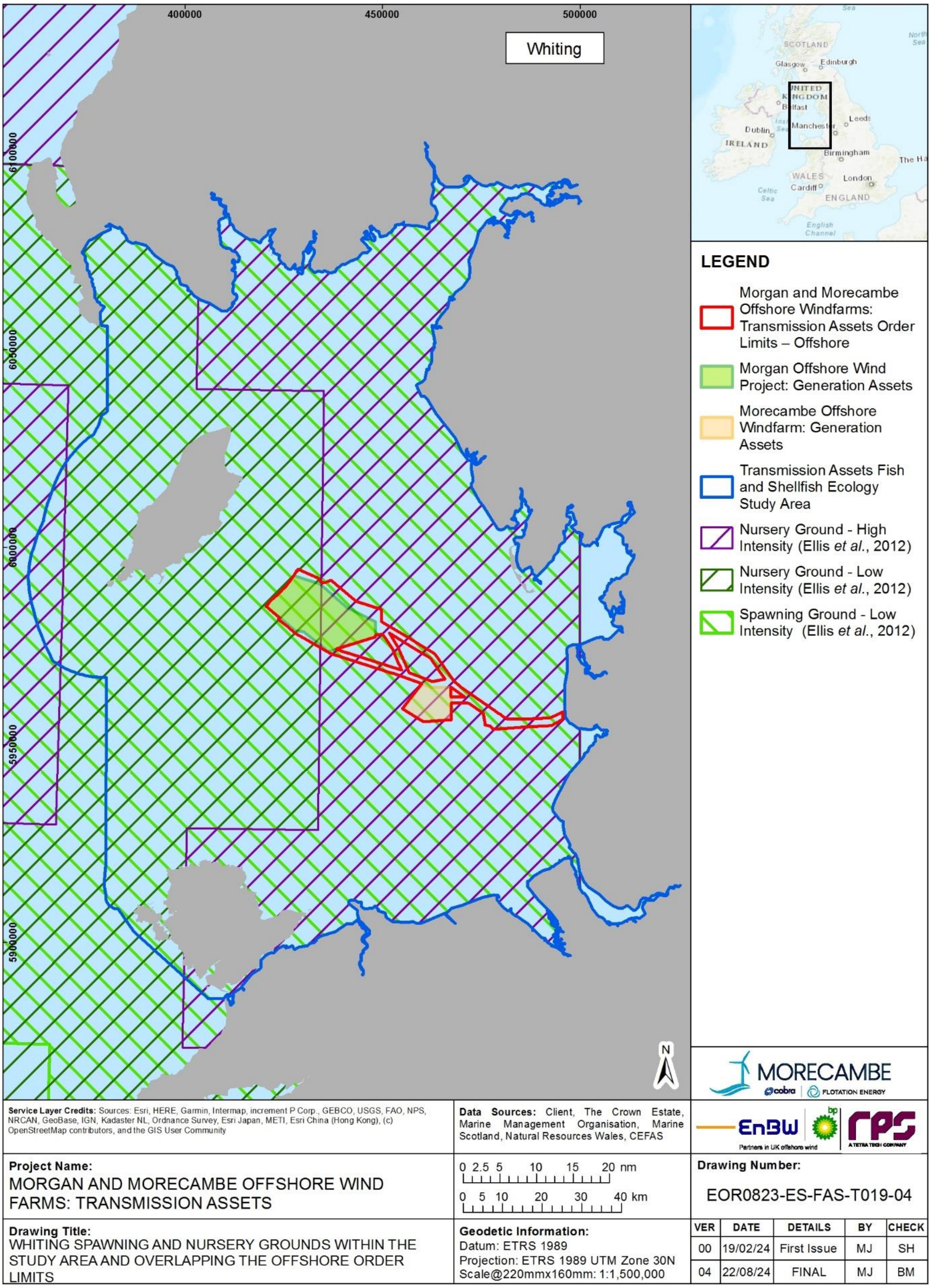
Drawing Number:
EOR0823-ES-FAS-T018-04

Drawing Title:
SPRAT SPAWNING GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
04	22/08/24	FINAL	MJ	BM

Figure 1.17: Sprat spawning grounds within the study area and overlapping the Offshore Order Limits



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

Drawing Number:
EOR0823-ES-FAS-T019-04

Drawing Title:
WHITING SPAWNING AND NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
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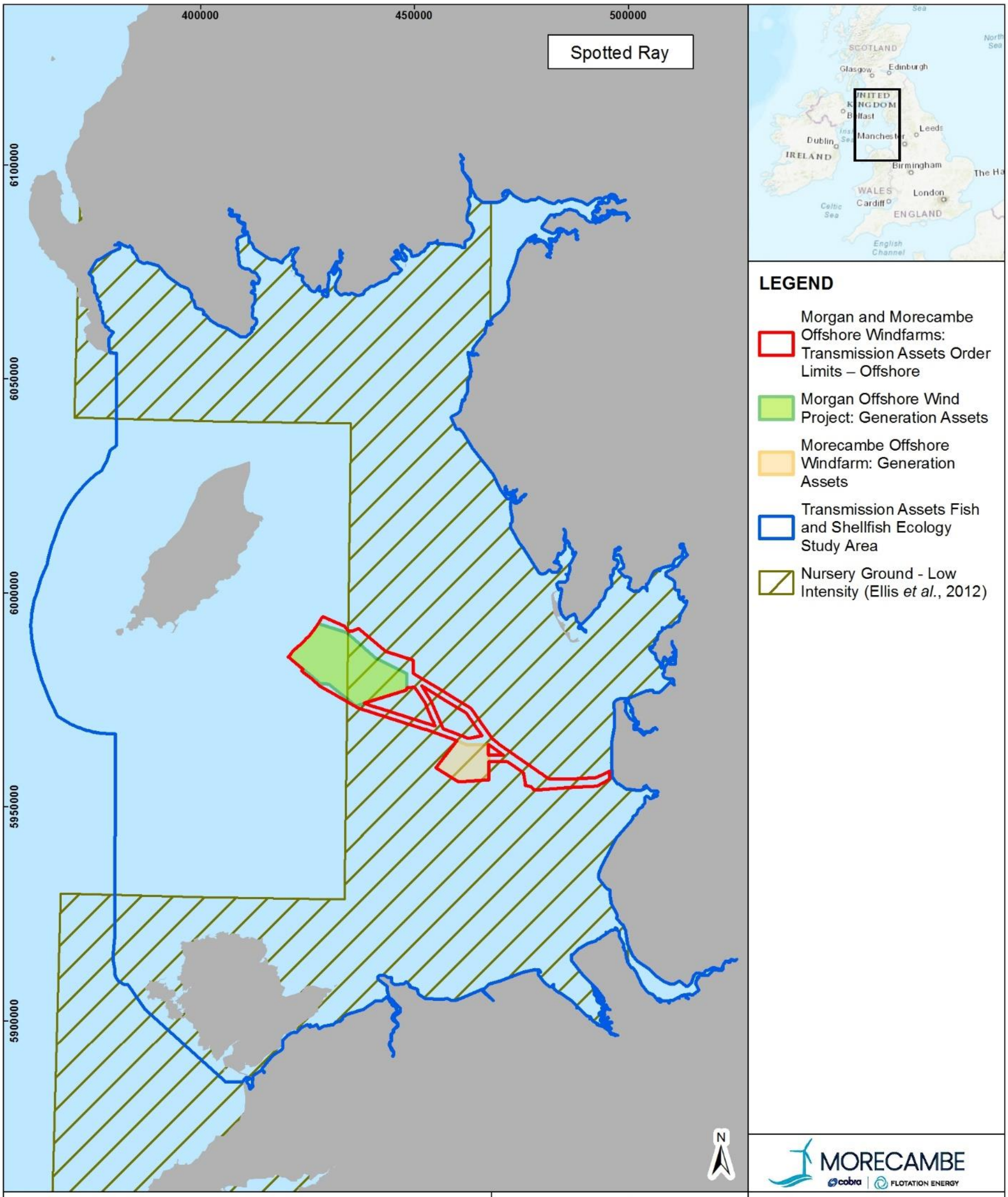
04	22/08/24	FINAL	MJ	BM

Figure 1.18: Whiting spawning and nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T020-04

Drawing Title:
SPOTTED RAY NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
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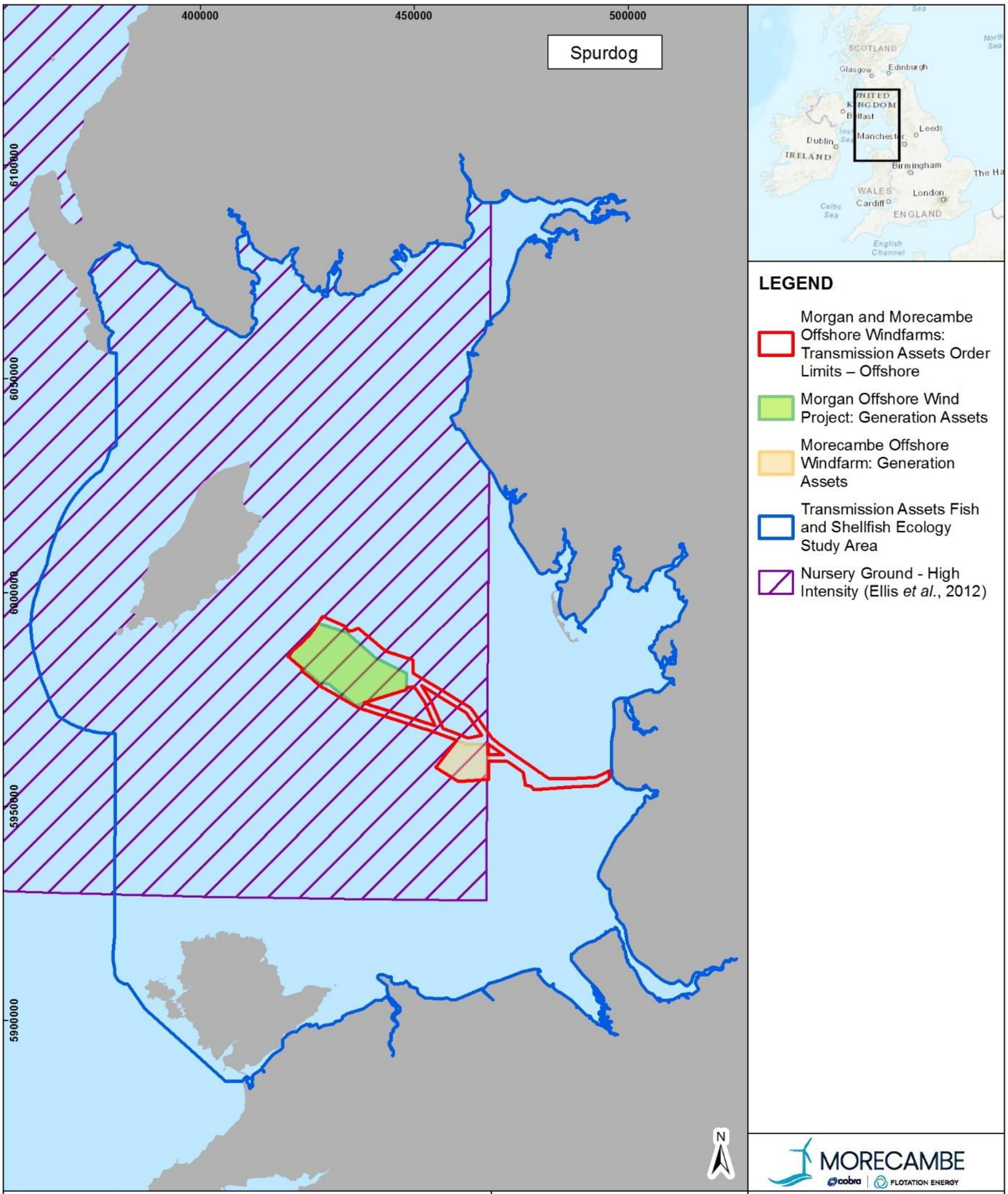
04	22/08/24	FINAL	MJ	BM

Figure 1.19: Spotted ray nursery grounds within the study area and overlapping the Offshore Order Limits



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T021-04

Drawing Title:
SPURDOG NURSERY GROUNDS WITHIN THE STUDY AREA AND OVERLAPPING THE OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
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04	22/08/24	FINAL	MJ	BM

Figure 1.20: Spurdog nursery grounds within the study area and overlapping the Offshore Order Limits

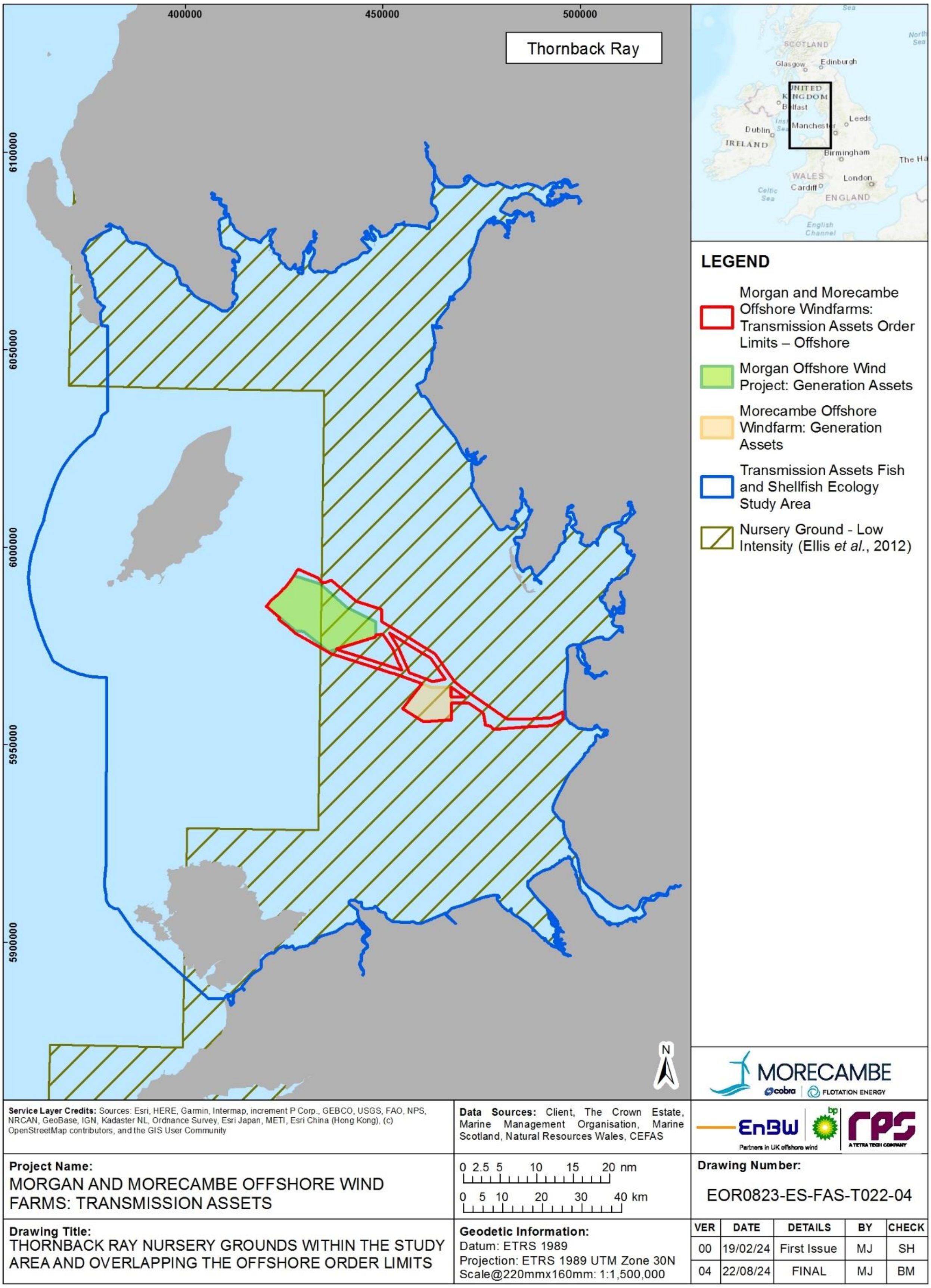


Figure 1.21: Thornback ray nursery grounds within the study area and overlapping the Offshore Order Limits

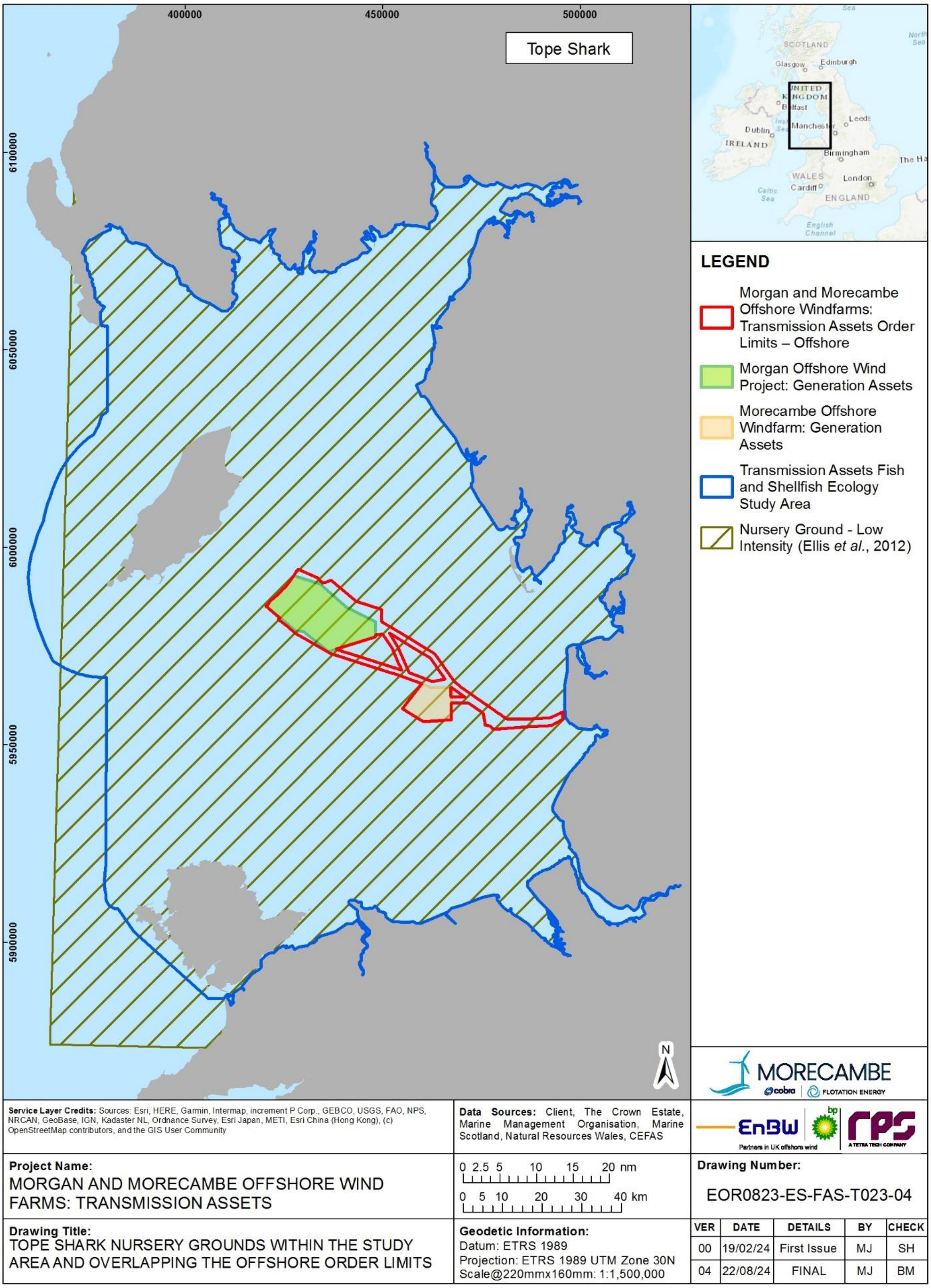


Figure 1.22: Tope shark nursery grounds within the study area and overlapping the Offshore Order Limits

1.3.4 Herring spawning

1.3.4.1 Herring are a commercially and ecologically important pelagic fish species as they are an important prey species for numerous fish, marine mammal and bird species and are common across much of the Irish Sea (Dickey-Collas *et al*., 2001). Herring are the target of a relatively large fishery; however, they are predominantly targeted by the Scottish fleet, known to target higher volume and lower priced marine species (MMO, 2021).

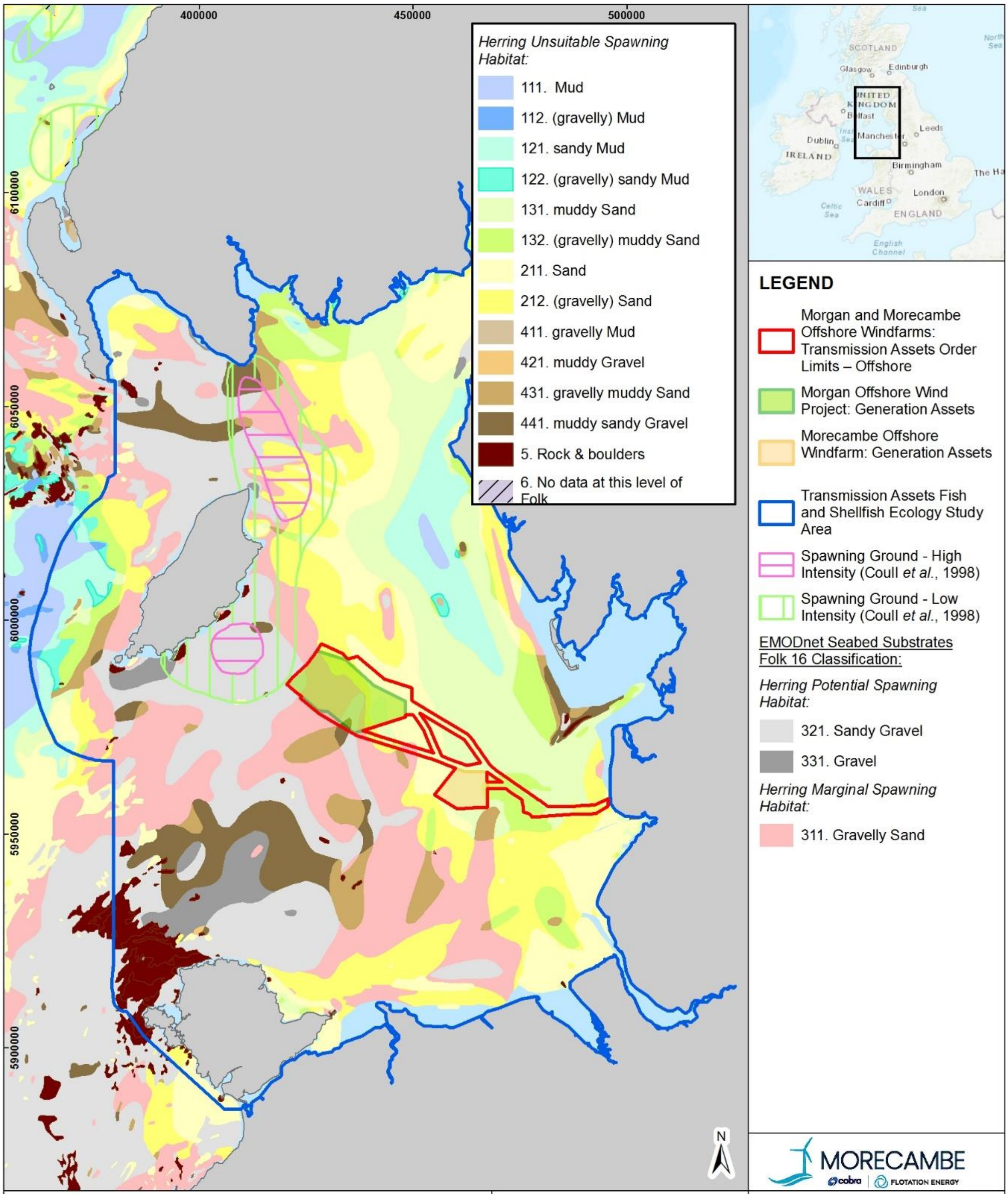
1.3.4.2 Herring are predominantly found in deeper waters in the benthopelagic and pelagic zone and have been observed throughout the Irish Sea. Their core range has been known to include St. George's Channel (at the south boundary of the Irish Sea); however, they are also present around the south and west coasts of Ireland and the north coast of Northern Ireland. In the north east Atlantic, herring are encountered from the north Bay of Biscay to Greenland and into the Barents Sea. The NIGFS has confirmed the presence of schools of herring within the study area, and broadly around the Offshore Order Limits, in data reviewed for the years 2012 to 2020, indicating a relatively consistent presence over time within this area (ICES, 2022a).

1.3.4.3 Adult herring can be found on continental sea shelfs to depths of 200 m; however, they can disperse over the abyssal plains during feeding migrations. Juvenile herring tend to occur in shallower waters, further away from adults and spawning grounds, moving into deeper waters after a couple years. During the daytime hours, herring shoals tend to remain close to the seabed or in deeper waters, moving towards the surface at dusk and dispersing over a wider area during night-time hours (FishBase, 2020f).

1.3.4.4 Herring nursery grounds, as described in **section 1.3.3** and shown in **Figure 1.9**, cover the majority of the Offshore Order Limits except the west portion of the Offshore Order Limits (Ellis *et al*., 2012), with post larvae juveniles up to sub adults that are yet to reach sexual maturity feeding here until migrating to feeding grounds further offshore where they remain until reaching sexual maturity (ICES, 2006).

1.3.4.5 Herring are benthic spawners, normally preferring gravel, stones and/or rock, on which to lay their eggs (O'Sullivan *et al.* 2013). Herring are known to utilise specific benthic habitats during spawning, which increases their vulnerability to activities impacting the seabed. Further, as a hearing specialist, herring are increasingly vulnerable to impacts arising from underwater sound. Herring deposit eggs on a variety of substrates from coarse sand and gravel to shell fragments and macrophytes; although gravel substrates have been suggested as their preferred spawning habitat. The spawning period for Manx herring using the Douglas Bank spawning ground is reported to occur from late September for three to four weeks with an approximately 8 km^2 area to the south of Douglas highlighted as a significant spawning ground (Bowers, 1969; Dickey-Collas *et al.*, 2001), relatively close to the Offshore Order Limits. This was supported and expanded upon by Coull *et al.* (1998) and evidenced around the entire east coast of the Isle of Man up to at least 2021 through collection of NINEL data (ICES, 2022a). Once spawning has taken place, the eggs take approximately three weeks to hatch after which the larvae drift in the plankton (Dickey-Collas *et al*., 2010; Ellis *et al*., 2012).

1.3.4.6 A detailed review of herring spawning has been undertaken following guidelines set out by Boyle and New (2018) and Reach *et al.* (2013) considering seabed sediment type and herring larval abundances. The full European Marine Observation and Data Network (EMODnet) seabed substrates classification (based upon Folk 16) is presented in **Figure 1.23**, distinguishing substrate classes that are considered suitable and unsuitable for herring spawning. Sediment data for the fish and shellfish ecology study area extracted from the Cefas OneBenthic tool has been classified using the defined process for herring suitability assessment and is presented in **Figure 1.23**. This data has been combined with the site-specific survey results from the 2021 and 2022 benthic subtidal ecology surveys for the Transmission Assets, Morgan Offshore Wind Project: Generation Assets and Mona Offshore Wind Project (Mona Offshore Wind Limited, 2024), and the 2021 benthic subtidal survey PSA data for the Morecambe Offshore Windfarm: Generation Assets (**Figure 1.24**)**.** The Morgan Offshore Wind Project: Generation Assets and Morecambe Offshore Windfarm: Generation Assets fall within the Offshore Order Limits, and these projects are closely located within the fish and shellfish ecology study area, therefore providing a broader context for results for the Transmission Assets alone.



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS, EMODnet

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T044-03

Drawing Title:
EMODNET SEABED SUBSTRATES (FOLK 16 CLASSIFICATION) - HERRING

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	25/04/24	First Issue	MJ	LS
03	22/08/24	FINAL	MJ	BM

Figure 1.23: EMODnet seabed substrate (Folk 16 classifications) and mapped herring spawning grounds within the study area (Coull *et al.*, 1998)

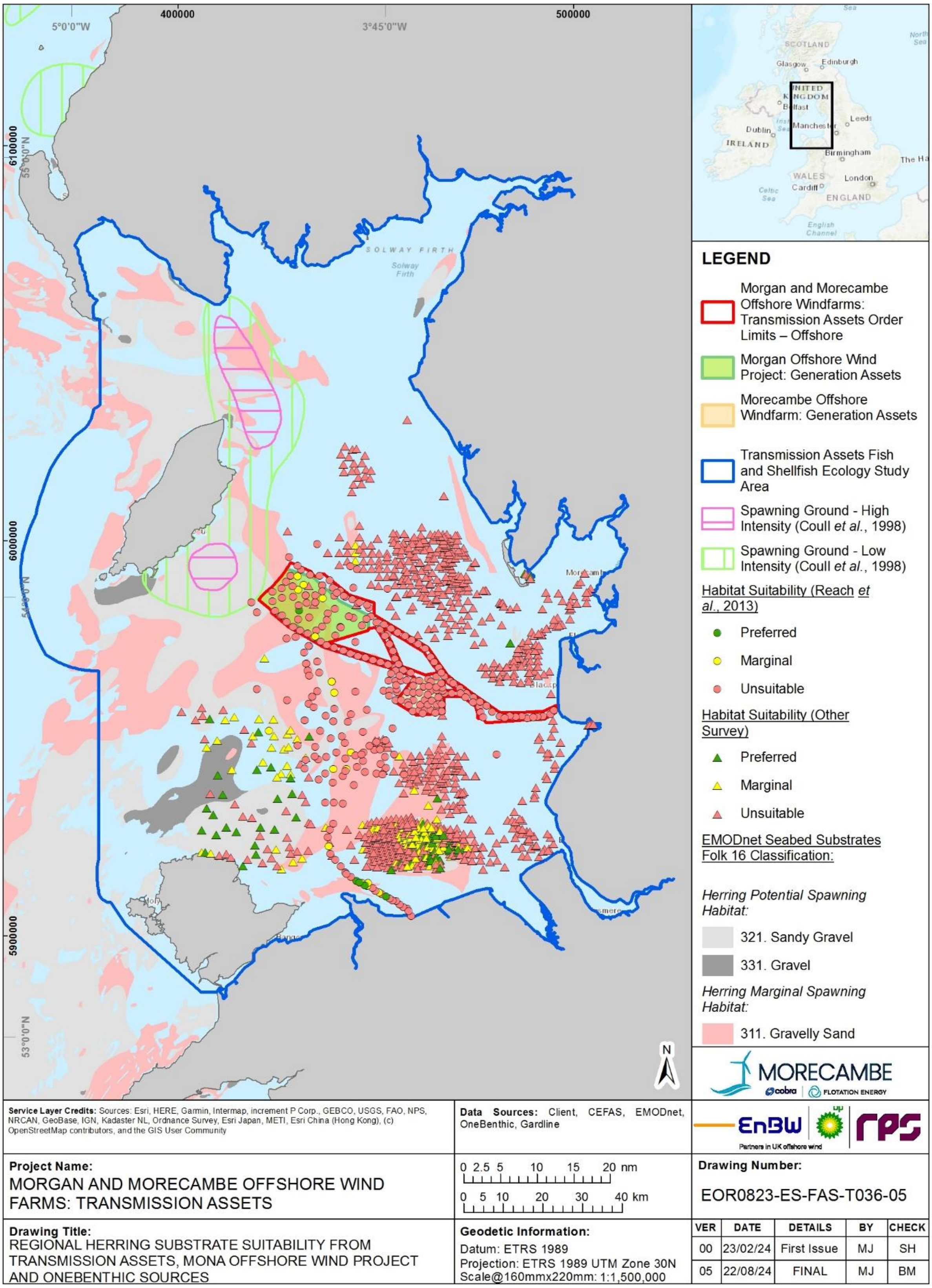


Figure 1.24: Regional substrate suitability classification for herring spawning based on benthic sampling for the Transmission Assets, Generation Assets, Mona Offshore Wind Project and OneBenthic sources

Particle size analysis

Morgan Offshore Wind Project: Generation Assets

1.3.4.7 The Morgan Offshore Wind Project: Generation Assets fall within the Offshore Order Limits; therefore, PSA data from the benthic surveys conducted in 2021 and 2022 for the Morgan Offshore Wind Project: Generation Assets has been used to support assessment of the substrate suitability for herring spawning. The full benthic survey data can be found in Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report to the ES.

1.3.4.8 In 2021, combined grab and DDV sampling were undertaken across 97 sampling stations, of which 37 were within the Morgan Offshore Wind Project: Generation Assets and therefore within the Offshore Order Limits (two of which were DDV only, i.e. with no grab samples collected; Morgan Offshore Wind Limited, 2024a). The remaining 60 sampling stations were within and around the Mona Offshore Wind Project Array Area. Site-specific survey data were collected in 2021 alongside desktop studies to assess the extent of suitable spawning habitat within the Morgan Offshore Wind Project: Generation Assets. Grab sampling was completed, and PSA was undertaken on sediment samples collected in 2021 which allowed classification of the sediment types according to Reach *et al.* (2013), as described in **Table 1.6**. These classifications were originally developed for the marine aggregates industry, drawing on work investigating spatial interactions between the aggregate application areas and herring spawning habitat.

1.3.4.9 Additional site-specific sampling within the Morgan Offshore Wind Project: Generation Assets and associated ZOI was undertaken in 2022 by Gardline. Combined grab and DDV sampling were undertaken across 26 stations, with 13 located within the Morgan Offshore Wind Project: Generation Assets, and 13 within the surrounding ZOI for the Morgan Offshore Wind Project: Generation Assets. For clarity, these were collected alongside a further 77 sampling stations (69 within the Transmission Assets, and eight within the Morecambe export cable corridor), and 60 more sampling stations for the Mona Offshore Wind Project. The 26 stations related to the Morgan Offshore Wind Project: Generation Assets were sampled with both DDV and sediment grabs. As in 2021, PSA data obtained from grabs was used to inform potential spawning grounds of herring (Morgan Offshore Wind Limited, 2024a).

1.3.4.10 Sediment composition results, processed as substrate suitability for herring spawning, are shown in **Figure 1.25** for the Morgan Offshore Wind Project: Generation Assets surveys conducted in 2021 and 2022.

Table 1.6: Herring potential spawning habitat sediment classifications derived from Reach *et al.* (2013)

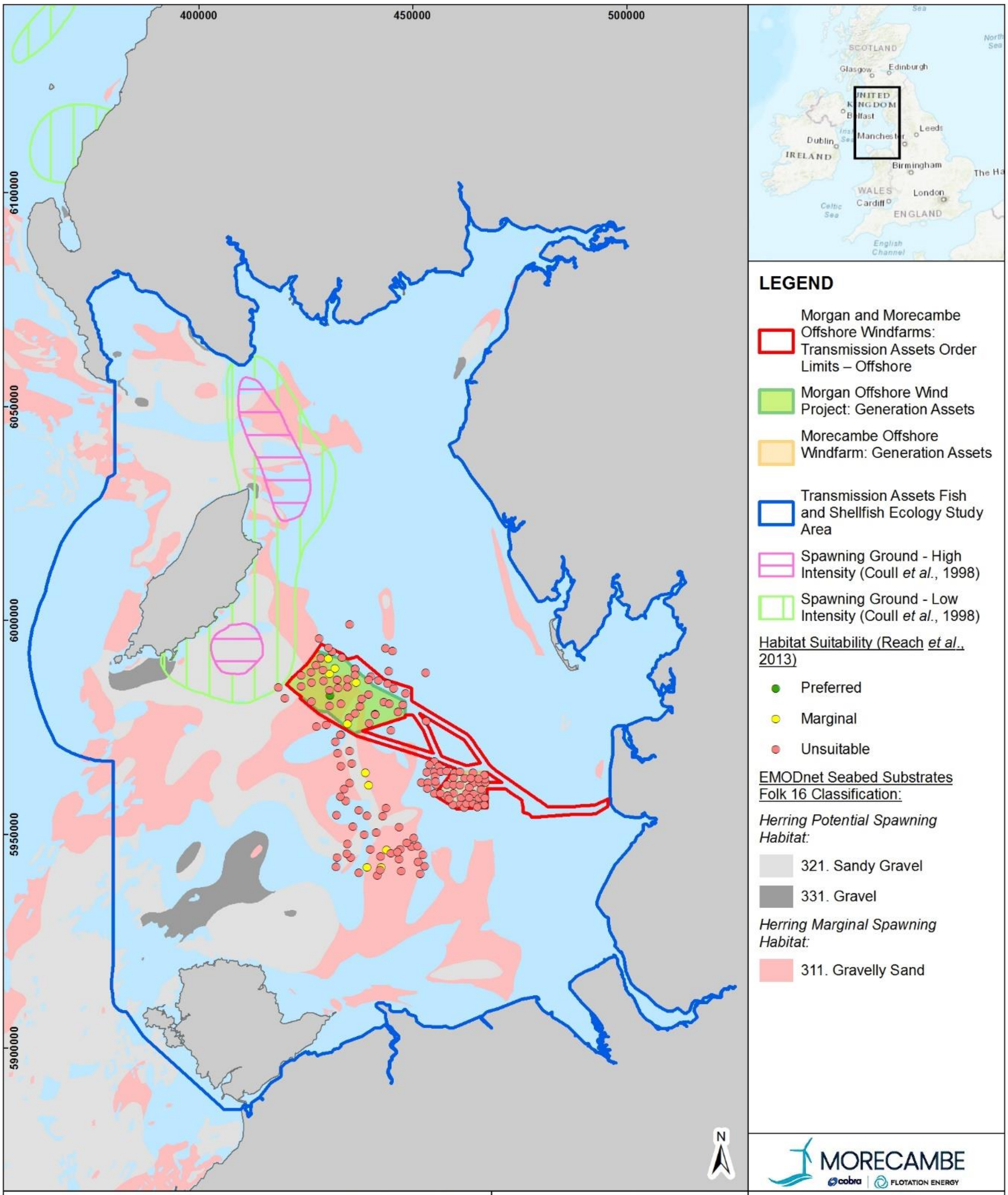
% Contribution (mud = <63 µm)	Habitat sediment preference (adapted from Reach *et al.* (2013)	Habitat sediment classification (adapted from Reach *et al.* (2013)
<5% mud, >50% gravel	Prime	Preferred
<5% mud, >25% gravel	Sub-prime	Preferred
<5% mud, >10% gravel	Suitable	Marginal
>5% mud, <10% gravel	Unsuitable	Unsuitable

1.3.4.11 Habitat suitability classifications for herring spawning, based on site-specific data from the 2021 and 2022 surveys within Morgan Offshore Wind Project: Generation Assets and the ZOI (**Figure 1.2**; **Figure 1.25**), illustrated that the overwhelming majority (90.2%) of the Morgan Offshore Wind Project: Generation Assets comprised unsuitable sediment composition for herring spawning with a mud content exceeding that reported to support successful herring spawning (>5%). Just four stations sampled in 2021, and one station from the 2022 survey were considered marginal for herring spawning and one station in 2022 represented preferred substrata. These stations were sparsely distributed with a small cluster of three stations in the north of the Morgan Offshore Wind Project: Generation Assets, one station in the central south (preferred) and one further station located in the south (Gardline, 2022; 2023).

1.3.4.12 Although the Morgan Offshore Wind Project: Generation Assets was predominantly comprised of sand and gravel substrates, which are considered optimal for herring spawning, results illustrated that the majority of stations comprised mud content in excess of 5%, rendering the sediments within the Morgan Offshore Wind Project: Generation Assets as largely unsuitable for supporting successful herring spawning activity.

1.3.4.13 **Figure 1.25** and **Figure 1.26** illustrate the 2021 and 2022 survey data from the Morgan Offshore Wind Project: Generation Assets and the Morecambe Offshore Windfarm: Generation Assets alongside EMODnet seabed substrate data. The EMODnet seabed substrate data can also be used to assign habitat suitability for herring spawning, showing sandy gravel and gravel as preferred spawning habitat and gravelly sand as marginal spawning habitat. Where no shading is present, the habitat in that area is unsuitable for herring spawning (the full Folk 16 classification is presented in **Figure 1.23**). Overall, the majority of the Morgan Offshore Wind Project: Generation Assets is considered unsuitable habitat for herring spawning, with sparse patches of marginal habitat. These results are consistent with the EMODnet broadscale seabed substrate data within the Morgan Offshore Wind Project: Generation Assets.

1.3.4.14 It is worth noting, that the EMODnet seabed substrate data are of lower resolution and accuracy than the results of the site-specific survey data but provides an overall broadscale picture of the surrounding substrate. The site-specific samples which were characterised as preferred were mostly associated with gravelly sand but were recorded as a mosaic between stations otherwise classified as unsuitable and marginal habitat for herring spawning. This highlights the fine scale sediment variability within the east Irish Sea, which the broadscale EMODnet substrate data is not able to fully represent.



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS, EMODnet, Gardline

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T024-05

Drawing Title:
HERRING SUBSTRATE SUITABILITY CLASSIFICATIONS FOR THE GENERATION ASSETS AND MONA OFFSHORE WIND PROJECT (2021 AND 2022 BENTHIC SURVEY DATA)

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
05	22/08/24	FINAL	MJ	BM

Figure 1.25: Herring spawning substrate suitability classifications for the Generation Assets and Mona Offshore Wind Project (2021 and 2022 benthic survey data)

Morecambe Offshore Windfarm: Generation Assets

1.3.4.15 A site-specific benthic subtidal grab and DDV characterisation survey was undertaken for the Morecambe Offshore Windfarm: Generation Assets in May/June 2022. The survey was undertaken by Ocean Ecology using standard methodologies for this type of survey, with 50 stations sampled for macrofaunal analysis, with locations and numbers of samples chosen in proportion to the underlying sediment types (**Figure 1.2**; Morecambe Offshore Windfarm Limited, 2024). Also, four additional stations were examined using DDV only, to confirm the presence of any potential features of interest within the survey area.

1.3.4.16 Based on the Folk 1954 sediment classifications, the Morecambe Offshore Windfarm: Generation Assets study area was predicted to comprise a mixture of sand and sandy mud (DigSBS250, British Geological Survey (BGS), 2015). However, site-specific PSA results found that the predominant sediment type across the Morecambe Offshore Windfarm: Generation Assets was fine sand. Average gravel content was 0.1% across 98% of samples, with only one station comprising a higher gravel content (20.6%), meaning that the substrates within the Morecambe Offshore Windfarm: Generation Assets area are generally considered unsuitable for herring spawning (Stratoudakis *et al.*,1998; **Figure 1.25**). These results corroborate with spawning grounds identified in Coull *et al.* (1998) which do not overlap the Morecambe Offshore Windfarm: Generation Assets (**Figure 1.9**).

Transmission Assets

1.3.4.17 As outlined in **section 1.2.6**, site-specific survey data were collected in 2022 to support the available desktop studies to assess the extent of suitable spawning habitat within the Offshore Order Limits. Grab sampling was completed, and PSA was undertaken on the sediment samples collected which allowed classification of the sediment types according to Reach *et al.* (2013), as described in **Table 1.6**. These classifications were originally developed for the marine aggregates industry, drawing on work investigating spatial interactions between the aggregate application areas and herring spawning habitat.

1.3.4.18 Habitat suitability classifications for herring spawning, based on site-specific data, illustrated that the overwhelming majority (98.1%) of the Offshore Order Limits has unsuitable sediment composition for herring spawning (**Figure 1.26**). Just two stations out of 103 sampled within the Offshore Order Limits (including the 26 stations sampled in 2022 discussed above for Morgan Offshore Wind Project: Generation Assets), were considered suitable for herring spawning (one preferred and one marginal). These stations were found in the north west of the Offshore Order Limits within the Morgan Offshore Wind Project: Generation Assets (Gardline, 2023).

1.3.4.19 Although the sediment within the Offshore Order Limits was predominantly comprised of sand and gravel substrates, which are considered optimal for herring spawning, results illustrated that most of the surveyed stations comprised mud content in excess of 5%, rendering the sediments unsuitable for successful spawning. Mud particles could stick to the surface of the eggs and egg mats, blocking the egg pores, thus increasing the risk of egg mortality through asphyxiation or oxygen deprivation, thereby resulting in reduced spawning success.

1.3.4.20 **Figure 1.25** and **Figure 1.26** illustrate the 2022 site-specific survey data within the Offshore Order Limits alongside EMODnet seabed substrate data (the full EMODnet Folk 16 classifications are presented in **Figure 1.23**). The EMODnet seabed substrate data can also be used to assign habitat suitability for herring spawning, showing sandy gravel and gravel as preferred spawning habitat and gravelly sand as marginal spawning habitat. Where no shading is present, the habitat in that area is unsuitable for herring spawning. Overall, the majority of the seabed within the Offshore Order Limits is considered unsuitable habitat for herring, with sparse patches of marginal and preferred habitat. These results are in line with the EMODnet broadscale seabed substrate data within the Offshore Order Limits (EMODnet, 2022). It is worth noting, that the EMODnet seabed substrate data are of lower resolution and accuracy than the results of the site-specific survey data but provides an overall broadscale picture of the surrounding substrate. The results from site-specific survey data from the Generation Assets collected within the Offshore Order Limits in 2021 strengthen the findings of unsuitable herring spawning habitats in the area. It also corroborates with spawning grounds identified in Coull *et al.* (1998), which do not overlap with the Offshore Order Limits (**Figure 1.9**).

1.3.4.21 Additional data sources have been incorporated into the ES to support regional characterisation including PSA data extracted from the Cefas OneBenthic tool (see **paragraph 1.3.5.6**). This data has been mapped to show the distribution of substrates beyond the Offshore Order Limits to provide an indication of broader suitability for herring spawning based upon *in situ* empirical data (**Figure 1.24**). These data suggest that the areas sampled in the east Irish Sea generally represent unsuitable substrata for supporting herring spawning activity, with patches of potential spawning habitat in the south and south west of the fish and shellfish ecology study area (see **Figure 1.24**).

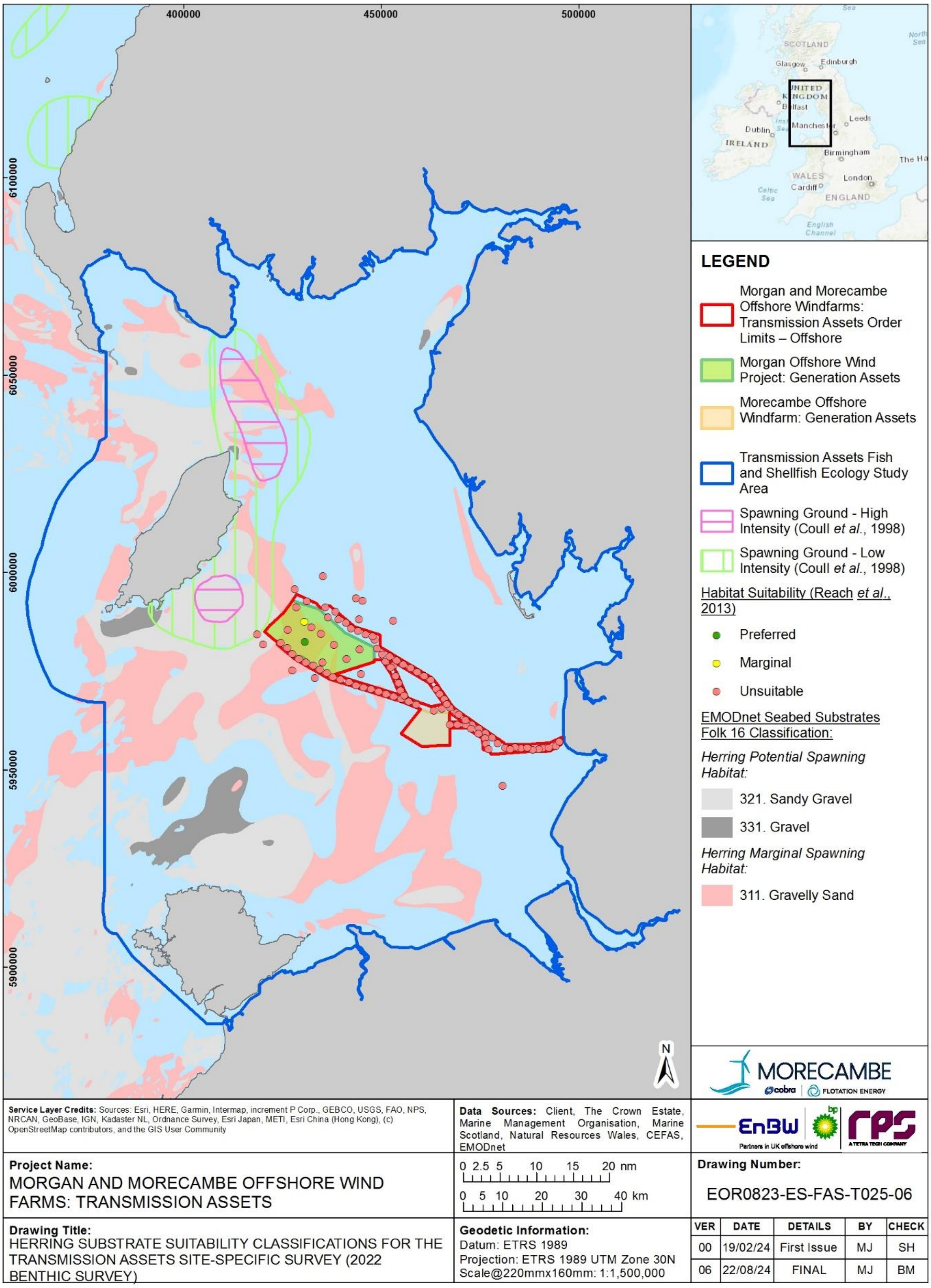


Figure 1.26: Herring spawning substrate suitability classifications for the Transmission Assets (2022 site-specific survey data)

Northern Irish Herring Larvae Survey

1.3.4.22 As outlined above, herring spawning grounds can be identified through monitoring of herring larval abundances, alongside data on sediment type. The NINEL conducts monitoring programmes in November each year in the Irish Sea (ICES, 2022a). Herring larvae are identified as being recently hatched by their size and therefore small herring larvae can be assumed to have been hatched recently and in close proximity to the area where eggs were laid. The NINEL datasets present raw herring larvae counts with flowrates and haul depths, which were used to calculate the number of larvae per m^2, with larvae <10 mm long used as a cut off point for recently spawned larvae (in line with standard International Herring Larvae Survey practice).

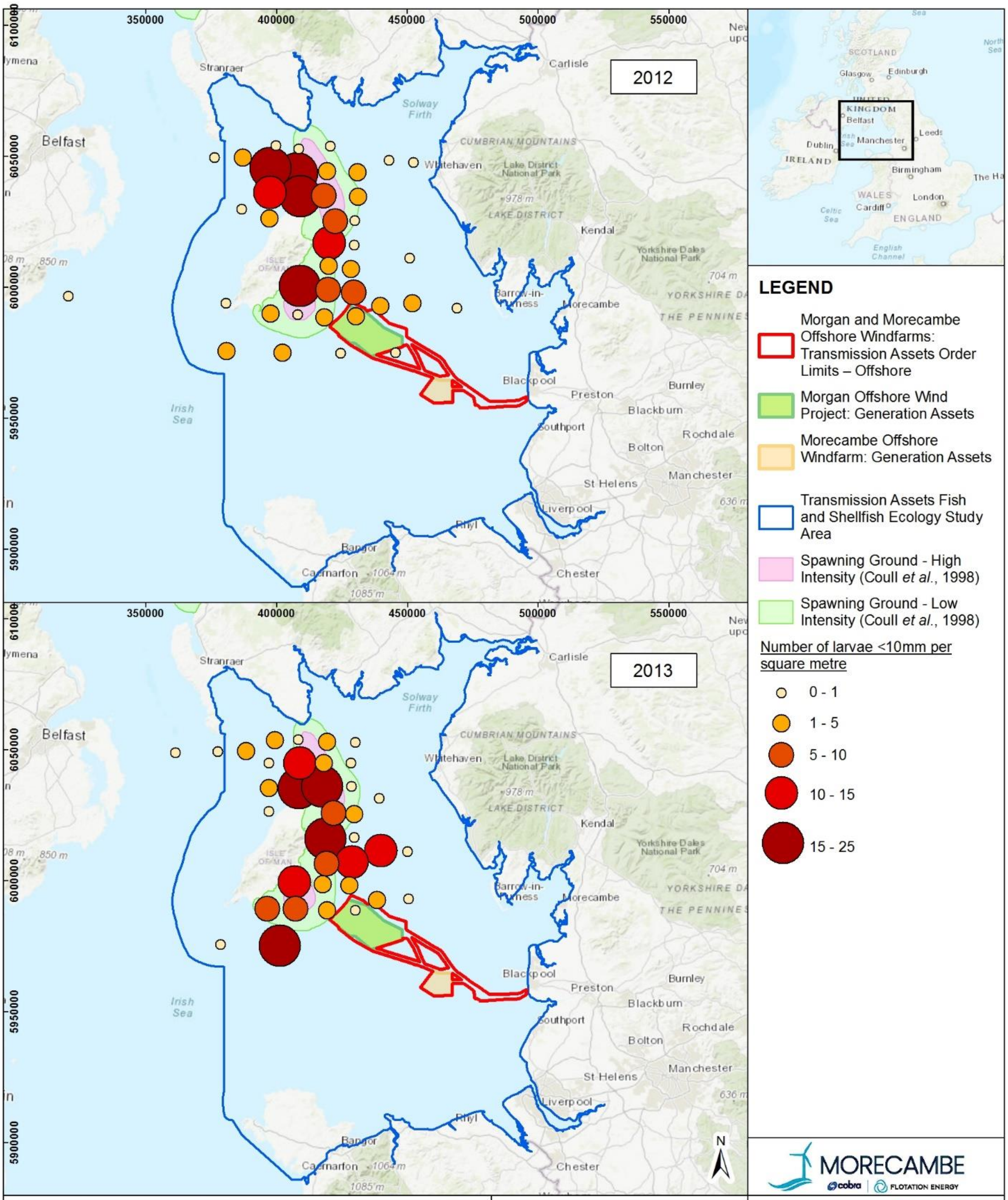
1.3.4.23 It should be noted that the NINEL datasets, despite being useful indicators of specific herring spawning locations, are considered to underestimate true recruitment numbers in this area, which is up to higher magnitude in some cases (Dickey-Collas and Nash, 2001). The NINEL surveys were re-evaluated in 2012 and are no longer used in Irish Sea stock assessments due to recorded herring larval abundances underestimating populations to such a large extent, when compared to acoustic surveys in the area (ICES, 2012). However, the survey is still conducted annually and has been used in this report because of the value of having a long-term dataset based on standardised methods to indicate the spatial coverage of the herring spawning grounds. These can also, to some degree, act as an indicator of changes in broader spawning patterns over time.

1.3.4.24 Recently spawned larvae will not have drifted far from the location where eggs were spawned on the seabed and high abundances of these larvae are therefore a good indication of recent spawning activity local to where these were sampled. These data were plotted for each year from 2012 to 2021 in **Figure 1.27** to **Figure 1.31** showing the changing spatial distribution of herring spawning over time relative to areas of historical spawning grounds as identified by Coull *et al*. (1998), in line with guidance from Boyle and New (2018). In addition, larval densities from 2012 to 2021 have been aggregated and plotted as a heatmap in **Figure 1.32** to highlight areas of consistently higher larval densities, and therefore considered of higher importance to Manx herring.

1.3.4.25 These data show that the spawning area directly north west of the Offshore Order Limits identified by Coull *et al*. (1998) has consistently shown evidence of recent spawning, albeit at relatively low abundances, with up to 24.3 individuals per m^2. Notably, the average numbers of herring larvae decreased overall between 2012 and 2021, dropping to a minimum of 0.73 herring larvae per m^2 in 2018, but rising again to an average of 4.05 herring larvae per m^2 in 2021. The highest average was found in 2013 (4.7 herring larvae per m^2); however, this result demonstrates skew based on low numbers of herring larvae in places. The highest individual number of herring larvae per m^2 (24.3) was found in 2017, highlighting very high interannual variability as a limitation of this dataset when examining spawning population densities. The NINEL data captures this variability generally but gives large underestimates of actual population densities. Acoustic data indicate populations of up to approximately 50,000 tonnes of herring in the same area overall (ICES, 2020), with approximately 49% of the population in the 2020 survey being herring of 0-1 years old (ICES, 2021b). Spatial variability of larval densities within the NINEL data are likely from variations in ocean and tidal current speeds and direction over time. The surveys were carried out in the same month each year directly following the spawning period of the Mourne stock of herring (**Table 1.4**), thus controlling for any variability potentially caused by changes in survey timings. These results demonstrate that the vast majority of larvae are found in the vicinity of the Douglas bank spawning ground and to the north of the Isle of Man, diminishing closer to the Offshore Order Limits.

1.3.4.26 As noted above, the NINEL dataset is useful as a spatial indicator of spawning grounds, due to being a repeated survey covering approximately the same area across the north Irish Sea. Specifically, the spatial distribution seen in the NINEL data, with the highest herring larvae densities to the south east and north east of the Isle of Man, matches the high intensity grounds identified by Coull *et al*. (1998) (**Figure 1.9**), with a broad distribution of low intensity spawning surrounding these areas in all years from 2012 to 2021. **Figure 1.27** shows the area of high intensity spawning south east of the Isle of Man and north west of the Offshore Order Limits, being predominantly sandy gravel (EMODnet Folk Classification 321) and the high intensity spawning area north east of the Isle of Man has a mix of sandy gravel and gravelly sand (EMODnet Folk Classification 311).

1.3.4.27 No high intensity spawning grounds identified by Coull *et al.* (1998) overlap with any part of the Offshore Order Limits and the NINEL data shows highly variable low to medium intensity larval densities throughout the entire north of the study area. This is supported by the habitat suitability data from both site-specific sampling effort and EMODnet (following classifications in Reach *et al*., 2013), as shown in **Figure 1.25** and **Figure 1.26**. The large patches of gravelly sand and >5% mud content reported provide unsuitable spawning habitat throughout much of the Offshore Order Limits, with only two areas of marginal/preferred spawning habitat identified out of 103 stations.



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS, NINEL

EnBW Partners in UK offshore wind

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

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

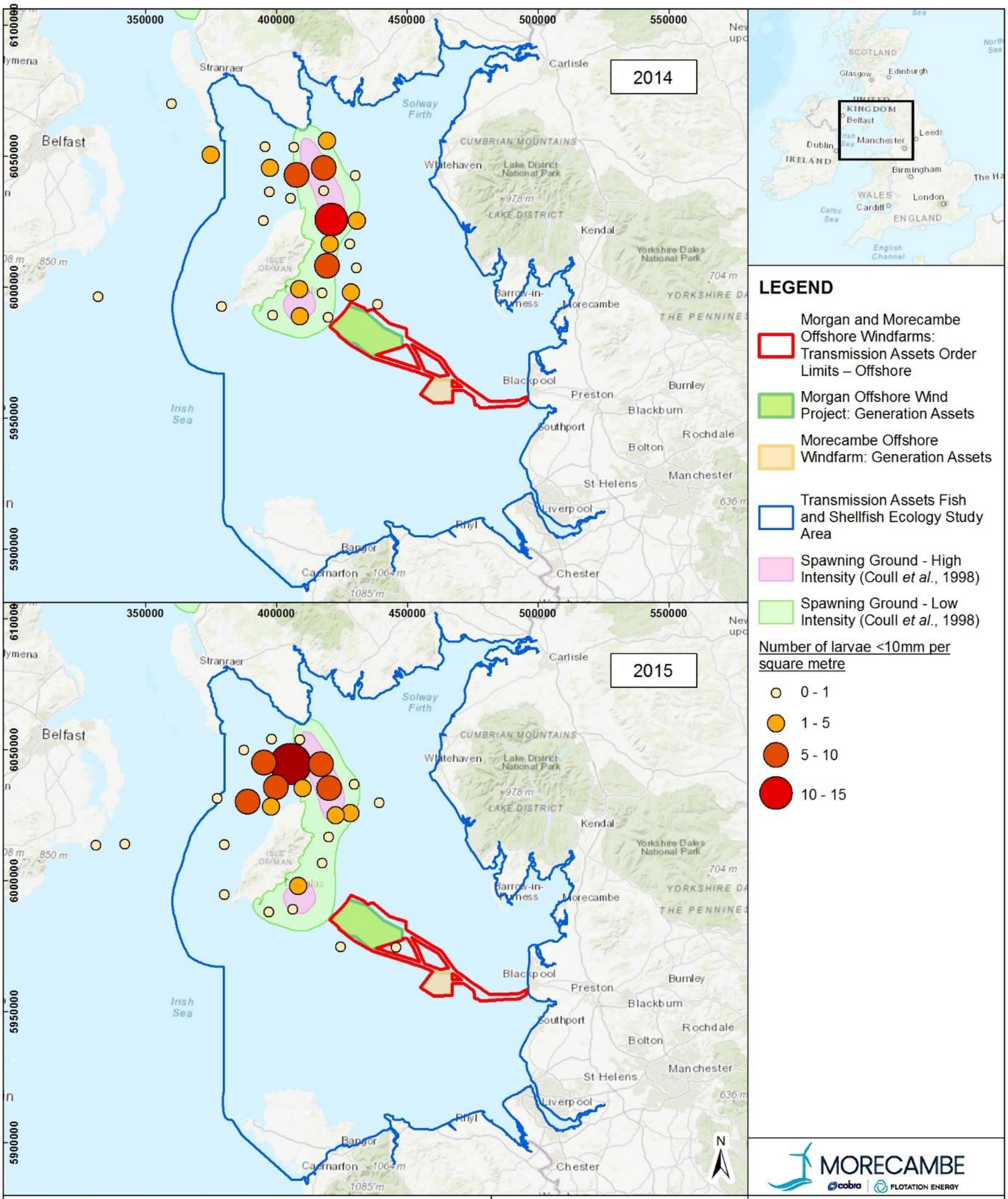
Drawing Number:
EOR0823-ES-FAS-T026-03

Drawing Title:
NINEL HERRING LARVAE POPULATION DENSITIES

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:2,450,000

VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
03	22/08/24	FINAL	MJ	BM

Figure 1.27: NINEL herring larvae population densities (larvae/m^2) in 2012 and 2013



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS, NINEL

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

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Drawing Number:
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Drawing Title:
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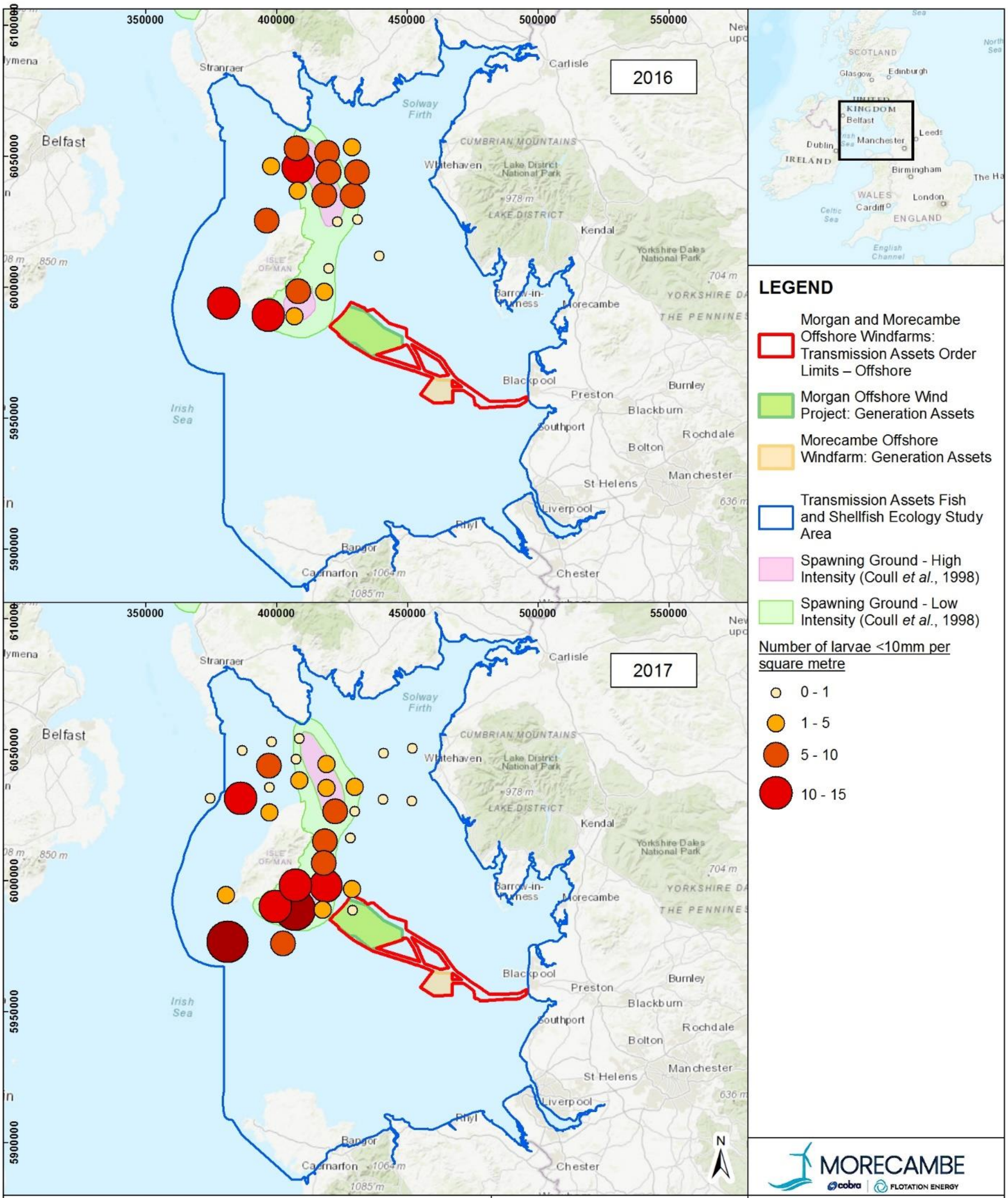
VER	DATE	DETAILS	BY	CHECK
00	19/02/24	First Issue	MJ	SH
03	22/08/24	FINAL	MJ	BM

Figure 1.28: NINEL herring larvae population densities (larvae/m^2) in 2014 and 2015



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS, NINEL

EnBW bp Partners in UK offshore wind rps A TETRA TECH COMPANY

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

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0 10 20 40 60 km

Drawing Number:
EOR0823-ES-FAS-T028-03

Drawing Title:
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VER	DATE	DETAILS	BY	CHECK
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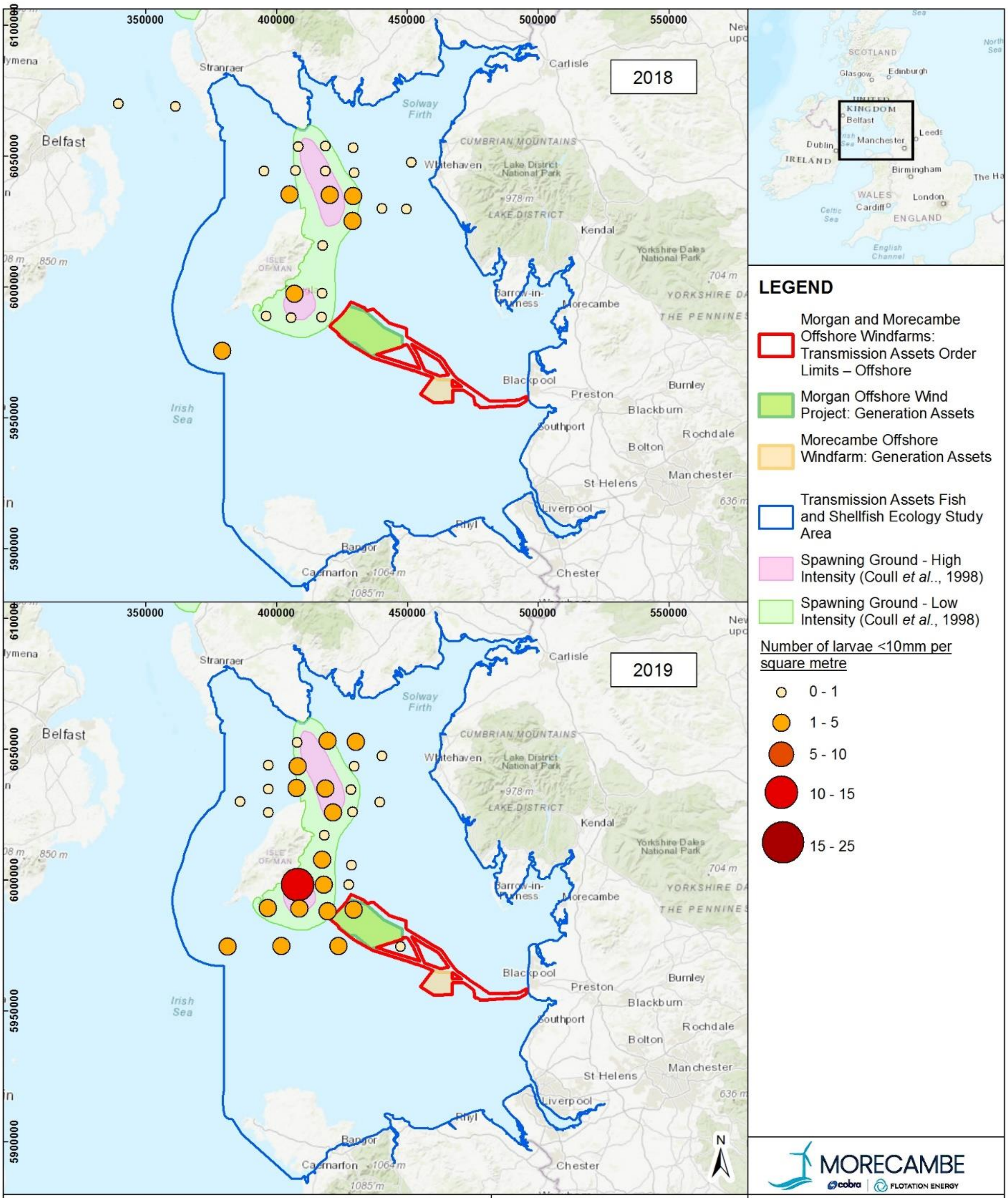
03	22/08/24	FINAL	MJ	BM

Figure 1.29: NINEL herring larvae population densities (larvae/m^2) in 2016 and 2017



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS, NINEL

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

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0 10 20 40 60 km

Drawing Number:
EOR0823-ES-FAS-T029-03

Drawing Title:
NINEL HERRING LARVAE POPULATION DENSITIES

Geodetic Information:
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VER	DATE	DETAILS	BY	CHECK
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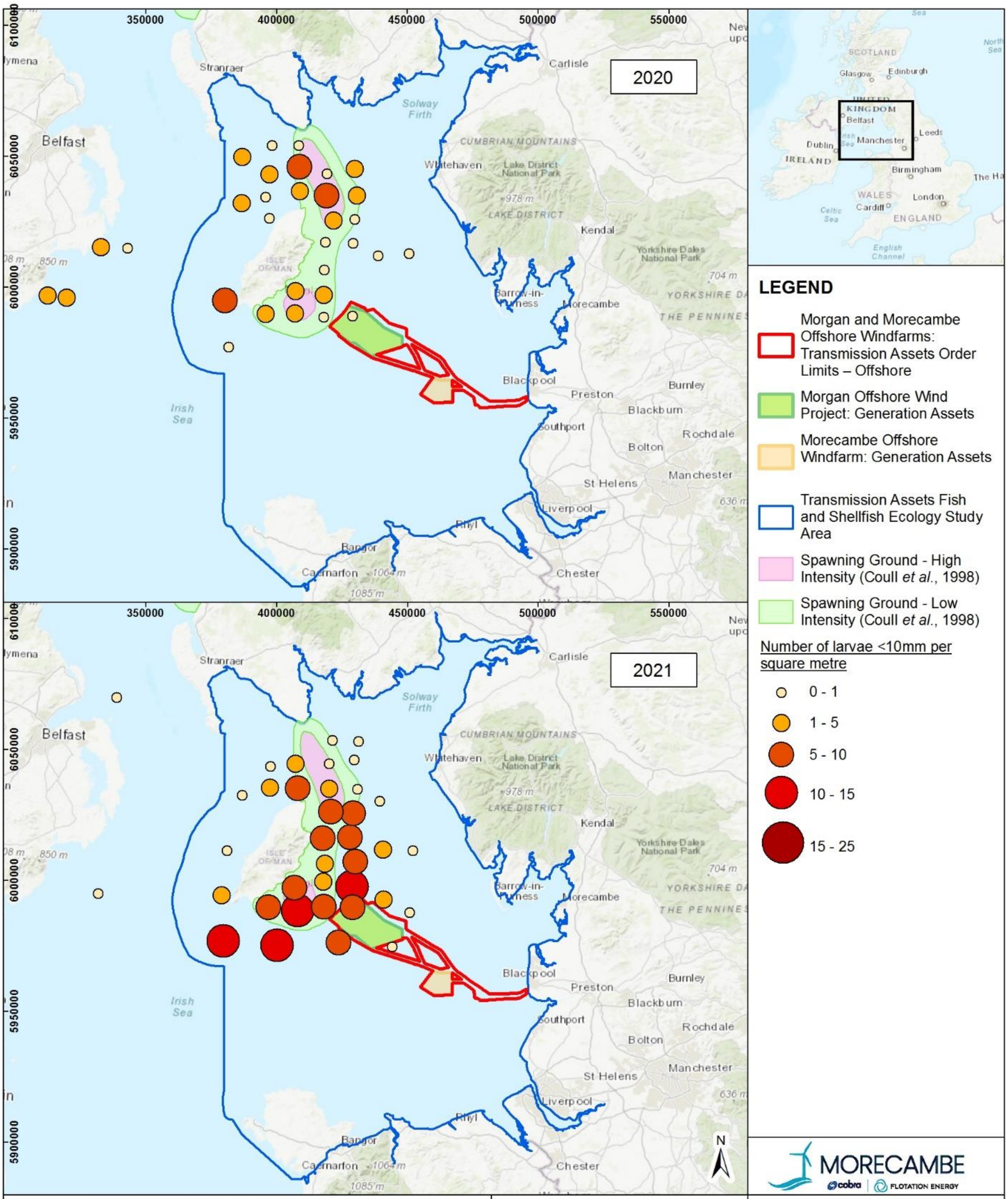
03	22/08/24	FINAL	MJ	BM

Figure 1.30: NINEL herring larvae population densities (larvae/m^2) in 2018 and 2019



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Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, CEFAS, NINEL

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

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

Drawing Number:
EOR0823-ES-FAS-030-03

Drawing Title:
NINEL HERRING LARVAE POPULATION DENSITIES

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:2,450,000

VER	DATE	DETAILS	BY	CHECK
00	20/02/24	First Issue	MJ	SH
03	22/08/24	FINAL	MJ	BM

Figure 1.31: NINEL herring larvae population densities (larvae/m^2) in 2020 and 2021

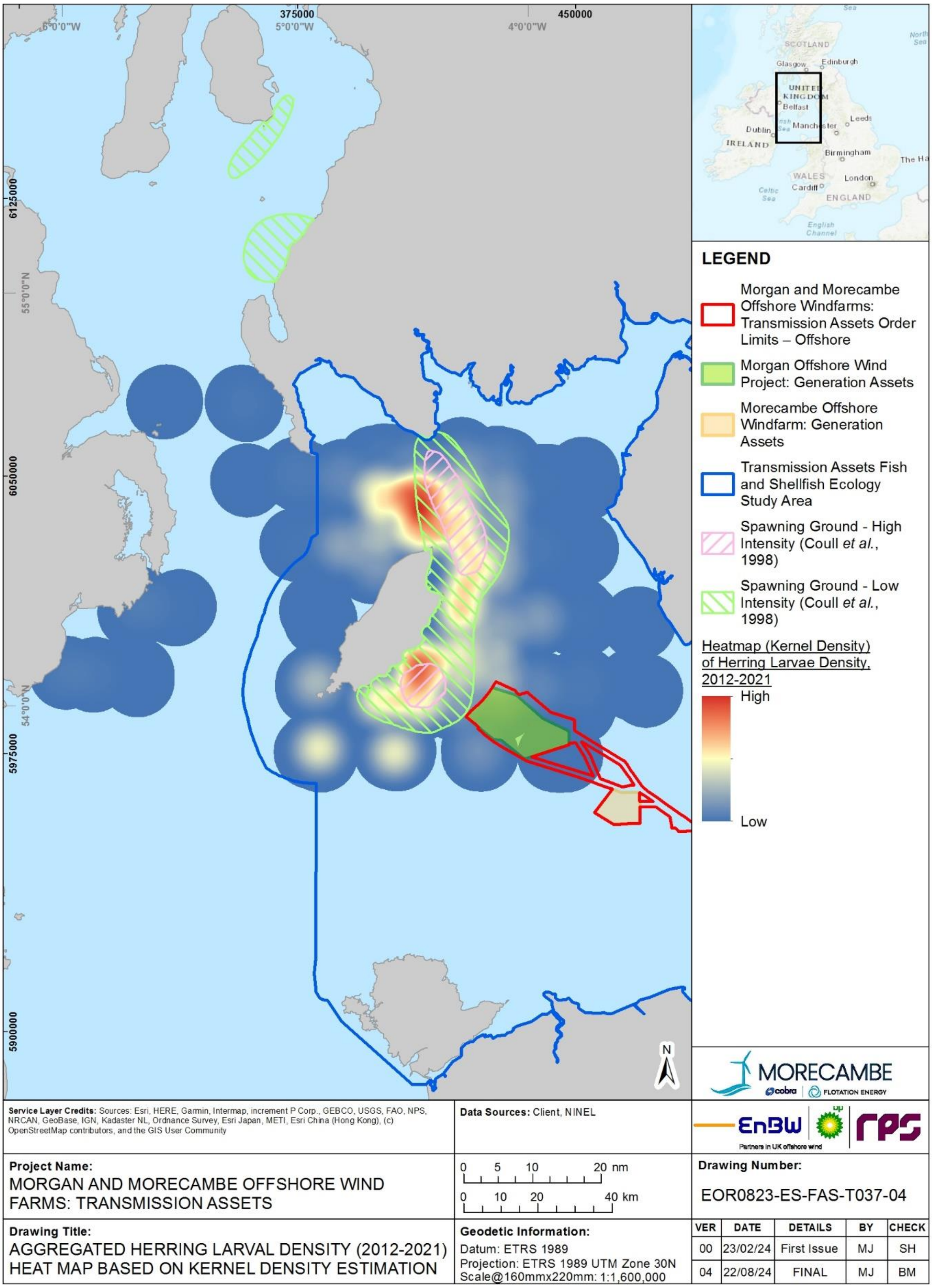


Figure 1.32: Aggregated herring larval density (2012-2021) heat map based on kernel density estimation (based on larvae/m^2)

1.3.5 Sandeel

1.3.5.1 While there are several species of sandeel present within the east Irish Sea (greater sandeel *Hyperoplus lanceolatus*, lesser sandeel, smooth sandeel *Gymnammodytes semisquamatus*, Raitt's sandeel *Ammodytes marinus* and Corbin's sandeel *Hyperoplus immaculatus*), this section will refer to sandeel species collectively, unless otherwise stated. Liverpool Bay and the wider east Irish Sea has been historically known to support important and ecologically valuable sandeel populations. This was supported by the NIGFS (ICES, 2022b), which found evidence of the presence of Raitt's sandeel, greater sandeel, smooth sandeel and Corbin's sandeel within the wider east Irish Sea in areas surrounding the Offshore Order Limits, in relatively low but consistent densities during annual surveys conducted between 2012 and 2022.

1.3.5.2 Sandeel species are known to feed exclusively on phytoplankton and zooplankton which inhabit the water column and survive by filter feeding during daylight hours (Freeman *et al*., 2004). Sandeels are evidenced to be an important prey for numerous fish, bird and marine mammal species due to their small size and aggregations in large numbers (Engelhard *et al*., 2008). For this reason, sandeel are known to be a critical part of the marine food web and act as an umbrella species, linking primary productivity throughout the food chain to higher trophic levels and ultimately, apex predators (Latto *et al*., 2013).

1.3.5.3 Due to high substrate specificity and limited larval exchange between sandeel populations, sandeel are particularly vulnerable to overfishing and other pressures. Recent findings have illustrated that sandeel species display a high level of site fidelity, which has the potential to make them vulnerable at a sub-population level in terms of direct habitat loss (Jensen *et al*., 2011 and Latto *et al*., 2013).

1.3.5.4 The lesser sandeel is a priority species under the UK Post-2010 Biodiversity Framework (JNCC, 2012) and a species garnering attention from the general public due to its significance in the marine food chain. Sandeel spend most of the year buried in the seabed, emerging in the winter to spawn (van der Kooij *et al*., 2008). Sandeel spawn a single batch of eggs in December to January, which are deposited on the seabed, several months after the active feeding season (April to September). The larvae hatch after several weeks, usually in February or March and drift in the currents for one to three months, after which they settle on the sandy seabed. During the spring and summer, sandeel emerge during the day to feed in schools and at night return to bury in the sand. This is an adaptation to conserve energy and to avoid predation. There are indications that the survival of sandeel larvae is linked to the availability of copepod prey in the early spring, especially *Calanus finmarchicus*, and that climate generated shifts in the *Calanus* species composition can lead to a mismatch in timing between food availability and the early life history of lesser sandeel (Wright and Bailey, 1996; van Deurs *et al*., 2009).

1.3.5.5 Sandeel have a close association with sandy substrates into which they burrow. They are largely stationary after settlement and show a strong preference to specific substrate types. Some work, in the laboratory (Wright *et al*., 2000) and in the natural environment (Holland *et al*., 2005) has focused on identifying the sediment characteristics that define the seabed habitat preferred by sandeel. Both approaches produced similar results, indicating that sandeel preferred sediments with a high percentage of medium to coarse grained sand (particle size 0.25 mm to 2 mm) and avoided sediment containing >4% silt (particle size <0.063 mm) and >20% fine sand (particle size 0.063 mm to 0.25 mm). As the percentage of fine sand, coarse silt, medium silt and fine silt (particles <0.25 mm in diameter) increased, sandeel increasingly avoided the habitat (this finding was also supported by Wright *et al*. (2000) as reported by Mazik *et al*. (2015). Conversely, as the percentage of coarse sand and medium sand (particles ranging from 0.25 mm to 2.0 mm) increased, sandeel showed an increased preference for this substrate. The mapped spawning grounds for sandeel (Ellis *et al*., 2012) are displayed over the Folk 16 sediment classification in **Figure 1.33**, distinguishing between those substrates which are considered suitable and unsuitable for sandeel habitation and spawning.

1.3.5.6 Work by Greenstreet *et al*. (2010) draws on the research by Holland *et al*. (2005), to define four sandeel sediment preference categories, using hydro acoustic seabed surveys and nocturnal grab surveys. They merged fine sand, three silt grades and two coarser sand grades, to define two particle size classes, silt and fine sand and coarse sand. They then examined the combined effect of these two size grades of sediment particles on the percentage of grab samples with sandeel present. Latto *et al*. (2013) used this research, in combination with the baseline of sandeel habitat types investigated by MarineSpace Ltd (2013b), to produce three sandeel sediment preference categories, which were defined as: preferred, marginal and unsuitable (see **section 1.2.6**). This classification has been applied to relevant data available using the Cefas OneBenthic tool and is presented below in **Figure 1.34** alongside the site-specific benthic subtidal ecology survey data for the Transmission Assets, Morgan Offshore Wind Project: Generation Assets, Morecambe Offshore Windfarm: Generation Assets and Mona Offshore Wind Project (Mona Offshore Wind Limited, 2024) to provide a regional context.

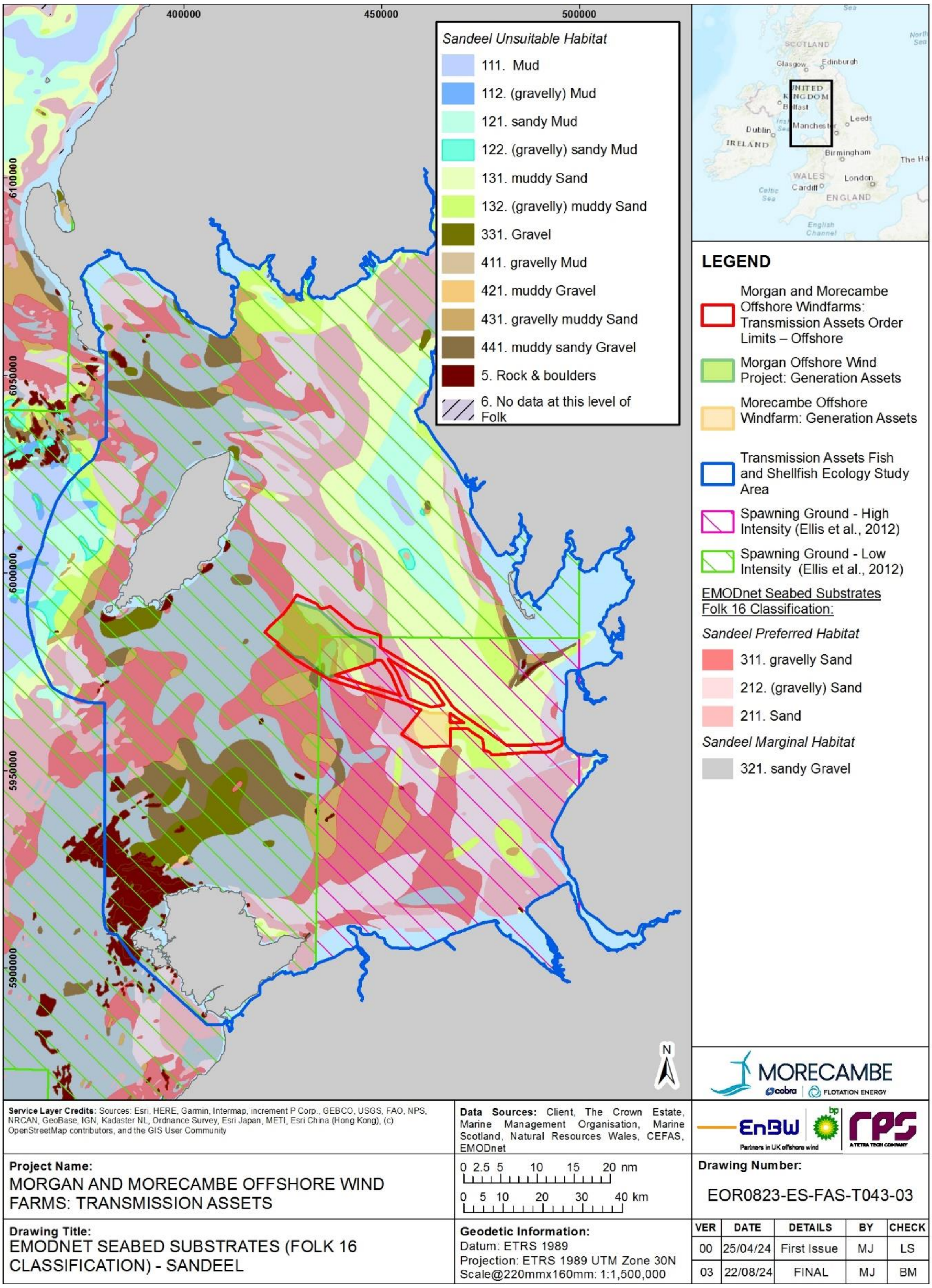


Figure 1.33: EMODnet seabed substrate Folk 16 classifications with mapped sandeel spawning grounds within the study area (Ellis *et al.*, 2012)

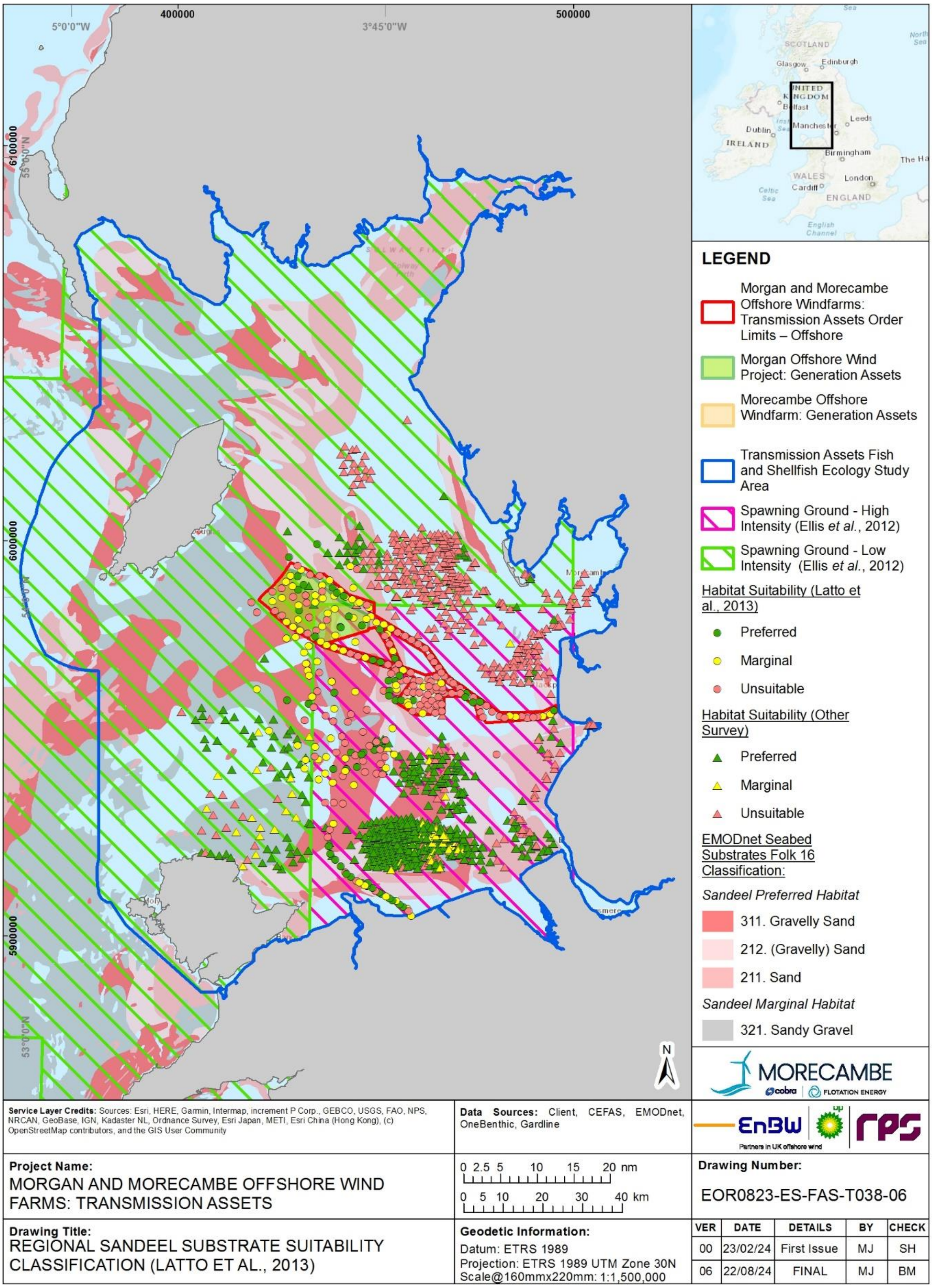


Figure 1.34: Regional substrate suitability classification for sandeel based on benthic sampling for the Transmission Assets, Generation Assets, Mona Offshore Wind Project and OneBenthic sources

Particle size analysis

Morgan Offshore Wind Project: Generation Assets

1.3.5.7 The Morgan Offshore Wind Project: Generation Assets fall within the Offshore Order Limits, therefore PSA data from the benthic survey for this project has been used to support assessment of the substrate suitability for sandeel habitation and spawning. The full benthic survey data can be found in Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report to the ES.

1.3.5.8 Site-specific survey data were collected in 2021 and 2022 and reviewed alongside desktop studies to assess the extent of suitable sandeel habitat within the Morgan Offshore Wind Project: Generation Assets. Grab sampling was undertaken and PSA completed on sediment samples collected during these surveys in the Morgan Offshore Wind Project: Generation Assets which allowed classification of the sediment types according to Latto *et al.* (2013), as described in **Table 1.7**. These classifications were originally developed for the marine aggregates industry, drawing on work from Greenstreet *et al.* (2010) and Holland *et al.* (2005), investigating spatial interactions between the aggregate application areas and sandeel habitat.

Table 1.7: Sandeel habitat sediment classifications derived from Latto *et al.* (2013)

% Contribution (mud = <63 µm)	Habitat sediment preference (Latto *et al.*, 2013)	Habitat sediment classification (Latto *et al.*, 2013)
<1% mud, >85% sand	Prime	Preferred
<4% mud, >70% sand	Sub-prime	Preferred
<10% mud, >50% sand	Suitable	Marginal
>10% mud, <50% sand	Unsuitable	Unsuitable

1.3.5.9 **Figure 1.35** illustrates the survey results of this analysis from 2021 and 2022 with sandeel habitat preference classifications of preferred, marginal and unsuitable denoted, presented with high and low intensity spawning grounds (Ellis *et al.,* 2012). The distribution of habitat suitability shows that the Morgan Offshore Wind Project: Generation Assets is variable, with a mosaic of substrates classified as unsuitable (27.9%; >10% mud), marginal (49.2%; >4% mud and >50% sand) and preferred habitat (23.0%; <4% mud and >70% sand; Gardline, 2022; 2023).

1.3.5.10 Results illustrated that 77% of the surveyed stations comprised mud content in excess of 4%, rendering the sediments within the Morgan Offshore Wind Project: Generation Assets outside of preferred sandeel habitat composition.

1.3.5.11 **Figure 1.35** illustrates survey data alongside EMODnet seabed substrate data which can also be used to assign broadscale habitat suitability for sandeel. Gravelly sand, (gravelly) sand and sand in the EMODnet substrate data were classified as preferred habitat and sandy gravel as marginal habitat. Where no shading is present, the habitat in that area is considered unsuitable for sandeel (the full Folk 16 classification is presented in **Figure 1.33**. Overall, the broadscale EMODnet data broadly aligns with the survey findings within the Morgan Offshore Wind Project: Generation Assets in terms of expected spawning ground suitability.

1.3.5.12 Preferred habitats identified from the site-specific survey are located within or on the periphery of the sandeel preferred EMODnet seabed substrates. It is worth noting that the EMODnet seabed substrate data are of lower resolution and accuracy than the results of the survey and so should be interpreted with caution due to not accounting well for local scale variance but provide a broadscale regional picture of the general surrounding substrate.

1.3.5.13 Further survey results from grab samples have provided incidental data on the presence of sandeel within the Morgan Offshore Wind Project: Generation Assets. No sandeel were captured during grab sampling within the Morgan Offshore Wind Project: Generation Assets during the 2021 and 2022 surveys (see **Figure 1.36**). However, during the 2021 survey, two stations, south of the Morgan Offshore Wind Project: Generation Assets recorded sandeel (four individuals caught in each station), hence providing incidental data on the presence of sandeel in the vicinity of the Morgan Offshore Wind Project: Generation Assets, and within the fish and shellfish ecology study area. However, it should be noted that this data collection method does not target sandeel specifically, therefore these results should be regarded as opportunistic. Conversely, whilst these opportunistic data may indicate higher abundances in specific areas (with regards to higher catchability due to higher density of burrows), it cannot be interpreted as low abundance or absence where sandeels were not recorded, due to the lack of specificity of sampling methods for sandeels. The desktop data indicate that sandeels may be present across the Morgan Offshore Wind Project: Generation Assets, although the site-specific data recorded within the Morgan Offshore Wind Project: Generation Assets were largely assessed to be unsuitable or marginal within a mosaic of variable habitats.

Morecambe Offshore Windfarm: Generation Assets

1.3.5.14 Based on the Folk 1954 sediment classifications, the study area was predicted to comprise of a mixture of sand and sandy mud (DigSBS250, BGS 2015). However, site-specific PSA surveys found that the predominant sediment type across the Morecambe Offshore Windfarm: Generation Assets was fine sand. The substrate suitability results from grab samples for sandeel habitat reflects a broad lack of suitable sandeel habitat within the Morecambe Offshore Windfarm: Generation Assets (largely to due to sediment mud content that is higher than preferred by the species), with a small area of potential suitable habitat in the southwest.

1.3.5.15 Average mud (particle size <0.63 μm) content across all samples was 18.5% (and therefore too high, on average, to support significant sandeel assemblages; Holland *et al.,* 2005, Wright *et al.,* 2000) and mud content was less than 10% in 30% of samples. Only nine of the 50 sample stations within the Morecambe Offshore Windfarm: Generation Assets revealed sediment composition with less than 4% mud content, again suggesting that the area is generally unsuitable for sandeel (Holland *et al.,* 2005, Wright *et al.,* 2000).

1.3.5.16 **Figure 1.35** illustrates the survey results of this analysis with sandeel habitat preference classifications of preferred, marginal and unsuitable denoted, presented with high and low intensity spawning grounds alongside EMODnet seabed substrate data (Ellis *et al.,* 2012). The distribution of habitat suitability shows that the Morecambe Offshore Windfarm: Generation Assets is largely classified as unsuitable (70.0%; >10% mud) with intermittent areas of marginal and preferred habitat.

1.3.5.17 Results illustrated that 82.0% of the surveyed stations comprised mud content in excess of 4%, rendering the sediments within the Morecambe Offshore Windfarm: Generation Assets outside of preferred sandeel habitat composition.

1.3.5.18 No sandeel were recorded in any of the 50 grab samples across the Morecambe Offshore Windfarm: Generation Assets, although it should be noted that grab samples are not an optimal sampling method for sandeel.

Transmission Assets

1.3.5.19 As outlined in **section 1.2.6**, site-specific survey data were collected and reviewed alongside desktop studies to assess the extent of suitable sandeel habitat within the Offshore Order Limits. Grab sampling was undertaken (see **section 1.2.6**) and PSA completed on the sediment samples collected in the

2022 Transmission Assets survey (Gardline Limited, 2023) which allowed classification of the sediment types according to Latto *et al*. (2013), as described in **section 1.2.6** (**Table 1.7**). Figure 1.37 illustrates the results of this site-specific analysis with sandeel habitat preference classifications of preferred, marginal and unsuitable denoted, presented with high and low intensity spawning grounds (Ellis *et al*., 2012). The distribution of habitat suitability shows that the Offshore Order Limits is largely classified as unsuitable (47.6%; >10% mud) and marginal (36.9%; between 4% and 10% of mud and between 50% and 70% of sand) habitat, with intermittent areas of preferred (15.5%) habitat. The majority of the sediments sampled in the south east portion of the Offshore Order Limits were found to comprise unsuitable sandeel habitat.

1.3.5.20 Results illustrated that 84.5% of the surveyed stations comprised mud content in excess of 4%, rendering the majority of sediments within the Offshore Order Limits outside of the preferred sandeel habitat composition. Excess mud content can prevent the sandeel maintaining their burrows, with higher chances of the burrows collapsing and can lead to clogging of gills and reduced oxygenation.

1.3.5.21 The site-specific survey data are also presented alongside EMODnet seabed substrate data in **Figure 1.37**. Overall, the broadscale EMODnet data broadly aligns with the site-specific survey findings in terms of expected spawning ground suitability. Preferred habitats resulting from the site-specific surveys are located within or on the periphery of the sandeel preferred EMODnet seabed substrates and within the closer inshore waters.

1.3.5.22 Results from the surveys for the Generation Assets also aligned with the EMODnet seabed substrate (**Figure 1.35**). Grab samples for the Generation Assets further support that the sediments within the Offshore Order Limits are mostly outside of the preferred habitat composition with most surveyed stations comprising mud content in excess of 4%.

1.3.5.23 No sandeel were observed with the samples or DDV imagery from the Offshore Order Limits. However, it should be noted that these results should not be regarded as an absence or low abundance, due to the lack of specificity of sampling methods for sandeels.

1.3.5.24 The desktop data indicate that sandeels may be present across the Offshore Order Limits, although the habitats recorded in the Transmission Assets site-specific survey were largely assessed to be unsuitable or marginal within a mosaic of variable substrates.

1.3.5.25 Additional data sources have been incorporated to support regional characterisation, including PSA data extracted from the Cefas OneBenthic tool. This data has been mapped in **Figure 1.34** to show the distribution of substrates beyond the Offshore Order Limits to provide an indication of broader suitability for sandeel habitation based upon *in situ* empirical data.

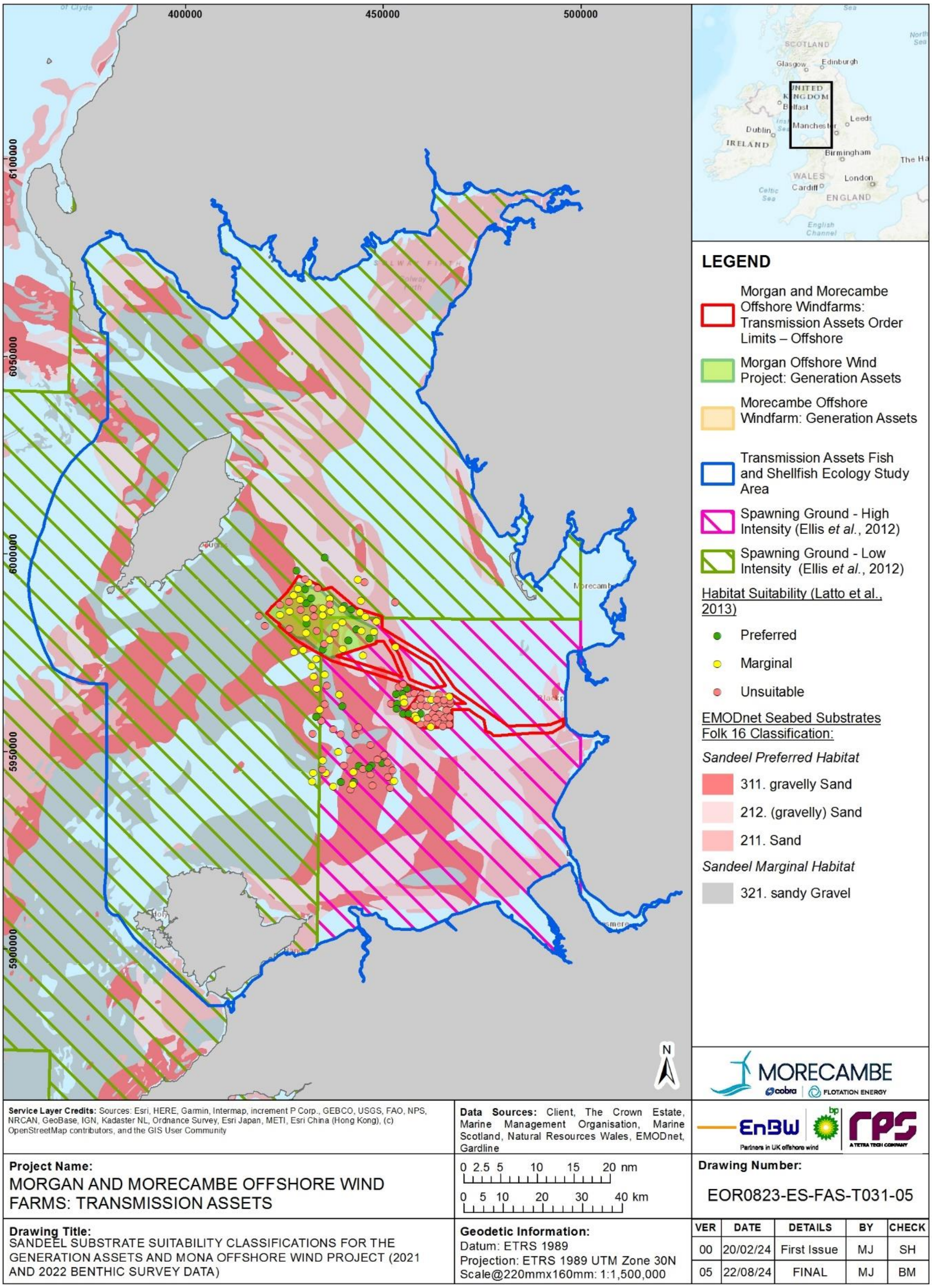


Figure 1.35: Sandeel substrate suitability classifications for the Generation Assets, and Mona Offshore Wind Project (2021 and 2022 benthic survey data)

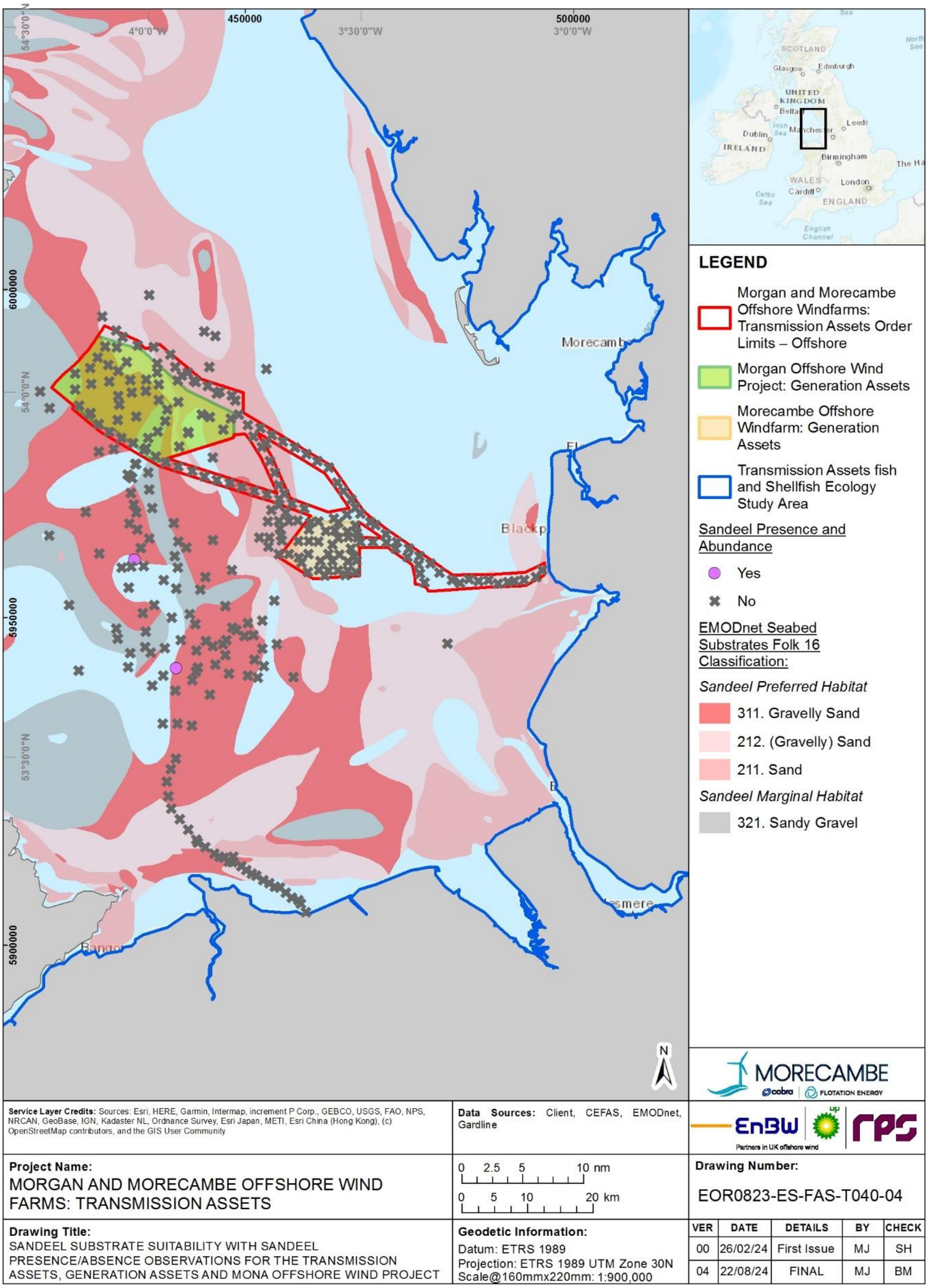


Figure 1.36: Sandeel substrate suitability with sandeel presence/absence observations for the Transmission Assets, Generation Assets and Mona Offshore Wind Project (2021 and 2022 benthic survey data)

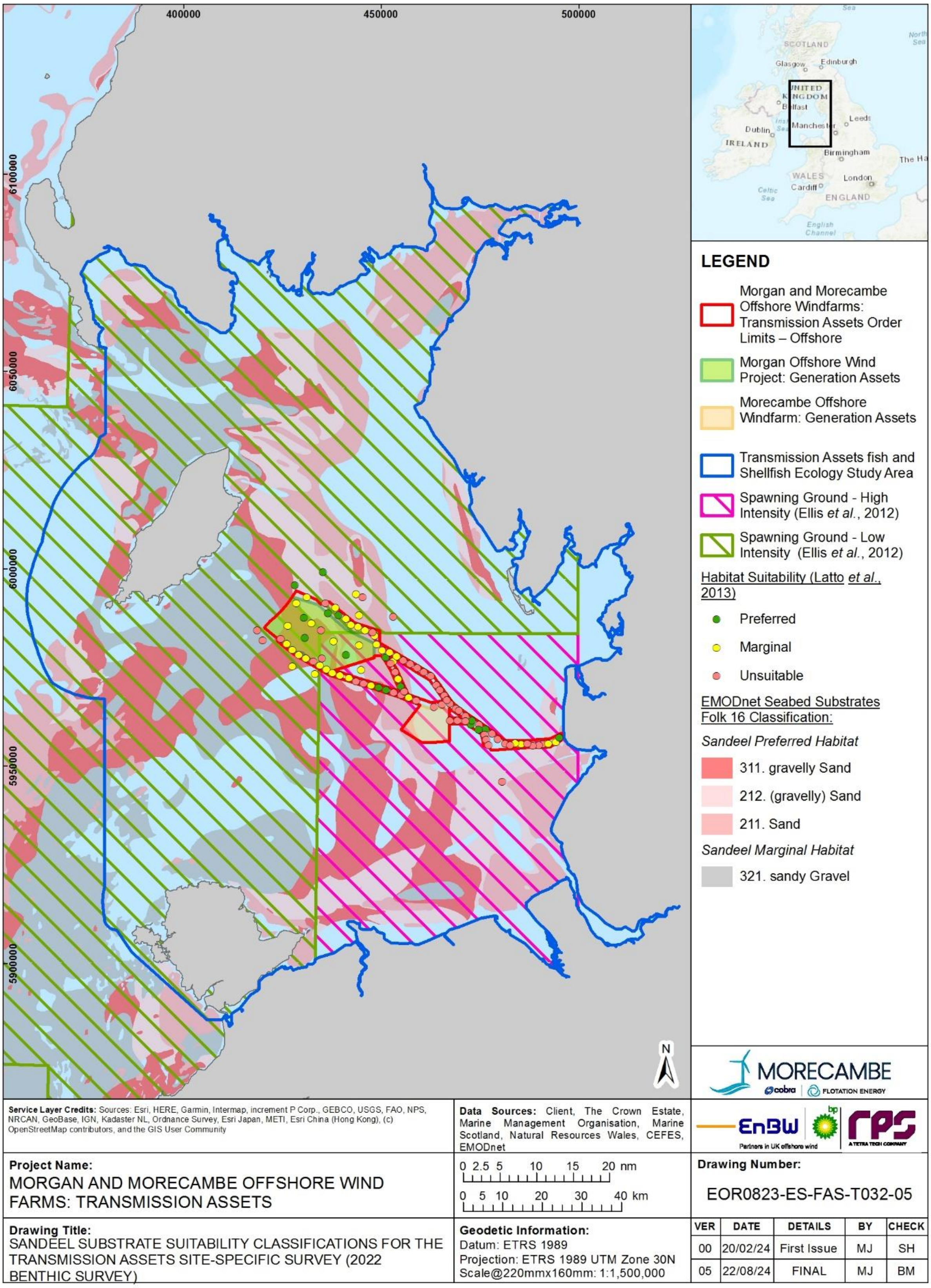


Figure 1.37: Sandeel substrate suitability classifications for the Transmission Assets site-specific survey (2022 benthic survey)

1.3.6 Elasmobranchs

1.3.6.1 Elasmobranchs are a cartilaginous fish group that comprises sharks, rays and skates. There are over 71 elasmobranch species that have been recorded in the Irish Sea, about half the number that live in European waters, with habitats supporting taxa ranging from sedentary to highly migratory (Clarke *et al.,* 2016). The most common elasmobranch species found in the Irish Sea are rays, including thornback ray, blonde ray, cuckoo ray and spotted ray, with common shark species including spurdog, lesser spotted dogfish and tope shark. Since 2005, many species of skates and rays have exhibited long-term declines; however, there are signs of recovery and increased biomass in recent years that may be attributed to reduced fishing effort and effort changes in the region (from whitefish to *Nephrops* fishing) (ICES, 2019b).

1.3.6.2 Species expected to be present in the study area include basking shark, tope shark, spurdog, common skate *Dipturus batis*, spotted ray and thornback ray. Some species of elasmobranchs have reported nursery grounds within and around the Offshore Order Limits (Doherty *et al*., 2017; Ellis *et al*., 2012; see **section 1.3.3**).

1.3.6.3 Thornback ray are known to support an important commercial and recreational fishery within Liverpool Bay. Monthly landings data occurring from the NW-IFCA District in North Wales and within Liverpool Bay illustrated that ray species were landed year-round, with August being the predominant month of targeted catch (Moore *et al*., 2020). Based on the context of historic declines within UK waters, thornback ray abundance in the Irish Sea is currently thought to be increasing (ICES, 2018; Volume 2, Annex 6.1: Commercial fisheries technical report of the ES, for additional information).

1.3.6.4 Skates and rays are known to represent one of the more vulnerable fish communities in the Irish Sea, often being data poor in comparison to other commercially exploited fish species (Dedman *et al*., 2015). Within the Irish Sea, the species distribution for skate and ray species was found to be driven by a general preference for both sand and coarser substrates, as well as higher salinities, current speeds and surrounding temperatures (Dedman *et al*., 2015).

1.3.6.5 The Irish Sea population of spotted and thornback ray are stable throughout their ranges, despite being commonly landed in fisheries. These small-bodied species have a wide geographic distribution throughout the north east Atlantic and Mediterranean and are some of the most common ray species recorded from Irish Sea waters. There is an inshore to offshore partition in habitat preference illustrated in spotted ray between adults and juveniles, with adults occurring offshore on sand and coarse sand-gravel substrates and juveniles illustrating a preference for inshore, sheltered sandy substrates. Abundant juveniles and egg cases have been found in the east Irish Sea, around Cardigan Bay and Anglesey, suggesting that these are important nursery areas for the spotted ray (Ellis *et al*., 2010; see **section 1.3.3**).

1.3.6.6 The cuckoo ray is widely distributed throughout the north east Atlantic and Mediterranean and Moriarty *et al*. (2015) suggests that the population in the

Irish/Celtic Seas is separate to the population in the west and north of Ireland. Cuckoo ray is a small bodied species that typically occurs offshore on the continental shelf and slope at depths of 20 m to 500 m. In the Irish Sea, the habitat preferences of cuckoo ray are coarse sand or gravel substrates, but the scarcity of egg cases recovered on the coast suggests that nurseries for this species are in deeper, offshore waters (Moriarty *et al*., 2015).

1.3.6.7 Lesser spotted dogfish have a broad habitat preference and are commonly found on a variety of substrates including sand, coralline algae and gravelly or muddy bottoms (Clarke *et al*., 2016). Lesser spotted dogfish is an oviparous species that lays its young in egg cases deposited on macroalgae in shallow coastal waters or on sessile invertebrates (such as sponges, hydroids and soft corals) in deeper waters (Ellis and Shackley, 1996). The population trend of lesser spotted dogfish in the UK is stable and is listed on Europe’s Red List for cartilaginous fish as Least Concern (IUCN, 2022).

1.3.6.8 Angel shark *Squatina squatina* are a Critically Endangered demersal elasmobranch (Morey *et al*., 2019) with a preference for relatively shallow coastal and continental shelf soft sediment habitats for feeding (Lawson *et al*., 2019) and historical evidence shows the use of stony reef habitats as juvenile nursery grounds around Wales (Moore and Hiddink, 2022). This habitat preference has caused them to be highly susceptible to demersal fishing activities (Ellis *et al*., 2020), with significant decreases in population historically related directly to these activities within the Irish Sea (Quigley, 2006, Hiddink *et al*., 2019). Most recently, the majority of sightings in the Irish Sea were between Bardsey Island and Strumble Head, but this was outside of the study area. Within the south west of the study area, up to 100 individuals in total were historically and recently sighted within Conwy Bay (Barker *et al*., 2022), indicating a potentially significant population concentration approximately 50 km from the Offshore Order Limits, although this population is only present intermittently throughout spring and summer for feeding.

1.3.6.9 Basking shark are known to migrate throughout the study area and therefore have the potential to be encountered within the Offshore Order Limits. The basking shark is a large, filter feeding species that is predominately solitary, but may also occur in aggregations where there is dense zooplankton abundance (Speedie, 1999). The basking sharks’ unique feeding strategy dominates all aspects of its ecology and life history; the basking shark is an obligate ram filter feeder whereby the flow of water across gill rakers within the mouth is controlled by swimming speed (Sims, 1999; Sims, 2008).

1.3.6.10 Basking shark migration routes cover large distances from North Africa to Scotland, using both the continental shelf and oceanic habitats in the upper 50 m to 200 m of the water column (Doherty *et al*., 2017). Their distribution has been shown to be influenced by a range of environmental conditions (Austin *et al*., 2019); surface sightings of basking sharks are typically reported where sea surface temperatures range between 15 °C and 17.5 °C (Cotton *et al*., 2005; Skomal *et al*., 2004) where thermal fronts are present (Sims and Quayle, 1998; Jeewoonarain *et al*., 2000) and where zooplankton is in its greatest abundance (Sims and Quayle, 1998; Sims, 1999).

1.3.6.11 Basking shark migrations have been evidenced throughout the Irish Sea, with high numbers of sighting recorded around the Isle of Man (NBN Atlas, 2019). This is corroborated by the data available from the Manx Whale and Dolphin Watch (2023), with at least 20 sightings around the Isle of Man within the first half of 2023. Historically, basking sharks have been sighted in a density of 11 to 50 individuals per 0.5 by 0.5 degrees to the north of the Isle of Man, within the study area (Southall *et al*., 2005; Sims *et al*., 2005). Basking shark have a north to south migration and are expected to occur in the vicinity of the study area during August to October and during the return migration in March to June (Doherty *et al*., 2017).

1.3.6.12 More recently, 28 basking shark tagged off the coast of Scotland and the Isle of Man in summer months over four years (2012 to 2015) illustrated an average post-summer migration distance of 1,057 km (Doherty *et al*., 2017). Some remained in UK and Irish waters but moved further offshore, whilst others migrated as far as the Bay of Biscay and North Africa. The tagging data also demonstrated that several sharks in this study migrated through the study area and therefore in proximity to the Offshore Order Limits. In addition, 17 basking shark that migrated outside UK waters returned to the Celtic Sea in March to June (Doherty *et al*., 2017). In summary, 18% of basking sharks tracked in this study entered the Economic Exclusive Zone of the UK, including the Irish Sea, indicating that this is an important area for overwintering that links foraging grounds in the waters off the west coast of the UK to the south migration destinations (Doherty *et al*., 2017).

1.3.6.13 Mating has not been observed in basking shark and most likely occurs in deep water with courtship-like behaviour as the precursor, particularly where individuals aggregate in food-rich waters (Sims, 2008). Individuals are thought to pair and mate in early summer (Sims *et al*., 2000) and gestation has been estimated over a range of 12 to 36 months (Parker and Stott, 1965; Sims *et al.,* 2008). As an ovoviviparous species, basking shark bear live young, hatched from eggs within the uterus of the female. Basking shark are a slow-growing species with late maturation (at 12 to 20 years of age) and a relatively low fecundity (producing litters of around six pups) (Sund, 1943). These characteristics suggest that basking shark would be vulnerable to environmental changes and the population would be slow to recover from any major losses. With a long history of exploitation, this species is listed as a Protected Species in the Isle of Man Wildlife Act 1990 (Isle of Man Government, 1990); on the International Union for the Conservation of Nature (IUCN) Red List globally as Vulnerable (Fowler, 2009) and on the European Red List for cartilaginous fish as Endangered (IUCN, 2022).

1.3.6.14 A number of elasmobranch species have been recorded in the vicinity of the Offshore Order Limits during surveys for other offshore wind farms notably observations of lesser-spotted dogfish, thornback ray, nursehound, tope shark, cuckoo ray, spotted ray, starry smooth-hound, starry ray and blonde ray (see **section 1.3.2**). Basking shark were not recorded within the Offshore Order Limits in the site-specific aerial surveys undertaken for birds and marine mammals for the Morgan Offshore Wind Project: Generation Assets (Morgan Offshore Wind Limited, 2024a) but were recorded during surveys for other offshore wind farms.

1.3.6.15 Blonde ray, thornback ray, cuckoo ray and lesser-spotted dogfish were observed within the Offshore Order Limits (specifically within the area of the Morgan Offshore Wind Project: Generation Assets) during benthic subtidal surveys undertaken for the Morgan Offshore Wind Project: Generation Assets (Morgan Offshore Wind Limited, 2024a). In addition, DDV observations during site-specific surveys recorded spotted ray and lesser spotted dogfish within the Offshore Order Limits.

1.3.7 Diadromous fish

1.3.7.1 The term diadromous fish is utilised to describe fish that migrate between both freshwater and the marine environments. There is the potential for diadromous fish species to migrate to and from English and Welsh rivers in the vicinity of the Offshore Order Limits. Therefore, the diadromous fish species have the potential to migrate through the Offshore Order Limits to rivers during certain periods of the year (NBN Atlas, 2019).

1.3.7.2 The east Irish Sea is home to diadromous fish species, which move between the sea and freshwater at different stages of their life cycle and may migrate through the study area and therefore the Offshore Order Limits. Atlantic salmon and sea trout are two commercially important diadromous fish species found in the Irish Sea. Sea lamprey, river lamprey and twaite shad *Alosa fallax* are known to occur in inshore waters off the coasts of England and Wales. Brook lamprey are also recorded in the north areas of the study area, although as a purely freshwater species, this species migrates between downstream river habitat to upstream areas to spawn and are therefore not considered further in this report as it is unlikely to interact with components of the Transmission Assets. With the exception of sea trout, all of these diadromous fish species are listed on Annex II of the Habitats Directive (Council Directive 92/43/EEC) which makes provision for their protection through designation of Special Areas of Conservation (SACs). The Solway Firth SAC, Aber Dyfrdwy SAC, River Derwent and Bassenthwaite Lake SAC, River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC and River Ehen SAC have all been designated for the protection of diadromous fish species (see **section 1.3.9**). Allis shad (*Alosa alosa*), twaite shad, European eel, river lamprey and sea lamprey in Welsh waters are also protected under Section 7 of the Wales Biodiversity Partnership (Welsh Government, 2016).

1.3.7.3 Fish and epibenthic surveys carried out in 2013 for the Walney offshore wind farm and in 2012 for the West of Duddon Sands offshore wind farm recorded sea trout, a diadromous species of relevance within the study area (Brown and May Marine Ltd., 2013).

1.3.7.4 Sea trout, European eel, river lamprey and Atlantic salmon have been recorded in the estuaries of rivers across the north west coast of England, within the study area. Twaite shad and allis shad have only been recorded at the mouth of the river Esk, located 118 km north of the Offshore Order Limits (NBN Atlas, 2019).

1.3.7.5 Sea lamprey have been recorded in the estuaries of the River Dee and the River Mersey however these records are from the 1960s and 1970s (NBN Atlas, 2019).

1.3.7.6 No site-specific surveys were undertaken to inform the baseline characterisation for diadromous fish species. For the purposes of the impact assessment, it will be assumed that the aforementioned species have the potential to occur within the Offshore Order Limits, during key migration periods (e.g., adult migration to spawning rivers and smolt migration from natal rivers in the vicinity and surrounding the Offshore Order Limits). Depending on the key migration periods of the diadromous fish species discussed, there will be both a greater or lesser likelihood of fish being present within the Offshore Order Limits during all phases of the project, depending on the timings of particular activities.

1.3.7.7 Timings of diadromous fish species migrations are presented in **Table 1.8,** which displays the key migration times and the length of time each species spends in fresh water and at sea. Uncertainty exists in the exact timings and routes of migrations due to the wide range of factors influencing these, and a precautionary approach has therefore been adopted where species may be present in the areas surrounding the Offshore Order Limits year-round. This approach was requested by Natural Resources Wales (NRW) and The Planning Inspectorate during consultation and is supported by evidence from the NIGFS (ICES, 2022b), which indicated the presence of European eel, trout and sea lamprey within the study area throughout the year, outside of the specific spawning periods. Peak migration periods for some species are documented and it is assumed that most individuals will migrate during the timeframe outlined in **Table 1.8**; however, acknowledgement of the degree of uncertainty thereby warrants application of a precautionary approach to baseline characterisation, which is taken forward into the assessment as described above (i.e. assuming the presence of diadromous fish within the study area year-round).

Table 1.8: Overview of life histories for diadromous fish relevant to the Transmission Assets

Species	Time Spent in Freshwater	Timing of Downstream Migration	Time Spent at Sea Before First Return	Timing of Upstream Migration
Atlantic salmon	two to three years	April to May	one, two or three years	All year round with peak in late summer early autumn
Sea trout	two to three years	Spring	two or more	April to June
European eel	Males seven to 20 years Females nine to 50 years	Late spring	Many do not return to fresh water	January to June
Sea lamprey	three to four years	July to September to open sea	18 to 24 months	April to May spawning in May/June
River lamprey	Five years or more. Remain in burrow in river silt beds until adults	July to September to feed in estuaries	two years spent in estuaries	Winter and spring when temperatures are <10°

Species	Time Spent in Freshwater	Timing of Downstream Migration	Time Spent at Sea Before First Return	Timing of Upstream Migration
Allis and Twaite shad	Short period	N/A	two years spent in estuaries and marine areas do not return to fresh water until they are sexually mature.	April to May spawning in freshwater
Sparling (European smelt) *Osmerus eperlanus*	Short period	N/A	Estuarine	February to April spawning in freshwater

Atlantic salmon

1.3.7.8 Atlantic salmon is of considerable cultural and conservation importance (Hindar *et al*., 2010) and in both England and Wales, represents an ecologically and economically important diadromous fish species in the UK (Parry *et al*., 2018). However, in recent decades and especially the past thirty or so years, there have been declines in rod catch data across much of the species range (Parry *et al*., 2018). There are many pressures on Atlantic salmon stocks in both marine and freshwater environments, including commercial and recreational exploitation of stocks, disease, impacts related to farmed salmon and climate change (ICES, 2017). Atlantic salmon is an Annex II species under the EU Habitats and Species Directive and is a feature of various SACs.

1.3.7.9 The UK salmon population is increasingly important as it has influenced the overall selection of various SACs and the site selection process has focused on the identification and designation of rivers holding significant Atlantic salmon populations across the geographical range of species within the UK (JNCC, 2022a).

1.3.7.10 There are 49 rivers in England and 31 rivers in Wales that are known to regularly support Atlantic salmon; however, it is worth noting that some of these stocks are relatively small and support minimal catches overall. Of these 80 rivers located in England and Wales, 64 have been designated as ‘principal salmon rivers’ and are further utilised to give annual advice on stock status and assess the need for management and conservation measures.

1.3.7.11 The Atlantic salmon is considered a Priority Species under the UK Post-2010 Biodiversity Framework. The species is known to be a relatively large-bodied fish that can be encountered in clean and healthy rivers throughout the UK. Like other salmonids, the Atlantic salmon spends most of its life at sea, returning to spawn in the same stretch of river or stream in which it was born.

1.3.7.12 Following spawning by adult Atlantic salmon in English and Welsh rivers, the ova mature into fry and then parr before migrating to sea as smolts. At sea, the smolts grow rapidly and after one to three years they return as adults to spawn, most commonly to their natal river. Many Atlantic salmon die after spawning, but some return to sea as kelts, and may return to rivers to spawn (Mills, 1989). Atlantic salmon are known to migrate in relation to diurnal cues. Evidence provided by Smith and Smith (1997) suggests that Atlantic salmon upstream migration into rivers is related to tidal phase and time of day. Up-estuary movements leading to river entry were found to be predominantly nocturnal and occur during ebb tides, with entry into nontidal reaches of rivers also being nocturnal, however significantly associated with tidal phase (Smith and Smith, 1997). Smolts migrating downstream/offshore have also been found to increase migratory activity nocturnally, with daytime utilised more for prey detection and predator avoidance (Hedger *et al*., 2008). Dempson *et al*. (2011) also found a small but significant increase in migratory movements nocturnally when compared to daytime, which suggests a slight preference for nocturnal migration.

1.3.7.13 An Environment Agency report on salmonid fisheries statistics for England and Wales (Environment Agency, 2022) summarised Atlantic salmon rod catches within a 5-year period between 2017 to 2021 based on completed fisheries returns. Results illustrated that there were 5,815 Atlantic salmon caught in 2021, 11,566 caught in 2020 and 9,163 caught in 2019. Additionally, the 5-year mean (2017 to 2021) catch number was found to be 9,580. These results further illustrate a 50.7% decrease from 2020 to 2021 Atlantic salmon rod catches and a 29.3% decrease from the 5-year mean (Environment Agency, 2022).

1.3.7.14 Atlantic salmon net catches in England and Wales reported 592 caught during 2021, 900 Atlantic salmon caught during 2020, 453 caught during 2019, and a five-year mean of 9,580 (2017 to 2021). This accounted for a 34% decrease from 2020 to 2021 and a very significant 93% decrease from the 5-year mean (2017 to 2021, when catches typically exceeded averaged 9,580) to 2020 (Environment Agency, 2022). Since 1993, when released Atlantic salmon started being recorded, a continuous increase in released rate was observed with almost all fish released in 2021 (95% Atlantic salmon released, 87% for 5-year average 2016 to 2020; Environment Agency, 2022).

1.3.7.15 Data analysed from multiple acoustic telemetry studies along the west coast of England has illustrated that Atlantic salmon smolts have been evidenced to use a northward migration pathway through the Irish Sea to reach feeding grounds (Green *et al*., 2022).

1.3.7.16 Atlantic salmon is subject to many pressures in Europe, including pollution, the introduction of non-native salmon stocks, physical barriers to migration, exploitation from netting and angling, physical degradation of spawning and nursery habitat, and increased marine mortality (Cefas, 2019).

Sea trout

1.3.7.17 Sea trout are known to be found in rivers, streams and lakes, often preferring cold and well oxygenated waters. Sea trout spawn in rivers and streams that have swift currents, which are usually characterised by the downward movement of water into gravel, favouring large streams and mountainous areas that have adequate cover resulting from submerged rocks, undercut banks and overhanging vegetation (Fishbase, 2021a). Post-smolts were observed to move downstream into the sea in late June and July before returning to freshwater in August and September indicating potentially limited migratory movements in the sea (Pemberton, 1976). Sea trout in the marine environment generally swim under the surface (<3 m) with movements down to 30 m (Johnstone *et al.*,1995, Rikardsen *et al.*, 2007). While there is limited information regarding sea trout migration patterns identified from the Celtic Sea Trout Project (CSTP), the information available suggests preferences are primarily limited to inshore and local waters within the marine environment (Malcolm *et al*., 2010; CSTP, 2016). Findings illustrate that sea trout migrate to and from a number of rivers in the vicinity of Offshore Order Limits notably to and from river Ribble and river Wyre which have their river mouth located approximately 9 km south and 20 km north of the Offshore Order Limits respectively (CTSP, 2016; Ribble Rivers Trust, 2023).

1.3.7.18 Wales is widely acclaimed for the quality of its sea trout fisheries due to the larger than average weight of individual fish, numerical abundance and innate potential to reach weights in excess of 5 kg (CSTP, 2016).

1.3.7.19 An Environment Agency report on salmonid fisheries statistics for England and Wales (Environment Agency, 2022) summarised sea trout rod catches within a 5-year period between 2017 to 2021 based on completed fisheries returns. Results illustrated that there were 12,533 sea trout caught in 2021, 19,277 caught in 2020 and 21,330 caught in 2019. Additionally, the 5-year mean number of sea trout caught (2017 to 2021) was found to be 17,777. These results further illustrate a 35% decrease from 2020 to 2021 sea trout rod catches and a 29.5% decrease from the 5-year mean (Environment Agency, 2022).

1.3.7.20 Sea trout net catches in England and Wales reported 5,482 caught during 2021, 12,703 caught during 2020, 14,599 caught during 2019 and 18,729 caught in the 5-year mean (2017 to 2021), with catches consistently decreasing annually from 36,778 in 2017 to 5,482 in 2021). This accounted for a -56% change from 2020 to 2021 and a -71% change from the 5-year mean (2017 to 2021; Environment Agency, 2022).

1.3.7.21 Sea trout, like salmon, are also known to be a host species for freshwater pearl mussel *Margaritifera margaritifera*, see **paragraph 1.3.7.27** for additional detail on the freshwater pearl mussel.

European eel

1.3.7.22 European eels are classified as Critically Endangered (IUCN, 2022) and inhabit various benthic habitats that range from streams, shores, rivers, lakes and ultimately migrates to the Sargasso Sea to spawn. Eel larvae are brought to European waters by the Gulf Stream and transform into glass eel, followed by elvers which migrate up estuaries around the English, Welsh and Irish coasts, colonising rivers and lakes. When the European eel reaches sexual maturity, the species leaves the river and migrates to sea, covering vast distances during their spawning migration (Fishbase 2021b). It is a possibility that European eel will pass through the vicinity of the Offshore Order Limits and therefore, given their critically endangered status, will be considered as an IEF.

Sea lamprey

1.3.7.23 The sea lamprey is a primitive, jawless fish that resembles an eel. It is the largest of the lamprey species found within the UK and occurs in estuaries and accessible rivers and is an anadromous fish that spawns in freshwater environments, but completes its lifecycle in the sea (JNCC, 2021a). Similar to the other species of lamprey found within UK waters, sea lamprey require clean gravel for spawning and marginal silt or sand is utilised by burrowing juveniles (ammocoetes). Sea lampreys are known to spend most of their adult life at sea and are parasitic on other fish species and marine fauna. Sea lamprey (and river lamprey) have both been recorded in the Dee estuary and in fish traps on the River Dee, near Chester Weir (NRW, Scoping Opinion 2022). It is a possibility that sea lamprey will be present in the vicinity of the Offshore Order Limits and therefore will be considered as an IEF.

River lamprey

1.3.7.24 The river lamprey is found in coastal waters, estuaries and accessible rivers, but some populations are permanent freshwater residents, however the species is normally anadromous (i.e., spawning in freshwater but completing part of its life cycle in the sea) (JNCC, 2021b). River lamprey live on hard bottoms or attached to larger fish like cod and herring due to their parasitic feeding behaviours, with spawning taking place in pre-excavated pits within riverbeds. Due to their preference for estuarine and nearshore coastal waters, such as the Dee Estuary SAC (see above for sea lamprey), it is possible that river lamprey will be encountered within inshore areas overlapping with the Offshore Order Limits. However, it is unlikely that river lamprey would be encountered in the west section of the Offshore Order Limits, further offshore.

Allis and Twaite shad

1.3.7.25 Allis and twaite shad are both members of the herring family and are difficult to distinguish between one another in the field (JNCC, 2021c; JNCC, 2021d). The habitat requirements of twaite shad are not decisively understood. On the River Usk and the River Wye, twaite shad are known to spawn at night in shallow areas near deeper pools, in which the species congregate. Their eggs are then released into the water column, sinking into the interstices between coarse gravel and cobble substrates (JNCC, 2021c). The allis shad also has poorly understood habitat requirements. It grows in coastal waters and estuaries, spending most of its adult phase in the marine environment, but migrates into rivers to spawn, swimming up to 800 km upstream in continental Europe. Both species have been heavily researched in their freshwater life phases which has subsequently resulted in scarce understanding of their spatial ecology during the species marine life-phases (Davies *et al*., 2020). Adult allis shad spawn at night with the eggs released into the current where they settle among gaps in gravelly substrates. Spawning sites tend to be shallow gravelly areas adjacent to deep pools (JNCC, 2021d). Twaite shad have been recorded in fish trap data in the River Dee (NRW, Scoping Opinion 2022).

Sparling (European smelt)

1.3.7.26 Sparling or European smelt are known to inhabit estuaries and large lakes, spending much of their life in the estuarine zone, with short incursions into the littoral zone. Sparling have been evidenced to enter rivers to spawn on both sandy and gravelly substrates, predominantly in fast flowing waters of lake tributaries or shallow shores of lakes and rivers (Fishbase, 2021c). Due to their preference of inhabiting estuarine waters upon entering the marine environment, it is unlikely that sparling will be found in offshore waters within the west portion of the Offshore Order Limits. However they could be encountered in inshore waters due to the relatively close proximity of the landfall to the River Ribble and River Wyre estuaries (i.e., 4.3 km and 19.4 km from the Offshore Order Limits respectively) where sparling is a qualifying feature of the Ribble Estuary and Wyre Lune Marine Conservation Zones (MCZs) and therefore, where some potential populations of sparling could be found (Ribble Rivers Trust, 2021; Natural England, 2017). This species has also been recorded in the River Dee and also the River Conwy (NRW, Scoping Opinion 2022).

Freshwater pearl mussel

1.3.7.27 The freshwater pearl mussel is an endangered species of freshwater mussel. Freshwater pearl mussel are similar in shape to common marine mussels but grow much larger and live far longer. They can grow as large as 20 cm and live for more than 100 years, making them one of the longest-lived invertebrates (Skinner *et al*., 2003). These mussels live on the beds of clean, fast flowing rivers, where they can be buried partly of wholly in coarse sand or fine gravel. Mussels have a complex life cycle, living on the gills of young Atlantic salmon or sea trout, for their first year, without causing harm to the fish (Skinner *et al*., 2003). Freshwater pearl mussel is fully protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) and is also listed on Annexes II and V of the Habitats Directive and Appendix III of the Bern Convention. The conservation status of the species is reflected in its listing as Endangered on the IUCN Invertebrate Red List. While there is no potential for direct impacts on this species from the Offshore Order Limits (as this is an entirely freshwater species), indirect impacts may occur due to effects on their host species (i.e., Atlantic salmon and sea trout) during their marine phase.

1.3.8 Shellfish

1.3.8.1 Shellfish is a colloquial and fisheries term for aquatic invertebrates used as food, including various species of molluscs, crustaceans and echinoderms. Shellfish communities contribute to the biodiversity of the benthic ecosystem and are an important link in the food chain, both as predators and prey. As described previously, there are a number of commercially important shellfish species within the study area. Edible crab, cockles, *Nephrops*, king scallop and whelks are the most commonly occurring shellfish in the Irish Sea, with higher proportions of *Nephrops* and scallops observed to the north (ICES, 2021a). Commercial landings data can be used as a proxy for identifying species present in the vicinity of the Offshore Order Limits, which include *Nephrops*, edible crab, European lobster, velvet swimming crab, king scallop and squid (Volume 2, Annex 6.1: Commercial fisheries technical report of the ES).

1.3.8.2 The 2022 site-specific survey results from grab/DDV samples within the Offshore Order Limits have provided incidental data on the presence of shellfish species within the Offshore Order Limits, including commercially important species, such as observations of razor clam, blue mussel, king scallop and other scallops. However, it should be noted that this data collection method does not target shellfish species specifically, therefore these results should be regarded as opportunistic and, at best, provides presence-absence data of shellfish.

King and queen scallop

1.3.8.3 Both king scallops and queen scallop show a preference for areas of clean firm sand, fine or sandy gravel and may occasionally be found on muddy sand, often in high densities (MarLIN, 2022). While king scallop are generally found in sandy, gravelly substrates, they can additionally be found on rougher ground. King scallop achieve reproductive maturity between three to five years, live upwards of 15 years and are evidenced to be most abundant in depths of 20 m to 70 m (Cappell *et al*., 2018; Howarth and Stewart, 2014; Salomonsen *et al*., 2015). Queen scallop are known to have particularly important commercial grounds located around the Isle of Man and can be found in depths of up to 100 m and are specifically protected against unlicenced towed gear fishing under Isle of Man bylaws (SD 2018/0186, 2018). Similarly, king scallop are protected by a range of measures, such as the Isle of Man King Scallop Long-Term Management Plan 2021, which specified alterations to fishing rights and technical specifications of dredges and tow-bars to minimise damage where possible. Key physical differences between king and queen scallop are that queen scallop possess two distinctive curved shells, while the king scallop upper shell is predominantly flat and are typically larger overall. Queen scallop stocks are known to be more highly mobile than king scallops, especially within the summer months when queen scallops are actively swimming (Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information).

1.3.8.4 King and queen scallop recruitment is generally understood to be unpredictable, due to the recruitment dependency on larval production and spawning, in addition to the transportation of larvae to areas optimum for development (Delargy, 2020). Therefore, king and queen scallop fisheries in the UK are strictly regulated through the utilisation of gear restriction measures, minimum legal landing sizes, effort controls and seasonal closures further described in Volume 2, Annex 6.1: Commercial fisheries technical report of the ES.

1.3.8.5 Distribution of both of these species is invariably patchy (Carter, 2008; Marshal and Wilson, 2009; Duncan *et al*., 2016), but the areas with greatest abundance tend to be areas of little mud and with good current strength. In general, within the same sea basins, king scallop populations are well connected, although localised currents can lead to isolated populations that become dependent on self-recruitment (Hold *et al.*, 2021). In English and Welsh waters, scallops spawn for the first time in the autumn of their second year and subsequently spawn each year in the spring or autumn. Modelling has found that larvae travel on residual currents, dispersing up to 100 km away from spawning grounds within a five-week period, with the spawning grounds being most abundant in areas closed to bottom-gear fishing activity (Neill and Kaiser, 2008). After settlement, scallops grow until their first winter, during which growth usually ceases. Thereafter, growth resumes each spring and ceases each winter, causing a distinct ring to be formed on the external surface of the shell.

1.3.8.6 Scallops (both king and queen) were the most valuable wild-caught seafood landed in Wales in 2012. However, both their value and the quantity of scallop landed have decreased since 2012. Despite this decrease in associated value, scallops are economically important and as of 2017, were the third most valuable wild-caught seafood in Wales (Delargy, 2020). Similarly, king and queen scallops are the most important fisheries by sale values in Manx waters, around the Isle of Man (Murray *et al.*, 2009; Duncan and Emmerson, 2018). However, since 2011, the stock assessment within the Manx waters indicates a decreasing trend of queen scallop biomass which is also illustrated by lower commercial landings (ICES, 2019c). In Northern Irish waters, CPUE for king scallop has been decreasing from a peak between 2012 and 2014 and landings of queen scallop have dropped after a peak in 2011 which is in line with the continuous decrease of the estimated abundance of queen scallop (ICES, 2019c).

1.3.8.7 Generally, queen scallop are more mobile than king scallop, which influences the gear type used to target them, as discussed further in Volume 2, Annex 6.1: Commercial fisheries technical report of the ES.

1.3.8.8 King scallop have historically been targeted commercially through dredge fisheries within the vicinity of the Offshore Order Limits, with the majority of the activity concentrated along the offshore west portions of the Offshore Order Limits and around the Isle of Man, as indicated from VMS data provided for local fisheries (**Figure 1.38**). These data, which indicated a wide distribution of this species was supported by surveys performed by the NIGFS, which confirmed the presence of king scallop in this same area at relatively stable population levels in the 2013 to 2021 survey period. Further details are provided within Volume 2, Annex 6.1: Commercial fisheries technical report of the ES.

1.3.8.9 While the value of landings has fluctuated over the last 10 years, the west portion of the Offshore Order Limits has yielded some of the highest outputs of shellfish landings over the last five years (ICES, 2020). This is consistent with the consultation feedback showing higher intensity queen scallop fishing in the west corner of the Offshore Order Limits (see **Figure 1.39** and Volume 2, Annex 6.1: Commercial fisheries technical report of the ES). Other areas around the Offshore Order Limits and within the Offshore Order Limits are rarely fished as they are considered important spawning grounds for the overall queen scallop stock. Specifically, these areas are located within the east half of the Offshore Order Limits (Volume 2, Annex 6.1: Commercial fisheries technical report of the ES) and extend more widely throughout the study area.

1.3.8.10 King scallop landings by weight within the study area were found to be greatest from November to May, with an overall landed weight range across these months ranging from 1,394 tonnes (t) to 2,997 t (Bloor, 2019; see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information). The landed weight of king scallop illustrated relatively similar seasonal trends across the 2020 to 2021 period. Additionally, there is known to be limited dredging occurring from July to October, due to king scallop seasonality. Around the Isle of Man, king scallop fisheries are usually inshore and mostly undertaken using dredges (Beukers-Stewards *et al.*, 2005).

1.3.8.11 Long term annual surveys in Isle of Man waters have shown a general increasing trend in the abundance of recruits between 1992 and 2007 and an overall decrease until 2021. Similarly, post-recruits densities have seen a general increase between 1992 to 2015 and a decrease until 2019. To note that for both recruits and post-recruits, an increase in abundance is visible in the latest surveyed years (Bloor and Jenkins, 2021). Similar trends have been observed during AFBI annual surveys in Northern Ireland where CPUE increased between 1992 to 2014 and decreased after that (ICES, 2020). Densities of king scallop have fluctuated between 2019 and 2021 with about half the stations surveyed recording an increase in density and the other half a decrease. In 2021, the inshore waters east and south of the Isle of Man had the highest abundances of king scallop (Bloor and Jenkins, 2021). In the Liverpool Bay, mean annual survey density indices for king scallop were stable but low between 2016 and 2018 (Delargy *et al.*, 2019)

1.3.8.12 Queen scallop landings by weight within the study area were found to be greatest during the months of July, August and September. Landings across these months ranged from 6,721 t to 8,999 t and illustrated varying seasonal trends similar to that of the aforementioned king scallop, with an estimated density in the Isle of Man waters directly north west of the Offshore Order Limits of one to 11 individuals per 100 m^2 during peak landings period for the area (Bloor *et al*., 2019). A notable lack of queen scallop landings can be observed between April and June, resulting from seasonal closures of the species within the east Irish Sea (Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information). In Isle of Man's territorial sea, queen scallops are the target of two types of fisheries from Manx (Isle of Man) and UK vessels which are now managed by quotas since 2020 instead of total allowable catches. Queen scallop stocks are exploited primarily by otter trawls but also with a small decreasing number of vessels that use towed dredges (Bloor *et al.*, 2019; Jenkins *et al.*, 2021).

1.3.8.13 Annual scallop surveys around the Isle of Man have highlighted an overall stable trend in densities of queen scallop between 2019 and 2021 with only two stations, located in managed areas (i.e., either with restricted access or closed) south west of the Isle of Man, that have recorded a large increase in abundances (Bloor and Jenkins, 2021). Over a larger timescale, recruits abundance is at a similar level to 1994 with showed important increases from 1999 until an annual decrease since 2009. Post-recruits densities had a similar trend with a decrease from 2011 to a level similar to that recorded between 1993 and 2007 (Bloor and Jenkins, 2021).

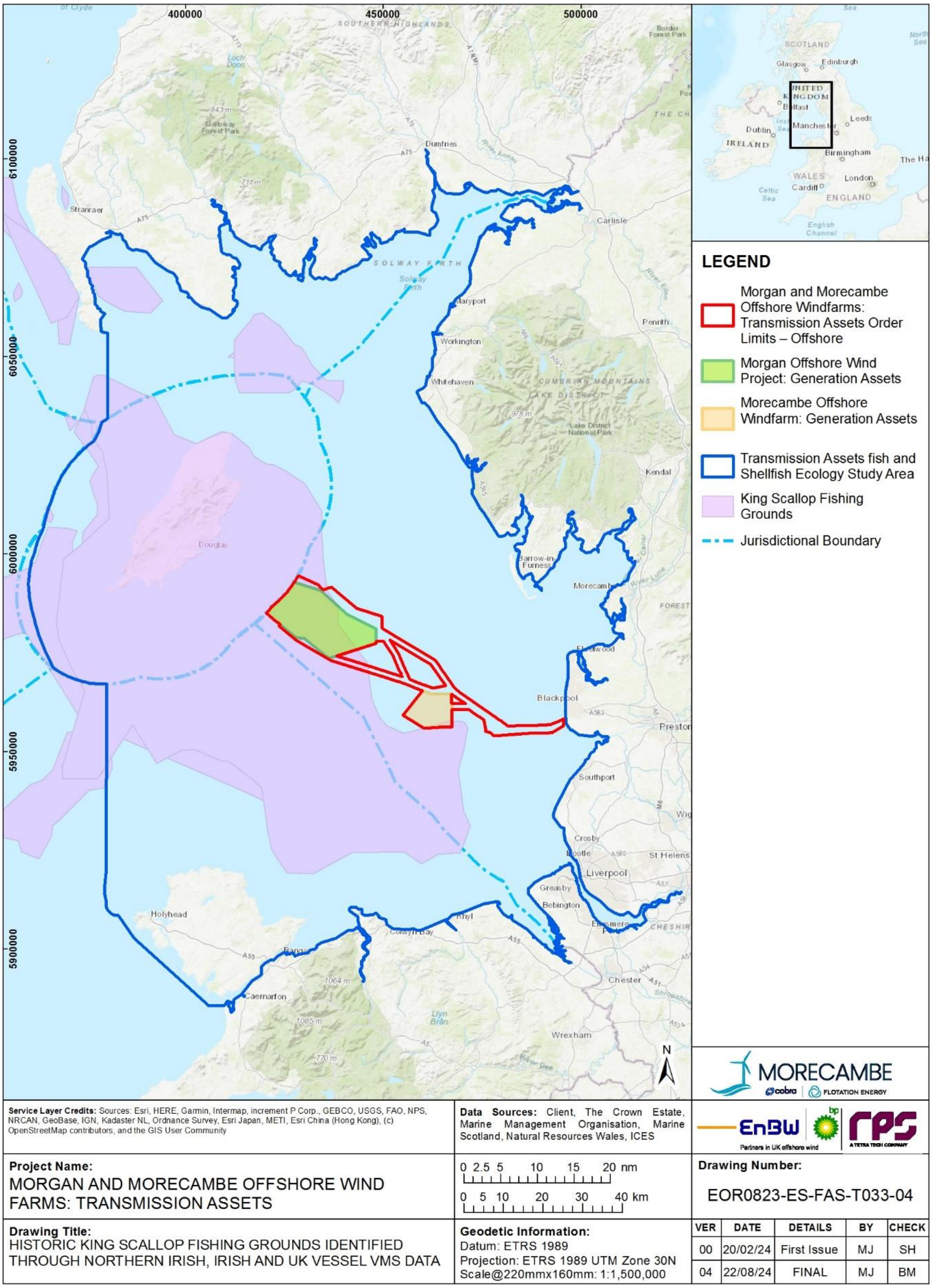


Figure 1.38: Historic King scallop fishing grounds identified through Northern Irish, Irish and UK vessel VMS data (adapted from ICES, 2020)

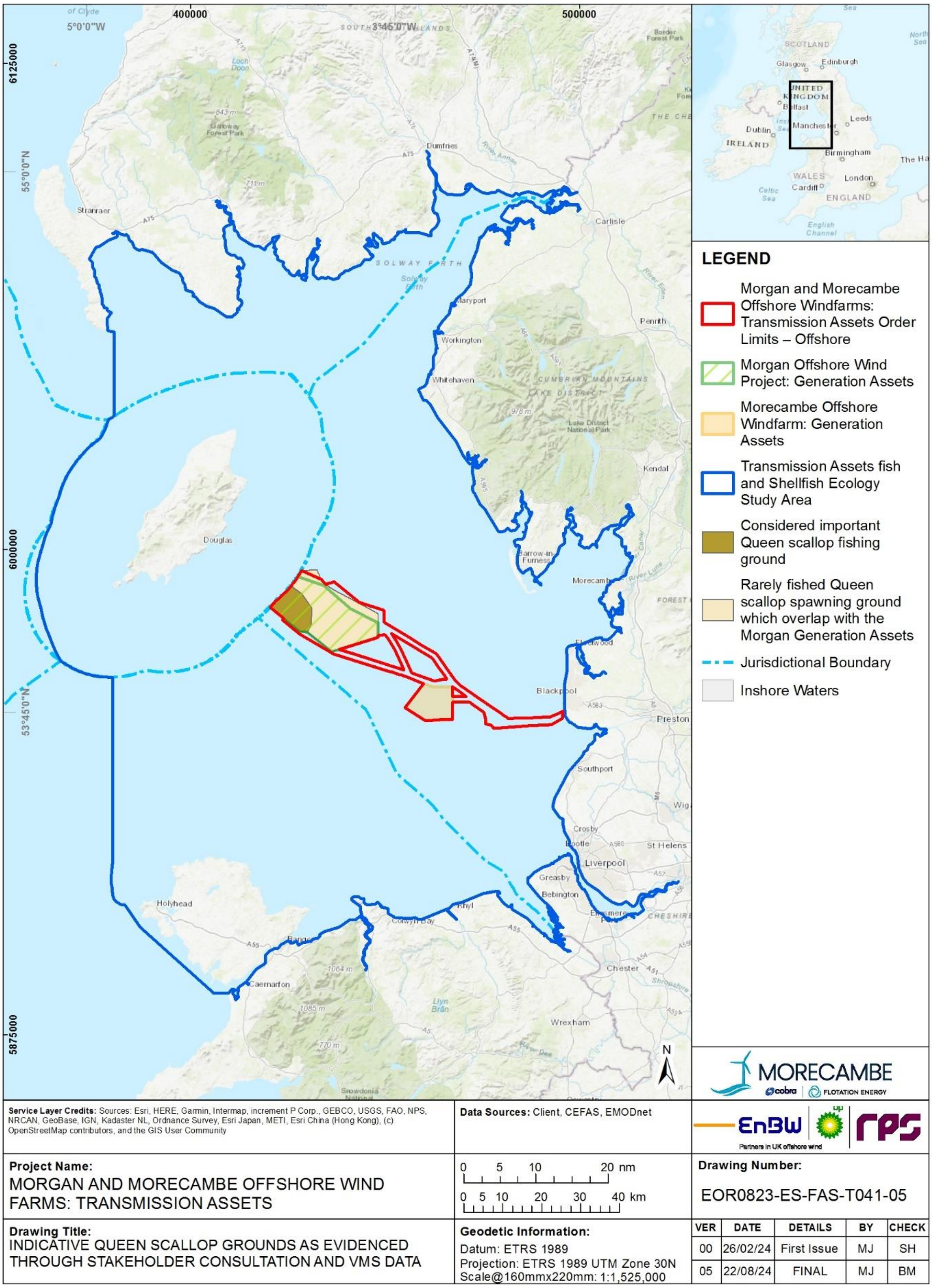


Figure 1.39: Indicative queen scallop grounds as evidenced through stakeholder consultation and VMS data

European lobster

1.3.8.14 The European lobster can be found throughout the British coasts on rocky substrata, down to depths of 60 m. European lobster are actively fished in areas within and around the Offshore Order Limits as the species is generally caught close to the shore, predominantly by inshore vessels operating out of Anglesey or in Manx waters (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information).

Edible crab

1.3.8.15 Edible crab is a relatively long-lived species that are found on all coasts around Britain from the intertidal zone down to depths of 100 m, preferring seabed temperatures of 11 °C to 15 °C in Welsh and Isle of Man waters (Jenkins, 2018). They live on rocky, gravelly substrate which they bury into. Following spawning there is a larval dispersal phase of around 30 to 50 days. Like European lobster, edible crab are actively fished in areas within and around the Offshore Order Limits using parlour pots (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information).

Velvet swimming crab

1.3.8.16 Velvet swimming crab can be found around the coast of Britain and are found on stony and rocky substrates intertidally and down to depths of 100 m (Howson and Picton, 1997). Velvet swimming crab are targeted by commercial fisheries with higher commercial values available in continental Europe and they are often caught alongside European lobster and edible crab (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information). Velvet swimming crab were recorded in historic surveys undertaken by other offshore wind projects in the vicinity on the Offshore Order Limits and therefore, are assumed to be present within the Offshore Order Limits.

1.3.8.17 Baited static trap and pot fishery independent surveys conducted around the Isle of Man in the Irish Sea evidenced that velvet swimming crab were the dominant bycatch species in the pot fisheries (Öndes, *et al*., 2018). Peak bycatch rates were found to occur in the spring months, declining into autumn and winter.

Squid

1.3.8.18 While loliginid squid species are reported to be found over sand and muddy bottoms (Wilson, 2006) and are mostly demersal in nature and therefore often captured as bycatch in demersal fisheries (Bellido *et al*., 2001), ommastrephid squid species are pelagic. Research on squid indicates that they are probably batch spawners, however, this can vary dependant on species, with some species utilising hard substrate for spawning purposes (Guerra and Rocha, 1994). In Scottish waters, squid exhibit a distinct seasonal migration pattern, travelling up to 500 km from the west coast of Scotland to the east coast in the winter months (Hastie *et al*., 2009). Squid are targeted by commercial fisheries, although main areas of fishing activity are concentrated within coastal waters (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information).

Whelk

1.3.8.19 The common whelk is an epibenthic mobile gastropod, inhabiting muddy sand, sand and mixed sediments from depths of 0 m to 50 m. This species is widely distributed from Iceland in the north to the Bay of Biscay, including throughout the Irish Sea and on all Irish and British coasts. Stocks are likely to be locally discrete due to the absence of a pelagic larval phase and therefore whelk in the Irish Sea comprises a number of populations with limited connectivity. The region immediately to the north west of the Offshore Order Limits is regularly assessed for whelk populations, with 37 scientific pots in 2017 finding individuals with an average shell length of 70 mm, well over the 45 mm minimum conservation reference size (Emmerson *et al.,* 2017), and densities recorded of up to 2.68 (± 1.10) individuals/m^2 (Robinson, 2015). Whelk are the third most important fishery species by quantity and value in Manx waters (Duncan and Emmerson, 2018). Potting for whelk is common across the Offshore Order Limits and has expanded over the last two decades. Whelk are landed year round and vessels are known to operate across the Offshore Order Limits. Whelk operators are known to operate out of both English and Welsh ports in proximity to the Offshore Order Limits (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES additional information).

Nephrops

1.3.8.20 *Nephrops*, known variously as the Norway lobster, Dublin Bay prawn, langoustine or scampi, 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). *Nephrops* are exploited throughout their geographic range, from Icelandic waters to the Mediterranean and the Moroccan coast.

1.3.8.21 *Nephrops* are opportunistic predators, primarily feeding on crustaceans, molluscs and polychaete worms. The species grows incrementally, by moulting their hardened exoskeleton and forming a larger, new one (NW-IFCA, 2022). They inhabit muddy seabed sediments and show 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 cm to 30 cm in depth (Dybern and Hoisaeter, 1965). Due to strong habitat preferences, distribution patterns of *Nephrops* are determined by the presence of suitable habitats, with higher abundances found on more favourable substrates.

1.3.8.22 Female *Nephrops* usually mature at three years of age and reproduce each year thereafter. After mating in early summer, *Nephrops* spawn in September and carry 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). Unspecified intensity nursery and spawning grounds for *Nephrops* are present across the west section of the Offshore Order Limits, extending west towards the Isle of Man and north towards Northern Ireland (**Figure 1.14**).

1.3.8.23 *Nephrops* has been consistently recorded across the Walney offshore wind project with the highest number of individuals (3,296) in a single otter trawl recorded in 2009. Otter trawl surveys for the Walney offshore wind project post-construction monitoring recorded *Nephrops* as the most abundant shellfish species and subsequently, *Nephrops* was identified as a species of key commercial importance in the area (Brown and May Marine Ltd., 2013). Additionally, *Nephrops* were found to be an important component of the trawl fishery near the Cumbrian coast (Walmsey and Pawson, 2007).

1.3.8.24 *Nephrops* display a strong preference for muddy sediments (silt and clay), therefore the majority of the west portion of the Offshore Order Limits is considered unsuitable for *Nephrops* as sand, gravels and coarser sediments with shell fragments dominate this portion of Offshore Order Limits. However, the sediments in the offshore export cable corridor and the area around the Morecambe Offshore Windfarm: Generation Assets, within the Offshore Order Limits, comprise higher proportions of mud and could be therefore suitable for *Nephrops,* with low abundances observed during DDV acquisition in areas classed as gravelly muddy sand in 2021.

1.3.8.25 No incidental observations were made of *Nephrops* from DDV deployments and grab sampling conducted at 103 locations within and around the Offshore Order Limits. The biotope they are typically associated with (sea pen and burrowing megafauna communities SS.SMu.CFiMu.SpnMeg) was potentially identified in 13 stations, based on a precautionary approach, within the offshore export cable corridor (Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the ES). As such, *Nephrops* could be present in the Offshore Order Limits but the Offshore Order Limits is unlikely to be an important area for this species. Further site-specific data was collected for the Morgan Offshore Wind Project: Generation Assets and associated ZOI during 2022, but similarly, no *Nephrops* were encountered during this survey.

Cockle

1.3.8.26 Common cockle are marine mollusc that are found in the intertidal area on muddy and sandy shores all around the UK. Cockle are filter-feeders. Cockle play an important role as prey items for wading birds, shore crab *Carcinus maenas* and flatfish. This infaunal species is widely distributed around the coasts of the UK and Ireland and is known to burrow to approximately 5 cm depth in areas of clean sand, muddy sand, mud of muddy gravel (Tyler-Walters, 2007). Cockle are commonly recorded in estuaries and on sandy beaches, occurring most often intertidally, but sometimes extending into the subtidal zone (Tyler-Walters, 2007). Cockle feed via active suspension, through creating feeding currents to bring food towards their feeding structures (Tyler-Walters, 2007). Common cockle were found in relatively high density within the Ribble Site of Special Scientific Interest (SSSI) during an intertidal sediments condition monitoring survey in 2013, with common cockle found in about half the sampled locations (Natural England, 2015).

1.3.8.27 Common cockle is also a commercially important species with cockle fishing grounds in the intertidal area of the Ribble Estuary near the Offshore Order Limits (i.e., approximately 2.03 km) managed by North Western Inshore Fisheries and Conservation Authority (NW-IFCA) (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information). In addition, the Ribble Estuary is designated as a common cockle production area, approximately 4.22 km from the Offshore Order Limits (**Figure 1.40**).

1.3.8.28 Cockle biomass data provided directly by NW-IFCA in February 2024 for Morecambe Bay and Ribble are presented in Table 1.9, demonstrating the variability in biomass reported per year within specific beds and overall and the proportions of cockles which were considered of size or undersized (i.e. those above or below the minimum conservation reference size of not passing through a 20 mm square opening).

Table 1.9: Historic cockle biomass (tonnes) within Morecambe Bay and Ribble from 2017 to 2023 (NW-IFCA, 2024)

Cockle Bed	Total Cockle Biomass (tonnes)						
	2017	2018	2019	2020	2021	2022	2023
Morecambe Bay							
Aldingham and Newbiggin	-	2,350	2,320	3,970	2,200	1,365	2,685
Leven	2,415	1,290	2,000	3,800	850	725	1,850
Flookburgh	4,706	12,300	6,600	3,800	1,225	1,450	5,075
Pilling	3,821	3,200	2,700	3,300	2,500	1,600	5,600
Warton	N/A	N/A	3,465	1,185	135	N/A	N/A
Middleton	N/A	265	450	500	505	800	732
Morecambe Bay Total	**10,942**	**19,140**	**17,535**	**16,555**	**7,415**	**5,940**	**15,942**
Percentage of Size and Undersize Cockle (Morecambe Bay)							
Size Cockle (%)	62.6	36.6	26.4	76.0	87.1	66.5	19.0
Undersize Cockle (%)	37.4	63.4	73.6	24.0	12.9	33.5	81.0
Ribble							
Southport/Penfold	N/A	N/A	N/A	N/A	N/A	2,500	920
Percentage of Size and Undersize Cockle (Ribble)							
Size Cockle (%)	N/A	N/A	N/A	N/A	N/A	48.0	87.0
Undersize Cockle (%)	N/A	N/A	N/A	N/A	N/A	52.0	13.0

Mussel

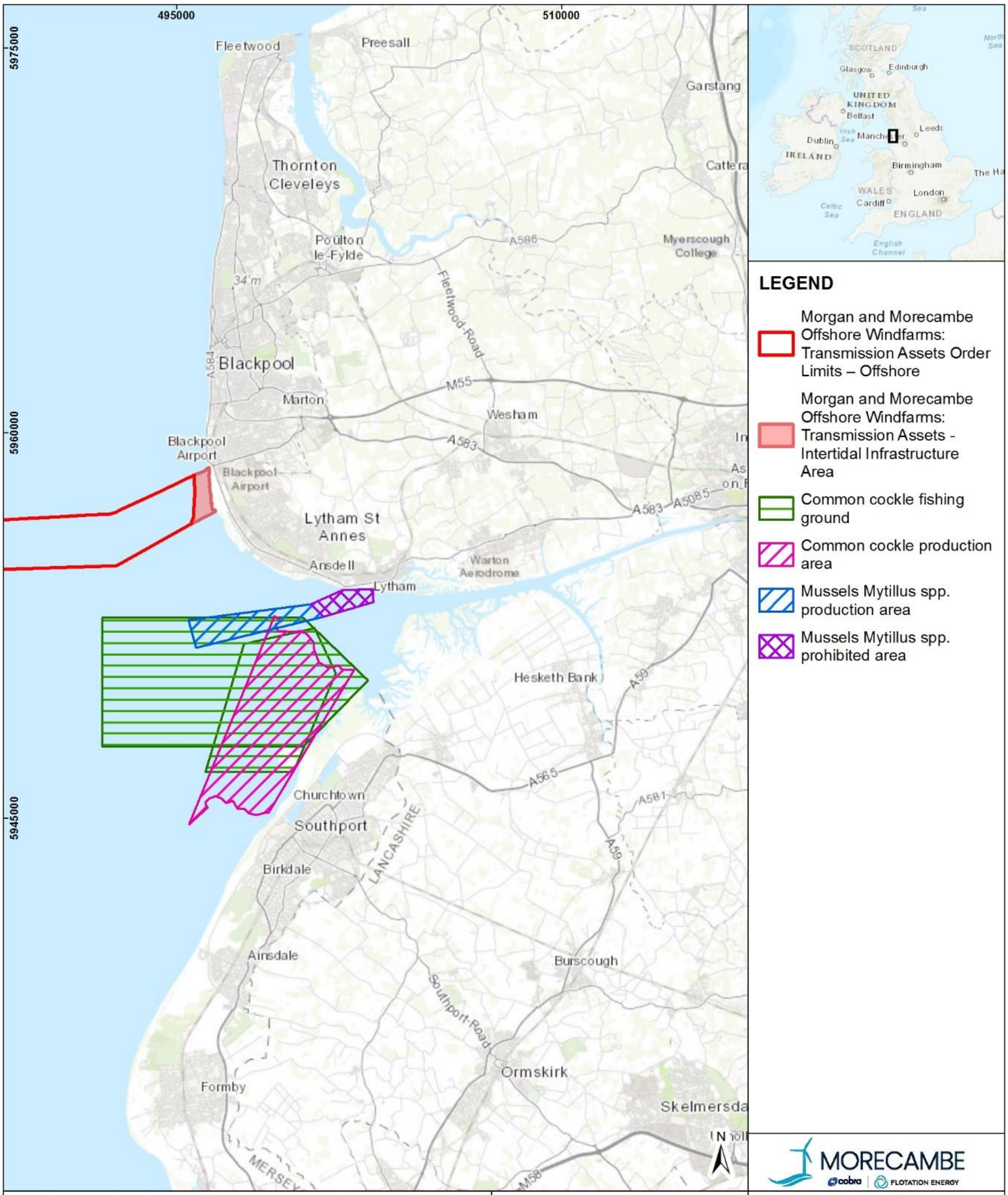
1.3.8.29 Mussel Mytilus spp., including the blue mussel, are marine filter feeders that live attached to rocks or other hard substrata in the intertidal zone and shallow waters all around the UK. Mussel can aggregate and form mussel beds with very high densities of individuals in one area. During intertidal sediment monitoring in 2015 within the Ribble Estuary SSSI, juvenile blue mussel were recorded across the area in relatively high abundances (Natural England, 2015).

1.3.8.30 Mussel are widely exploited for food and are subject to intensive aquaculture (see Volume 2, Annex 6.1: Commercial fisheries technical report of the ES for additional information). The Ribble Estuary encompasses a mussel production area located 3.22 km from the Offshore Order Limits (**Figure 1.40).**

1.3.8.31 Mussel biomass data provided directly by NW-IFCA in February 2024 for permanent mussel beds within Morecambe Bay are presented in Table 1.10, demonstrating the variability in biomass reported per year within specific beds and overall and the proportions of mussels which were considered of size or undersized (i.e. those above or below the minimum conservation reference size of 45 mm along the longest part of the shell).

Table 1.10: Historic mussel biomass (tonnes) from permanent mussel beds within Morecambe Bay from 2020 to 2023 (NW-IFCA, 2024)

Mussel Bed	Total Mussel Biomass (tonnes)			
	2020	2021	2022	2023
Foulney Skear	6,771	8,251	9,023	5,497
Walney Channel	1,623	3,081	642	648
Low Bottom	N/A	N/A	2,792	2,336
Morecambe Bay Total	**8,394**	**11,332**	**12,289**	**8,343**
Percentage of Size and Undersize Mussel (Morecambe Bay)				
Size Mussel (%)	90.6	79.4	45.7	64.9
Undersize Mussel (%)	9.4	20.6	54.3	35.1



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 0.5 1 2 3 nm
0 1 2 4 6 km

Drawing Number:
EOR0823-ES-FAS-T034-05

Drawing Title:
INTERTIDAL SHELLFISH HARVESTING AREAS IN PROXIMITY TO THE TRANSMISSION OFFSHORE ORDER LIMITS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:250,000

VER	DATE	DETAILS	BY	CHECK
00	20/02/24	First Issue	MJ	SH
05	22/08/24	FINAL	MJ	BM

Figure 1.40: Intertidal shellfish harvesting areas in proximity to the Transmission Offshore Order Limits

1.3.9 Designated sites

1.3.9.1 There are a number of sites of nature conservation importance, which are designated for fish and shellfish features within the study area. Designated sites with relevant fish and shellfish qualifying features and which occur within the study area are described in **Table 1.11** and the locations of the SACs, MCZs and Marine Nature Reserves (MNRs) are illustrated in **Figure 1.41**. Further MCZs which are designated for benthic features are examined in Volume 2, Annex 2.1: Benthic ecology technical report of the ES.

1.3.9.2 Note that species such as Ocean quahog *Arctica islandica*, dog whelk *Nucella lapillus,* horse mussel *Modiolus modiolus* beds, spiny scallop *Chlamys hastata,* blue mussel beds and flame shell *Limaria hians,* which are features of interest of some MNRs, are considered benthic subtidal and intertidal ecology features and are therefore characterised in Volume 2, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the ES and assessed within Volume 2, Chapter 2: Benthic subtidal and intertidal ecology of the ES. These species are not considered further within the fish and shellfish ecology technical report of the ES.

1.3.9.3 While brook lamprey are listed as a qualifying feature of some of the identified designated sites, they are not considered further, as it is a wholly freshwater species.

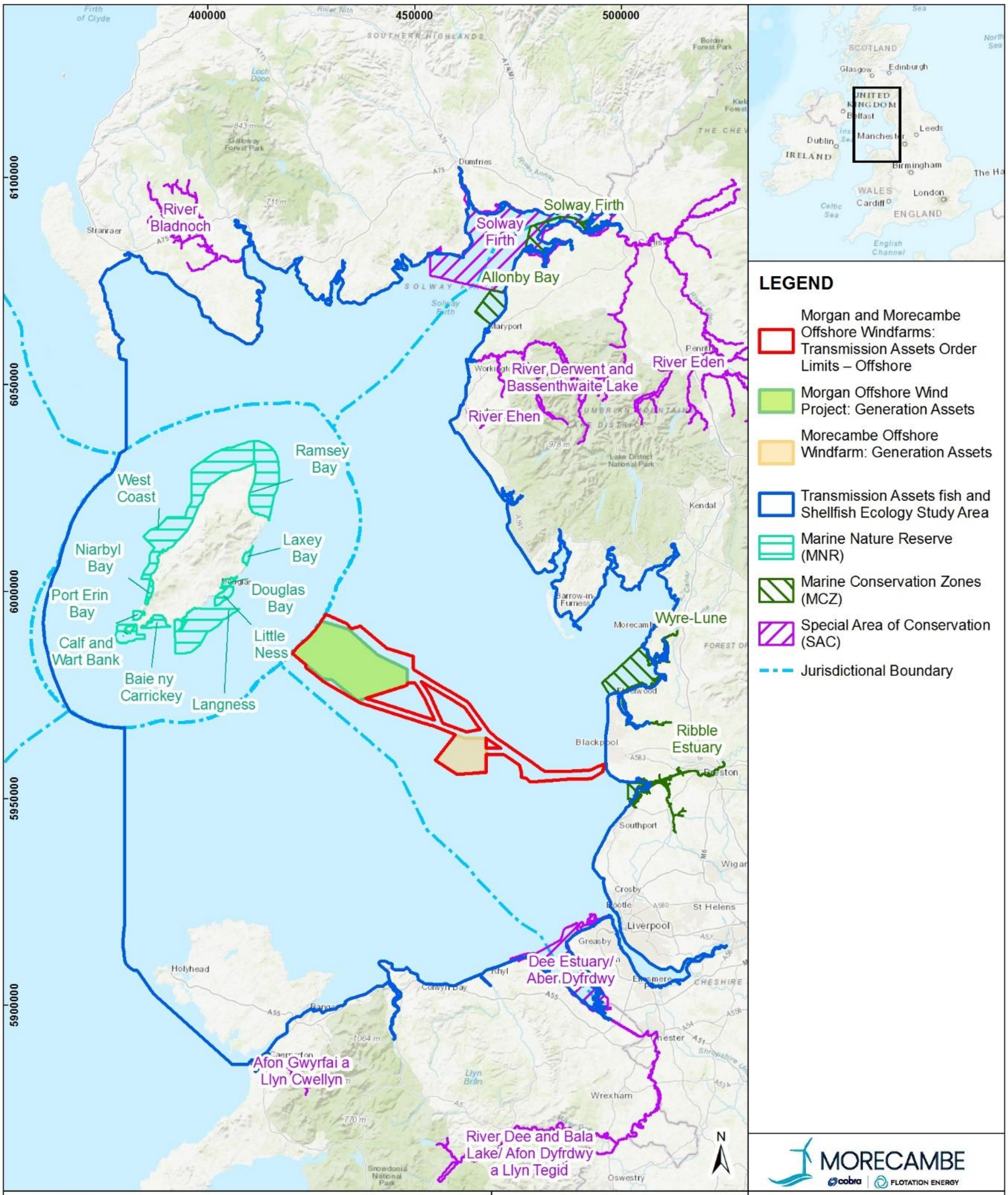
1.3.9.4 European sites and MCZs, including all their relevant qualifying features are also assessed in the ISAA and the MCZ Assessment, respectively.

Table 1.11: Summary of designated sites within the study area and relevant qualifying interest features

Designated Site	Closest Distance from the Offshore Order Limits (km)	Relevant Features of Interest
Ribble Estuary MCZ	0	Sparling
Langness MNR	16.75	European eel Basking shark Lobster nursery ground Cod spawning and nursery ground
Wyre Lune MCZ	16.8	Sparling
Little Ness MNR	20.42	Basking shark European eel Scallops Pectinidae spp. Common whelk
Douglas Bay MNR	22.31	European eel Scallops Pectinidae spp. Common whelk

Designated Site	Closest Distance from the Offshore Order Limits (km)	Relevant Features of Interest
Laxey Bay MNR	22.40	Atlantic salmon Sea trout European eel Scallops Pectinidae spp. Common whelk
Ramsey Bay MNR	26.45	European eel Sea bass nursery Sandeel Ammodytidae spp. Scallops Pectinidae spp. Common whelk
Baie Ny Carrickey MNR	30.22	European eel Basking shark Spiny lobster Paniluridae sp.
Dee Estuary/Aber Dyfrdwy SAC	32.81	Sea lamprey River lamprey
Calf of Man and Wart Bank MNR	35.77	European eel Basking shark Sandeel Ammodytidae spp. Spiny lobster
Port Erin Bay MNR	40.03	Basking shark Plaice nursery
West Coast MNR	40.50	European eel Sandeel Ammodytidae spp. Seabass nursery Basking shark Scallops Pectinidae spp. Common whelk
Niarbyl Bay MNR	44.50	Basking shark
River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC	59.0	Sea lamprey River lamprey Atlantic salmon Brook lamprey
River Ehen SAC	62.7	Atlantic salmon Freshwater pearl mussel
River Derwent and Bassenthwaite Lake SAC	71.29	Sea lamprey River lamprey Atlantic salmon Brook lamprey

Designated Site	Closest Distance from the Offshore Order Limits (km)	Relevant Features of Interest
Solway Firth SAC	84.32	Sea lamprey River lamprey
Afon Gwyrfai a Llyn Cwellyn SAC	88.15	Atlantic salmon
River Bladnoch SAC	89.95	Atlantic salmon
Solway Firth MCZ	98.84	Sparling
River Eden SAC	125.30	Sea lamprey River lamprey Atlantic salmon



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, The Crown Estate, Marine Management Organisation, Marine Scotland, Natural Resources Wales, ICES

EnBW bp Partners in UK offshore wind
rps A TETRA TECH COMPANY

Project Name:
MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
EOR0823-ES-FAS-T035-05

Drawing Title:
DESIGNATED SITES IN PROXIMITY TO THE OFFSHORE ORDER LIMITS AND WITHIN THE STUDY AREA WITH RELEVANT QUALIFYING INTEREST FEATURES

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@220mmx160mm: 1:1,550,000

VER	DATE	DETAILS	BY	CHECK
00	20/02/24	First Issue	MJ	SH
05	22/08/24	FINAL	MJ	BM

Figure 1.41: Designated sites in proximity to the Offshore Order Limits and within the study area with relevant qualifying interest features

Ribble Estuary MCZ

1.3.9.5 The Ribble Estuary MCZ is located on the west coast of Britain, on the north west coast of England, near Preston and Blackpool. The MCZ covers 15 km^2, some of which overlaps with the Offshore Order Limits, and is designated for the protection of sparling (European smelt), with the management goal of returning the population to a favourable condition (DEFRA, 2019a). Sparling congregate in the lower estuary in early spring, when water temperatures are approximately 5 °C to 6 °C, before transitioning to the river freshwater habitats upstream for spawning upstream in the east of the main river channel and approximately halfway upstream of the river south tributary. Further data on more exact spawning locations and population numbers are being collected in an ongoing and recurring sparling study by the Ribble Rivers Trust (2021), but with no data yet published.

Langness MNR

1.3.9.6 The Langness MNR is located on the south east coast of the Isle of Man and 16.8 km north west of the Offshore Order Limits. This MNR covers 88.7 km^2 and is important for a variety of fauna including sea birds and seals as well as benthic species (DEFA, 2022a). The Langness MNR is designated for the presence of European eel, dog whelk and Iceland clam. The site is also designated for the protection of eelgrass meadows, kelp forests and maerl beds which provide important habitats for crabs, lobster, molluscs and various fish species. At the coast there is also a series of small subtidal caves which are thought to be nursery sites for lobsters, and the wider area supports cod spawning and nursery habitats (Isle of Man Government, 2019).

Wyre Lune MCZ

1.3.9.7 The Wyre Lune MCZ is located on the west coast of Britain, in Lancashire, in the south part of Morecambe Bay, 16.8 km north of the Offshore Order Limits. The MCZ covers 92 km^2 and is designated for the protection of sparling (European smelt), with the management goal of returning the population to a favourable condition (DEFRA, 2019b). Data on local sparling populations exist from 1963 in the Lune River and 1981 in the Wyre River, with the Environment Agency taking responsibility for data collection from 2004, recording 21 sparling datasets in the 2004 to 2014 period, suggesting regular usage of the site as a spawning ground, usually in the February to March period (Natural England, 2017).

Little Ness MNR

1.3.9.8 The Little Ness MNR is located on the west coast of the Isle of Man and 20.4 km north west of the Offshore Order Limits. The MNR covers 10.15 km^2 and one of the most important sites because of its very high species diversity (DEFA, 2022b). The Little Ness MNR is designated for the presence of diverse horse mussel beds, with up to 296 individual species associated with the beds within this MNR (Isle of Man, 2019), through specific seabed habitat surveys conducted in 2010 (Hinz *et al.,* 2010). The MNR also acts as a nursery and protected transition ground for the European eels during their spawning period (Howe *et al*., 2018). As a result of this rich benthic environment, a variety of seabird and marine mammals can also be found in this area including basking shark, scallop and whelk species (Howe *et al*., 2018).

Douglas Bay MNR

1.3.9.9 Douglas Bay MNR is located on the south east coast of the Isle of Man and 22.3 km north west of the Offshore Order Limits. The MNR covers 4.6 km^2 and is designated to protect king and queen scallop populations, with the Sea Fisheries (Douglas Bay Closed Area) Byelaws 2008 prohibiting the use of towed gear in the area (DEFA, 2022c), as well as for the protection of European eel and whelk populations.

1.3.9.10 This MNR encompasses an area of maerl bed, a red coralline seaweed which creates a fine layer over the seabed. This habitat attracts a high diversity of species including shellfish and anemones, as well as being a refuge for juvenile queen scallops and whelks which are commercially important to the Isle of Man (DEFA, 2022c).

1.3.9.11 In the south portion of the MNR, a dense and highly diverse horse mussel bed was discovered (Hanley *et al*., 2013), with a bed coverage of approximately 0.2 km^2 present, with up to 240 individuals per m^2 noted, with the main bed running parallel to the coast for 780 m at a distance of 800 m offshore (Perry and Roriston, 2009). An annual closure to protect spawning herring populations is also active within and extending east from this MNR.

Laxey Bay MNR

1.3.9.12 The Laxey Bay MNR is located on the east coast of the Isle of Man and 22.4 km north west of the Offshore Order Limits. The MNR covers approximately 4 km^2 and was initially created to protect juvenile scallops released for potential ranching. Since 2014, the bay became a scallop larval production area (DEFA, 2022d). The Laxey Bay MNR is designated for the presence of Iceland clams, which is listed as an Oslo and Paris Convention (OSPAR) regionally threatened/declining species and thus the site has been closed to bottom-towed scallop dredging activities (Hanley *et al*., 2013).

1.3.9.13 This MNR contains a wide variety of benthic habitats such as seagrass meadows, rocky reefs, sandy seabed and maerl beds (DEFA, 2022d). This MNR supports ocean quahog and common whelk which is one of the five commercially fished species around the Isle of Man (DEFA, 2022d). The MNR also provides protection for the Annex II protected European eel and Atlantic salmon and sea trout in their anadromous spawning migrations (DEFA, 2022d).

1.3.9.14 The MNR also acts as a nursery and protected transition ground for the European eels during their spawning period (Howe *et al.*, 2018).

Dee Estuary SAC/Aber Dyfrdwy SAC

1.3.9.15 The Dee Estuary/Aber Dyfrdwy SAC comprises both the Dee Estuary SPA and Aber Dyfrdwy SAC and is located 32.81 km south east of the Offshore Order Limits. The area lies on the boundary between England and Wales and the estuary itself is large, sheltered and funnel shaped, supporting extensive areas of intertidal sandflats, mudflats and saltmarsh (NRW, 2018; MMO, 2019).

1.3.9.16 The Dee Estuary is one of the largest estuaries in the UK, with an area of over 140 km^2. The Dee Estuary is hyper-tidal with a mean spring tidal range of 7.7 m at the mouth. The estuary historically stretched as far inland as Chester and its form has been modified considerably over the past 300 years as a direct result of human intervention. The intertidal area is currently dominated by mudflats and sandflats with the remainder being largely saltmarsh. At low water spring tides, over 90% of the estuary dries out. The extensive intertidal flats of the Dee Estuary form the fifth largest such area within an estuary in the UK (NRW, 2018).

1.3.9.17 The Dee Estuary SAC/Aber Dyfrdwy SAC has been designated as a SAC due to supporting a significant presence of both sea and river lamprey (MMO, 2019). Freshwater populations of river lamprey were found to be favourable while the associated marine habitat was denoted unfavourable. The activities that were found to directly impact the condition of the river lamprey feature at this site were found to be associated with water quality issues (NRW, 2018). Regarding sea lamprey data, both the freshwater population and marine habitat were found to be unfavourable; similarly, water quality issues were found to have a direct impact upon this qualifying feature (NRW, 2021).

Baie Ny Carrickey MNR

1.3.9.18 The Baie Ny Carrickey MNR is located on the south coast of the Isle of Man and 30.2 km west of the Offshore Order Limits. The MNR covers an area of 11.4 km^2 and is designated primarily for seabird protection, but also for a wide range of habitats (e.g., rocky kelp reefs, eelgrass) that support various species within the food chain which are important prey for basking shark. This MNR was originally established as a fishery-restricted area in 2012 to reduce gear conflict between scallopers and pot fishermen and protect rocky reefs. The MNR is also designated for basking shark that transit in the bay (DEFA, 2022e).

Calf of Man and Wart Bank MNR

1.3.9.19 The Calf of Man and Wart Bank MNR is located on the south west coast of the Isle of Man surrounding the Calf of Man island and 35.8 km west of the Transmission Assets Order Limits: Offshore. The MNR covers an area of 20.1 km^2 and encompass the Wart Bank, a submerged sandbank (DEFA, 2022g). The site is designated primarily for the protection of birds and marine mammals, but also for sandeel and basking shark (Isle of Man Government, 2019c). These are protected by prohibition of use of mobile fishing gear, seabed extraction and any other activities which might damage important habitats relevant to fish and shellfish populations, such as kelp forests, and the species which utilise these habitats such as spiny lobster (Thomas *et al.,* 2018).

Niarbyl Bay MNR

1.3.9.20 The Niarbyl Bay MNR is located on the south west coast of the Isle of Man and 44.5 km north west of the Offshore Order Limits. This MNR covers approximately 5.7 km^2 and was initially created for scallop reseeding trials in 2009 (DEFA, 2022h).

1.3.9.21 The Niarbyl Bay MNR is split into two main sediments providing distinct habitats and species composition. While rocky sediments in the north provide great conditions for kelp forests, the coarse gravel habitats found in the south support scallops and ocean quahog. This MNR also contains intertidal blue mussel beds in large number. However, the beds are dominated by seed mussels with only a limited colony of adults within the site (DEFA, 2022). Basking shark are listed as important species within the Niarbyl Bay MNR and can be sighted from the coast. Specifically, the designation helps with the protection of relatively low-density king scallop populations in the gravelly sediment to the south of the MNR, up to a density of 4 per 100 m^2, with individuals measuring from 24 to 186 mm in length and 54% of individuals being above the minimum landing size of 110 mm (Garratt *et al.,* 2022a).

Port Erin Bay MNR

1.3.9.22 The Port Erin Bay MNR is located to the west of the Isle of Man and 40.0 km north west of the Offshore Order Limits and covers approximately 4.3 km^2. Research on scallop lead to the initial closure of the area to be used as a source of larvae for offshore fishing grounds (DEFA, 2022h).

1.3.9.23 The Port Erin Bay MNR encompasses habitats such as rocky reefs, kelp forest and brittlestar beds (DEFA, 2022h), all of which take advantage of the site being closed for fishing since 1989 (DEFA, 2022h). The site is designated for the presence of feeding basking shark and the area is also listed to support a nursery ground for plaice. Sightings of basking shark feeding on zooplankton in the MNR have been recorded. (Isle of Man Government, 2019d).

West Coast MNR

1.3.9.24 The West Coast MNR is located to the west of the Isle of Man and 40.5 km north west of the Offshore Order Limits. The West Coast MNR is the largest, at around 185 km^2, of the protected area network within the Isle of Man (DEFA, 2022i).

1.3.9.25 The West Coast MNR has a distinctive physical environment as a result of the strong tidal currents around the Point of Ayre (DEFA, 2022i). The seabed is composed of sand deposits as well as rock fragments as a result of the glacial history of this area. These sediments have enabled the creation of rocky reefs, intertidal mussel beds and kelp beds (DEFA, 2022i). The main habitat within this MNR is mixed soft sediment which is inhabited by scallops and whelks (DEFA, 2022i).

1.3.9.26 This MNR also supports nursery grounds for sea bass, which is an important angling fish around the island, helping to maintain offshore populations. Conservation measures have been introduced in 2016 for their protection. Sandeel, European eel and basking shark are also important species found within the West Coast MNR (DEFA, 2022i).

River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC

1.3.9.27 The River Dee and Bala Lake SAC, located 59.0 km from the Offshore Order Limits, crosses the border between England and Wales. The River Dee has its source in Snowdonia at the outflow of Llyn Tegid and it includes the Ceiriog, Meloch, Tryweryn and Mynach tributaries. Its catchment contains a wide spectrum of landscape from high mountains around Bala, rugged peaks near Llangollen, steep sided wooded valleys and the plains of Cheshire, Flintshire, north Shropshire and Wrexham. There is a tidal influence as far upstream as Farndon and high tides regularly exceed the Chester weir crest level (Natural England, 2019a).

1.3.9.28 The River Dee is recognised as one of North Wales premier rivers for Atlantic salmon. The Mynach, Meloch and Ceiriog tributaries are the most important Atlantic salmon spawning tributaries in the Dee catchment. Other diadromous fish utilising the river system include river lamprey and sea lamprey. The Dee also supports important populations of non-migratory fish including brook lamprey (Natural England, 2019a). At least one record of twaite shad has been noted (Morgan Offshore Wind Limited, 2024a) although there is no evidence of a spawning population of this species in this designated site.

1.3.9.29 The SAC is underpinned by two SSSIs divided by the national boundary; the Afon Dyfrdwy (River Dee) SSSI and the River Dee (England) SSSI. The Welsh SSSI includes the upper part of the main stem Dee, Afon Mynach, Afon Meloch, Afon Tryweryn and the upper part of the River Ceiriog (except the headwaters). The English SSSI includes the lower part of the main stem Dee and the lower part of the River Ceiriog (Natural England, 2019a).

1.3.9.30 The River Dee and Bala Lake SAC has received designation status due to the Atlantic salmon, which is an Annex II species and was the primary reason for the site selection. Additionally, brook lamprey, sea lamprey and river lamprey are Annex II species which are qualifying features, however, not the primary reason behind the site selection of this specific SAC (JNCC, 2022a).

River Ehen SAC

1.3.9.31 The River Ehen SAC is an oligotrophic river located in west Cumbria, 62.7 km from the Offshore Order Limits. The designated stretch of the river, between Ennerdale Water and the confluence with the River Keekle at Cleator Moor, meanders across a narrow floodplain with areas of riparian woodland and trees.

1.3.9.32 This site supports England largest population of the freshwater pearl mussel which is listed on the IUCN Red List of Protected Species as critically endangered in Europe. Atlantic salmon whilst designated in its own right as a feature of this site, is an important host for the larvae (glochidia) of freshwater pearl mussel. Glochidia attach to juvenile salmon in late summer and over-winter in the fish gills. Juvenile mussels drop-off of their fish host in spring where they burrow into the river gravels, where they remain for several years. This buried stage within the life cycle is particularly susceptible to changes in river flow regime, siltation, excess algal biomass and eutrophication. The river has shown some juvenile mussel recruitment within the last 20 years, but not at levels capable of sustaining the population (Natural England, 2019b).

1.3.9.33 The River Ehen SAC is designated due to its Annex II qualifying species, the freshwater pearl mussel and Atlantic salmon. The River Ehen supports the largest freshwater pearl mussel population in England. The freshwater pearl mussel grows to around 150 mm in length and can live to be over 130 years old (Bauer, 1992; Skinner *et al*., 2003). Freshwater pearl mussel require clean, fast flowing, highly oxygenated rivers and burrows into sand/gravel substrates, often between boulders and pebbles (Geist and Auerswald, 2007).

1.3.9.34 The mussel requires a salmonid fish host for its larval (glochidial) stage; it is thought that the appropriate host fish in the river Ehen is Atlantic salmon. As this species does not reach reproductive maturity until at least 12 years old and may live for over 130 years (Bauer 1992), population age-structure is vitally important when assessing viability. The presence of juveniles (a feature essential to the long-term sustainability of mussel populations) is a clear indicator of the structural and functional features of the habitat required for the survival and reproduction of the species (Natural England, 2019b).

1.3.9.35 Exceptionally high densities (greater than 100 individuals/m^2) are found at some locations, with population estimates for the entire river exceeding 500,000. The conservation importance of the site is further enhanced by the presence of juvenile pearl mussels, indicating recruitment in recent years. Worryingly, juvenile recruitment over the past decade has been poor indicating unsustainable pressures on the population which could lead to its extinction within a lifetime (Natural England, 2019b).

1.3.9.36 In the River Ehen SAC, the population has declined because of factors such as habitat modification and associated impacts on natural flow regimes, pollution, nutrient enrichment, aggravated erosion of riverbanks and declining salmonid stocks. The freshwater pearl mussel is classified critically endangered across Europe (Cuttelod *et al*., 2011) and in the UK it is protected under Schedule 5 of the Wildlife and Countryside Act (1981).

1.3.9.37 Additionally, the river Ehen holds a significant population of Atlantic salmon and the Environment Agency classifies the population as “probably at risk” based on the 2017 assessment and was predicted to remain in that status over the following five years (Environment Agency, 2016). In the latest assessment, undertaken for the River Ehen SSSI, Atlantic salmon and freshwater pearl mussel were deemed to be in unfavourable no change condition and unfavourable declining condition, respectively (Natural England, 2023). October through to the end of January is the key time for salmon migration into the River Ehen SAC.

River Derwent and Bassenthwaite Lake SAC

1.3.9.38 The River Derwent and Bassenthwaite Lake SAC is a large water body with an extensive catchment area subject to rapid through-flows of water and nutrients. It is located approximately 71.3 km to the north of the Offshore Order Limits. The SAC is a designated site due to the Annex II species present, which include sea lamprey, brook lamprey, river lamprey and Atlantic salmon (JNCC, 2015).

1.3.9.39 Furthermore, the River Derwent and Bassenthwaite Lake SAC has extensive occurrences of gravels and silts in the lower to middle reaches of the river which subsequently results in the ability for the SAC to support a large population of sea lamprey. The SAC also has features that are known to provide necessary conditions for both spawning and nursery areas (extensive gravel shoals, good water quality and areas of marginal silt) of brook lamprey (JNCC, 2015).

1.3.9.40 Additionally, the Derwent is utilised by river lamprey and is considered an oligotrophic lake in north west England. River lamprey are known to occur within this area as the river holds features that provide necessary conditions for spawning and nursery areas, which are comprised of good water quality, extensive gravel shoals and areas of marginal silt (JNCC, 2015).

1.3.9.41 Atlantic salmon is also represented within the River Derwent with populations that take advantage of the surrounding water quality and presence of extensive gravel shoals which help to create a particularly suitable river for breeding which subsequently enables the river to support a larger population of this species (JNCC, 2015).

Solway Firth SAC

1.3.9.42 The Solway Firth SAC is a large, complex estuary on the west coast of Britain. It is located approximately 84.3 km to the north of the Offshore Order Limits. It is known to be one of the least industrialised, yet largest and most natural estuaries in Europe (JNCC, 2014). The sediment habitats are predominantly comprised of dynamic sandflats and subtidal sediment banks that are separated by river channels that continually change their patterns of erosion and accretion (JNCC, 2014).

1.3.9.43 Additionally, the Solway Firth SAC is representative of sublittoral sandbanks on the coast of north west England, where they are predominantly comprised of gravelly, clean sands. Dominant species of infaunal communities include annelid worms, crustaceans, molluscs and echinoderms (JNCC, 2014).

1.3.9.44 The conservation objectives for the Solway Firth SAC are to maintain favourable conservation conditions for each of the Annex I habitats and Annex II species that are designated features of the site. The sea lamprey and river lamprey within the Solway Firth SAC are provided migratory passage to and from spawning and nursery grounds in a number of rivers, including the Eden (JNCC, 2014).

Afon Gwyrfai a Llyn Cwellyn SAC

1.3.9.45 The Afon Gwyrfai a Llyn Cwellyn SAC, which is located 88.2 km from the Offshore Order Limits, encompasses the Afon Gwyrfai and Llyn Cwellyn and is designated for Atlantic salmon as a primary reason. The Gwyrfai flows out of Llyn y Gader near Rhyd Ddu and passes through Llyn Cwellyn before reaching the sea at Caernarfon Bay, south of the study area. The lake Llyn Cwellyn is a deep oligotrophic lake, recognised for its conservation importance. The Gwyrfai river system is recognised for outstanding ecological and water quality and is designated for an extensive Atlantic salmon population, one of the best supporting rivers in the UK (NRW, 2022).

River Bladnoch SAC

1.3.9.46 The River Bladnoch SAC is located 90.0 km from the Offshore Order Limits. The River Bladnoch flows from Mayberry Loch in South Ayrshire for seven miles to Wigtown Bay and flows into the north of the study area in south west Scotland. The River Bladnoch is designated for Atlantic salmon as a primary reason and the site supports a high-quality salmon population and a spring run of salmon (JNCC, 2022b). The river’s ecological and water quality characteristics are influenced by a moderate-sized catchment with diverse upland and lowland areas (JNCC, 2022b).

Solway Firth MCZ

1.3.9.47 The Solway Firth MCZ is located on the west coast of Britain, in Cumbria, within the Solway Firth estuary, approximately 98.8 km north of the Offshore Order Limits. The MCZ covers 45 km^2 within this estuary and is designated specifically for the protection of sparling or smelt, with the goal of this management being to recover the population traversing the estuary for spawning behaviour to favourable condition (DEFRA, 2019c). Historically, sparling were abundant in this environment (Lyle and Maitland, 1997), but overfishing and pollution pressures are believed to have caused a significant localised decline in population (Maitland and Lyle, 1996), although this is not replicated at a wider scale, with currently sparling being a species of Least Concern on the IUCN Red List.

River Eden SAC

1.3.9.48 The River Eden SAC is located 125.3 km from the Offshore Order Limits. The river Eden flows on sandstone and hard limestone with calcareous waters from limestone and more acidic waters from other streams. Designated fish species as primary reason for the selection of the River Eden SAC includes Atlantic salmon, sea lamprey and river lamprey. The river Eden maintains a large population of Atlantic salmon owing to the extensive suitable habitat available including areas of gravel and finer silt owing to the highly erodible nature of the rock within the river, which provide conditions for spawning and nursery areas (Natural England, 2018). The river Eden also supports river lamprey and a large population of sea lamprey in the middle to lower regions of the river.

1.4 Summary

1.4.1 Introduction

1.4.1.1 The following sections provide a summary of the fish and shellfish baseline characterisation and detail the IEFs to be considered in the EIA, as informed by the baseline characterisation.

1.4.2 Baseline

1.4.2.1 The fish assemblages within the Offshore Order Limits are typical of the east Irish Sea. This is confirmed through site-specific survey and baseline data available from other offshore wind projects in the vicinity of the Offshore Order Limits, with a mix of both demersal and pelagic species. There are known spawning and nursery grounds for 19 fish and shellfish species, including but not limited to cod, herring, lemon sole, mackerel, *Nephrops*, plaice, sandeel, Dover sole and whiting, along with a range of elasmobranchs including tope shark and spurdog. Herring spawning grounds were further investigated, the results showing that while there is some potential spawning activity in the far north west of the Offshore Order Limits (in the vicinity of the Morgan Offshore Wind Project: Generation Assets), the majority of herring spawning occurs to the north and north west of the Offshore Order Limits, aligned with grounds identified by Coull *et al.* (1998). The site-specific PSA data supports very low proportions of the Offshore Order Limits being suitable for herring spawning activity. Habitat suitability for sandeel was also assessed, with approximately half of the Offshore Order Limits considered unsuitable habitat (mostly in the south east) and the remaining sampled sites classed as marginal and preferred habitat, mostly concentrated within the areas in the west section (i.e. further offshore) overlapping the Offshore Order Limits.

1.4.2.2 Eight species of diadromous fish were identified as having the potential to be present within and in proximity to the study area and the Offshore Order Limits: Atlantic salmon, sea trout, sea lamprey, river lamprey, European eel, allis and twaite shad and sparling, with potential secondary impacts to the freshwater pearl mussel. Eight SACs designated for diadromous fish species (Solway Firth SAC, Aber Dyfrdwy SAC, River Derwent and Bassenthwaite Lake SAC, River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC, River Ehen SAC, Afon Gwyrfai a Llyn Cwellyn SAC, River Bladnoch SAC and River Eden SAC) are present within the wider vicinity of the Offshore Order Limits and within the study area.

1.4.2.3 Shellfish known to occur in the study area and therefore with potential to occur within the Offshore Order Limits include *Nephrops*, European lobster, edible crab, velvet swimming crab, squid, whelk, king scallop and queen scallop, which are targeted by commercial fisheries in the locality.

1.4.2.4 Basking sharks migrate through the Irish Sea during spring and summer and migration routes are known to cover large distances from the north of Scotland to North Africa. Additionally, basking sharks have been recorded moving through the Irish Sea between March to June indicating that this is an important area for overwintering that links foraging grounds in the waters surrounding the west coast of Ireland and the UK to south migration destinations.

1.4.3 Important Ecological Features

1.4.3.1 IEFs are habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Transmission Assets. Guidance from CIEEM was used to assess IEFs within the area (CIEEM, 2022). IEFs can be attributed to individual species (such as plaice) or species groups (for example flat fish species). Each IEF is assigned a value or importance rating which is based on commercial, ecological and conservation importance, including Species of Principal Importance (SPI) and features of SACs. SPIs are those species most threatened, in greatest decline, or where England and Wales hold a significant proportion of the world total population in some cases, as outlined in Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006. This statutory designation applies to allis shad, twaite shad, Raitt's (sometimes referred to as lesser) sandeel, European eel, herring, cod, anglerfish, European hake, ling, whiting, plaice, mackerel, Dover sole, Atlantic salmon, sea trout, river lamprey, sea lamprey, sparling, basking shark, spurdog and tope shark, which are found within the Irish Sea (Cefas, 2005) and are expected to be found within the fish and shellfish ecology study area. **Table 1.12** details the criteria used for determining IEFs and **Table 1.13** applies the defining criteria to specific species, providing justifications for importance rankings.

Table 1.12: Defining criteria for IEFs

Value of IEF	Defining criteria
International	Internationally designated sites. Species protected under international law (i.e., Annex II species listed as qualifying interests of SACs).
National	Nationally designated sites. Species protected under national law. Annex II species which are not listed as qualifying interests of SACs in the study area. OSPAR List of Threatened or Declining Species and IUCN Red List species that have nationally important populations within the Offshore Order Limits, particularly in the context of species/habitat that may be rare or threatened in English and Welsh waters. Priority habitats and species (SPI) have been deemed features characteristic of the English and Welsh marine environment and where nationally important habitats/communities are present in the study area. Species that have spawning or nursery areas within or in the immediate vicinity of the Offshore Order Limits that are important nationally (e.g., may be primary spawning/nursery area for that species).
Regional	OSPAR List of Threatened or Declining Species and IUCN Red List species that have regionally important populations within the Offshore Order Limits (i.e., are locally widespread or abundant). Priority habitats and species (SPI) have been deemed features characteristic of the English and Welsh marine environment. Species that are of commercial value to the fisheries which operate within the Offshore Order Limits. Species that form an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages within the Offshore Order Limits. Species that have spawning or nursery areas within the Offshore Order Limits that are important regionally (i.e., species may spawn in other parts of English and Welsh waters, but this is a key spawning/nursery area within the Offshore Order Limits).
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Offshore Order Limits (e.g., they may be exploited in deeper waters outside the Offshore Order Limits). The spawning/nursery area for the species are outside the Offshore Order Limits. The species is common throughout English and Welsh waters but forms a component of the fish assemblages in the Offshore Order Limits.

Table 1.13: IEF species and representative groups within the Offshore Order Limits

IEF	Specific Name/Representative Species	Importance	Justification
Marine fish IEF species			
Plaice	*Pleuronectes platessa*	Regional	Listed as a SPI. High intensity spawning and low intensity nursery grounds identified throughout the Offshore Order Limits and low intensity spawning nursery grounds identified throughout the offshore export cable corridor. Plaice is an important commercial species throughout the Offshore Order Limits and within the surrounding east Irish Sea.
Lemon sole	*Microstomus kitt*	Local	Intensity of spawning grounds are undetermined and intensity of nursery grounds are unspecified within the west portion of Offshore Order Limits and wider east Irish Sea. It is an important and abundant commercial fish species, but not in the immediate vicinity of the Offshore Order Limits (i.e. within the wider east Irish Sea).
Dover sole	*Solea solea*	Regional	Listed as a SPI. High intensity spawning and nursery grounds identified across the majority of the Offshore Order Limits. Sole is an important commercial species throughout the Offshore Order Limits and within the surrounding east Irish Sea.
Other flatfish species		Local	Other flatfish species, including common dab, solenette and flounder, are likely to occur within the Offshore Order Limits. These species either have no known spawning or nursery grounds or low intensity/undetermined spawning and nursey grounds within the area.

IEF	Specific Name/Representative Species	Importance	Justification
Cod	*Gadus morhua*	Regional	Listed as a SPI. Listed by OSPAR as threatened or declining and listed as vulnerable on the IUCN Red List. High intensity nursery grounds are present throughout the Offshore Order Limits, high intensity spawning grounds throughout the west portion of the Offshore Order Limits and low intensity spawning grounds throughout the offshore export cable corridor. It continues to be a species of commercial importance, but not in the immediate vicinity of the Offshore Order Limits (i.e. in the wider east Irish Sea) following the collapse of the cod fishery stock and subsequent poor recovery.
Haddock	*Melanogrammus aeglefinus*	Regional	Listed as a SPI. Nursery grounds of unspecified intensity identified in the north east Irish Sea and marginally within the Offshore Order Limits. Haddock is an important commercial species throughout the Offshore Order Limits and within the surrounding east Irish Sea.
Whiting	*Merlangius merlangus*	Regional	Listed as a SPI. Low intensity spawning and high intensity nursery grounds identified throughout the Offshore Order Limits. Whiting is an important commercial species throughout the Offshore Order Limits and within the surrounding east Irish Sea.
Other demersal species		Local	Species including anglerfish, ling, European seabass and European hake (all listed as SPI) are common throughout English and Welsh waters and are likely to be within the Offshore Order Limits. These species either have no known spawning or nursery grounds or low intensity spawning and nursey grounds within the area. They are important commercial species, but not in the immediate vicinity of the Offshore Order Limits (i.e. in the wider east Irish Sea.

IEF	Specific Name/Representative Species	Importance	Justification
Sandeel species		Regional	Raitt's sandeel listed as a SPI. There are five species of sandeel found in UK waters with lesser sandeel and greater sandeel *Hyperoplus lanceolatus* being the most commonly found species in British waters. Sandeel are important prey species for fish, birds and marine mammals. Both high and low intensity spawning grounds are denoted as being present across the Offshore Order Limits. Identified as likely to be present in the Offshore Order Limits based on historic data and habitat preference.
Herring	*Clupea harengus*	National	Listed as a SPI. Low intensity spawning grounds present immediately outside of the Offshore Order Limits and within the study area. High intensity nursery grounds present throughout the Offshore Order Limits. Although herring spawning grounds do not directly overlap the Offshore Order Limits, this specific area of the Irish Sea has been denoted as key spawning habitat for the species. Herring is an important commercial species, including in the immediate vicinity of the Offshore Order Limits and in the wider east Irish Sea.
Mackerel	*Scomber scombrus*	Regional	Listed as a SPI. Important prey species for larger fish, birds and marine mammals. Low intensity spawning throughout the Offshore Order Limits and low nursery grounds throughout the west portion of the Offshore Order Limits and the wider east Irish Sea. Mackerel is an important commercial species, but not in the immediate vicinity of the Offshore Order Limits (i.e. in the wider east Irish Sea).
Sprat	*Sprattus sprattus*	Regional	Important prey species for larger fish, birds and marine mammals. Unspecified intensity spawning grounds within the Offshore Order Limits. Sprat is an important commercial species, but not in the immediate vicinity of the Offshore Order Limits or in the wider east Irish Sea.

IEF	Specific Name/Representative Species	Importance	Justification
Horse mackerel	*Trachurus trachurus*	Local	Listed as a SPI. Low intensity spawning marginally overlapping the Offshore Order Limits. Horse mackerel is an important commercial species, but not in the immediate vicinity of the Offshore Order Limits or in the wider east Irish Sea.
Elasmobranchs IEF species			
Basking shark	*Cetorhinus maximus*	International	Listed as a SPI. The north east Atlantic population are classed as Endangered on the IUCN Red List. Additionally, they are listed under Convention on International Trade in Endangered Species of Wild Fauna and Flora Annex II and classified as a Priority Species under the UK Post-2010 Biodiversity Framework. Protected in the UK under the Wildlife and Countryside Act and in the Isle of Man under the Isle of Man Wildlife Act 1990. Basking shark are likely to be present in low abundances (if present at all) near the Isle of Man and in proximity to the Offshore Order Limits.
Tope shark	*Galeorhinus galeus*	Regional	Listed as a SPI. Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds throughout the Offshore Order Limits.
Spurdog	*Squalus acanthias*	Regional	Listed as a SPI. Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. High intensity nursery grounds throughout the west of the Offshore Order Limits, further offshore.
Rays	Rajidae spp.	Regional	Ray species including spotted ray and thornback ray. These species either have low intensity nursery grounds and/or no known spawning grounds within the Offshore Order Limits.
Shellfish IEF species			
Edible crab	*Cancer pagurus*	Regional	Commercially important species. Identified as being likely to be present within the Offshore Order Limits.

IEF	Specific Name/Representative Species	Importance	Justification
Nephrops	*Nephrops norvegicus*	Regional	Commercially important species. Identified as being likely to be present within the Offshore Order Limits. Intensity of spawning and nursery grounds are undetermined and unspecified throughout the west section of the Offshore Order Limits, further offshore.
European lobster	*Homarus gammarus*	Regional	Commercially important species. Identified as being likely to be present within the Offshore Order Limits.
King scallop	*Pecten maximus*	Regional	Commercially important species. Identified as being likely to be present within the Offshore Order Limits.
Queen scallop	*Aequipecten opercularis*	Regional	Commercially important species. Identified as being likely to be present within the Offshore Order Limits.
Velvet swimming crab	*Necora puber*	Local	Commercially important species. Identified as being likely to be present within the Offshore Order Limits.
Other crustaceans		Local	Other crustaceans including, swimming crab, spider crab, cockle, blue mussel and shrimp have been identified as being likely to occur within the Offshore Order Limits. These are all important commercial species, but not in the immediate vicinity of the Offshore Order Limits (i.e. in the wider east Irish Sea).
Diadromous fish IEF species			
Sea trout	*Salmo trutta*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. Listed as a OSPAR threatened/declining species. Likely to migrate through the Offshore Order Limits. Not a feature of any designated sites in the vicinity of the Offshore Order Limits.
European eel	*Anguilla anguilla*	National	Listed as a SPI. Listed as Critically Endangered by the IUCN Red List. Listed as an OSPAR threatened/declining species. Likely to migrate through the Offshore Order Limits. This species is a qualifying feature of multiple MNRs in the vicinity of the Offshore Order Limits.

IEF	Specific Name/Representative Species	Importance	Justification
Sea lamprey	*Petromyzon marinus*	International	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Offshore Order Limits. Likely to migrate through the Offshore Order Limits.
River lamprey	*Lampetra fluviatilis*	International	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Offshore Order Limits. Likely to migrate through the Offshore Order Limits, although only in coastal/estuarine areas.
Twaite shad	*Alosa fallax*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Likely to migrate through the Offshore Order Limits.
Allis shad	*Alosa alosa*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Likely to migrate through the Offshore Order Limits.
Atlantic salmon	*Salmo salar*	International	Listed as a SPI. Listed as Vulnerable by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Offshore Order Limits. Likely to migrate through the Offshore Order Limits.
Sparling/ European smelt	*Osmerus eperlanus*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. This species is a qualifying feature of multiple MCZs in the vicinity of the Offshore Order Limits. Likely to migrate through the Offshore Order Limits, although only in coastal/estuarine areas.

IEF	Specific Name/Representative Species	Importance	Justification
Freshwater pearl mussel	*Margaritifera margaritifera*	International	Listed as a SPI. Listed in Annexes II and V of the Habitats Directive and Annex III of the Bern Convention. Listed as Endangered on the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Offshore Order Limits.

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Appendix A: Morgan Offshore Wind Project: Generation Assets fish and shellfish ecology technical report

MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Environmental Statement

Volume 4, Annex 3.1: Fish and shellfish ecology technical report

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F01

Image of an offshore wind farm

www.morganandmona.com/morgan

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Contents

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Glossary

Term	Meaning
Anadromous fish	Fish species that regularly migrate from sea to fresh water to spawn.
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 usually float in the water column just above the sea floor and can occupy either shallow coastal waters or deep waters offshore. Examples of benthopelagic species in Irish waters include dogfish, cod, haddock, whiting, monkfish, and saithe.
Berried	Egg bearing individual whereby eggs are attached to its tail or some other exterior part.
Demersal fish	Fish species that live close to the sea floor and are bottom feeders. There are two types: benthic fish which rest on the sea floor (e.g. flatfish, dragonets, skates and rays) or benthopelagic fish (see above).
Demersal spawning species	Species which deposit eggs onto the seabed during spawning
Diadromous fish	Fish species that regularly migrate between sea and freshwater systems.
Elasmobranchs	Elasmobranchs like sharks, rays and skates have a skeleton composed entirely of cartilage.
Fecundity	The potential for reproduction of an organism measured by number of gametes (eggs), seed set or asexual propagules.
Intertidal area	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS).
Marine Conservation Zone	Marine Conservation Zones (MCZs) are a type of marine protected area that can be designated in English, Welsh and Northern Irish territorial and offshore waters.
Nursery habitat	A habitat where juveniles of a species regularly occur as a population.
Oslo-Paris Convention (OSPAR)	The Convention for the Protection of the Marine Environment of the northeast Atlantic or OSPAR Convention regulates international cooperation on environmental protection in the North East Atlantic.
Oviparous	A mode of reproduction in which eggs laid with little or no other embryonic development within the mother. This is the reproductive method of most fish, amphibians, reptiles and birds.
Pelagic fish	Pelagic fish are species which live and feed within the water column.
Shellfish	For the purposes of this assessment, shellfish is considered a generic term to define commercially targeted molluscs and crustaceans.
Site of Special Scientific Interest (SSSI)	A Site of Special Scientific Interest (SSSI) is a formal conservation designation. Usually, it describes an area that’s of particular interest to science due to the rare species of fauna or flora it contains - or even important geological or physiological features that may lie in its boundaries.
Spawning grounds	Spawning grounds are the areas of water or seabed where fish spawn or produce their eggs.

Term	Meaning
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.

Acronyms

Acronym	Description
AFBI	Agri-Food Biosciences Institute
Cefas	Centre for Environment Fisheries and Aquaculture Science
CIEEM	Chartered Institute of Ecology and Environmental Management
CITES	Convention on International Trade in Endangered Species
CMACS	Centre for Marine and Coastal Studies
CPUE	Catch per unit of effort
CSTP	Celtic Sea Trout Project
DDV	Drop Down Video
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
IBTS	International Bottom Trawl Survey
ICES	International Council for Exploration of the Sea
IEF	Important Ecological Feature
IFCA	Inshore Fisheries Conservation Authority
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MarLIN	Marine Life Information Network
MCZ	Marine Conservation Zone
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MNR	Marine Nature Reserve
NBN	National Biodiversity Network
NIGFS	Northern Irish Ground Fish Trawl Survey
NINEL	Northern Irish Herring Larvae Survey
NRW	Natural Resources Wales
OSPAR	Oslo-Paris Convention
PEIR	Preliminary Environmental Information Report

Acronym	Description
PSA	Particle Size Analysis
SEA6	Strategic Environmental Assessment
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
SPI	Species of Principal Importance
UK	United Kingdom
VMS	Vessel Monitoring Systems
ZoI	Zone of Influence

Units

Unit	Description
%	Percentage
km^2	Square kilometres
km	Kilometres (distance)
m^2	Square metres
m	Metre (distance)
cm	Centimetre
mm	Millimetre
nm	Nautical mile
ºC	Degrees Celsius
kg	Kilogram
t	Tonnes

1 Fish and shellfish technical report

1.1 Introduction

1.1.1.1 This fish and shellfish ecology technical report provides a detailed baseline characterisation of the fish and shellfish ecology (e.g. species, communities and habitats) associated with the Morgan Offshore Wind Project: Generation Assets (hereafter referred to as the Morgan Generation Assets). The Morgan Generation Assets are located within the east Irish Sea, north of Conwy, Wales, west of Lancashire, England and southeast of the Isle of Man.

1.1.1.2 Data were collated through a detailed desktop study of the fish and shellfish species, habitats and communities within a defined fish and shellfish ecology study area within the east Irish Sea (Figure 1.1), incorporating site-specific survey data and data from third party organisations.

1.1.1.3 The aim of this technical report is to provide a robust baseline characterisation of the fish and shellfish receptors within the defined study area (see section 1.2) against which the potential impacts of the Morgan Generation Assets can be assessed. To support the assessment of effects in the Environmental Impact Assessment (EIA), the ecological information presented in this technical report was used to identify a number of Important Ecological Features (IEFs). IEFs were determined based on the conservation, ecological, and commercial importance of each identified feature within the Morgan Generation Assets and within the wider fish and shellfish ecology study area, in line with published EIA guidelines (CIEEM, 2019, updated in 2022).

1.1.1.4 This technical report is structured as follows:

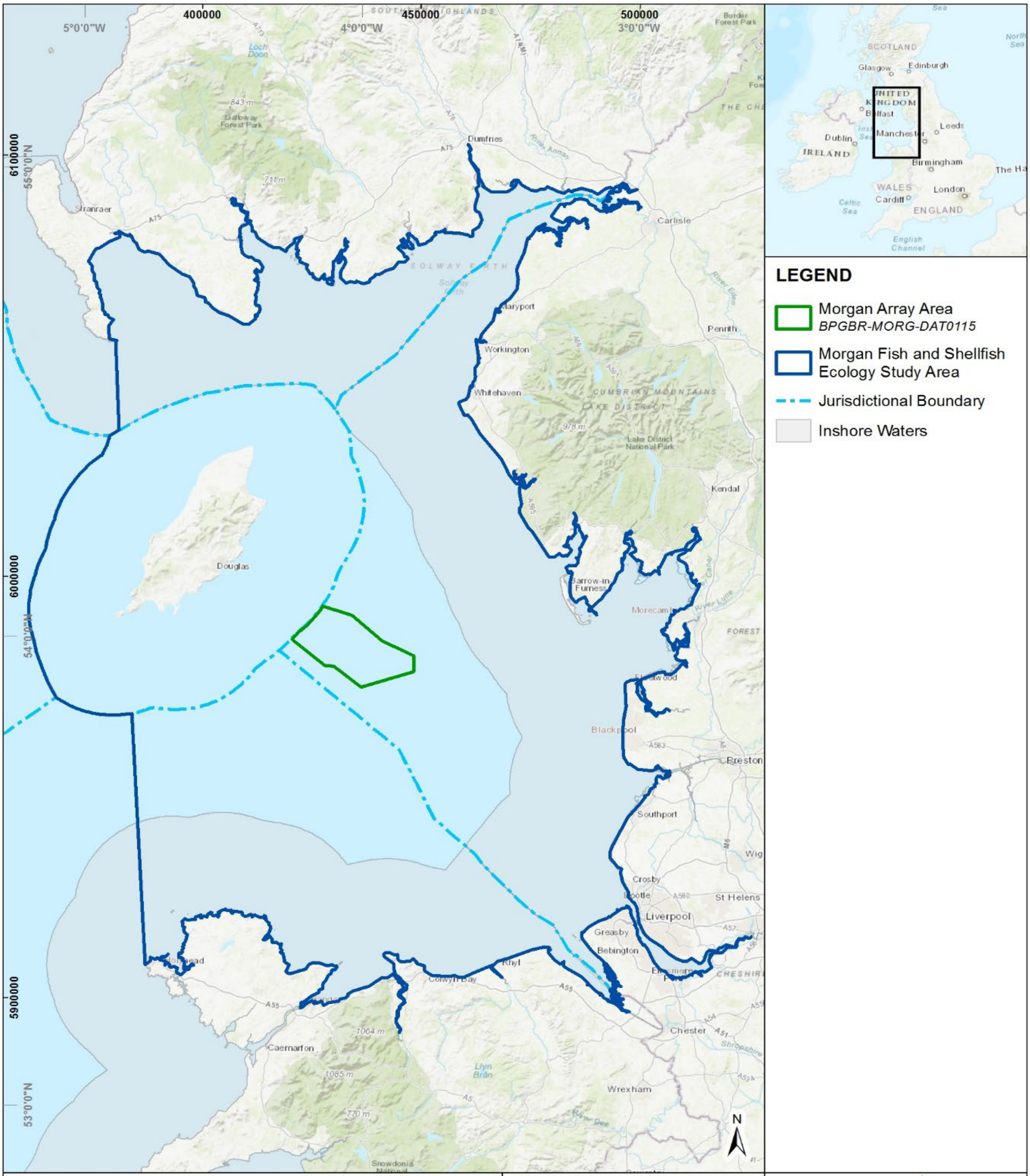
- Section 1.2: Study Area – Overview of the fish and shellfish ecology study area that is relevant to the report
- Section 1.3: Methodology – Overview of desktop reports and data and site-specific surveys used to inform the baseline
- Section 1.4: Baseline Characterisation – Details the results of the desktop study and site-specific surveys
  - Section 1.4.1: Broad overview and description of the fish and shellfish assemblages within the east Irish Sea
  - Section 1.5: Fish Spawning and Nursery Grounds – Spawning and nursery grounds are described for key species
  - Section 1.6: Herring – A description of herring habitats and ecology (focussing on spawning)
  - Section 1.7: Sandeel – A description of sandeel habitats and ecology
  - Section 1.8: Elasmobranchs – A description of elasmobranch fish ecology
  - Section 1.9: Diadromous Fish – A description of diadromous fish ecology and designated sites associated with them
  - Section 1.10: Shellfish – A description of shellfish habitats and ecology
  - Section 1.11: Designated sites – A description of designated sites within the east Irish Sea which may be affected by the Morgan Generation Assets
- Section 1.12: Summary – A summary of the information provided in the report

  - Section 1.12.2: Baseline – A summary of the fish and shellfish ecology baseline characterisation
  - Section 1.12.3: Important Ecological Features – Describing the IEFs to be considered within the EIA.

1.2 Study area

1.2.1.1 Fish and shellfish species, habitat and communities are spatially and temporally variable, therefore for the purposes of the fish and shellfish ecology characterisation, a broad study area has been defined. The fish and shellfish ecology study area is presented in Figure 1.1 and described below:

- The fish and shellfish ecology study area covers the east Irish Sea, extending from Mean High Water Springs (MHWS) west from the Mull of Galloway in Scotland to the west tip of Anglesey, following the 12 nm limit (territorial waters) of the Isle of Man. This study area has been selected to account for the spatial and temporal variability of fish and shellfish populations, including fish migration. This area was considered appropriate as it will ensure the characterisation of all fish and shellfish receptors within the east Irish Sea and is therefore large enough to consider all direct (e.g. habitat loss/disturbance within project boundaries) and indirect impacts (e.g. underwater sound over a wider area) associated with the Morgan Generation Assets on the identified receptors.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
RPSE-MG-FAS-001-00

Drawing Title:
MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,500,000

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Figure 1.1: Fish and shellfish ecology study area extending across the east Irish Sea, including the Morgan Generation Assets.

1.3 Methodology

1.3.1 Desktop study

1.3.1.1 Information on fish and shellfish ecology within the fish and shellfish ecology study area was collected through a detailed desktop review of existing studies and datasets. Additionally, information collected as part of the commercial fisheries baseline characterisation (including landings data and consultation with fisheries organisations) has been incorporated into this baseline (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement for additional information), with regard given to the best practice advice for offshore wind assessments recently published by Natural England (2022). These are summarised in Table 1.1.

Table 1.1: Summary of key desktop reports.

Title	Source	Year	Author
Fisheries Sensitivity Maps in British Waters	United Kingdom Offshore Operators Association Ltd.	1998	Coull *et al*.
Rhyl Flats Offshore Wind Farm, Fish and Fisheries Baseline Study	Marine Data Exchange	2002 to 2006	Coastal Fisheries Conservation and Management (COWL, 2002; CMACS, 2005)
Effects of climate variability on basking shark abundance off southwest Britain	Fisheries Oceanography	2005	Cotton *et al*.
Walney and West of Duddon Sands Offshore Wind Farms, Baseline Benthic Survey – Epifaunal Beam Trawl Results	Marine Data Exchange	2005	Titan Environmental Surveys Ltd.
Herring larvae surveys of the northern Irish Sea 1993 to 2021	The Agri-Food and Biosciences Institute (AFBI)	2006 to 2022	AFBI (ICES, 2006; Dickey-Collas *et al*., 2010; ICES, 2022a)
Burbo Bank Offshore Wind Farm, Pre-construction Commercial Fish Survey (2m Beam Trawl)	Marine Data Exchange	2006a, b	Centre for Marine and Coastal Studies Ltd. (CMACS)
Burbo Bank Offshore Wind Farm, Electromagnetic Fields and Marine Ecology Study	Marine Data Exchange	2007	CMACS
Walney Offshore Wind Farm Pre-Construction Fish Survey	Marine Data Exchange	2009a	Brown and May Marine Ltd.
Ormonde Offshore Wind Farm Pre-Construction Juvenile & Adult Fish Survey	Marine Data Exchange	2009b, c	Brown and May Marine Ltd.
Ormonde Offshore Wind Farm, Construction (Year 1) Environmental Monitoring	Marine Data Exchange	2010	RPS Energy
Rhiannon Wind Farm Round 3 Autumn Fish Trawl Surveys	Marine Data Exchange	2010, 2013	CMACS
Burbo Bank Extension Offshore wind farm: Adult and Juvenile Fish Characterisation Survey	Marine Data Exchange	2011a, b	Brown and May Marine Ltd.
Gwynt y Môr Offshore Wind Farm, Pre-construction Baseline Beam Trawl Data	Marine Data Exchange	2011	CMACS

Title	Source	Year	Author
West of Duddon Sands Offshore Wind Farm, Adult and Juvenile Fish and Epibenthic Pre-Construction Surveys	Marine Data Exchange	2012a, 2012b	Brown and May Marine Ltd.
Mapping the Spawning and Nursery Grounds of Selected Fish for Spatial Planning	Centre for Environment Fisheries and Aquaculture Science (Cefas)	2012	Ellis *et al.*
Northern Irish Ground Fish Trawl Survey (NIGFS) 2013 to 2022	International Council for the Exploration of the Sea (ICES)	2012-2022 (2022b)	ICES
Walney Offshore Wind Farm, Year 2 Post-construction Monitoring Fish and Epibenthic Survey	Marine Data Exchange	2013a	Brown and May Marine Ltd.
Welsh waters scallop survey – Cardigan Bay to Liverpool Bay July-August 2013	Bangor University	2013	Lambert *et al.*
Celtic Array – Rhiannon Wind Farm Preliminary Environmental Information Chapter 10: Fish and Shellfish Ecology	Marine Data Exchange	2013	Celtic Array Ltd.
Ormonde Offshore Wind Farm, Adult and Juvenile Fish and Epi-benthic Post-construction Survey	Marine Data Exchange	2014	Brown and May Marine Ltd.
Updating Fisheries Sensitivity Maps in British Waters	Scottish Marine and Freshwater Science Report	2014	Aires *et al.*
Marine Life Information Network (MarLIN)	MarLIN	2018	Tyler Walters *et al*.
ICES Celtic Seas ecoregion fisheries overview	Summary of commercial fisheries in the Celtic Sea	2018a, b	ICES
Isle of Man scallop surveys 1992 to 2019	Bangor University - Sustainable Fisheries Isle of Man	2019	Bangor University Sustainable Fisheries and Aquaculture Group (Bloor *et al*., 2019; Delargy, 2019)
Manx Marine Environmental Assessment	Isle of Man Government – Fisheries Division	2018	Howe *et al*.
National Biodiversity Network (NBN) Atlas	NBN Atlas	2019	NBN Atlas
Welsh Waters Scallop Surveys and Stock Assessment	Bangor University	2019	Delargy *et al*.
Joint Nature Conservation Committee (JNCC) Marine Protected Area Mapper	JNCC	2019	JNCC
ICES scallop assessment working group	ICES	2019c	ICES
Bass and Ray Ecology in Liverpool Bay	Bangor University Sustainable Fisheries and Aquaculture Group.	2020	Moore *et al.*
UK Sea Fisheries Annual Statistics Report	Marine Management Organisation (MMO)	2021	MMO
Annual Fisheries Science Report	Bangor University Sustainable Fisheries and Aquaculture Group	2021	Jenkins *et al.*

Title	Source	Year	Author
Spawning and nursery grounds of forage fish in Welsh and surrounding waters	Cefas	2021	Campanella and van der Kooij
SeaLifeBase	https://www.sealifebase.ca/	2022	Palomares and Pauly
ICES working group on surveys on ichthyoplankton in the North Sea and adjacent seas	ICES	2022b	ICES
Awel y Môr Offshore Wind Farm. Category 6: Environmental Statement	Awel y Môr Offshore Wind Farm Ltd.	2022	RWE Renewables UK
Annual scallop surveys 1992 to 2020	AFBI	2022	AFBI
Marine Recorder Public UK Snapshot	JNCC	2022a	JNCC
Cefas OneBenthic	Cefas	2023	Cefas
Manx Basking Shark Watch 1987 to 2022	Manx Whale and Dolphin Watch	2023	Manx Whale and Dolphin Watch
Morecambe Offshore Windfarm: Generation Assets Preliminary Environmental Impact Report (PEIR) Volume 1 Chapter 10: Fish and shellfish ecology.	Morecambe Offshore Windfarm Ltd	2023	Morecambe Offshore Windfarm Ltd
Fish and shellfish survey results for the east Irish Sea	Environment Agency	Various	Environment Agency
Cefas Pelagic ecosystem in the western English Channel and eastern Celtic Sea (PELTIC) surveys	Cefas	Various	Cefas
Fish and shellfish sensitivity reports	https://www.marlin.ac.uk/activity/pressures_report	Various	Various

1.3.2 Site-specific subtidal surveys

1.3.2.1 A summary of the site-specific surveys undertaken to inform the fish and shellfish ecology baseline characterisation is outlined in Table 1.2. The location of site-specific sampling is further presented in Figure 1.2.

1.3.2.2 Given the wide ranging and comprehensive desktop information and data sources available to characterise the fish and shellfish ecology baseline, site-specific surveys specifically targeting fish and shellfish receptors were not proposed in order to inform the EIA for the Morgan Generation Assets. However, the results from site-specific surveys (2021 and 2022) primarily designed to inform the benthic subtidal and intertidal ecology baseline characterisation (see Volume 4, Annex 2.1: Benthic subtidal ecology technical report of the Environmental Statement for comprehensive details of the benthic survey), which include records of small demersal fish and shellfish species, have been used to additionally inform the baseline characterisation for fish and shellfish ecology.

1.3.2.3 The site-specific subtidal benthic surveys were undertaken within the fish and shellfish ecology study area to characterise the benthic habitats in the vicinity of the Morgan Generation Assets in 2021 and 2022. The sampling strategy was designed to adequately sample the area to provide data for baseline characterisation. The survey design was discussed and agreed with Natural England, JNCC and Natural Resources Wales (NRW). The 2021 benthic subtidal survey was undertaken by Gardline Limited

(Gardline) between June and September 2021 onboard the multi-role survey vessel MV *Ocean Resolution.*

1.3.2.4 Combined grab and Drop-down Video (DDV) sampling was undertaken across 97 sampling stations, of which 37 were located within the Morgan Array Area. Two additional stations within the Morgan Array Area during the 2021 survey were DDV-only. Particle Size Analysis (PSA) data obtained from grabs was used to inform habitat characterisation for sandeel Ammodytidae spp. and potential spawning grounds of Atlantic herring *Clupea harengus*. Further, species presence/absence records were also recorded from both grab samples and DDV sampling (Figure 1.2), although these should be noted as purely opportunistic and incidental data, as surveys were not specifically designed to target fish and shellfish species.

1.3.2.5 As outlined in Table 1.2, additional site-specific sampling within the Morgan Array Area and Zone of Influence (ZoI) was undertaken in 2022 by Gardline. The 2022 survey was designed to adequately sample the Morgan Generation Assets ZoI and to collect some repeat samples within the Morgan Array Area, and the survey design was discussed and agreed with Natural England, JNCC and NRW. The Morgan Generation Assets ZoI survey was undertaken by Gardline from April to August 2022 onboard two vessels, the MV *Ocean Observer* and the MV *Titan Endeavour*.

1.3.2.6 Combined grab and DDV sampling was undertaken across 26 stations, with 13 located within the Morgan Generation Assets, and 13 within the surrounding ZoI. No samples collected in this area during this survey were DDV-only. As in 2021, PSA data obtained from grabs was used to inform habitat characterisation for sandeel and potential spawning grounds of herring, although again this survey was designed primarily for benthic characterisation and most other fish and shellfish data collected was opportunistic.

1.3.2.7 Herring spawning habitat characterisation was undertaken using results of the PSA to determine the composition of the sediment type at grab locations. Samples were categorised into preferred, marginal and unsuitable based on their suitability as herring spawning habitat, using classifications derived from Reach *et al*. (2013) based on the relative proportions of gravel and mud in the grab samples. Data from the Northern Irish Herring Larvae Survey (NINEL) were also utilised to show potential herring spawning habitats in line with guidelines published by Boyle and New (2018). The abundances of larvae ≤10 mm per m^2 were plotted as density maps for the years 2012 to 2021 to show temporal variance in larval densities. Further, following Expert Working Group consultation, this data was aggregated into a single ten-year dataset, and was plotted as a heat map to indicate spatial trends based on multi-year results, and is presented in Figure 1.30. These maps, combined with the PSA data from site-specific grab sampling (as noted above, from the Morgan Generation Assets and surrounding ZoI), were used to determine where key spawning habitats were located within the vicinity of the Morgan Generation Assets (see section 1.5, Figure 1.24 to Figure 1.30).

1.3.2.8 Sandeel habitat characterisation was also completed, using a similar method as above where samples were categorised into preferred, marginal and unsuitable, based on their suitability as sandeel habitat. Classifications were derived from Latto *et al*. (2013) based on the proportion of sand and mud in the grab samples. Incidental sandeel observations were collated from the benthic surveys to inform presence/absence of individuals caught by grab samples. The data was plotted into maps and reviewed alongside additional desktop data sources to further characterise sandeel habitats within and in the vicinity of the Morgan Generation Assets (see section 1.7 for results).

1.3.2.9 To more comprehensively characterise the herring and sandeel sediment suitability throughout the fish and shellfish ecology study area, data from 1,766 sediment samples from a broad range of nearby benthic surveys were extracted from the publicly available online Cefas OneBenthic tool (Cefas, 2023). This data was processed using the same criteria as was used for the site-specific surveys to assign suitability, and was plotted for herring in Figure 1.23 and for sandeel in Figure 1.31.

1.3.2.10 Norway lobster *Nephrops norvegicus* (hereafter referred to as *Nephrops*) presence within the vicinity of the Morgan Generation Assets was assessed through presence/absence data derived from DDV sampling (taken at grab sample sites in 2021 and 2022, and specific DDV-only transects in 2021). Where present, these data were plotted alongside favourable *Nephrops* habitat as identified in a benthic biotope map as shown in Volume 4, Annex 2.1: Benthic subtidal ecology of the Environmental Statement (see section 1.10.8 for additional results).

1.3.2.11 Basking shark *Cetorhinus maximus* were not recorded from the site-specific aerial marine mammal surveys (Morgan Offshore Wind Ltd., 2023). However, they are known to travel through the area (Cotton *et al*., 2005; Shark Trust, 2022; Manx Whale and Dolphin Watch, 2023).

Table 1.2: Summary of surveys undertaken to inform the fish and shellfish ecology baseline characterisation.

*: The Morgan Offshore Cable Corridor was surveyed in this campaign, but the results will be incorporated into the combined Morgan Offshore Wind Project and Morecambe Offshore Windfarm Transmission Assets Environmental Statement and are not discussed in the context of the Offshore Cable Corridor further herein.

Title	Survey extent	Overview of survey	Survey contractor	Date	Reference to further information
Benthic Subtidal Survey	Morgan and Mona Array Areas	Grab samples, Visual survey outputs (DDV sampling) and laboratory testing	Gardline Limited	2021	Gardline Limited, 2022
Benthic Subtidal Survey	Morgan and Mona Offshore Cable Corridors, array areas and ZoI*	Grab samples, Visual survey outputs (DDV sampling) and laboratory testing	Gardline Limited	2022	Gardline Ltd., 2023

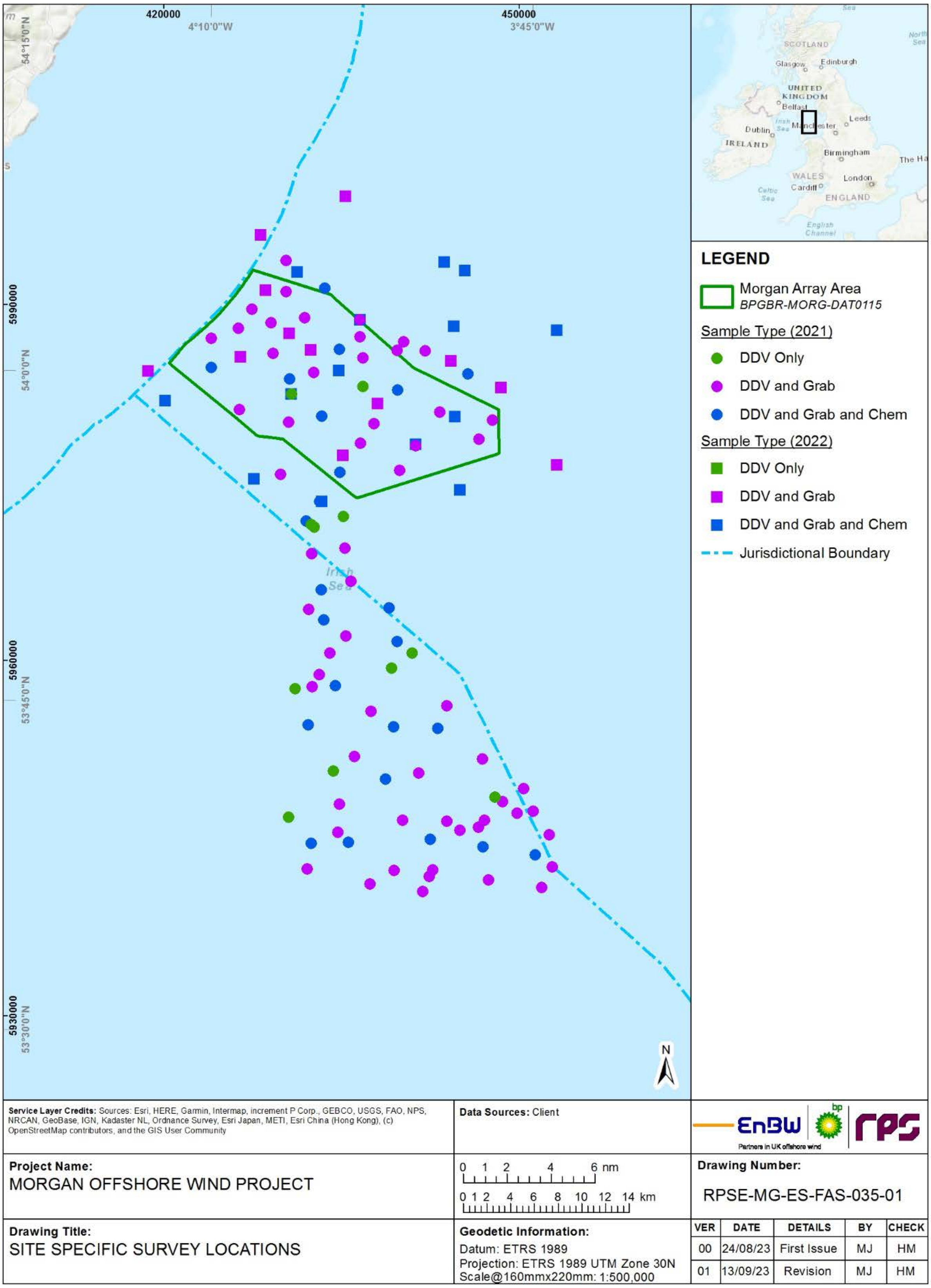

Figure 1.2: Morgan Generation Assets site-specific subtidal survey locations.

1.4 Baseline characterisation

1.4.1 East Irish Sea – desktop study

1.4.1.1 This section provides an overview of the fish and shellfish assemblages in the fish and shellfish ecology study area through a comprehensive desktop review. This review primarily covers fish species and communities from regional datasets including other offshore developments within the area, with some additional information on shellfish species and communities. A more detailed characterisation of key shellfish species in the fish and shellfish ecology study area, including species of commercial importance, is presented in section 1.10.

1.4.1.2 The fish and shellfish ecology study area comprises the Strategic Environmental Assessment (SEA6) area and ICES Region VIIa according to the UK Government. SEA6 corresponds to the east half of the St George's Channel and Irish Sea, comprising a major portion of the ICES division VIIa, generally used for fisheries assessment purposes (UK Government, 2022).

1.4.1.3 The east Irish Sea supports valuable fisheries assemblages, including demersal, pelagic and shellfish species. Historically, several of these species were known to be targeted by international fleets (Cefas, 2005). Important commercial species include flatfish, gadoids, and elasmobranchs, as these species are typically caught by beam and otter trawls, which are frequently used gear types in the area (Cefas, 2005). The east Irish Sea is also known to be an important spawning ground and nursery area for several species (further discussed in section 1.5), subsequently making it a focal point of seasonal fisheries. Pelagic species are of lesser commercial importance than the demersal species, while shellfish species are known to be highly commercially important within the east Irish Sea, specifically king and queen scallops and *Nephrops* (ICES, 2021a).

1.4.1.4 The sediments of the Irish Sea can be subdivided into three broad regions: two 'mudbelts' comprising of soft muds which occupy the east and west inshore areas separated by a central 'gravel belt' which comprises coarser sediment and hard substrate (Mellet *et al.,* 2015). The east and west areas of the Irish Sea are known for their muddy sediments (clay and silt) that support one of the most valuable fisheries for *Nephrops* (Lundy *et al*., 2019; Parker-Humphreys, 2004). In the area northwest of the Morgan Generation Assets, in territorial waters within the 12 nm limit of the Isle of Man, the sediment is split between mixed sands to the north, and mixed gravel to the west (Howe *et al*., 2018).

1.4.1.5 The distribution of fish and shellfish species is determined by a range of factors including abiotic parameters such as water temperature, salinity, depth, local scale habitat features and substrate type, and biotic parameters such as predator prey interactions, competition, and anthropogenic factors such as infrastructure and commercial fishing intensity. Specific population sizes and habitat ranges within the Irish Sea tend to be limited largely by fishing activity, with increasing pressure from the renewable energy and aggregate extraction industries acting alongside broader pressures such as climate change, sound, and marine litter to limit fish and shellfish distributions (van der Kooij *et al*., 2021).

1.4.1.6 The fish assemblages likely to be observed within the fish and shellfish ecology study area include demersal species: plaice *Pleuronectes platessa*, dab *Limanda limanda*, solenette *Buglossidium luteum*, Dover sole *Solea*, whiting *Merlangius merlangus*, lesser spotted dogfish *Scyliorhinus canicula* and cod *Gadus morhua*, with pelagic species including herring, European seabass *Dicentrarchus labrax* and Atlantic mackerel *Scomber scombrus.*

1.4.1.7 Dominant shellfish species in the Irish Sea include blue mussel *Mytilus edulis*, European lobster *Homarus gammarus*, *Nephrops*, common whelk *Buccinum undatum*, great/king scallop *Pecten maximus*, queen scallop *Aequipecten opercularis*, edible crab *Cancer pagurus*, brown/common shrimp *Crangon crangon*, and pelagic and demersal squid species. As key components of the shellfish community, these species are also commercially valuable within this region (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement for additional information).

1.4.1.8 Ellis *et al*. (2000) described the macro-invertebrate and demersal fish assemblages within the Irish Sea from 101 beam trawl survey stations and found that fine substrates in inshore waters of the east and west portions of the Irish Sea are typically dominated by flatfish including plaice, dab and Dover sole. In coarse substrates further offshore, abundant species include thickback sole *Microchirus variegatus* whilst muddy sediments are characterised by *Nephrops* and witch flounder *Glyptocephalus cynoglossus* (Ellis *et al*., 2000). Additionally, from samples collected within inshore waters, Ellis *et al*. (2000) described an *Alcyonium* assemblage in which dab and velvet swimming crab *Necora puber* were typical of the fish and shellfish features.

1.4.1.9 The International Bottom Trawl Survey (IBTS) is a historical time series of bottom and pelagic fish trawl surveys undertaken in the northeast Atlantic and Baltic Seas regions. The fish and shellfish ecology study area and more specifically, the Morgan Generation Assets sits within the IBTS S5, S6, and S7 survey zones. These areas, in addition to IBTS zones S1 to S4 and S8 to S10 have been utilised to gain a more comprehensive understanding of the fish assemblages present within the Irish Sea (IBTS, 2021).

1.4.1.10 Bottom trawl surveys conducted by the IBTS across the Irish Sea are conducted annually. One such survey was conducted during March 2020 and undertaken with a rockhopper trawl fitted with a 20 mm cod-end liner towed between one and three nautical miles in the Irish Sea and St George’s Channel (IBTS, 2021). Of the 58 trawls that were successfully undertaken within the area, a total of 128 species were recorded (IBTS, 2021). Catches predominantly comprised of the following species in order of abundance: whiting, haddock *Melanogrammus aeglefinus*, plaice, red gurnard *Chelidonichthys cuculus*, cod, lemon sole *Microstomus kitt*, thornback ray *Raja clavata*, spotted ray *Raja montagui*, European hake *Merluccius merluccius*, spiny dogfish/spurdog *Squalus acanthias*, brill *Scophthalmus rhombus*, John Dory *Zeus faber*, megrim *Lepidorhombus whiffiagonis* and European pollock *Pollachius pollachius* (IBTS, 2021).

1.4.1.11 Trawl surveys as part of the IBTS have also been undertaken throughout the Irish Sea, and particularly in the east Irish Sea, through the Northern Irish Groundfish Survey (NIGFS). Data was reviewed for survey years between 2012 and 2022 which indicated that the distributions and species composition of catches recorded remained fairly consistent across the years reviewed, with similar proportions of catches per species as recorded across the broader Irish Sea. Plaice, lesser-spotted dogfish, whiting, herring, dab, common dragonet *Callionymus lyra*, thornback ray, *Nephrops*, haddock, grey gurnard *Eutrigla gurnardus* were the most commonly caught species. The fish and shellfish assemblages recorded in NIGFS align with the other data sources which have historically surveyed the same area and corroborate the presence and long-term stability of these communities within the fish and shellfish ecology study area and around the Morgan Generation Assets, as supported by Campanella and van der Kooij (2021). This indicates that older datasets detailing fish and shellfish distribution and spawning (Coull *et al*., 1998; Ellis *et al*., 2012), along with those collected from historic project-specific fish and shellfish surveys also remain broadly relevant to the current baseline conditions of the east Irish Sea and can be used to support characterisation of projects within this area.

1.4.1.12 Despite not being recorded in the 2012 and 2022 sampling, the NIGFS survey recorded queen scallop in higher abundances than *Nephrops* in the 2013 to 2021 survey years across the fish and shellfish ecology study area, with limited observations of queen scallop reported within the 12 nm inshore waters limit. Herring records were also distributed across the fish and shellfish ecology study area with only few inshore locations with reported herring catches (ICES, 2021b; 2022b).

1.4.1.13 Several species of both commercial and ecological importance are known to be present within the east Irish Sea. These species include European plaice, dab, Dover sole, whiting, cod, European seabass, spurdog, spotted ray, herring, mackerel, sprat *Sprattus sprattus,* ling *Molva molva* and sandeel. As previously stated, the east Irish Sea hosts important and valuable populations of shellfish species including king scallop, queen scallop, European lobster, edible crab, velvet swimming crab, and *Nephrops* (ICES, 2021a).

1.4.1.14 Beam trawl surveys undertaken throughout the Irish Sea from 1993 to 2001 found that plaice accounted for the largest proportion of the catches by biomass, resulting in 24.44% of the total (Parker-Humphreys, 2004). Plaice is a widespread and common species throughout European waters and in the east Irish Sea, showing a preference for sandy sediments throughout its lifespan. This species spawns in offshore areas where eggs and larvae are then transported on currents to coastal nurseries. Tagging studies show that individuals have strong site fidelity, returning to the same location to spawn and feed (Hunter *et al*., 2003). Plaice make use of tidal currents in various life stages. For example, plaice have been evidenced moving downstream with the tide in mid-water during seasonal migrations between spawning and feeding grounds (Arnold and Metcalfe, 1996). Their preferred diet is polychaete worms, small crustaceans, siphons of bivalve molluscs, and in some areas, brittle stars (Rijnsdorp and Vingerhoed, 2001).

1.4.1.15 Dab was the most abundant species recorded during demersal beam trawl surveys of the Irish Sea accounting for 28.04% of the catch by number and 17.40% by biomass (Parker-Humphreys, 2004). Adult dab live mainly on sandy substrates from depths of a few metres to 100 m and feed on crustaceans and small fish (Braber and Groot, 1973). Ellis *et al*. (2000) described the inshore waters of the east Irish Sea as plaice-dab assemblages, with plaice, dab and sole dominating the fish component of the assemblage. Dover sole is widespread and abundant in European waters and lives buried in both sandy and muddy sediments. Juveniles spend the first year in shallow coastal waters and estuaries, migrating to deeper offshore waters following this period, although they are largely restricted to depths of <50 m. From the months of March to May, sole return to inshore waters to spawn with spawning migrations occurring at night (Kruuk, 1963). Sole is both a nocturnal and olfactorial feeder, making use of sensory organs to detect prey. They are known to feed on polychaete worms, small echinoderms and sea urchins (Braber and Groot, 1973).

1.4.1.16 Atlantic herring, European hake, whiting, blue whiting *Micromesistius poutassou*, Atlantic mackerel and Atlantic cod are predominantly found in deeper waters in the benthopelagic or pelagic zone and have been observed throughout the east Irish Sea. Their core range includes St. George’s Channel (at the south boundary of the Irish Sea); however, they have additionally been found to be present around the south and west coast of Ireland and north coast of Northern Ireland.

1.4.1.17 European hake is focused within the northeast Atlantic as one population and is distributed across the Irish Sea (Figure 1.6), Celtic Sea, English Channel and the North Sea. They are a relatively fast-growing species, with males maturing at around 35 cm and females at 50 cm within 3 to 5 years for both sexes (FishBase, 2020a). Adult hake live close to the seabed during the day but move up from the seabed at night for opportunistic feeding within the water column (Riccioni *et al*., 2018). The ICES 2019 stock assessment which included the Celtic Sea, suggests a relatively stable population of this species since 1978 (ICES, 2019a).

1.4.1.18 Whiting is abundant throughout the northeast Atlantic, Mediterranean and European Seas. They are most commonly found in depths of 10 m to 100 m, predominantly on mud and gravel bottoms, but also on sand and rock. Year one fish feed primarily on crustaceans such as shrimps and crabs, and on small fish and molluscs. After the first year, whiting have been evidenced to move further offshore in search of prey (FishBase, 2020b).

1.4.1.19 Similar to whiting, blue whiting is distributed throughout the north Atlantic and found on continental shelves at depths of 300 m to 400 m but have been found at depths exceeding 1,000 m. This species is known to make daily migrations from the surface waters at night to the benthos during the day where they feed on small crustaceans, small fish and cephalopods (FishBase, 2020c).

1.4.1.20 Atlantic mackerel is abundant and widespread in the cold and temperate shelf areas of the east Irish Sea. This species overwinters in deeper waters but moves closer inshore during spring when water temperatures increase. Atlantic mackerel within the Irish Sea are part of the British Isles (west) stock (the other being the North Sea (east) stock). They are generally a pelagic species, forming large schools near the surface, but their habitat preferences are poorly understood (FishBase, 2020d).

1.4.1.21 Atlantic cod is widely distributed in a variety of habitats. Juveniles typically inhabit shallow sublittoral waters with seagrass or coarse substrate (gravel, rocks or boulders). Adults prefer deeper, colder waters; during the day they form large schools which swim just above the seabed, whilst at night they disperse to feed. Cod migrate between spawning, feeding and overwintering areas within the boundaries of their stock. Spawning occurs between winter and start of spring when they congregate in large numbers to spawn, utilising vocalisations during courtship and spawning behaviour (Finstad and Nordeide, 2004). Spawning sites are usually in offshore waters, at or near the bottom at depths of 50 m to 200 m (FishBase, 2020e). An omnivorous species, cod feed on invertebrates and fish, including young cod.

1.4.1.22 European seabass is known to support an important commercial and recreational fishery within the UK (Moore *et al*., 2020). Bass caught within the Irish Sea fisheries consistently showed a significant bias (79.8% of catches) towards females, findings which were supported by data collected from North Wales, suggesting potential localised spawning within the area (Moore *et al*., 2020). Monthly landings data between 2019 and 2020 illustrated that the bass fishery within Liverpool Bay is highly seasonal, with the majority of spawning occurring before May, and peal landings reported between July and November (Moore *et al*., 2020).

1.4.1.23 Many of these aforementioned fish species have high ecological value as prey species for marine mammals, seabirds and other fish (e.g. sandeel, herring, mackerel, whiting, and sprat) as well as being of high importance to commercial fisheries (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement).

1.4.1.24 Additional offshore wind farm developments, either in the construction or planning stages, are present within the fish and shellfish ecology study area (Figure 1.3). Data collected through site-specific surveys undertaken for additional offshore renewable energy developments can therefore be utilised to help better characterise the fish and shellfish assemblages within the vicinity of the Morgan Generation Assets.

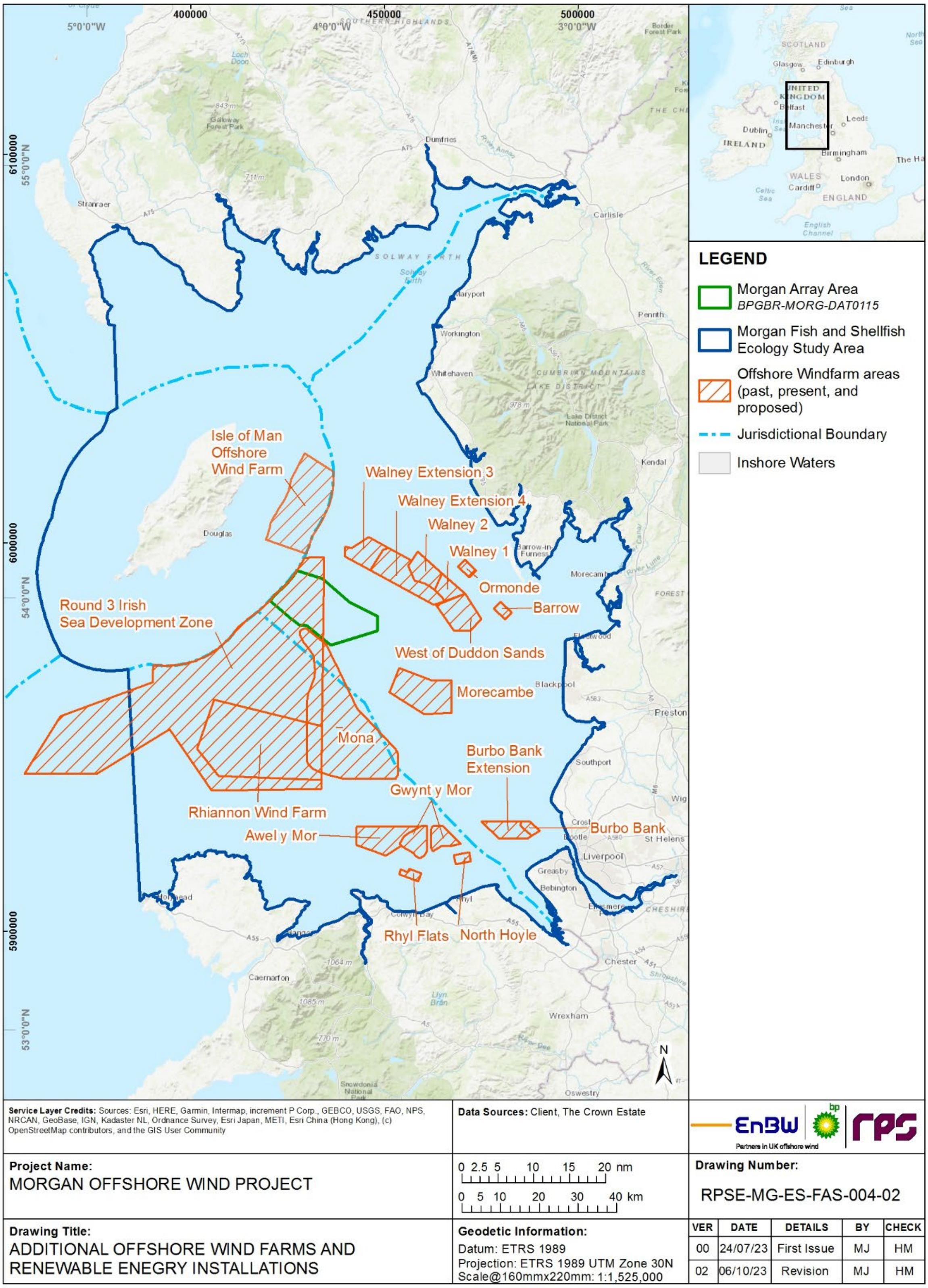

Figure 1.3: Locations of other offshore wind projects[1] in the fish and shellfish ecology study area.

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[1] The Awel y Môr agreement for lease area extends further to the west than the application boundary presented, however Awel y Môr Offshore Wind Farm Ltd. have decided to develop in the area presented.

Irish Sea round 3 development zone

1.4.1.25 Beam trawl surveys were undertaken in the autumn of both 2010 and 2011 across the Irish Sea Round 3 development zone which overlaps the west area of the Morgan Generation Assets. In terms of the fish and shellfish ecology study area, the Irish Sea Round 3 Development Zone is located within the southwest corner of the area (Figure 1.3).

1.4.1.26 The surveys conducted within the Irish Sea Round 3 Development Zone reported that the most dominant fish species present were poor cod *Trisopterus minutus* and the lesser spotted dogfish. The next most common species were common dragonet *Callionymus lyra*, grey gurnard *Eutrigla gurnardus* and red gurnard *Chelidonichthys cuculus*. The most common commercially valuable fish species was plaice, followed by thickback sole and lemon sole (CMACS, 2010; Celtic Array Ltd., 2013).

1.4.1.27 Furthermore, seven elasmobranch species were recorded, including lesser spotted dogfish, cuckoo ray *Leucoraja naevus*, spotted ray, thornback ray, nursehound *Scyliorhinus stellaris*, starry smooth-hound *Mustelus asterias* and starry ray *Amblyraja radiata*. Moreover, there were no observations of rare or endangered fish species reported from the survey (CMACS, 2010; Celtic Array Ltd., 2013).

Gwynt y Môr offshore wind project

1.4.1.28 The Gwynt y Môr offshore wind project is located approximately 65 km southeast of the Morgan Generation Assets (Figure 1.3). Pre-construction beam trawl and benthic grab surveys were undertaken in autumn 2010 to monitor the status of organisms and seabed sediments.

1.4.1.29 Across the Gwynt y Môr offshore wind project, 472 individual fish from 23 species were recorded at 30 trawl stations. The highest number of individuals encountered were consistently observed from inshore, shallow waters compared to those further offshore in water depths ranging from 20 m to 30 m (CMACS, 2011).

1.4.1.30 Utilising beam trawl, benthic grab and DDV data, the general sediments within the site were described as coarse sands and gravels with flatfish such as plaice, dab and solenette being the predominant fish species present. During the survey relatively few elasmobranch species were encountered (CMACS, 2011).

1.4.1.31 Similar to findings evidenced from the Irish Sea Round 3 Development Zone, plaice was found to be the most commonly recorded fish species during the surveys and was found in 15 of 30 (50%) sampling sites. The second most abundant species was solenette, recorded in 14 of 30 (47%) sites and sand goby *Pomatoschistus minutus*, recorded in 15 of 30 (50%) sites. The only elasmobranch species that were recorded within the Gwynt y Môr offshore wind project were lesser spotted dogfish, thornback ray, and blonde ray *Raja brachyura*. Other teleost species recorded infrequently and in low numbers include grey, red, and tub gurnard *Chelidonichthys lucerna*, John Dory, thickback sole, and whiting (CMACS, 2011).

1.4.1.32 Five commercially valuable shellfish species were recorded from within and surrounding the Gwynt y Môr offshore wind project. These species include whelk, edible crab, common mussel, brown shrimp, and pink shrimp *Pandalus montagui*. With the exception of whelk, none of these species were known to be commercially targeted within the Gwynt y Môr offshore wind project or wider surrounding area at the time of survey reporting (CMACS, 2011).

1.4.1.33 Although the sand goby, which was commonly encountered during the beam trawl surveys is a scheduled species in the Bern Convention and protected for its important contribution to the marine trophic level, the species is not subject to any UK conservation measures and is known to be abundant in shallow, sandy habitats (CMACS, 2011).

West of Duddon Sands offshore wind project

1.4.1.34 Baseline otter and beam trawl surveys were conducted in May and September 2012 for the West of Duddon Sands offshore wind project pre-construction site investigation surveys, located approximately 10 km east of the Morgan Generation Assets in inshore waters (Figure 1.3).

1.4.1.35 The West of Duddon Sands offshore wind project found that plaice, dab, and lesser spotted dogfish were the most abundant species encountered during both surveys and the total catch rates (catch per unit of effort; CPUE) per station were highest to the southeast of the array (Brown and May Marine Ltd., 2012a; 2012b). Although the surveys recorded a total of 35 species in the May survey, and 32 species in September, plaice and dab were found to represent the majority of the catch at most of the 23 otter trawl sampling stations in both surveys.

1.4.1.36 Otter trawl catch rates within the West of Duddon Sands offshore wind project were as high as 4,331 individuals per hour and 4,063 individuals per hour from sampling within the wind farm and along the export cable corridor, respectively, with the highest CPUE in both areas recorded during the spring survey. Between the wind farm and export cable corridor, plaice, dab lesser spotted dogfish, whiting, grey gurnard, tub gurnard, thornback ray, Dover sole, sprat, starry smooth-hound, common dragonet, nursehound, poor cod, cod, lemon sole, herring, tope, anglerfish, bib, mackerel, scaldfish *Arnoglossus laterna*, lesser weaver *Echiichthys vipera*, flounder *Platichthys flesus*, pogge *Agonus cataphractus* sea trout *Salmo trutta*, streaked gurnard *Chelidonichthys lastoviza* and brill were the fish species observed across the two surveys. The shellfish species recorded in these areas included edible crab, whelk, squid *Alloteuthis* spp*.* velvet swimming crab, European lobster, spiny spider crab *Maja brachydactyla* and *Nephrops* (Brown and May Marine Ltd., 2012a, 2012b).

1.4.1.37 Beam trawl surveys found a total of 13 species of fish in the May survey, and 14 in the September survey. Overall, solenette was the most abundant species caught during both surveys, followed by scaldfish in the spring, and dab in the autumn. Beam trawl catch rates illustrated abundances as high as 423 individuals per hour from within the wind farm boundary and 387 individuals per hour from along the export cable corridor, with the highest total CPUE in the wind farm found in the autumn, and along the export cable corridor in the spring. Fish species captured during the two surveys included solenette, dab, goby (Gobiidae spp.), scaldfish, sand goby, plaice, whiting, Dover sole, common dragonet, pogge, lesser spotted dogfish, poor cod, lesser pipefish *Syngnathus rostellatus*, thornback ray, four bearded rockling *Enchelyopus cimbrius*, Norway pout *Trisopterus esmarkii* and grey gurnard (Brown and May Marine Ltd., 2012a; 2012b).

Walney offshore wind project

1.4.1.38 Beam and otter trawl surveys were undertaken for the Walney offshore wind project (Walney 1 and Walney 2) from May 2009 (pre-construction surveys) to June 2013 (year 2 post-construction surveys), with surveys typically conducted in the summer of each year. The Walney offshore wind project is located approximately 7 km northeast of the Morgan Generation Assets (Figure 1.3). Walney 1 is located to the east of Walney 2, in inshore waters. The key species of commercial importance that were observed during these surveys were *Nephrops*, Dover sole, and cod (Brown and May Marine Ltd. 2009a, 2013a).

1.4.1.39 Collectively, between Walney 1 and Walney 2, plaice, dab, solenette, whiting and lesser spotted dogfish were the most abundant fish species observed during the surveys, while *Nephrops* was the most abundant shellfish species encountered. *Nephrops* grounds are known to occur within the Walney offshore wind project area and were identified during the pre-construction and post-construction monitoring surveys (Brown and May Marine Ltd., 2013a).

1.4.1.40 Walney 1 pre- and post- construction surveys found that Dover sole had have a slightly increased abundance in most post-construction surveys, but overall, there were no significant changes observed between the pre- and post-construction survey results (Brown and May Marine Ltd., 2013a). *Nephrops* were highly varied in the Walney 1 surveys and higher yields were consistently recorded in the summer months of May and June, illustrating a degree of seasonal variability in population patterns (Brown and May Marine Ltd., 2013a), with the caveat that further study in different seasons would provide a more rounded view of the post-construction population characteristics. Otter trawl catch rates collected in Walney 1 evidenced abundances as high as 3,900 *Nephrops* individuals per hour trawled.

1.4.1.41 Walney 2 catch rates for fish and shellfish species illustrated that the overall number of species caught slightly increased during post-construction surveys, suggesting that the Walney offshore wind project may have had a positive effect on the localised fish and shellfish populations, although it’s important to note that these surveys provide only a snapshot of highly mobile species at the time of sampling (Brown and May Marine Ltd., 2013a). Otter trawl catch rates during the survey recorded abundances as high as 1,700 individuals per hour trawled.

1.4.1.42 Infrequent numbers of cod, herring, dragonet, grey gurnard, lesser spotted dogfish, tub gurnard and scaldfish were recorded within the Walney 1 and Walney 2 otter trawl surveys (Brown and May Marine Ltd., 2013a). Higher catch rates were recorded in April for whiting and Atlantic herring, whereas the highest catch rates pertaining to *Nephrops*, lesser spotted dogfish, dragonet, scaldfish, grey gurnard and tub gurnard were recorded in June, suggesting some degree of seasonality among these species (Brown and May Marine Ltd., 2013a).

1.4.1.43 Beam trawl surveys undertaken at Walney 1 evidenced abundances as high as 369 individuals per hour trawled, while Walney 2 illustrated a slightly lower number of individuals caught per hour at 293 (Brown and May Marine Ltd., 2013a). Solenette was found to be the most abundant species encountered within both of these survey areas during the months of April and June. Amongst the survey stations with the highest total catch rates in Walney 1 and Walney 2, solenette represented more than 50% of the catch repeatedly (Brown and May Marine Ltd., 2013a).

Ormonde Offshore Wind Project

1.4.1.44 The Ormonde offshore wind project is located approximately 20 km northeast of the Morgan Generation Assets (Figure 1.3). Pre-construction otter and beam trawl surveys were undertaken in April and October 2009 and post-construction surveys were undertaken in 2012 to 2014 (Brown and May Marine Ltd., 2009b, 2009c, 2013b, 2013c, 2013d, 2014).

1.4.1.45 The Ormonde offshore wind project otter trawl surveys found that dab and plaice were the most abundant species encountered during all surveys. The 2 m beam trawl samples generally reflected highest abundances of solenette and dab from all surveys. The total number of fish and shellfish species captured during otter trawling ranged from 14 in the spring pre-construction survey to 38 in the October 2012 and 2013 post-construction surveys. During beam trawl sampling, the total number of fish species captured ranged from 13 in October 2009 to 28 in October 2013. Elasmobranch species recorded during the otter trawl sampling included lesser spotted dogfish, thornback ray, nursehound, starry smooth-hound, blonde ray and cuckoo ray. Shellfish species captured with the otter trawl included edible crab, *Nephrops*, European lobster, long-finned squid *Loligo forbesii* and velvet crab. Beam trawl surveys also recorded a similar array of species, with the addition of razor clam *Ensis ensis*.

Burbo Bank and Burbo Bank Extension Offshore Wind Projects

1.4.1.46 Beam trawl surveys were undertaken for the Burbo Bank and Burbo Bank Extension offshore wind projects between 2005 and 2010 and in May and September 2011 respectively (CMACS, 2006a, 2006b; Brown and May Marine Ltd., 2011a, 2011b; Dong Energy Burbo Extension Ltd., 2013). The Burbo Bank offshore wind project and extension is located approximately 20 km southeast of the Morgan Generation Assets.

1.4.1.47 Pre-construction surveys at Burbo Bank in 2005 and 2006 were undertaken using a 2 m beam trawl and 4 m beam trawl, respectively (CMACS, 2006a; 2006b). In addition, the 2 m beam trawl survey reports from 2007 and 2009 Burbo Bank post-construction surveys and the 4 m beam trawl survey report from 2010 were available for review (SeaScape, 2008, 2011a, 2011b). A total of 22 species of fish were recorded from both the 2006 and 2010 4 m beam trawl surveys at Burbo Bank. The fish species composition remained similar during all pre- and post-construction fish surveys with dab, plaice, solenette and whiting being the most commonly recorded species. One juvenile sea trout was captured during the 2006 4 m beam trawl survey which was surmised to be present in the area for feeding.

1.4.1.48 Three species of elasmobranchs were caught during the pre-construction 4 m beam trawl survey: thornback ray, lesser spotted dogfish and starry smooth-hound and four species were reported from the 2010 post-construction survey, encompassing the above three species plus the spotted ray. Thornback ray were abundant during both pre- and post-construction surveys and were largely identified as juvenile, with approximately equal proportions of males and females present; the area was considered important for juvenile ray species.

1.4.1.49 Baseline otter trawl surveys within the Burbo Bank Extension area in 2011 found dab, plaice and flounder to be most abundant in catches in the spring survey, with the addition of herring to this group of species in the autumn survey (Brown and May Marine Ltd., 2011a, 2011b; Dong Energy Burbo Extension Ltd., 2013). During 2 m beam trawl sampling, dab and sandeel were the most abundant species caught in May whereas in September, whiting and dab were most commonly captured. The overall composition was broadly consistent with that reported from the Burbo Bank pre- and post-construction surveys between 2005 and 2010. Thornback ray and lesser-spotted dogfish were the most abundant elasmobranch species during both 2011 otter trawl surveys. Other elasmobranch species recorded using the two techniques were starry smooth-hound, spotted ray, blond ray and nursehound. Herring and sprat were among the most abundant pelagic teleost species caught during both otter trawl surveys with higher catches for herring in September and sprat in May. Other fish species of interest, such as Dover sole, sandeel, horse mackerel *Trachurus trachurus*, cod, river lamprey *Lampetra fluviatilis* and seabass were caught in relatively low numbers.

Awel y Môr offshore wind project

1.4.1.50 The Awel y Môr offshore wind project is located approximately 47 km to the south of the Morgan Generation Assets (Figure 1.3). The Awel y Môr offshore wind project utilised findings from Gwynt y Môr, Burbo Bank Extension, North Hoyle, Rhyl Flats (CMACs, 2005), and the Celtic Array to better inform and undertake their 2021 PEIR. Data assessed from other offshore wind projects in the region illustrated similar patterns as discussed above regarding the dominant species that would be expected within this part of the Irish Sea.

1.4.1.51 Based on the data sources described above and findings presented within the Awel y Môr PEIR, it was found that a wide range of fish and shellfish species were expected to inhabit the project area, which may also be present within the Morgan Generation Assets. These species include Atlantic salmon, Atlantic cod, whiting, plaice, Dover sole, herring, mackerel, lesser sandeel (*Ammodytes tobianus*), spotted and thornback ray (MacNab and Nimmo, 2021).

1.4.1.52 Additionally, the Awel y Môr offshore wind project analysed long-term time series data across the whole of the Irish Sea, including findings from the North Irish Groundfish Survey (NIGS). Otter trawls conducted across the Irish Sea from 2005 to 2018 were found to be dominated by whiting, haddock, lesser spotted dogfish, plaice and herring, similar results to those illustrated within the IBTS survey zones overlapping the Morgan Generation Assets (ICES, 2010; MacNab and Nimmo, 2021).

1.4.1.53 Furthermore, characterising species recorded within site-specific surveys for various local offshore wind projects (Gwynt y Môr , Burbo Bank Extension, North Hoyle, Rhyl Flats, Celtic Array, Walney and West of Duddon Sands) within the vicinity of the Morgan Generation Assets and located inside the fish and shellfish ecology study area, illustrated good agreement with species recorded in regional surveys, further suggesting that monitoring data is not only consistent within the area, but remains relevant as the temporal span of these surveys covers the last decade (MacNab and Nimmo, 2021).

Mona Offshore Wind Project

1.4.1.54 The fish and shellfish ecology baseline characterisation for the Morgan Generation Assets was based upon a combination of desktop information sources, findings from previous targeted fish and shellfish surveys undertaken for wind farm projects within the east Irish Sea and relevant site-specific benthic survey results from the Mona Array Area in 2021, and along the Mona Offshore Cable Corridor and ZoI in 2022 (Gardline Ltd., 2023, Mona Offshore Wind Ltd., 2023). Imagery data from digital aerial surveys were examined for presence of basking shark, however none were identified within the survey area at the time of surveying.

1.4.1.55 Site-specific benthic subtidal survey results supported the assessment for habitat suitability for herring spawning and sandeel and provided a number of opportunistic observations of fish and shellfish species of interest. Data from the Mona Offshore Wind Project benthic surveys illustrated similar patterns as would be expected within this part of the Irish Sea. Specifically, observations of queen and king scallop, *Nephrops*, other bivalves including *Ensis magnus*, common dab, lemon sole, plaice, thickback sole, haddock, sandeel, blonde ray, thornback ray, cuckoo ray and lesser spotted dogfish were recorded during the benthic subtidal surveys (Gardline Ltd., 2023, Mona Offshore Wind Ltd., 2023).

Morecambe Offshore Windfarm: Generation Assets

1.4.1.56 No survey specifically targeting fish or shellfish species was undertaken for the Morecambe Offshore Windfarm: Generation Assets (Morecambe Offshore Windfarm Ltd, 2023). However, benthic subtidal surveys and digital aerial surveys have been used to inform the baseline characterisation for fish and shellfish ecology, notably for habitat suitability for herring spawning and sandeel, opportunistic observations of fish and shellfish species and use of the aerial imagery to determine the presence of basking shark, although none were noted during these surveys. Observations of razor clam and unspecified fish were recorded during the benthic subtidal surveys at Morecambe Offshore Windfarm: Generation Assets (Ocean Ecology, 2022).

1.5 Spawning and nursery grounds

1.5.1.1 A number of fish species are known to have spawning and nursery grounds within the fish and shellfish ecology study area. Data from Cefas (Ellis *et al*., 2012; Coull *et al*., 1998) provides spatially explicit maps of the spawning and nursery areas of multiple key species. It is worth noting that Coull *et al*. (1998) data may lack accuracy due to the age of the study and for this reason, it has only been used where no other data from Ellis *et al*. (2012) are available.

1.5.1.2 Potential nursery and spawning areas in the Irish Sea for a range of species were identified by Coull *et al*. (1998), based on larvae, egg and benthic habitat data. Ellis *et al*. (2012) reviewed these data for several finfish species in the Irish Sea, including cod, whiting and herring, providing an updated understanding of areas of low and high intensity nursery and spawning grounds. Further information regarding nursery areas is provided in Aires *et al*. (2014). The study assessed evidence of aggregations of ‘0 group fish’ (fish in the first year of their lives) around the UK coastline. These data were ascertained from species distribution modelling combining observations of species occurrence or abundance with environmental data (Aires *et al*., 2014). The outputs of this process have been suggested to be used as a guide for the most likely locations of aggregations of 0 group fish. Recent modelling based on collated survey data in the Isle of Man territorial waters (Campanella and van der Kooij, 2021) provides up-to-date evidence to support the distribution of the previously identified spawning and nursery grounds for a range of foraging species, with any slight changes in mapped species distribution likely being due to natural interannual variation. Broadly, these studies all describe the same patterns of spawning and nursery habitat within the fish and shellfish ecology study area, and thus the maps available from Coull *et al*. (1998) and Ellis *et al*. (2012) data can be considered reliable.

1.5.1.3 Based on the above data sources, spawning areas for several species overlap the Morgan Generation Assets, including high intensity spawning areas for cod, plaice, sole, sandeel and herring. Species with known spawning periods and nursery habitats identified overlapping with the Morgan Array Area and otherwise near to the Morgan Generation Assets within the fish and shellfish ecology study area have been summarised in Table 1.3 and Table 1.4 and presented in Figure 1.4 to Figure 1.22.

1.5.1.4 Spawning and nursery habitats are often influenced by the seabed sediments and substrates. As such, site-specific information on sediments can be useful to characterise spawning and nursery habitats within the Morgan Generation Assets and have been utilised to characterise herring and sandeel habitats in later sections of this Technical Report (section 1.6.2 and section 1.7.2).

1.5.1.5 Subtidal benthic sediments across the Morgan Array Area were found to range from gravelly sand to muddy sandy gravel, with gravelly muddy sand (40% of samples), gravelly sand (31%) and sand (20%) representing the three most common sediment types reported. All sediment samples classified as sand were found in the east section of the Morgan Array Area. The sediments within the east of the Morgan Array Area were dominated by sand and gravelly sand with areas of slightly gravelly sand in the north and south, and gravelly muddy sand moving westwards. The sediments within the west of the Morgan Array Area were typically slightly coarser and characterised by gravelly muddy sand sediments in addition to gravelly sand and the one sample of muddy sandy gravel (see Volume 4, Annex 2.1: Benthic subtidal ecology technical report of the Environmental Statement for comprehensive details on results of the benthic survey).

1.5.1.6 Areas important for supporting juvenile fish (i.e. that provide adequate food resources and shelter) are known as nursery areas. Nursery areas for several species, including herring, mackerel, lemon sole, anglerfish *Lophius piscatorius* (Figure 1.16), haddock, cod, whiting and *Nephrops* are found within the Irish Sea (Figure 1.4 to Figure 1.22). These species are further discussed in Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement. A large proportion of the east Irish Sea, including the environment around the Morgan Generation Assets, has been mapped as a nursery habitat for cod and whiting.

1.5.1.7 Cod are commonly found throughout the east Irish Sea and have high intensity spawning and nursery grounds overlapping the majority of the Morgan Array Area (Figure 1.4; Ellis *et al*., 2012), with spawning occurring between January and April and peaking in February and March. Spawning behaviour involves courtship in demersal environments typically consisting of sandy and boulder sediments (Grabowski *et al*., 2012), following by release of buoyant eggs into the water column (Hutchings *et al*., 1999). The presence of cod nursery grounds is supported by Aires *et al*. (2014).

1.5.1.8 Haddock spawning occurs predominantly between February and May. Similar to cod and whiting, haddock have a demersal courting period followed by pelagic egg release and larval phases (Casaretto and Hawkins, 2012), feeding on plankton before juveniles move down towards the seabed to exploit demersal prey resources, including small crustaceans and small fish. There is an unspecified intensity nursery ground to the north of the Morgan Generation assets, which marginally overlaps with the north area of the Morgan Array Area (Figure 1.5). The extent of haddock nursery grounds is supported by outputs from Aires *et al*. (2014) and may suggest higher intensity nursery grounds extend further north of the Morgan Generation Assets.

1.5.1.9 Ling were found to have a low intensity spawning ground located across most of the Morgan Generation Assets, extending north towards Solway Firth and west to Ireland (Figure 1.7; Ellis *et al*., 2012). Ling are known to spawn in February to July (Cohen *et al*., 1990; Table 1.4), with pelagic eggs released into the water column (Wheeler, 1992).

1.5.1.10 Whiting are common in the Irish Sea and spawning occurs between February and June. The Irish Sea provides ideal conditions for whiting spawning with sandy substrate and fast movement of water for release of eggs into the water column. After the eggs hatch, the larvae drift in surface waters for a year, and then move closer to the seabed as juveniles. The majority of the Morgan Array Area coincides with high intensity spawning and nursery grounds for whiting (Figure 1.8).

1.5.1.11 Herring have high intensity nursery grounds found primarily within the areas inshore of the Morgan Array Area. Specifically, both high and low intensity spawning grounds are located near the Isle of Man to the north, with neither of these spawning grounds having any direct overlap with the Morgan Array Area (Figure 1.9; Ellis *et al.,* 2012; Coull *et al*., 1998). Spawning times for herring are dependent on sub populations, with both spring and autumn spawning populations occurring in the fish and shellfish ecology study area.

1.5.1.12 Generally, for the Mourne herring stock, spawning is seen between September and October. The Manx herring stock (which includes the Douglas Bank spawning population) spawn over a period of three to four weeks from late September, which is reported to have remained consistent since the 1940s (Dickey-Collas *et al.*, 2001). Sticky eggs are deposited preferably on gravel substrate and the eggs adhere to the seabed forming extensive beds which can be several layers thick (Drapeau, 1973; Rogers and Stocks, 2001). After hatching the larvae enter the plankton and drift with the current until reaching inshore nursery grounds. A year later they migrate further offshore to join adults at feeding grounds. The presence of high intensity nursery grounds for herring is supported by outputs from Aires *et al*. (2014), with predicted aggregations of 0-group herring found inshore and near the Isle of Man. A further review of herring spawning has been included in section 1.5. The AFBI in Northern Ireland has undertaken herring larvae surveys of the north Irish Sea in November every year since 1993. The 2019 survey results recorded that the majority of herring larvae were captured in the east Irish Sea in the vicinity of the Douglas Bank spawning ground and to the north of the Isle of Man (ICES, 2021a).

1.5.1.13 Sprat spawning grounds (unspecified intensity) coincide with the Morgan Generation Assets and the whole of the east Irish Sea (Figure 1.10). The presence of sprat nursery grounds is supported by outputs from Aires *et al*. (2014), with aggregations of 0 group fish occurring throughout the fish and shellfish ecology study area, and a spawning period of May to August, with peak spawning in May and June (Table 1.4).

1.5.1.14 Mackerel have low intensity spawning grounds which coincide with the entirety of the Morgan Array Area and low intensity nursery grounds across the Morgan Array Area (Figure 1.11; Ellis *et al*., 2012). Mackerel spawn over spring and summer months from March to July. Peak spawning occurs during the months of May and June (Table 1.4). Spawning behaviour involves the release of eggs into the water column, where fertilisation also occurs (Walsh and Johnstone, 2006), indicating a low level of reliance on sedimentary habitats for spawning. The presence of mackerel nursery grounds is not supported by outputs from Aries *et al*. (2014), with no modelled observations of 0 group fish within the fish and shellfish ecology study area. Horse mackerel spawning grounds are detailed in Figure 1.12, with spawning occurring between March and August, and peaking in May and June (Table 1.4).

1.5.1.15 Lemon sole are found throughout the fish and shellfish ecology study area but have unspecified spawning and nursery grounds within the Morgan Generation Assets, specifically within the entirety of the Morgan Array Area (Figure 1.13; Coull *et al*., 1998). These findings are supported by outputs from Aires *et al*. (2014). Lemon sole are known to spawn primarily in March to May (Table 1.4), with spawning in some places known to occur until September (Smith, 2014). Evidence also exists of spawning in October to November dependent on the stock and location (Geffen *et al*., 2021), with lemon sole utilising their preferred benthic habitats for spawning behaviour (Hinz *et al*., 2006).

1.5.1.16 Plaice spawn between January and March, with each female producing up to half a million eggs which drift passively in the plankton. Once the larvae reach a suitable size for settlement, they metamorphose into the asymmetric body shape. As juveniles, they inhabit mostly shallow water including tidal pools. In their second year they move into deeper water and are mostly found in a depth range of 10 m to 50 m. Plaice have high intensity spawning grounds within the Morgan Array Area, with high intensity nursery grounds occurring in the east sections of the Morgan Array Area (Figure 1.14; Ellis *et al*., 2012).

1.5.1.17 Sole spawning and nursery grounds are similar to those presented above for plaice, with spawning occurring between February and April and peaking in March (Table 1.4), with evidence of spawning behaviour up to the end of June in some places (Savina *et al*., 2010). High intensity spawning and nursery grounds were found to be concentrated along the east sections of the Morgan Array Area (Figure 1.15). These findings are further supported by outputs illustrating the presence of 0 group aggregations in inshore waters from Aires *et al*. (2014).

1.5.1.18 During the winter months, sandeel remain in the sediment only emerging to spawn. 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). A review of spawning and nursery grounds suggests that there is an overlap of the Morgan Generation Assets with both sandeel spawning and nursery grounds (Figure 1.17). Low intensity nursery grounds are present amongst the east sections of the Morgan Array Area. High intensity spawning grounds are denoted as being present along the east section of the Morgan Array Area (Figure 1.17; Ellis *et al*., 2012).

1.5.1.19 There are several low intensity nursery grounds for elasmobranch species within or in close proximity to the Morgan Generation Assets including spotted ray, thornback ray and tope (Figure 1.18, Figure 1.20 and Figure 1.21, respectively). Additionally, the offshore area which comprises the Morgan Array Area has been classified as a high intensity nursery ground for spurdog (Figure 1.19; Ellis *et al*., 2012). These classifications are in line with desktop data sourced from other offshore wind projects in the area and data related to commercial fisheries landings.

1.5.1.20 *Nephrops* are opportunistic predators that leave their burrows at dawn and dusk to forage. They reach sexual maturity after two to three years and they have an annual reproductive cycle. *Nephrops* spawning and nursery grounds (unspecified intensity) coincide with the entirety of the Morgan Array Area (Figure 1.22, Coull *et al*., 1998).

1.5.1.21 Of the shellfish species within the fish and shellfish ecology study area and more specifically, in proximity to and overlapping the Morgan Generation Assets, queen scallop are known to spawn in the region. Vessel Monitoring Systems (VMS) data and feedback from commercial fisheries stakeholders indicated that the east sections of the Morgan Array Area are known to be important queen scallop spawning areas (further discussed in section 1.10.2).

Table 1.3: Key species with spawning and nursery grounds overlapping Morgan Generation Assets (Coull *et al*., 1998 and Ellis *et al*., 2012).

Common Name	Species Name	Spawning (Morgan)	Nursery (Morgan)
Anglerfish	*Lophius piscatorius*		✓
Cod	*Gadus morhua*	✓	✓
Haddock	*Melanogrammus aeglefinus*		✓
Herring	*Clupea harengus*		✓

Common Name	Species Name	Spawning (Morgan)	Nursery (Morgan)
Horse Mackerel	*Trachurus trachurus*	✓	
Lemon Sole	*Microstomus kitt*	✓	✓
Ling	*Molva molva*	✓	
Mackerel	*Scomber scombrus*	✓	✓
Nephrops	*Nephrops norvegicus*	✓	✓
Plaice	*Pleuronectes platessa*	✓	✓
Sandeels	Ammodytidae spp.	✓	✓
Sole	*Solea*	✓	✓
Spotted Ray	*Raja montagui*		✓
Sprat	*Sprattus sprattus*	✓	
Spurdog	*Squalus acanthias*		✓
Thornback Ray	*Raja clavata*		✓
Tope Shark	*Galeorhinus galeus*		✓
Whiting	*Merlangius merlangus*	✓	✓

Table 1.4: Periods of spawning activity for key species in the fish and shellfish ecology study area (adapted from Coull *et al*., 1998 and Ellis *et al*., 2012).

Spawning periods are highlighted in light blue, peak spawning periods are marked dark blue. *Refers to Mourne Stock.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglerfish	▨	▨	▨	▨	▨	▨						
Cod	▨	■	■	▨								
European Hake	▨	■	■	▨	▨	▨						
Haddock		■	■	■	▨							
Herring*									▨	▨		
Horse Mackerel			▨	▨	■	■	▨	▨				
Lemon Sole			▨	■	▨							
Ling		▨	▨	▨	▨							
Mackerel			▨	▨	■	■	▨					
Nephrops	▨	▨	▨	■	■	■	▨	▨	▨	▨	▨	▨
Plaice	■	■	▨									▨
Sandeels	▨	▨									▨	▨
Sole		▨	■	▨								
Spotted Ray					■	■	■					
Sprat					■	■	▨	▨				

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spurdog	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Thornback Ray		▨	▨	■	■	■	■	■	▨			
Tope Shark	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Whiting		▨	▨	▨	▨	▨						

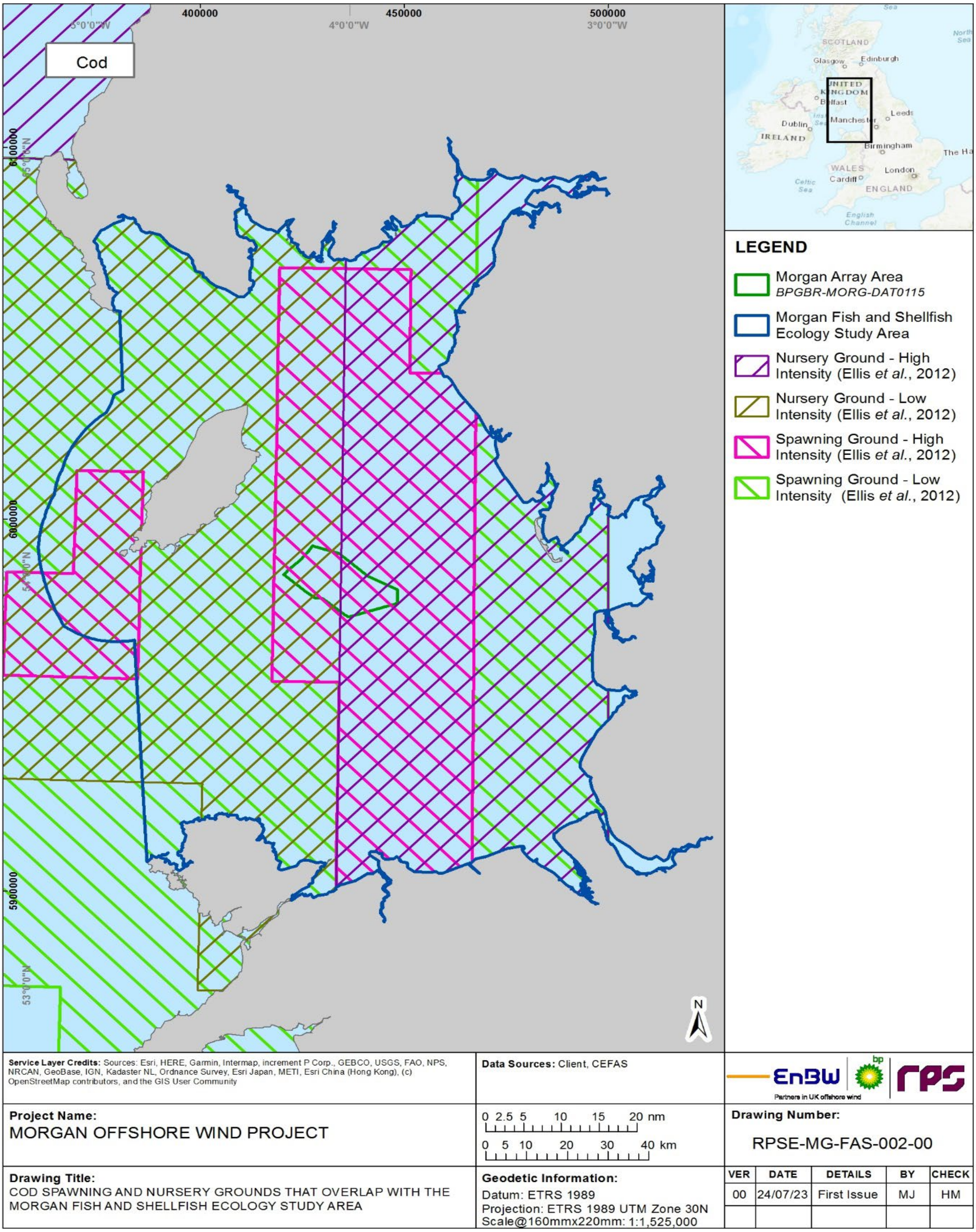
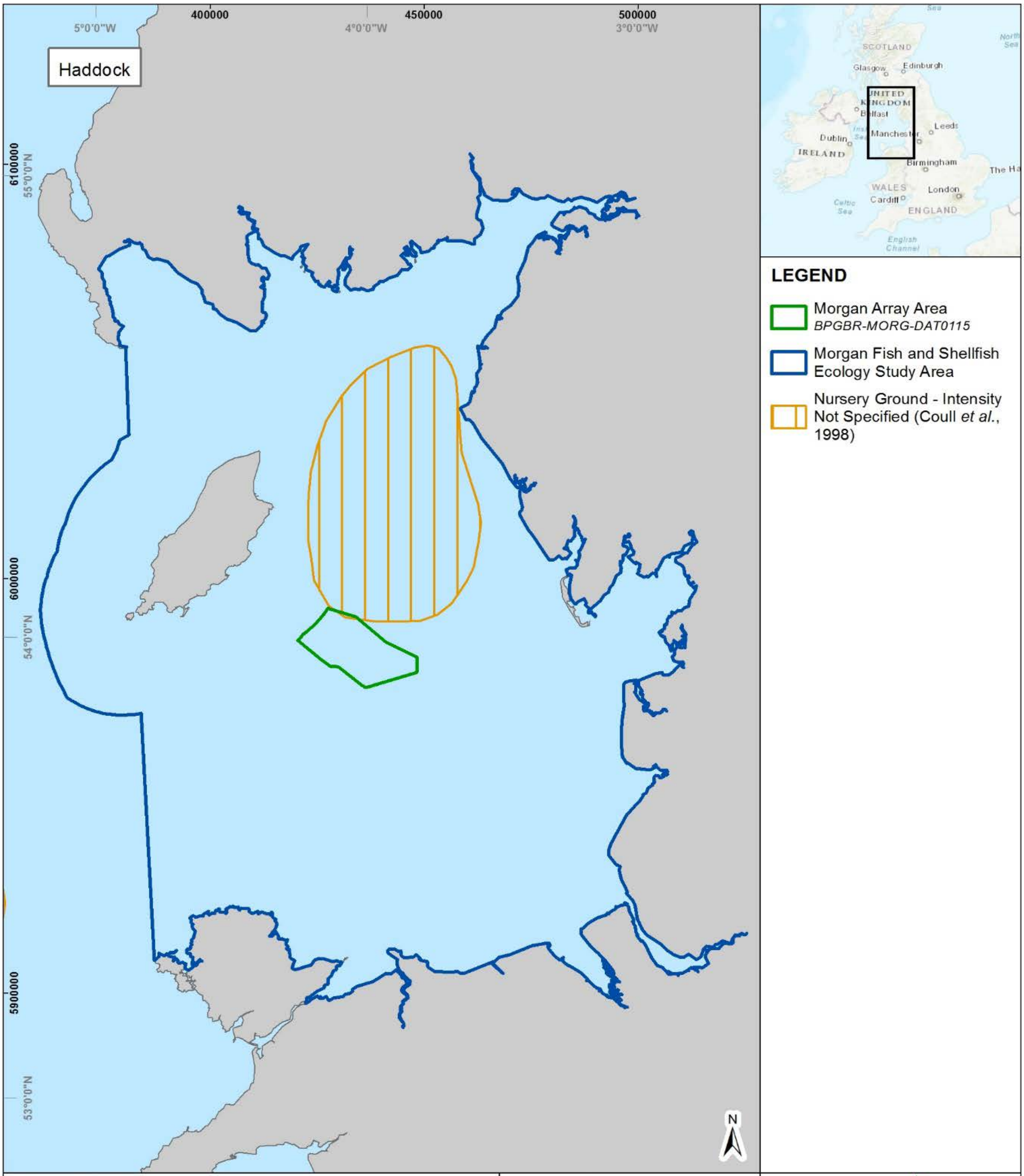


Figure 1.4: Cod spawning and nursery grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

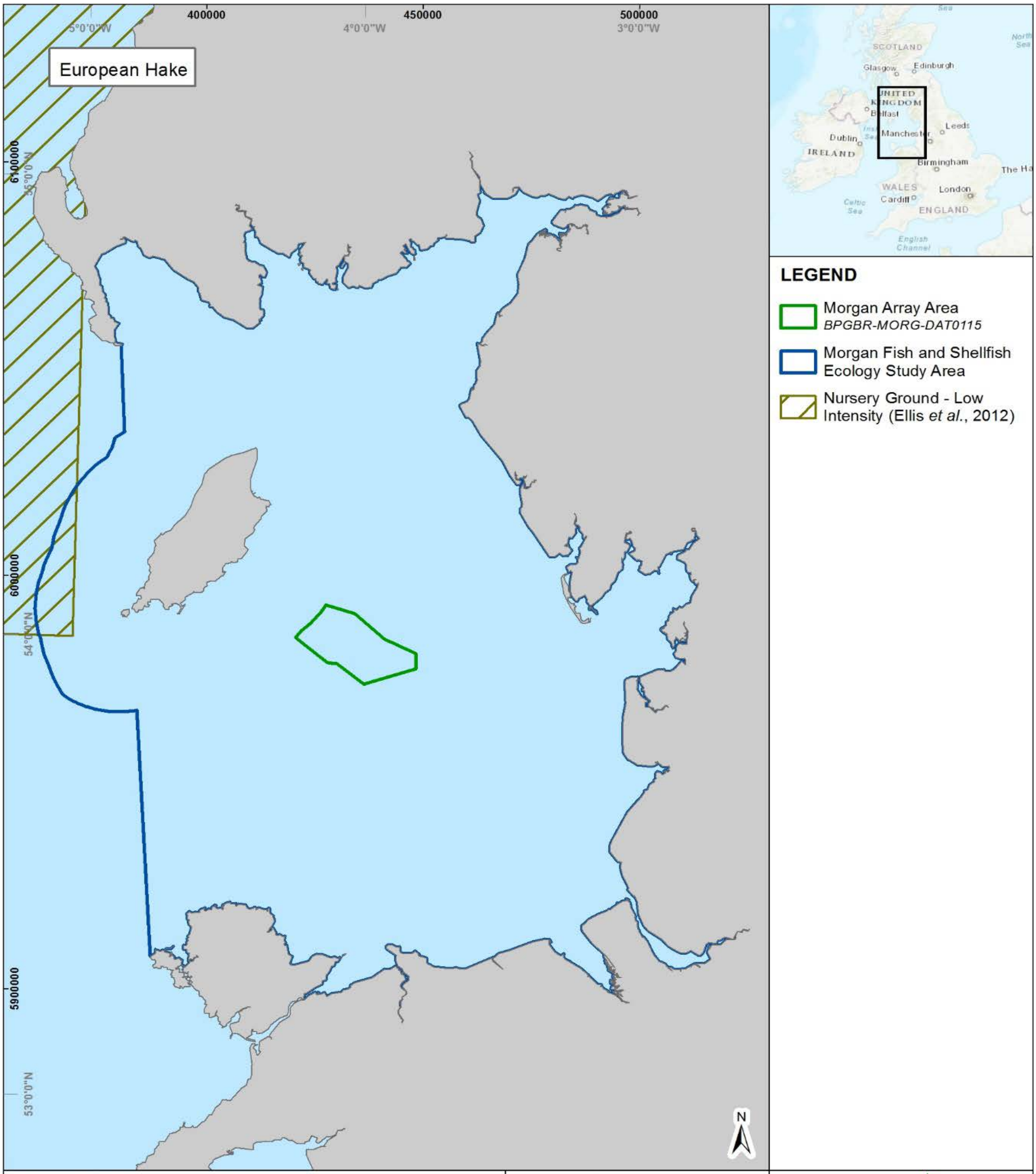
Drawing Number:
RPSE-MG-FAS-003-00

Drawing Title:
HADDOCK NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	24/07/23	First Issue	MJ	HM

Figure 1.5: Haddock nursery grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
RPSE-MG-FAS-005-00

Drawing Title:
EUROPEAN HAKE NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	24/07/23	First Issue	MJ	HM

Figure 1.6: European hake nursery grounds overlapping with the fish and shellfish ecology study area.

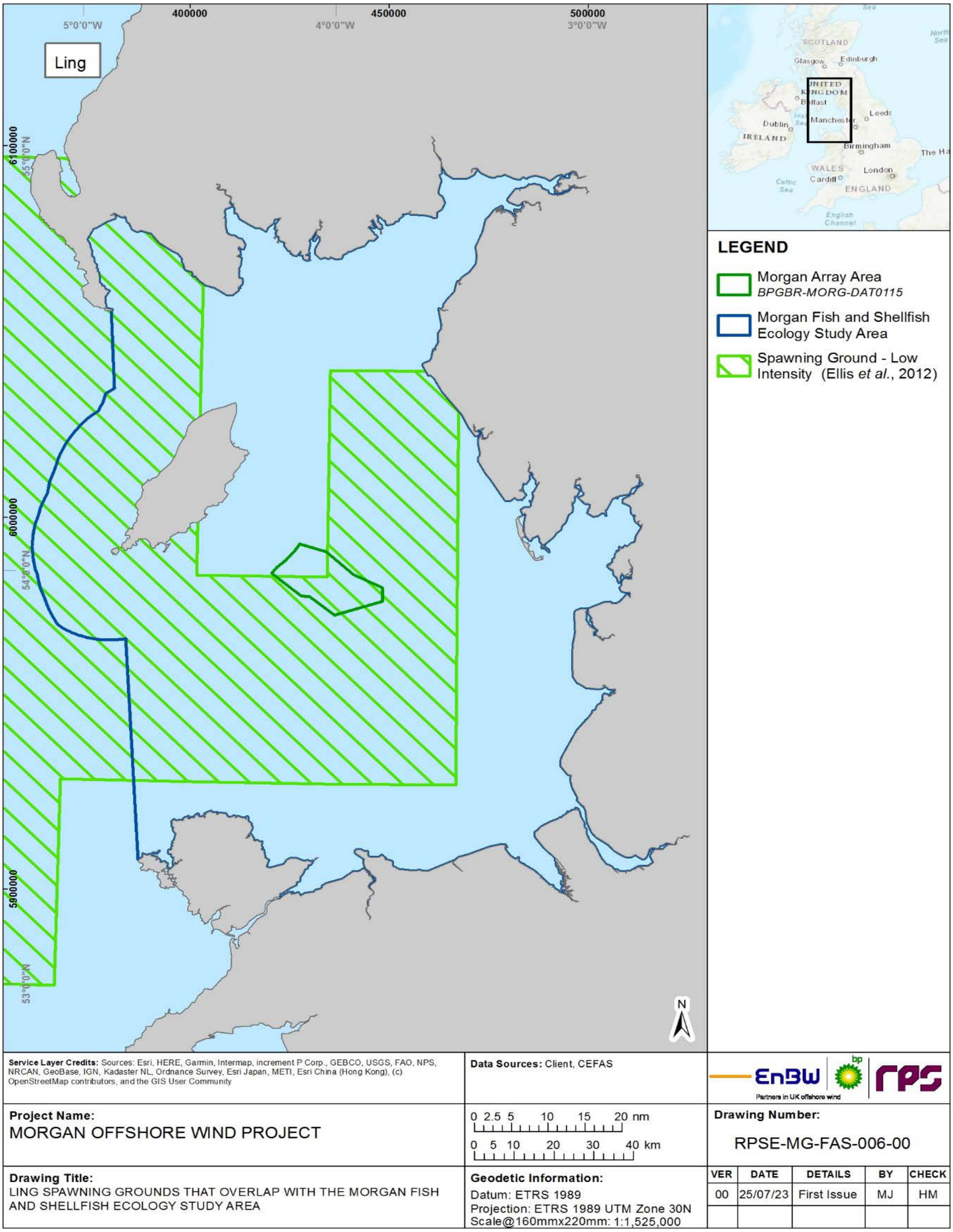
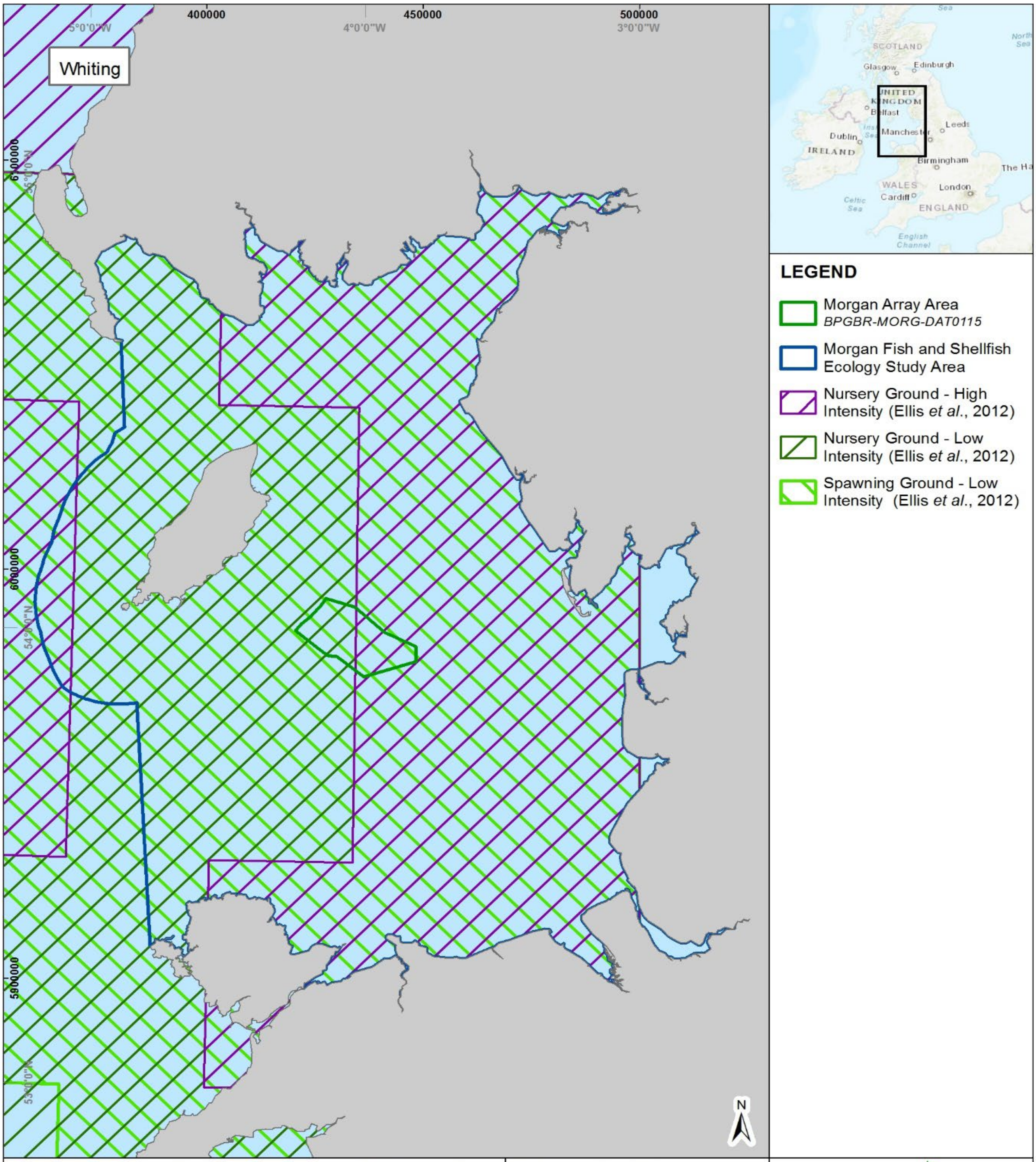


Figure 1.7: Ling spawning grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

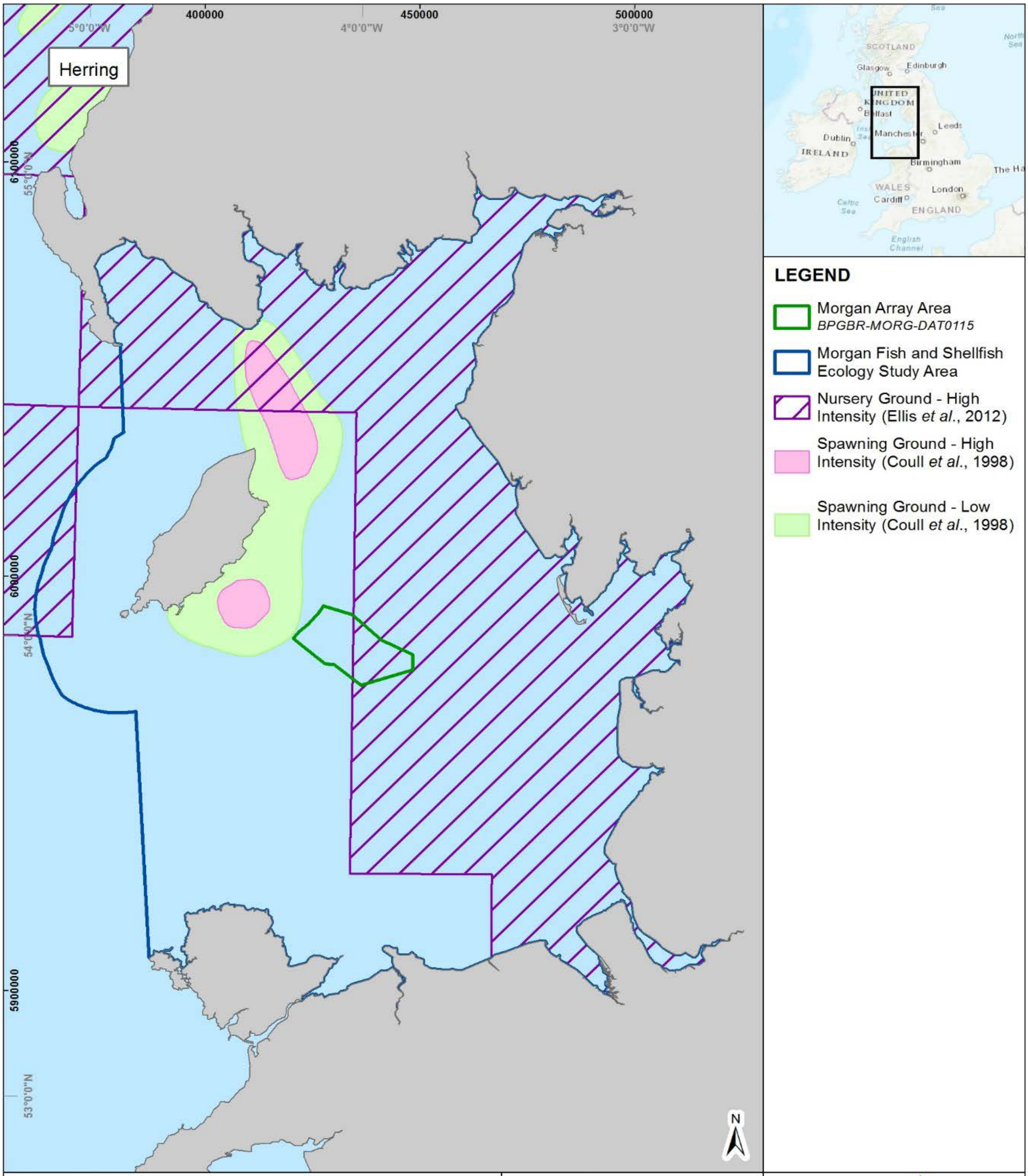
Drawing Number:
RPSE-MG-FAS-007-00

Drawing Title:
WHTING SPAWNING AND NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.8: Whiting spawning and nursery grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

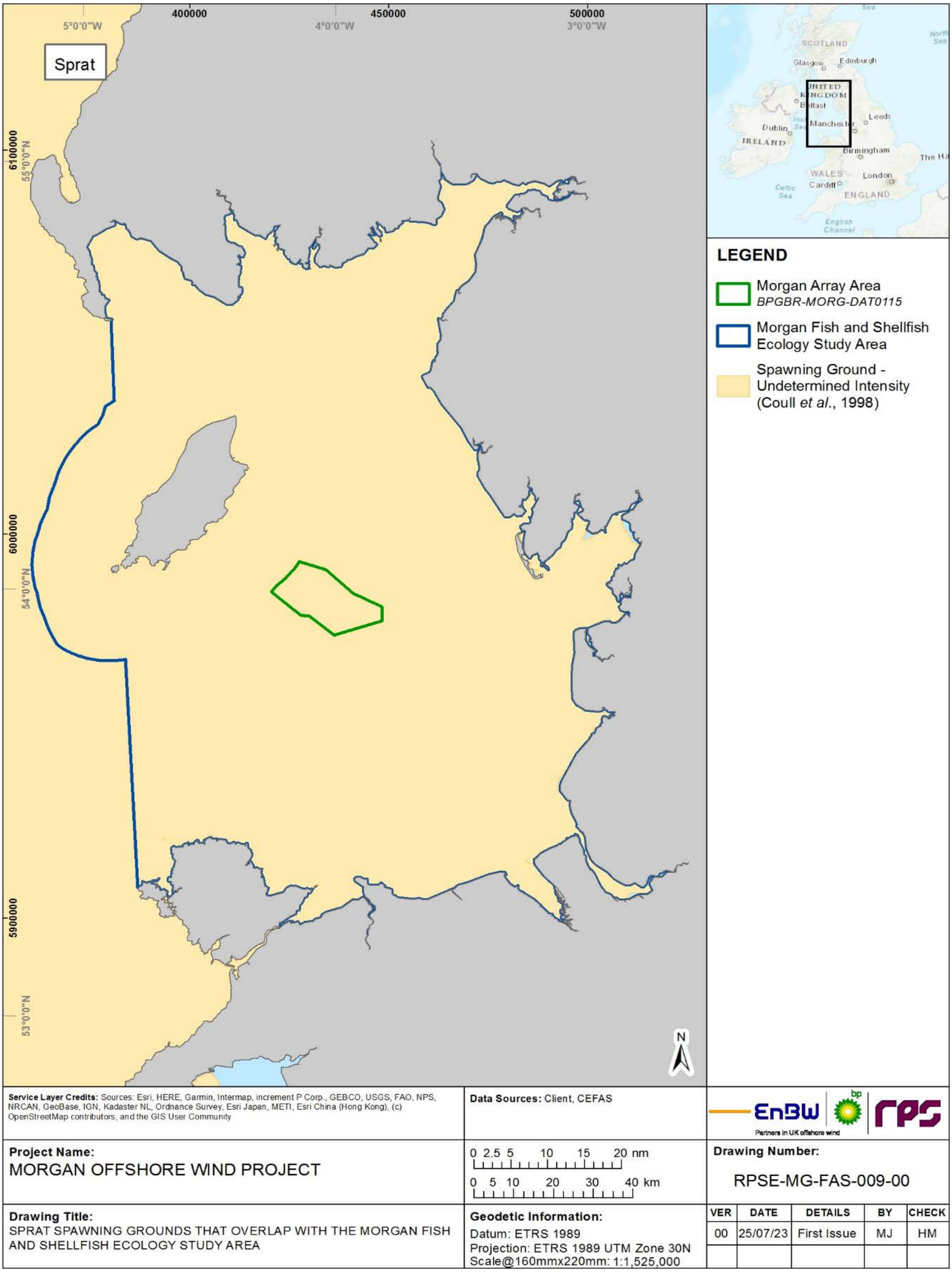
Drawing Number:
RPSE-MG-FAS-008-00

Drawing Title:
HERRING SPAWNING AND NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.9: Herring spawning and nursery grounds overlapping with the Morgan Generation Assets.



🟩 Morgan Array Area *BPGBR-MORG-DAT0115*

🟦 Morgan Fish and Shellfish Ecology Study Area

🟨 Spawning Ground - Undetermined Intensity (Coull *et al.*, 1998)

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

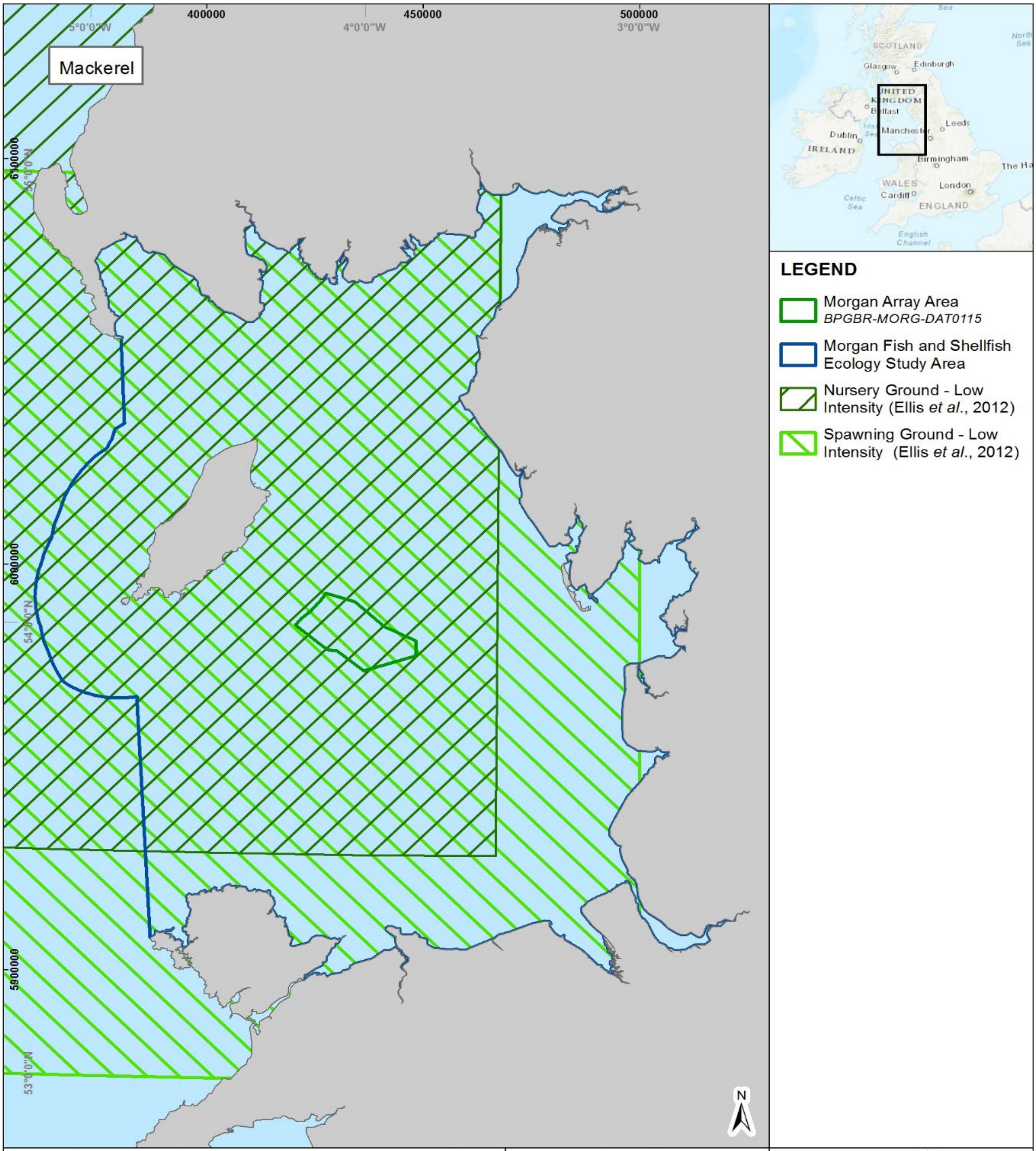
Drawing Number:
RPSE-MG-FAS-009-00

Drawing Title:
SPRAT SPAWNING GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.10: Sprat spawning grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
RPSE-MG-FAS-010-00

Drawing Title:
MACKEREL SPAWNING AND NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.11: Mackerel spawning and nursery grounds overlapping with the Morgan Generation Assets.

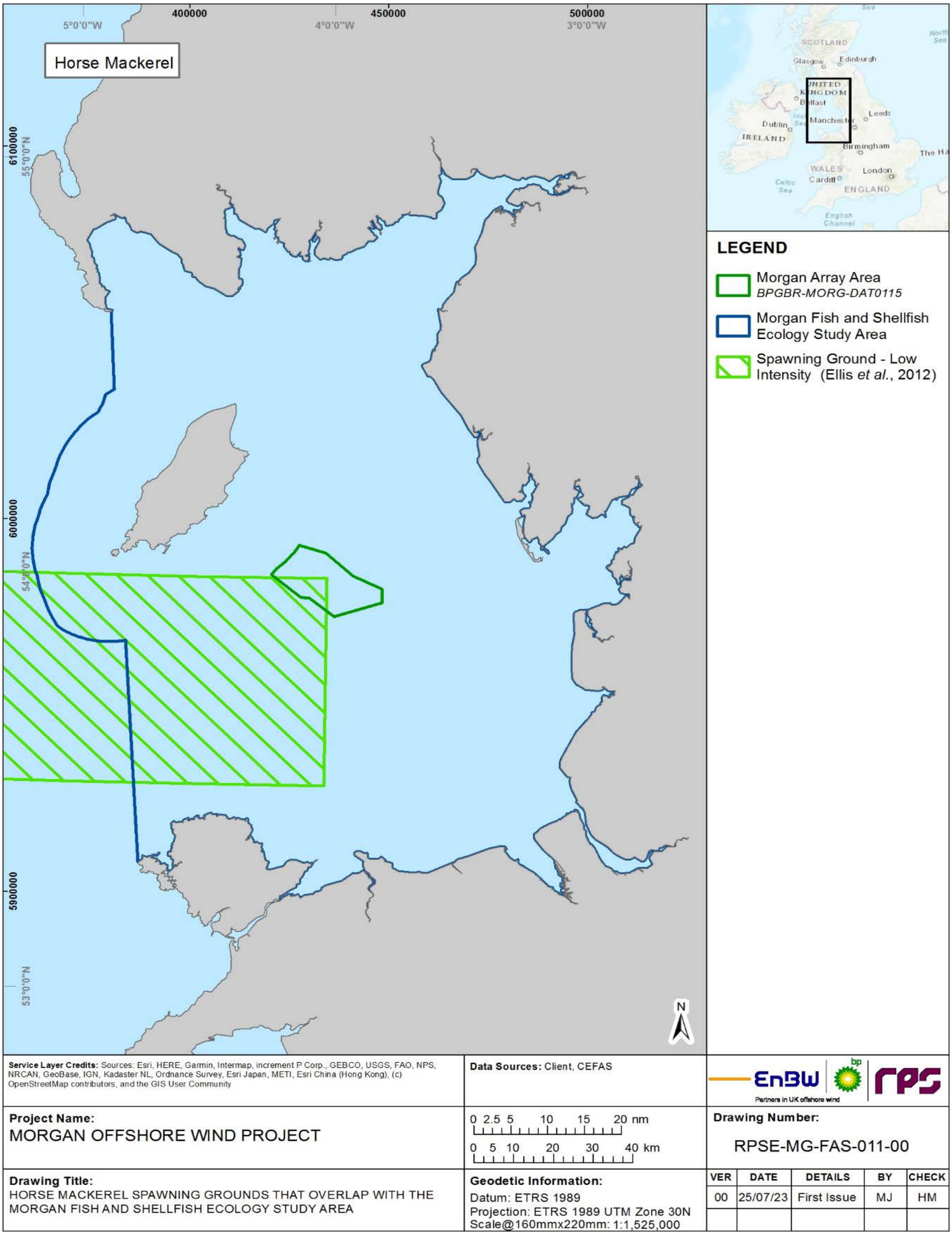
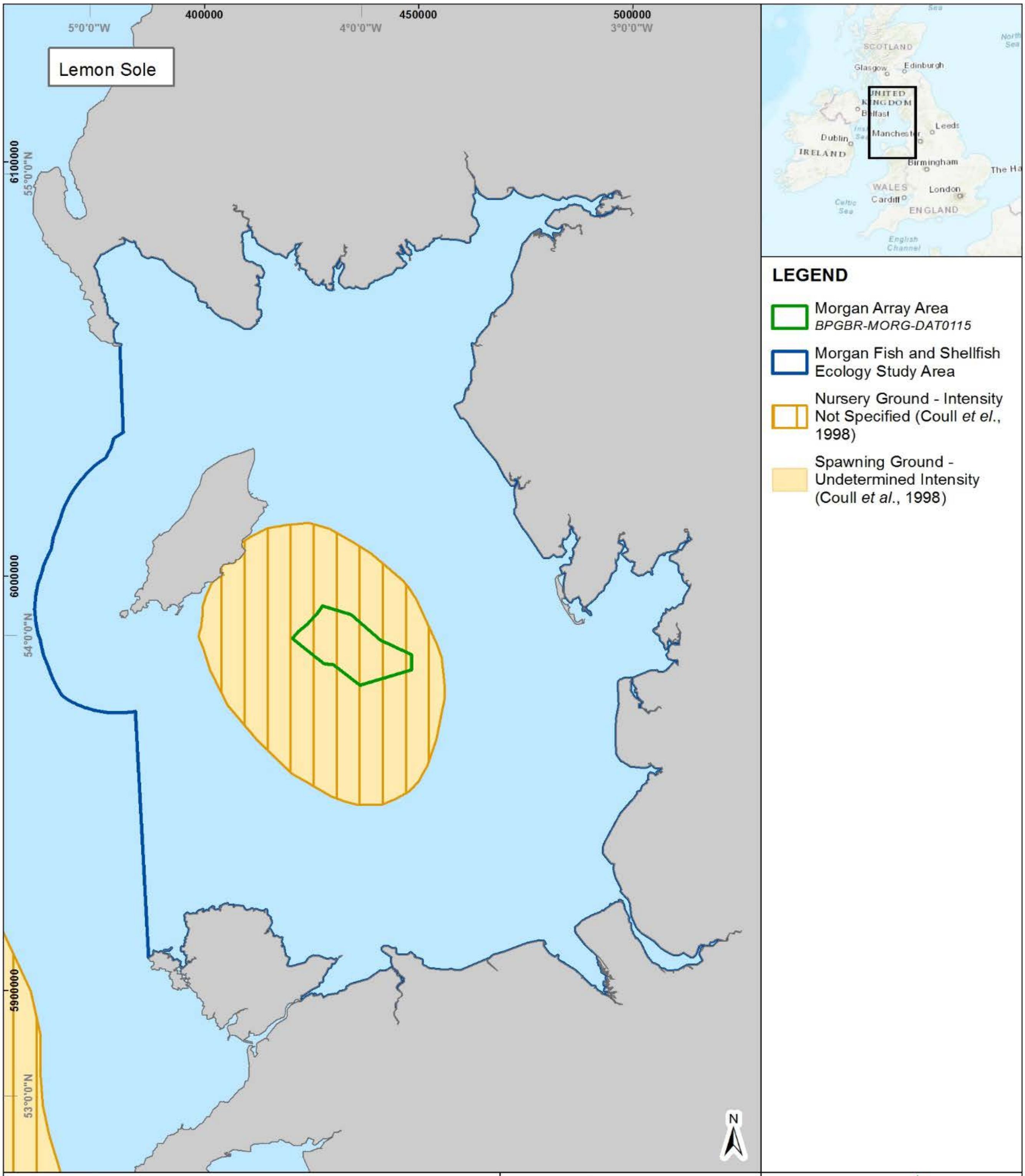


Figure 1.12: Horse mackerel spawning grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
RPSE-MG-FAS-012-00

Drawing Title:
LEMON SOLE SPAWNING AND NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.13: Lemon sole spawning and nursery grounds overlapping with the Morgan Generation Assets.

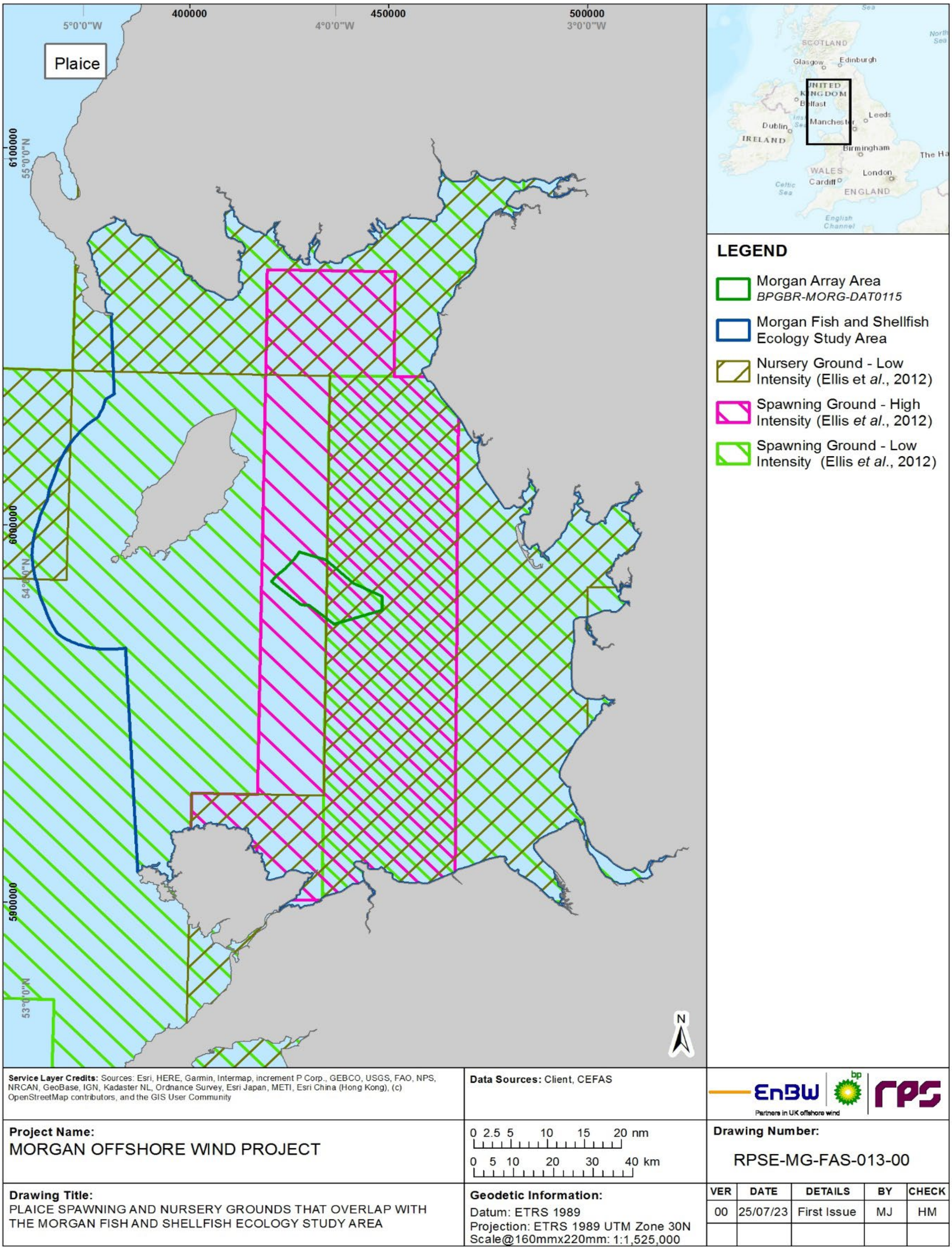
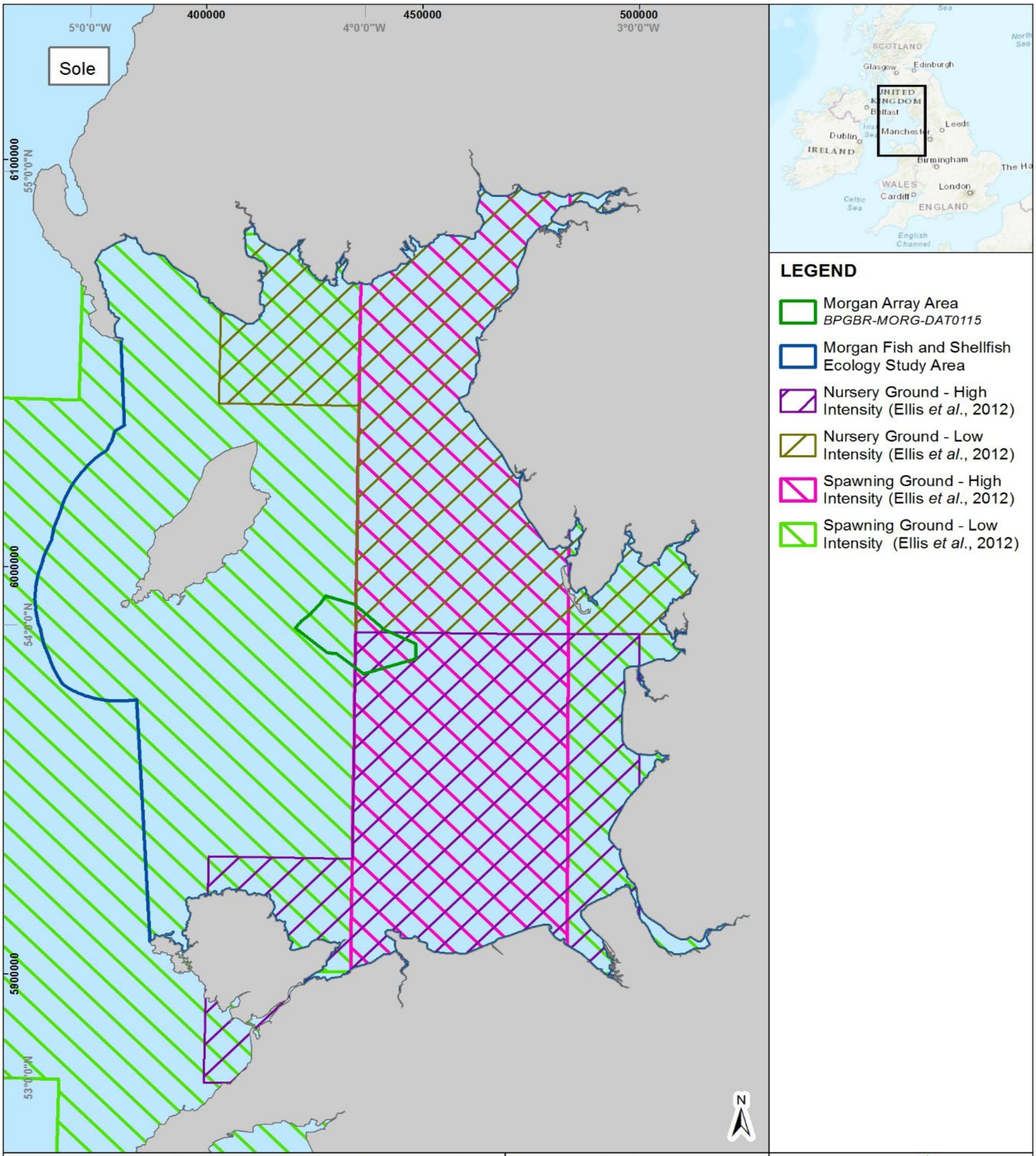


Figure 1.14: Plaice spawning and nursery grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

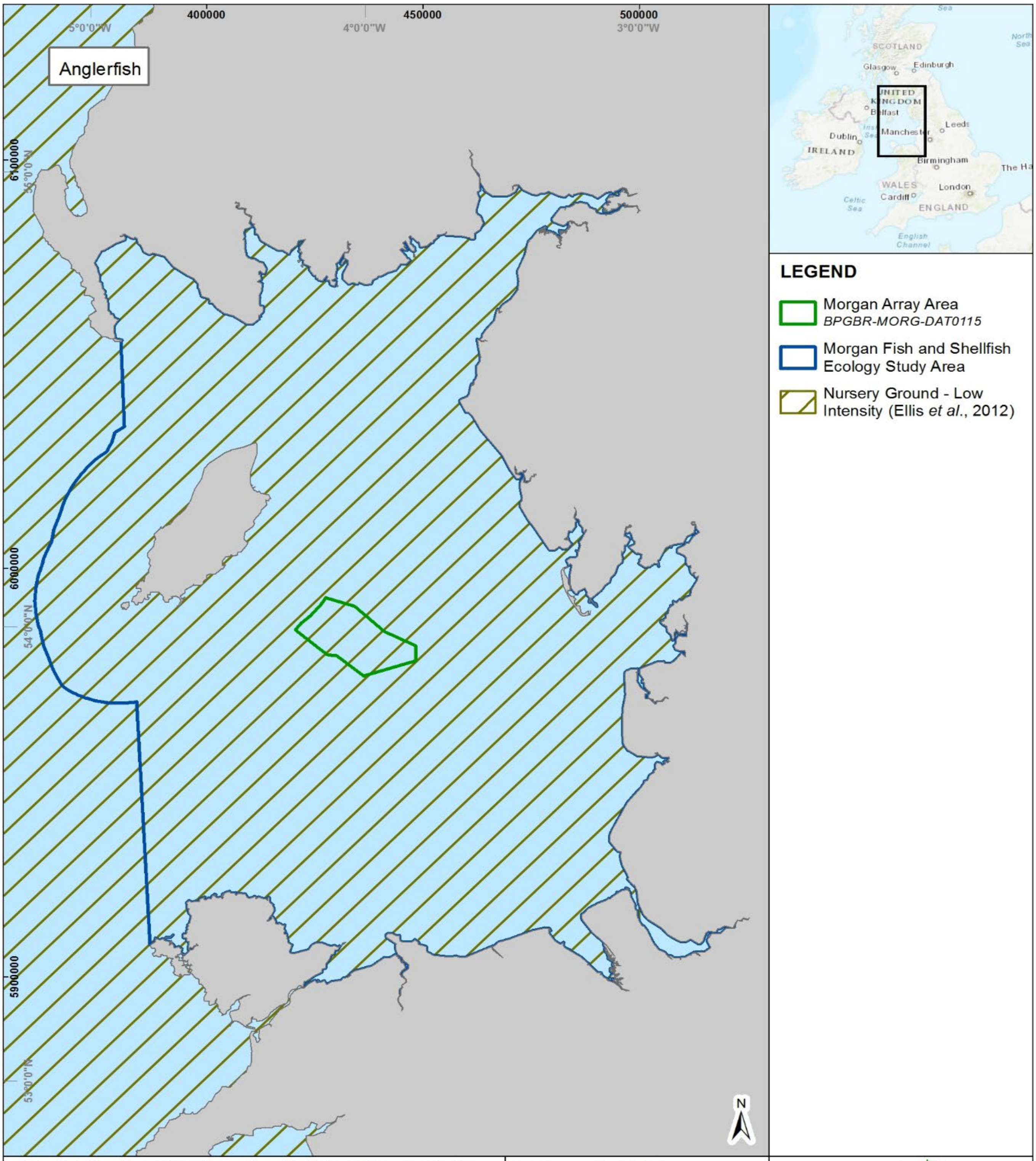
Drawing Number:
RPSE-MG-FAS-014-00

Drawing Title:
SOLE SPAWNING AND NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.15: Sole spawning and nursery grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
RPSE-MG-FAS-015-00

Drawing Title:
ANGLERFISH NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.16: Anglerfish nursery grounds overlapping with the Morgan Generation Assets.

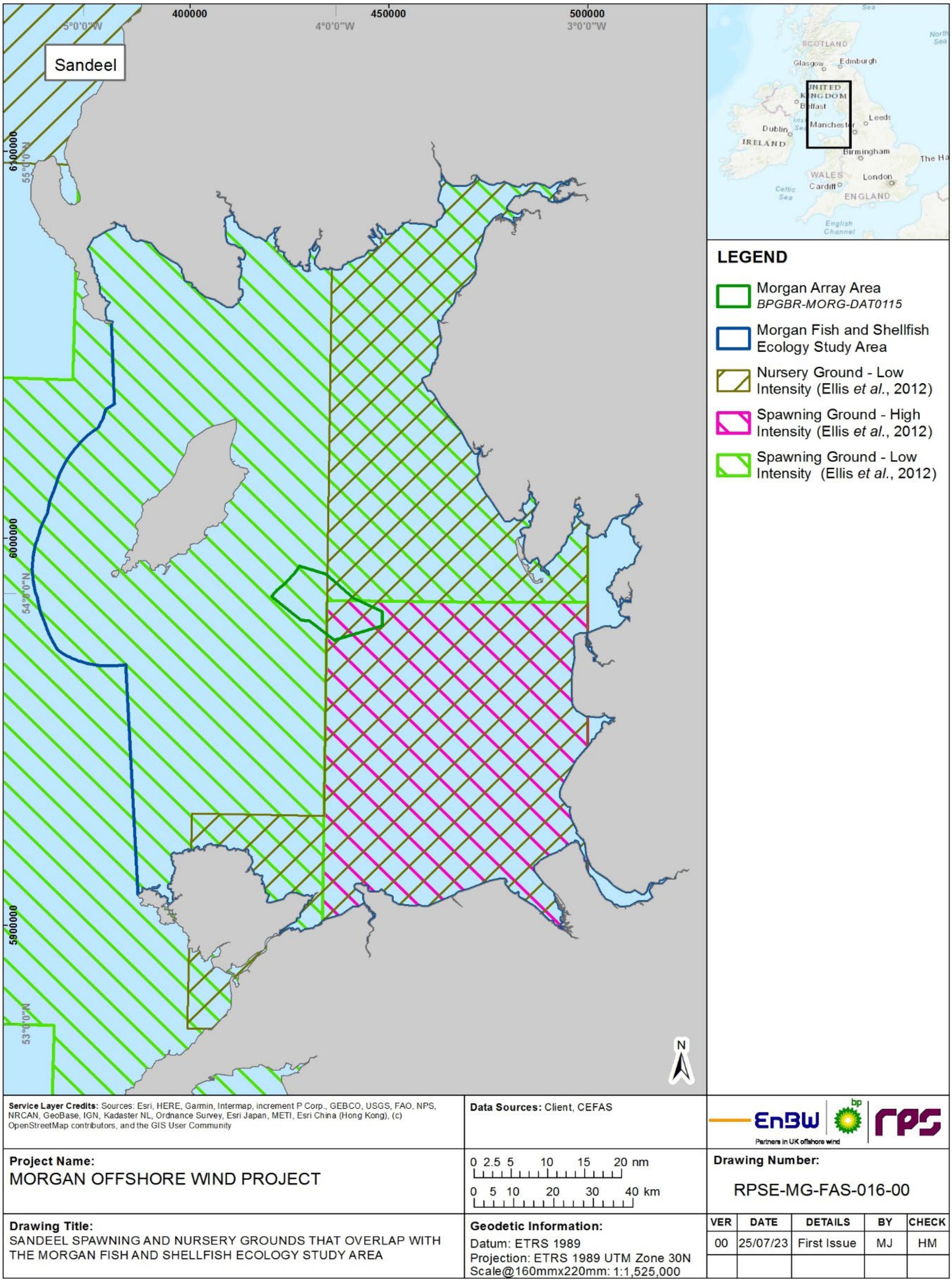
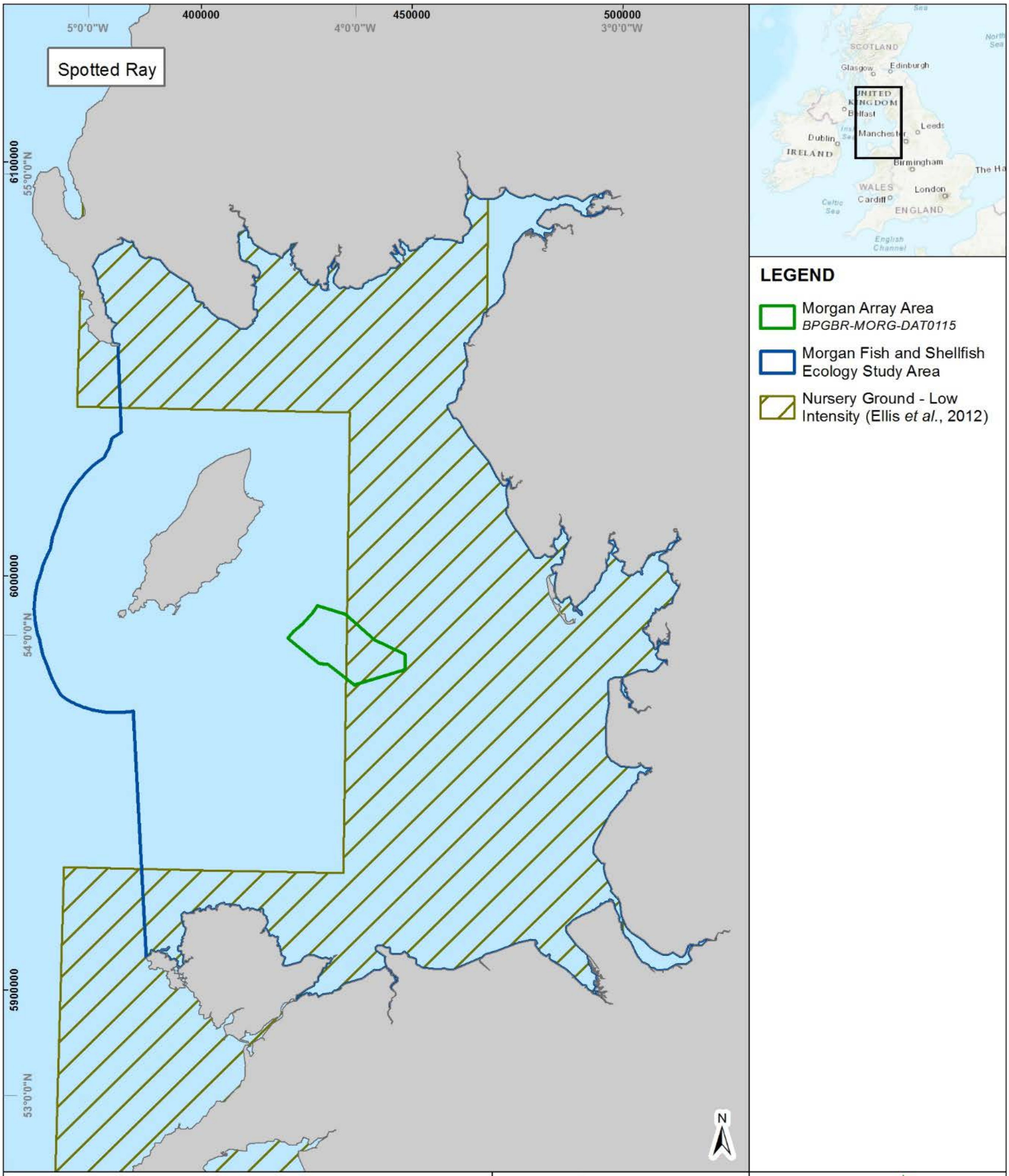


Figure 1.17: **Sandeel spawning and nursery grounds overlapping with the Morgan Generation Assets.**



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

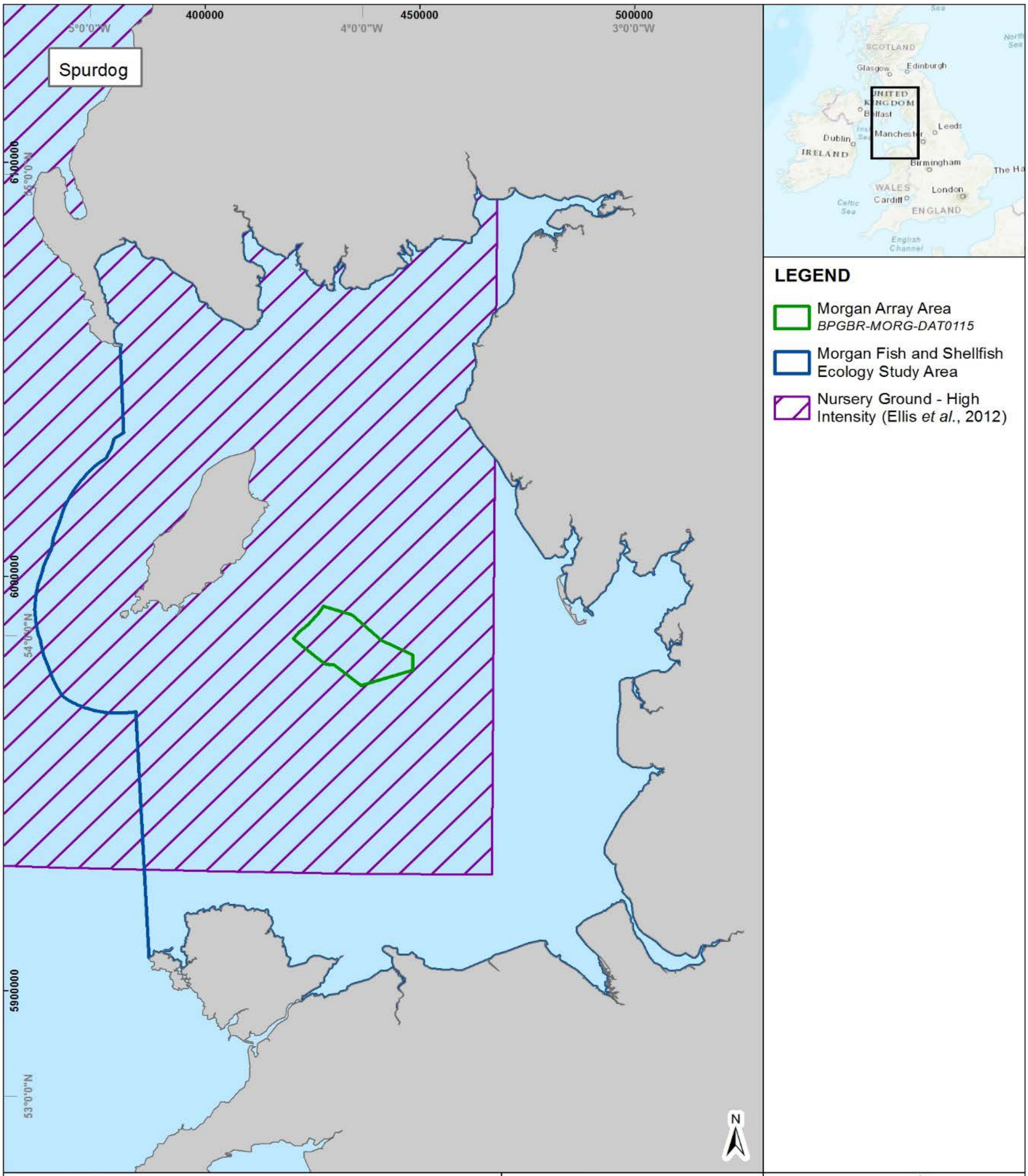
Drawing Number:
RPSE-MG-FAS-017-00

Drawing Title:
SPOTTED RAY NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.18: Spotted ray nursery grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
RPSE-MG-FAS-018-00

Drawing Title:
SPURDOG NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.19: Spurdog nursery grounds overlapping with the Morgan Generation Assets.

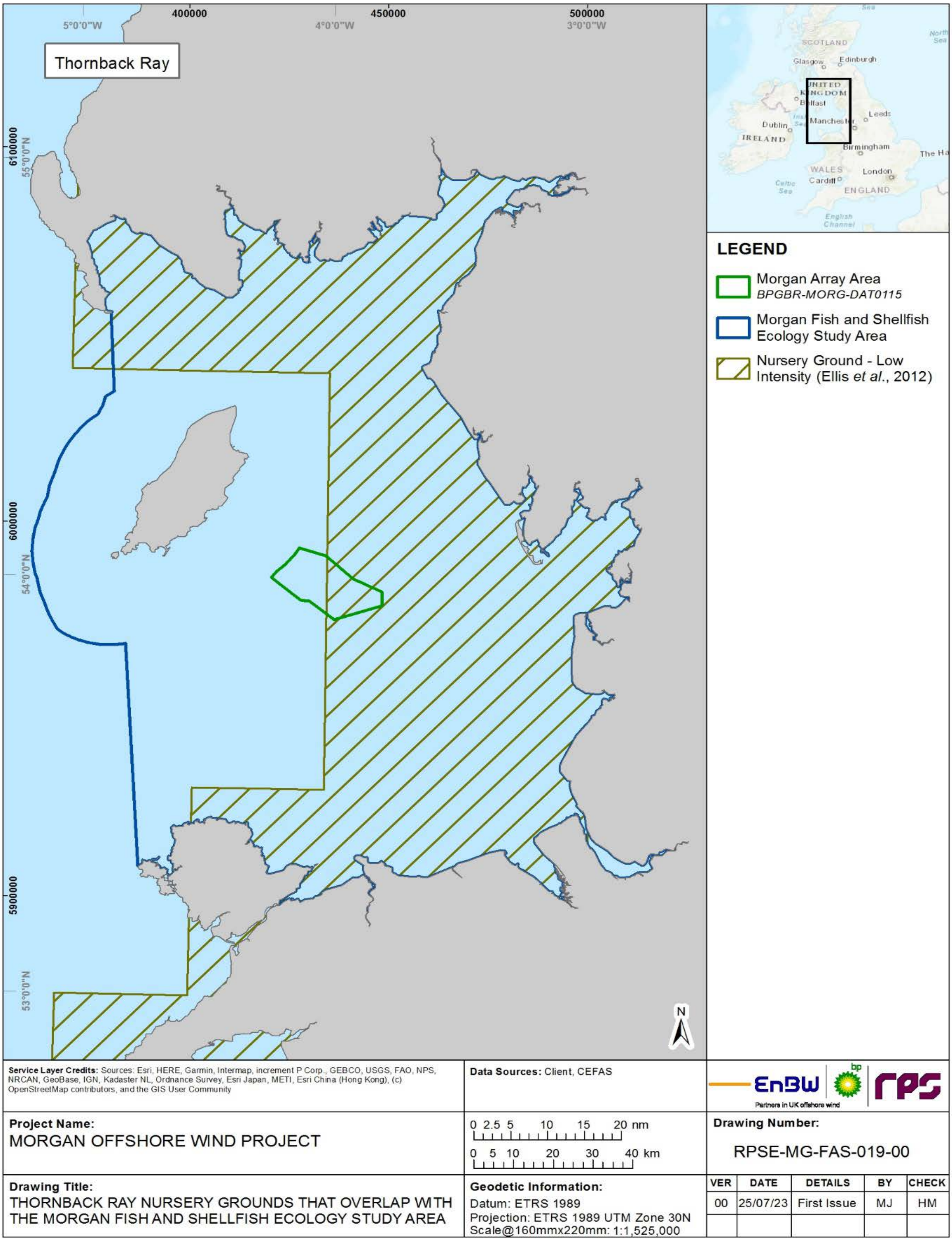
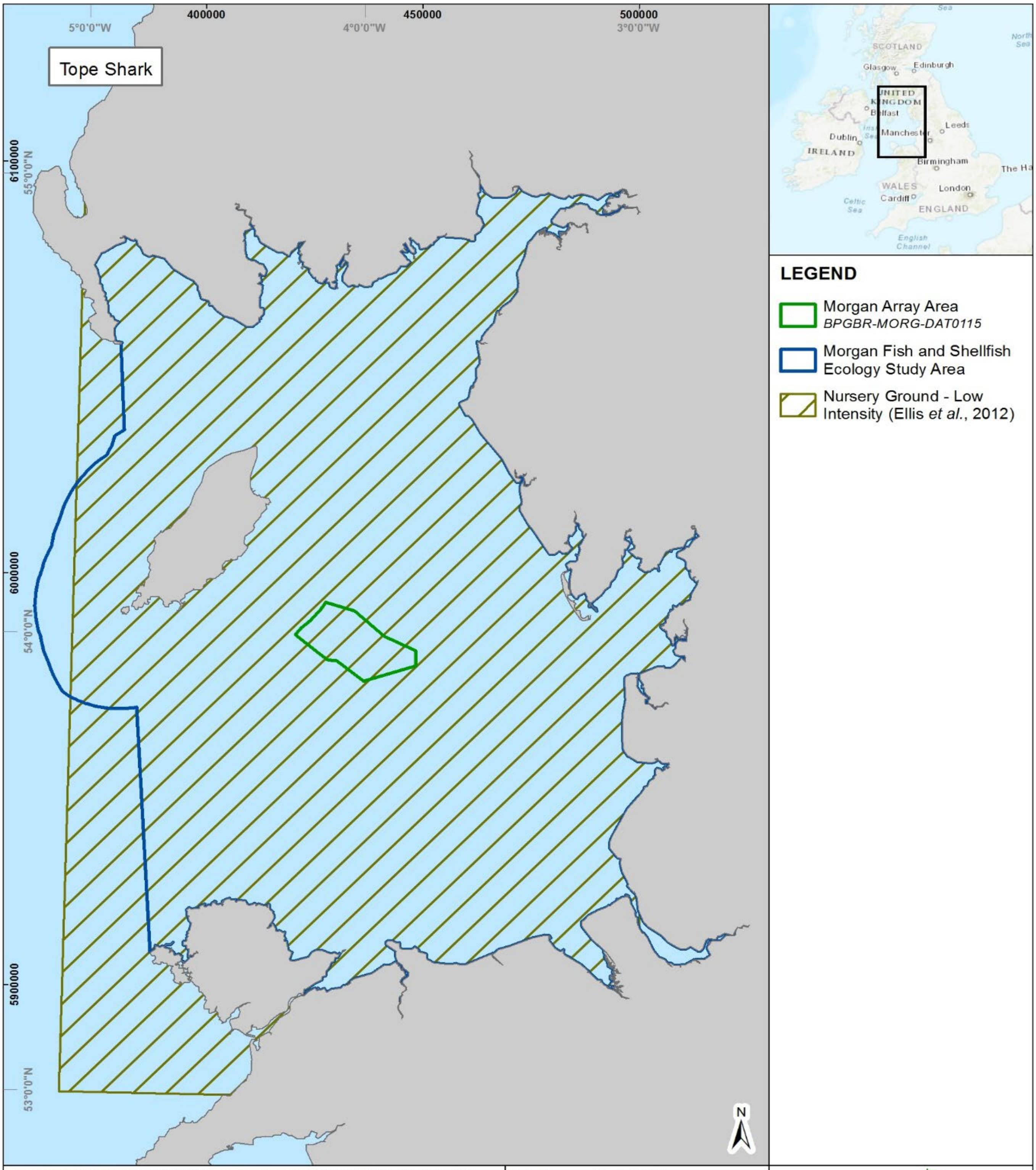


Figure 1.20: Thornback ray nursery grounds overlapping with the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

Drawing Number:
RPSE-MG-FAS-020-00

Drawing Title:
TOPE SHARK NURSERY GROUNDS THAT OVERLAP WITH THE MORGAN FISH AND SHELLFISH ECOLOGY STUDY AREA

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.21: Tope shark nursery grounds overlapping with the Morgan Generation Assets.

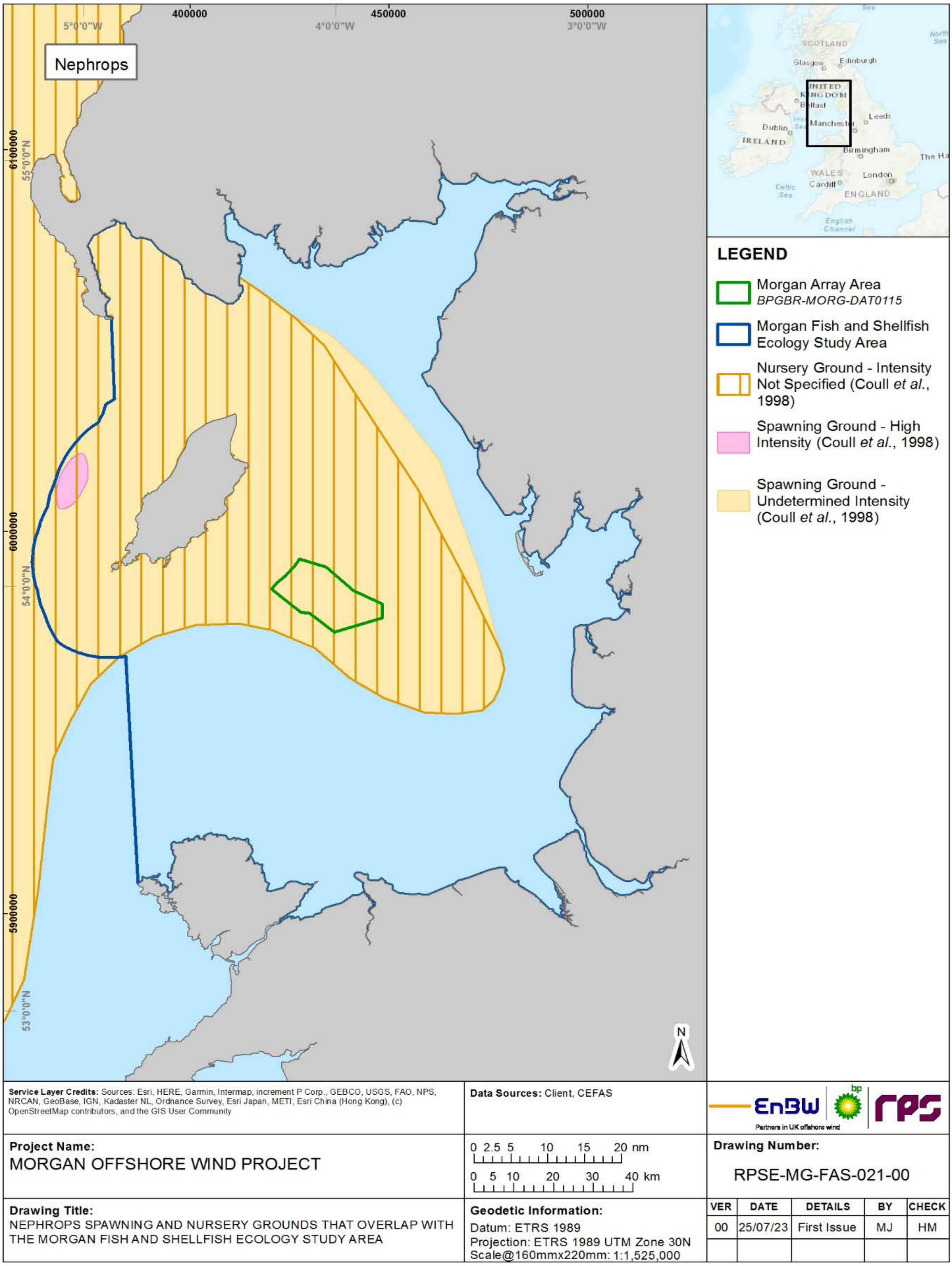


Figure 1.22: ***Nephrops*** **spawning and nursery grounds overlapping with the Morgan Generation Assets.**

1.6 Herring spawning

1.6.1 Desktop study

1.6.1.1 Herring are a commercially and ecologically important pelagic fish species as they are an important prey species for numerous fish, marine mammal, and bird species and are common across much of the Irish Sea (Dickey-Collas *et al*., 2001). Herring is the target of a relatively large fishery; however, it is predominantly targeted by the Scottish fleet, known to target higher volume and lower priced marine species (MMO, 2021).

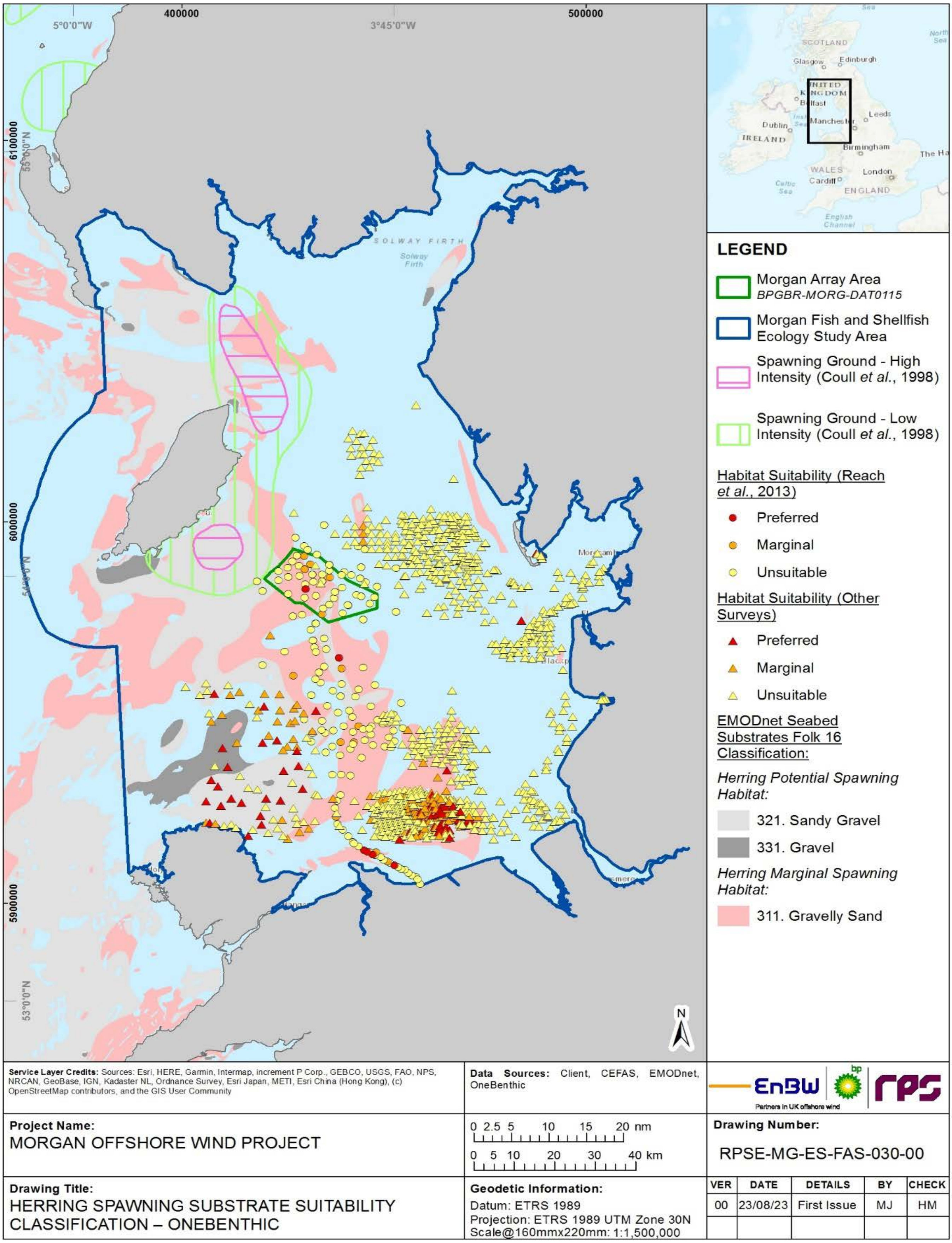
1.6.1.2 Herring are predominantly found in deeper waters in the benthopelagic and pelagic zone and have been observed throughout the Irish Sea. Their core range has been known to include St. George's Channel (at the south boundary of the Irish Sea); however they are also present around the south and west coasts of Ireland and the north coast of Northern Ireland. In the northeast Atlantic, herring are encountered from the north Bay of Biscay to Greenland and into the Barents Sea. The NIGFS has confirmed the presence of schools of herring within the fish and shellfish ecology study area, and broadly around the Morgan Generation Assets in data reviewed for the years 2012 to 2020, indicating a relatively consistent presence over time within this area (ICES, 2022a).

1.6.1.3 Adult herring can be found on continental sea shelfs to depths of 200 m, however they can disperse over the abyssal plains during feeding migrations. Juvenile herring tend to occur in shallower waters, further away from adults and spawning grounds, moving into deeper waters after a couple years. During the daytime hours, herring shoals tend to remain close to the seabed or in deeper waters, moving towards the surface at dusk and dispersing over a wider area during night-time hours (FishBase, 2020f).

1.6.1.4 Herring nursery grounds, as described in section 1.5 and shown in Figure 1.9, are also concentrated inshore of the Morgan Generation Assets (Ellis *et al.,* 2012), with post larvae juveniles up to sub adults that are yet to reach sexual maturity feeding here until migrating to feeding grounds further offshore where they remain until reaching sexual maturity (ICES, 2006).

1.6.1.5 Herring are known to utilise specific benthic habitats during spawning, normally preferring to lay their eggs on gravel, stones or rock (O'Sullivan *et al*., 2013), which increases their vulnerability to activities impacting the seabed. Further, as a hearing specialist, herring can be highly vulnerable to impacts arising from underwater sound. Herring deposit eggs on a variety of substrates from coarse sand and gravel to shell fragments and macrophytes; although gravel substrates have been suggested as their preferred spawning habitat. The peak spawning months are known to be September and October for the Mourne stock and the Isle of Man stock, with an approximately 8 km^2 area to the south of Douglas highlighted as a significant spawning ground (Bowers, 1969), relatively close to the north of the Morgan Generation Assets. This was supported and expanded by Coull *et al*. (1998) and evidenced around the entire east of the Isle of Man up to at least 2021 through collection of NINEL data (ICES, 2022a). Once spawning has taken place, the eggs take approximately three weeks to hatch after which larvae become planktonic (Dickey-Colas *et al.,* 2010; Ellis *et al*., 2012).

1.6.1.6 A detailed review of herring spawning has been undertaken following guidelines set out by Boyle and New (2018) and Reach *et al*. (2013) considering seabed sediment type and herring larval abundances. Sediment data for the fish and shellfish ecology study area from the OneBenthic tool has been classified using the defined process for herring suitability assessment and is presented in Figure 1.23, combined with site-specific survey results from the 2021 and 2022 benthic subtidal ecology surveys for the Morgan Generation Assets.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS, EMODnet, OneBenthic

Project Name:
MORGAN OFFSHORE WIND PROJECT

Drawing Number:
RPSE-MG-ES-FAS-030-00

Drawing Title:
HERRING SPAWNING SUBSTRATE SUITABILITY CLASSIFICATION – ONEBENTHIC

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	23/08/23	First Issue	MJ	HM

Figure 1.23: OneBenthic and site-specific survey data showing suitability of sediment within the fish and shellfish ecology study area for herring spawning.

1.6.2 Site-specific surveys

Particle size data

1.6.2.1 As outlined in section 0, site-specific survey data were collected in 2021 alongside desktop studies to assess the extent of suitable spawning habitat within the Morgan Array Area. Grab sampling was completed, and PSA was undertaken on the sediment samples collected which allowed classification of the sediment types according to Reach *et al*. (2013), as described in Table 1.5. These classifications were originally developed for the marine aggregates industry, drawing on work investigating spatial interactions between the aggregate application areas and herring spawning habitat.

Table 1.5: Herring potential spawning habitat sediment classifications derived from Reach *et al*. (2013).

%Contribution (mud = <63 µm)	Habitat sediment preference (adapted from Reach *et al.* (2013)	Habitat sediment classification (adapted from Reach *et al.* (2013)
<5% mud, >50% gravel	Prime	Preferred
<5% mud, >25% gravel	Sub-prime	Preferred
<5% mud, >10% gravel	Suitable	Marginal
>5% mud, <10% gravel	Unsuitable	Unsuitable

1.6.2.2 Habitat suitability classifications for herring spawning, based on site-specific data, illustrated that the sediment composition at the stations sampled within the Morgan Generation Assets is almost entirely unsuitable for herring spawning. Just four stations out of 35 within the Morgan Array Area sampled in 2021 were considered suitable for herring spawning (one preferred and three marginal habitats). These stations were sparsely distributed in the north (three stations) and south of the site (one station; Gardline, 2022).

1.6.2.3 Of the 26 stations sampled in 2022 within the Morgan Generation Assets, including the ZoI, one station (ENV002) in the west of the Morgan Array Area was found to have sediment characteristics preferred for herring spawning, based on the criteria set out by Reach *et al*. (2013). Also, one station (ENV011) in the centre north of the Morgan Array Area was found to have the sediment characteristics of marginal spawning ground. All sampled stations within the wider ZoI surrounding this area were found to be unsuitable, with mud concentrations being too high for herring spawning at most stations.

1.6.2.4 Although the Morgan Array Area was predominantly comprised of sand and gravel substrates, which are considered optimal for herring spawning, results illustrated that the majority of the surveyed stations comprised mud content in excess of 5%, rendering the sediments within the Morgan Array Area as unsuitable for herring spawning.

1.6.2.5 Figure 1.24 illustrates collated 2021 and 2022 site-specific survey data alongside European Marine Observation and Data Network (EMODnet) seabed substrate data. The EMODnet seabed substrate data can also be used to assign habitat suitability for herring spawning, showing sandy gravel and gravel as preferred spawning habitat and gravelly sand as marginal spawning habitat. Where no shading is present, the habitat in that area is unsuitable for herring spawning. Overall, the majority of the Morgan

Array Area is considered unsuitable habitat for herring spawning, with a patchy distribution of overall five marginal (suitable, with the additional four stations being added from the inclusion of the 2021 survey data) and one preferred (sub-prime) habitat. These results are in line with the EMODnet broadscale seabed substrate data within the Morgan Array Area.

1.6.2.6 The EMODnet seabed substrate data (Folk, 1954) is of lower resolution and accuracy than the results of the site-specific survey data but provides an overall broadscale picture of the surrounding substrate. The site-specific samples which were characterised as preferred were mostly associated with gravelly sand but were recorded as a mosaic between stations otherwise classified as unsuitable and marginal habitat for herring spawning. This highlights the fine scale sediment variability within the east Irish Sea, which the broadscale EMODnet substrate data is not able to fully represent.

1.6.3 Northern Irish Herring Larvae Survey

1.6.3.1 As outlined above, herring spawning grounds can be identified through monitoring of herring larval abundances, alongside data on sediment type. The NINEL conducts monitoring programmes in November each year in the Irish Sea (ICES, 2022a). Herring larvae are identified as being recently hatched by their size, and therefore small herring larvae can be assumed to have been hatched recently and in close proximity to the area where eggs were laid. The NINEL datasets present raw herring larvae counts with flowrates and haul depths, which were used to calculate the number of larvae per m^2, with larvae <10 mm long used as a cut off point for recently spawned larvae (in line with standard International Herring Larvae Survey practice).

1.6.3.2 It should be noted that the NINEL datasets, despite being useful indicators of specific herring spawning locations, are considered to underestimate of the true recruitment numbers in this area, which is up to orders of magnitude higher in some cases (Dickey-Collas and Nash, 2001). The NINEL surveys were re-evaluated in 2012 and are no longer used in Irish Sea stock assessments due to recorded herring larval abundances underestimating populations to such a large extent, when compared to acoustic surveys in the area (ICES, 2012). However, the survey is still conducted annually, and has been used in this report because of the value of having a long-term dataset based on standardised methods to indicate the spatial coverage of the herring spawning grounds. These can also, to some degree, act as an indicator of changes in broader spawning patterns over time.

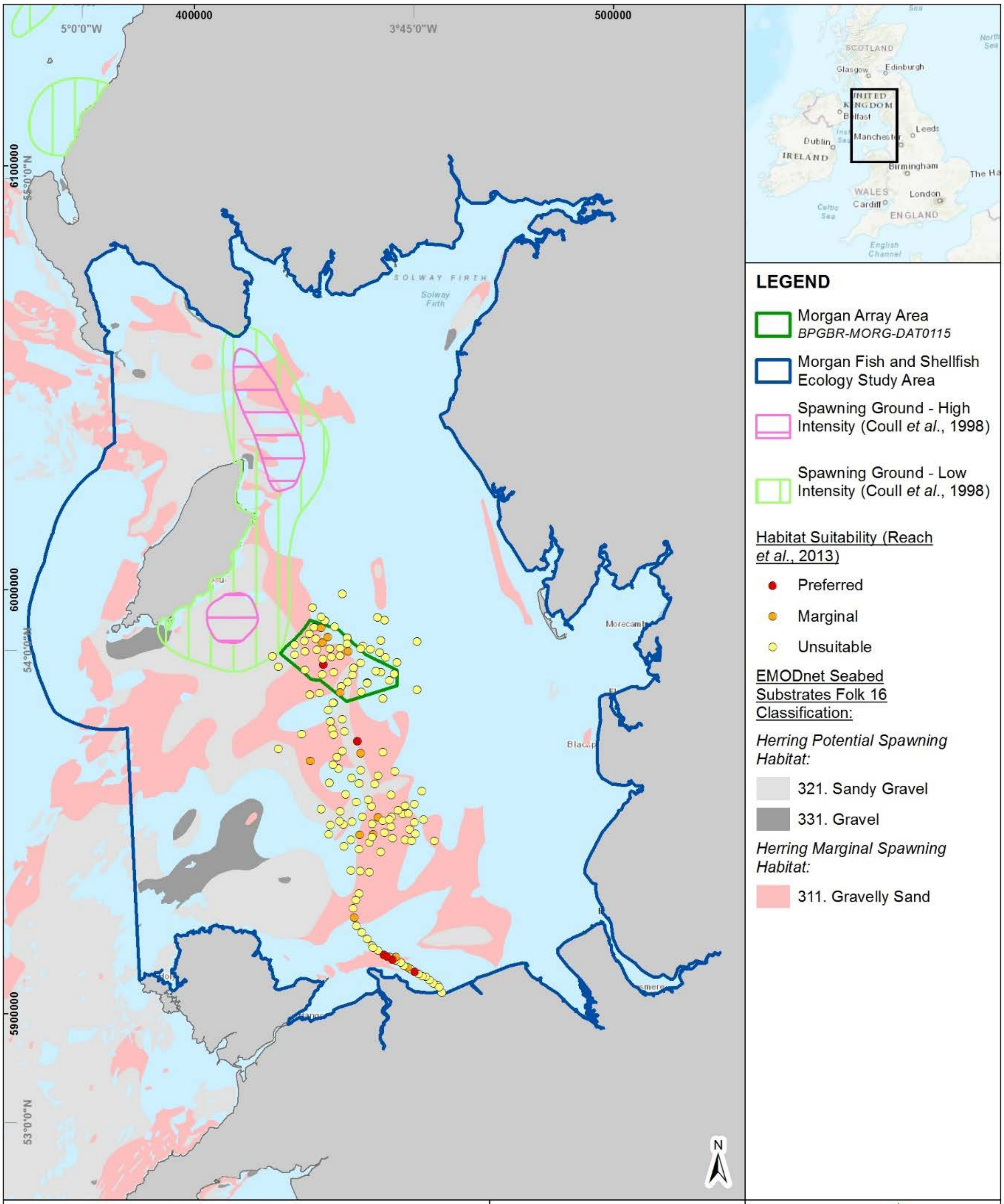
1.6.3.3 Recently spawned larvae will not have drifted far from the location where eggs were spawned on the seabed and high abundances of these larvae are therefore a good indication of recent spawning activity local to where these were sampled. These data were plotted for each year from 2012 to 2021 in Figure 1.25 to Figure 1.29 showing the changing spatial distribution of herring spawning over time relative to areas of historical spawning grounds as identified by Coull *et al*. (1998), in line with guidance from Boyle and New (2018). In addition, larval densities from 2012 to 2021 have been aggregated and plotted as a heatmap in Figure 1.30 to highlight areas of consistently higher larval densities.

1.6.3.4 These data show that the spawning area directly northwest of the Morgan Generation Assets identified by Coull *et al*. (1998) has consistently shown evidence of recent spawning, albeit at relatively low abundances, with up to 24.3 individuals per m^2. Notably, the average numbers of herring larvae decreased overall between 2012 and 2021, dropping to a minimum of 0.73 herring larvae per m^2 in 2018, but rising again to an average of 4.05 herring larvae per m^2 in 2021. The highest average was found in

2013 (4.7 herring larvae per m^2), however this result demonstrates skew based on low numbers of herring larvae in places. The highest individual number of herring larvae per m^2 (24.3) was found in 2017, highlighting very high interannual variability as a limitation of this dataset when examining spawning population densities. This interannual variability in spawning population size is a well-documented feature of the Irish Sea Mourne Herring Stock (Marine Institute, 2021), likely due to regular mixing with the Celtic Sea Herring Stock. The NINEL data therefore does capture this variability generally but gives large underestimates of actual population densities. Acoustic data indicate populations of up to approximately 50,000 tonnes of herring in the same area overall (ICES, 2020), with approximately 49% of the population in the 2020 survey being herring of 0-1 years old (ICES, 2021b). Spatial variability of larval densities within the NINEL data is likely from variations in ocean and tidal current speeds and direction over time. The surveys were carried out in the same month each year directly following the spawning period of the Mourne stock of herring (Table 1.4) thus controlling for any variability potentially caused by changes in survey timings.

1.6.3.5 As noted above, the NINEL dataset is useful as a spatial indicator of spawning grounds, due to being a repeated survey covering approximately the same area across the north Irish Sea. Specifically, the spatial distribution seen in the NINEL data, with the highest herring larvae densities to the southeast and northeast of the Isle of Man, matches the high intensity grounds identified by Coull *et al*. (1998; Figure 1.24), with a broad distribution of low intensity spawning surrounding these areas in all years from 2012 to 2021. This is supported by the heat map generated using 10 years of aggregated larval density data (2012 to 2021), shown in Figure 1.30. Figure 1.24 shows the area of high intensity spawning southeast of the Isle of Man, and north and northwest of the Morgan Generation Assets, being predominantly sandy gravel (EMODnet Folk Classification 321), and the high intensity spawning area northeast of the Isle of Man has a mix of sandy gravel and gravelly sand (EMODnet Folk Classification 311).

1.6.3.6 No high intensity spawning grounds identified by Coull *et al*. (1998) overlap with any part of the Morgan Array Area, and the NINEL data shows highly variable low to medium intensity larval densities throughout the entire north of the fish and shellfish ecology study area. This is supported by the habitat suitability data from both site-specific sampling effort and EMODnet (following classifications in Reach *et al*., 2013), as shown in Figure 1.24. The large patches of gravelly sand and >5% mud content reported provide unsuitable spawning habitat throughout much of the Morgan Array Area, with only four areas of preferred and marginal spawning habitat identified out of 35 stations in 2021 (Gardline, 2022), and two preferred and marginal habitat stations in similar areas within the Morgan Generation Assets in 2022 (Gardline, 2023).



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS, EMODnet

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 nm
0 5 10 20 30 40 km

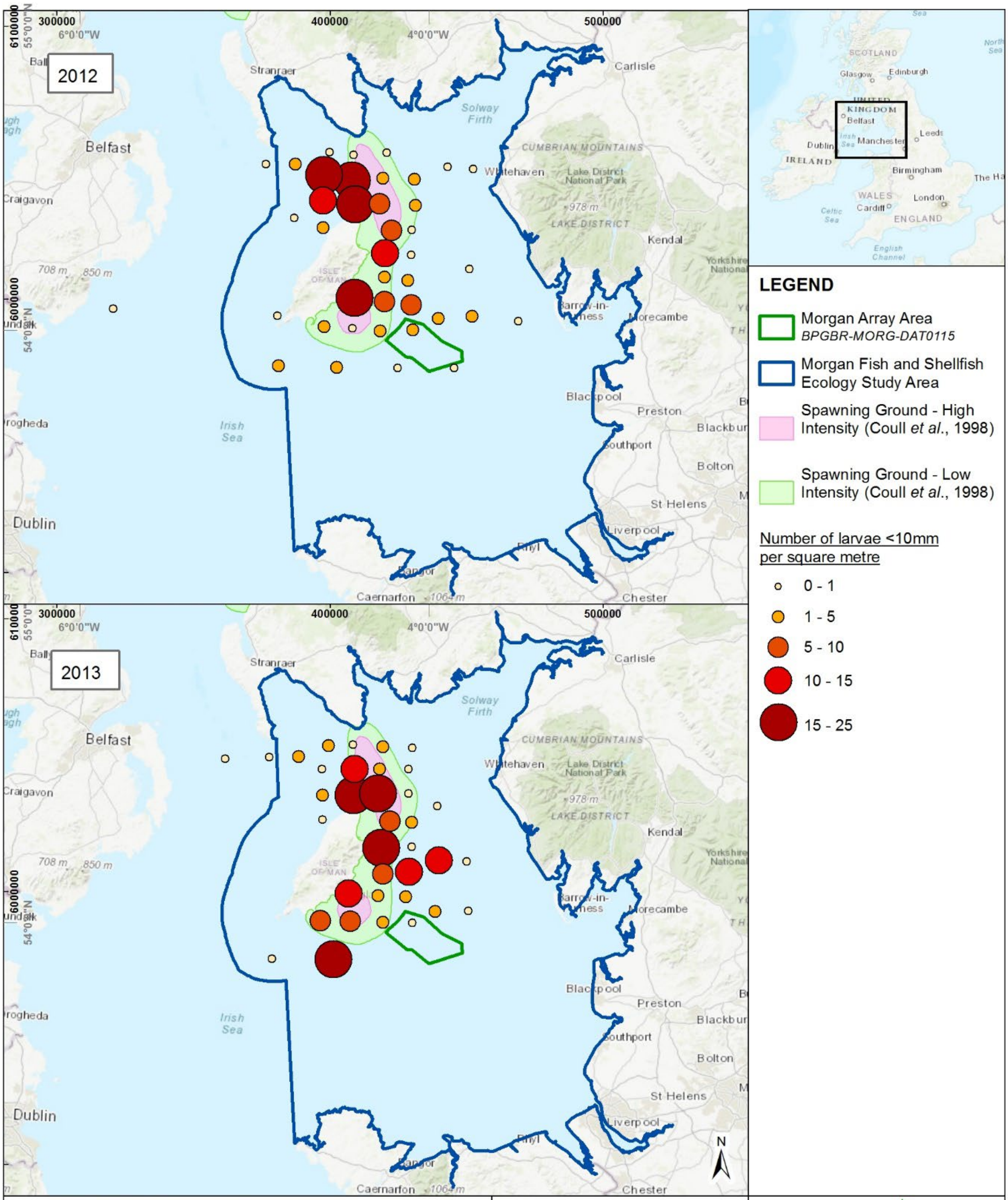
Drawing Number:
RPSE-MG-ES-FAS-033-00

Drawing Title:
POTENTIAL HERRING SPAWNING SEDIMENT CLASSES

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,525,000

VER	DATE	DETAILS	BY	CHECK
00	23/08/23	First Issue	MJ	HM

Figure 1.24: Herring spawning habitat preference classifications from EMODnet and site-specific survey data.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 70 km

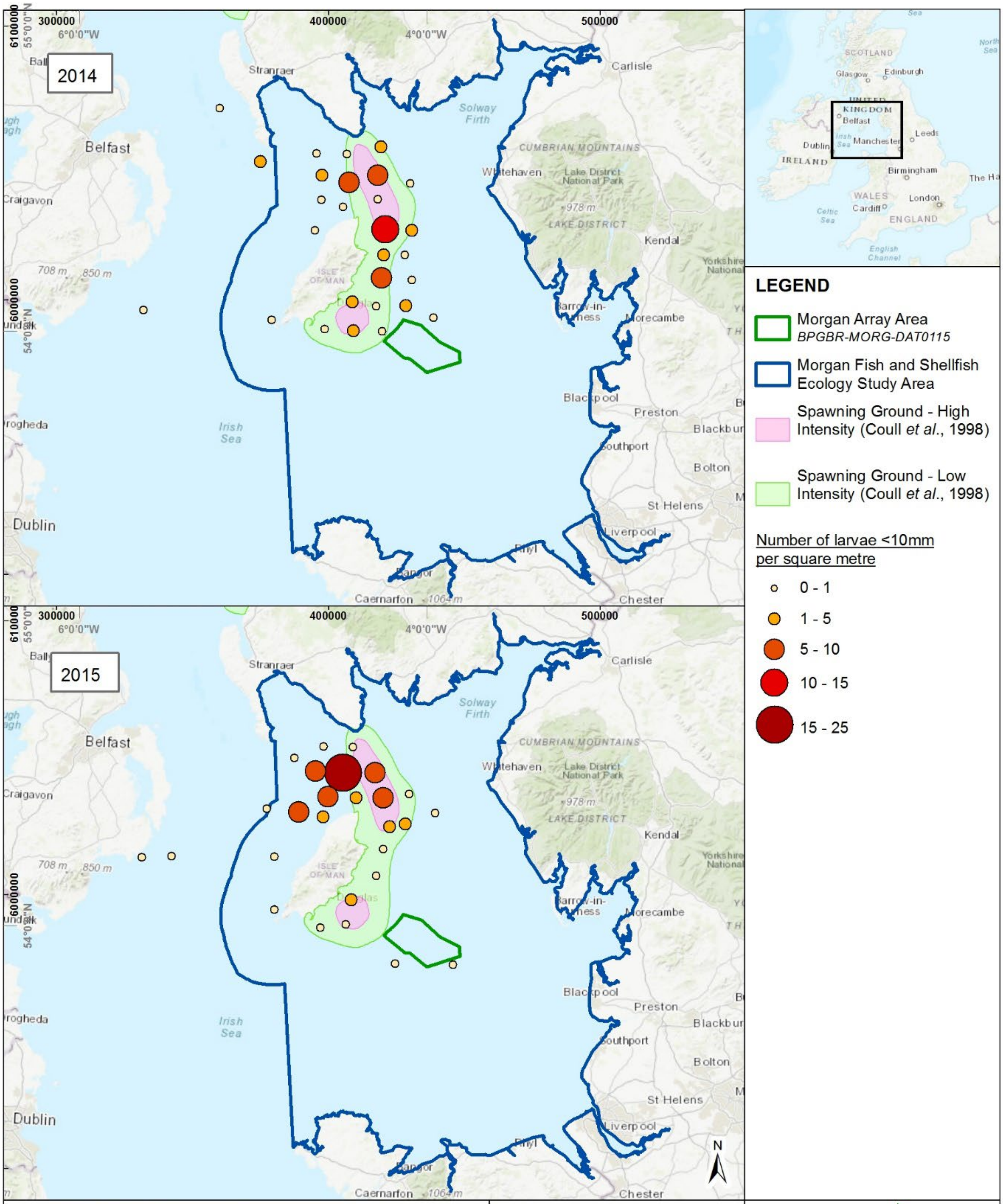
Drawing Number:
RPSE-MG-FAS-022-00

Drawing Title:
NINEL HERRING LARVAE DISTRIBUTION 2012-2013

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,350,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.25: NINEL Herring Larvae population densities (larvae/ m^2) in 2012 to 2013.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 70 km

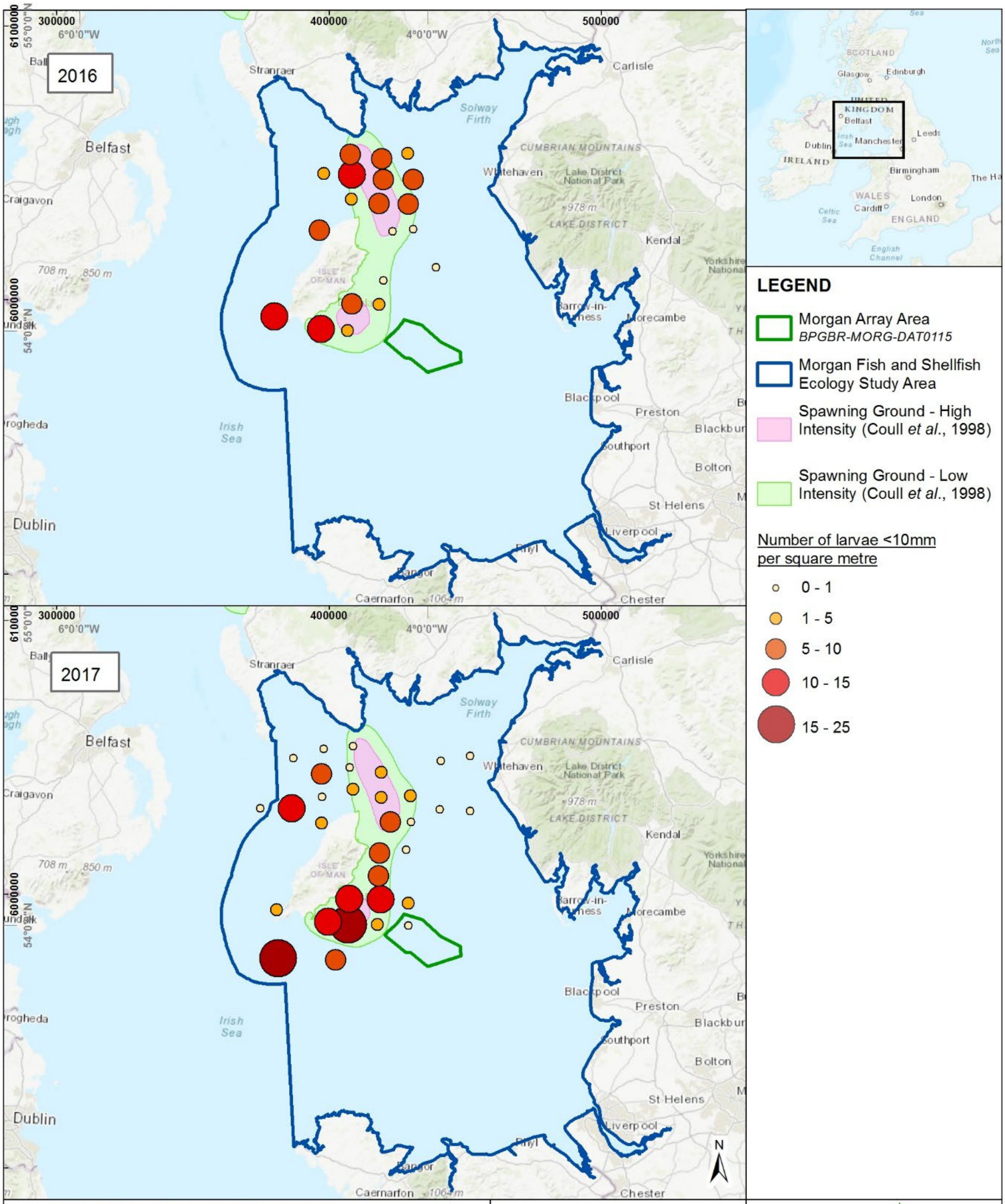
Drawing Number:
RPSE-MG-FAS-023-00

Drawing Title:
NINEL HERRING LARVAE DISTRIBUTION 2014-2015

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,350,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.26: NINEL Herring Larvae population densities (larvae/ m^2) in 2014 to 2015.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 70 km

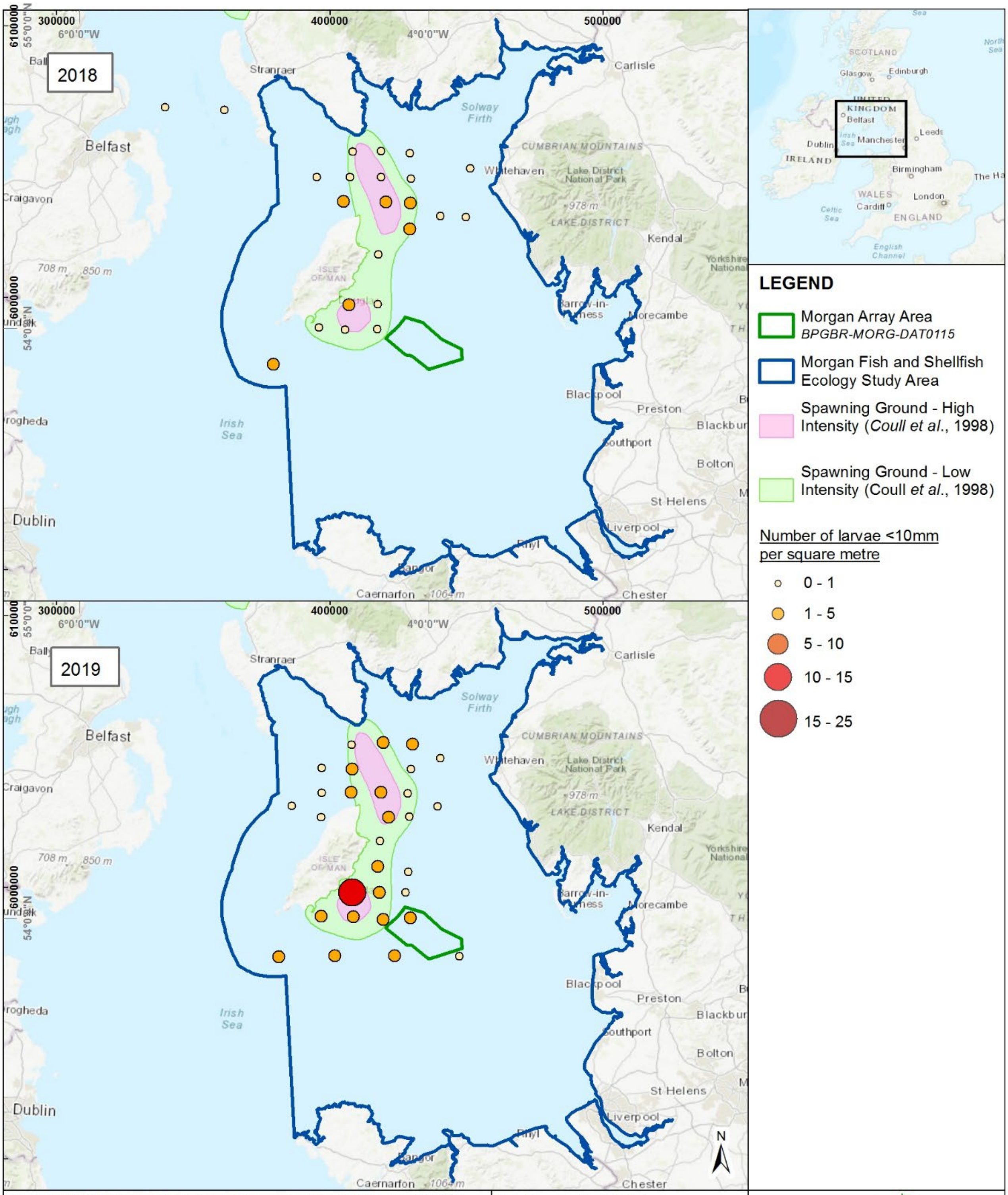
Drawing Number:
RPSE-MG-FAS-024-00

Drawing Title:
NINEL HERRING LARVAE DISTRIBUTION 2016-2017

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,350,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.27: NINEL Herring Larvae population densities (larvae/ m^2) in 2016 to 2017.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 70 km

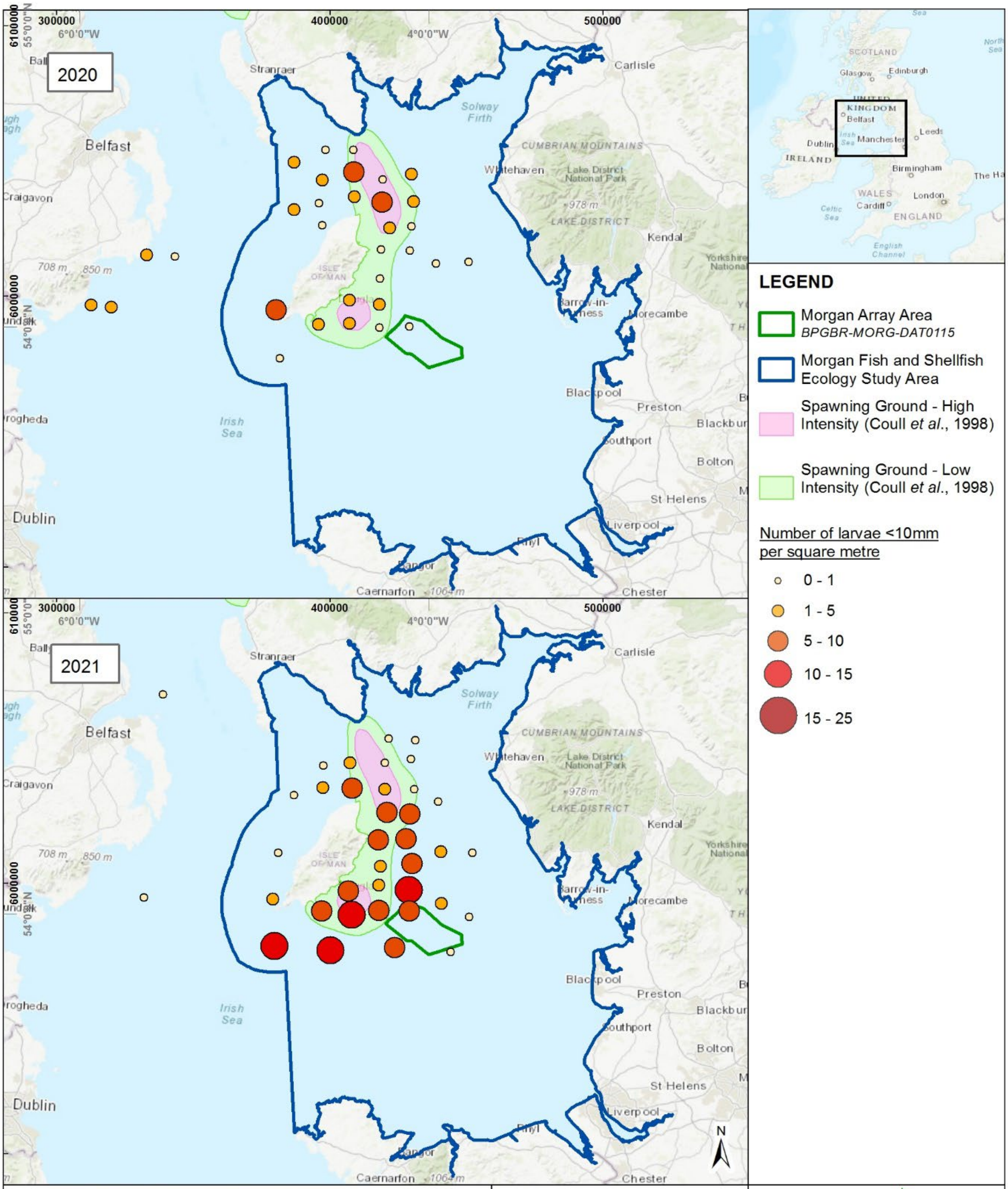
Drawing Number:
RPSE-MG-FAS-025-00

Drawing Title:
NINEL HERRING LARVAE DISTRIBUTION 2018-2019

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,350,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.28: NINEL Herring Larvae population densities (larvae/ m^2) in 2018 to 2019.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 70 km

Drawing Number:
RPSE-MG-FAS-026-00

Drawing Title:
NINEL HERRING LARVAE DISTRIBUTION 2020-2021

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,350,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.29: NINEL Herring Larvae population densities (larvae/ m^2) in 2020 to 2021.

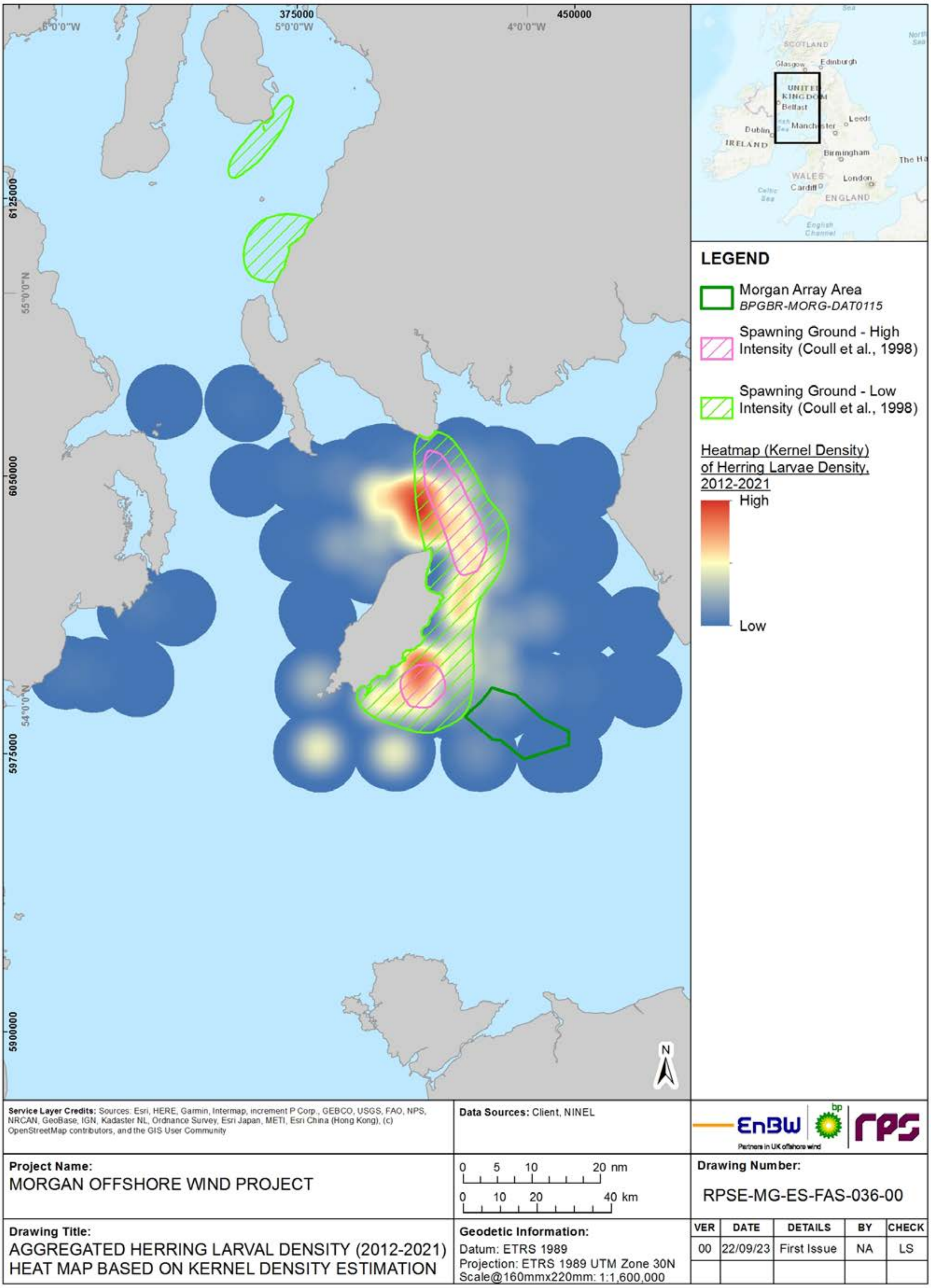


Figure 1.30 Heatmap of aggregated NINEL herring larval densities from 2012 to 2021.

1.7 Sandeels

1.7.1 Desktop study

1.7.1.1 While there are several species of sandeel present within the east Irish Sea (greater sandeel *Hyperoplus lanceolatus*, lesser sandeel, smooth sandeel *Gymnammodytes semisquamatus*, Raitt's sandeel *Ammodytes marinus*, and Corbin's sandeel *Hyperoplus immaculatus*), this section will refer to sandeel species collectively, unless otherwise stated. Liverpool Bay, and the wider east Irish Sea has been historically known to support important and ecologically valuable sandeel populations. This was supported by the NIGFS (ICEs, 2022b), which found evidence of the presence of Raitt's sandeel, greater sandeel, smooth sandeel and Corbin's sandeel within the wider east Irish Sea in areas surrounding the Morgan Generation Assets, in relatively low but consistent densities during annual surveys conducted between 2012 and 2022.

1.7.1.2 Sandeel species are known to feed exclusively on phytoplankton and zooplankton which inhabit the water column and survive by filter feeding during daylight hours (Freeman *et al*., 2004). Sandeels are evidenced to be an important prey for numerous fish, bird, and marine mammal species due to their small size and aggregations in large numbers (Engelhard *et al*., 2008). For this reason, sandeel are known to be a critical part of the marine food web and act as an umbrella species, linking primary productivity throughout the food chain to higher trophic levels and ultimately, apex predators (Latto *et al*., 2013).

1.7.1.3 Recent findings have illustrated that sandeel species display a high level of site fidelity, which has the potential to make them vulnerable at a sub-population level in terms of direct habitat loss (Jensen *et al*., 2011 and Latto *et al*., 2013).

1.7.1.4 The lesser sandeel is a priority species under the UK Post-2010 Biodiversity Framework (JNCC, 2012) and a species garnering attention from the general public due to its significance in the marine food chain. Sandeel spend most of the year buried in the seabed, emerging in the winter to spawn (van der Kooij *et al.,* 2008). Sandeel spawn a single batch of eggs in December to January, which are deposited on the seabed, several months after the active feeding season (April to September). The larvae hatch after several weeks, usually in February or March, and drift in the currents for one to three months, after which they settle on the sandy seabed. During the spring and summer, sandeel emerge during the day to feed in schools and at night return to bury in the sand. This is an adaptation to conserve energy and to avoid predation. There are indications that the survival of sandeel larvae is linked to the availability of copepod prey in the early spring, especially *Calanus finmarchicus* and that climate generated shifts in the *Calanus* species composition can lead to a mismatch in timing between food availability and the early life history of lesser sandeel (Wright and Bailey, 1996; van Deurs *et al.,* 2009). Sandeel is a critically important prey species for many marine predators.

1.7.1.5 Sandeel have a close association with sandy substrates into which they burrow. They are largely stationary after settlement and show a strong preference to specific substrate types. Recent work, in the laboratory (Wright *et al*., 2000) and in the natural environment (Holland *et al*., 2005) has focused on identifying the sediment characteristics that define the seabed habitat preferred by sandeel. Both approaches produced similar results, indicating that sandeel preferred sediments with a high percentage of medium to coarse grained sand (particle size 0.25 mm to 2 mm), and avoided sediment containing >4% silt (particle size <0.063 mm) and >20% fine sand (particle size 0.063 mm to 0.25 mm). As the percentage of fine sand, coarse silt, medium silt and fine silt (particles <0.25mm in diameter) increased, sandeel increasingly avoided the habitat (this finding was also supported by Wright *et al.* (2000) as reported by Mazik *et al.* (2015). Conversely, as the percentage of coarse sand and medium sand (particles ranging from 0.25 mm to 2.0 mm) increased, sandeel showed an increased preference for this substrate.

1.7.1.6 Work by Greenstreet *et al*. (2010) draws on the research by Holland *et al*. (2005), to define four sandeel sediment preference categories, using hydro acoustic seabed surveys and nocturnal grab surveys. They merged fine sand, three silt grades and two coarser sand grades, to define two particle size classes, silt and fine sand and coarse sand. They then examined the combined effect of these two size grades of sediment particles on the percentage of grab samples with sandeel present. Latto *et al*. (2013) used this research, in combination with the baseline of sandeel habitat types to produce four sandeel sediment preference categories, which were defined as; Prime, Sub-Prime, Suitable and Unsuitable (see Table 1.6). This was further refined to ‘preferred’, ‘marginal’, and ‘unsuitable’ classifications based on Latto *et al*. (2013), and this classification has been applied to relevant data available on the OneBenthic tool and is presented below in Figure 1.31 alongside the site-specific benthic subtidal ecology survey data for the Morgan Generation Assets.

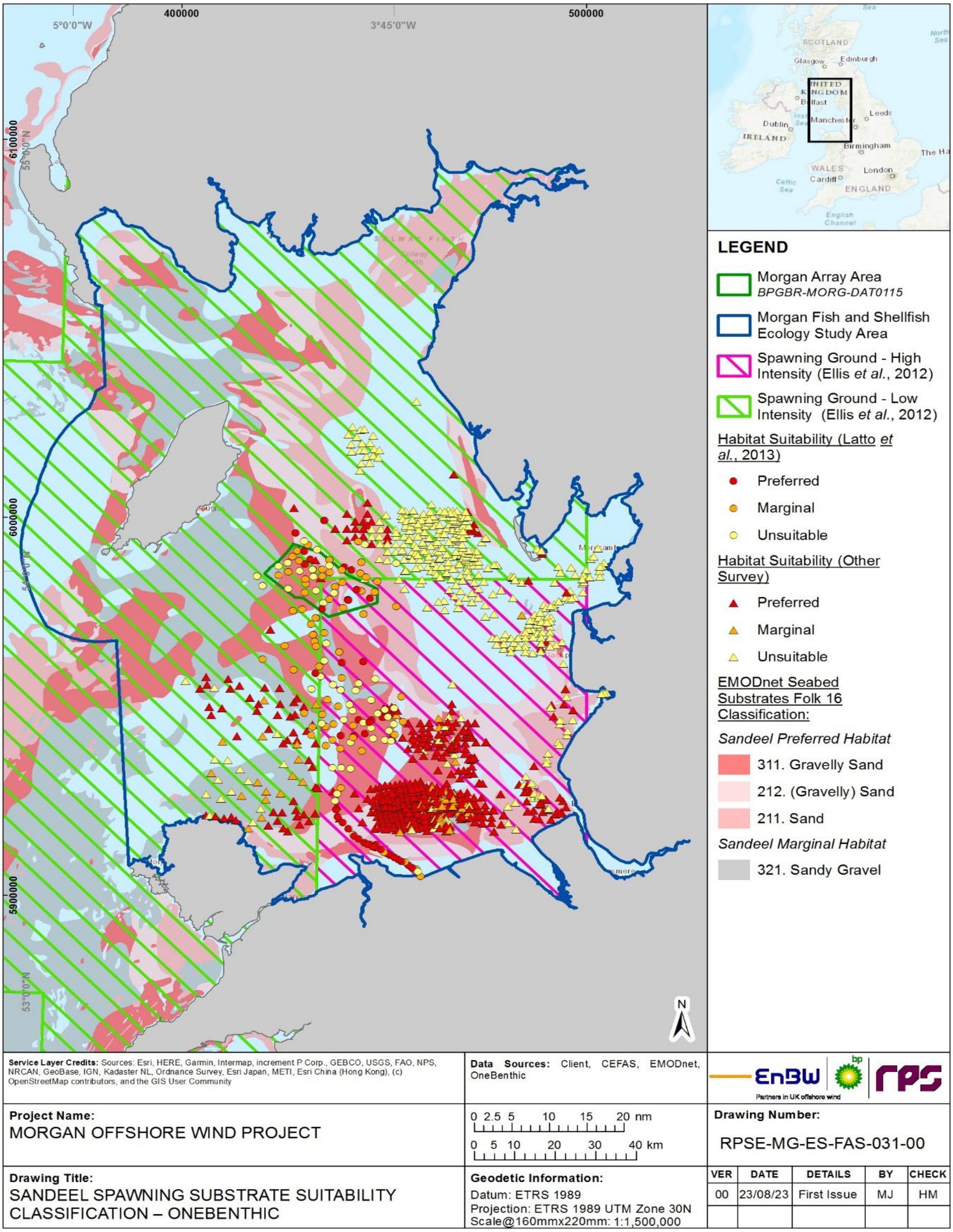


Figure 1.31: OneBenthic data showing the suitability of sediments within the fish and shellfish ecology study area for sandeel.

1.7.2 Site-specific survey

1.7.2.1 As outlined in section 0, site-specific survey data were collected and reviewed alongside desktop studies to assess the extent of suitable sandeel habitat within the Morgan Generation Assets. Grab sampling was undertaken (see section 0) and PSA completed on the sediment samples collected in 2021 in the Morgan Array Area which allowed classification of the sediment types according to Latto *et al*. (2013), as described in section 0. These classifications were originally developed for the marine aggregates industry, drawing on work from Greenstreet *et al*. (2010) and Holland *et al*. (2005), investigating spatial interactions between the aggregate application areas and sandeel habitat.

1.7.2.2 Figure 1.32 illustrates the results of this site-specific analysis with sandeel habitat preference classifications of preferred, marginal and unsuitable denoted, presented with high intensity spawning grounds (Ellis *et al*., 2012). The distribution of habitat suitability assessment results shows that the Morgan Array Area in 2021 was largely classified as unsuitable (31%; >10% mud) and marginal (46%; >4% to <10% mud) habitat, with intermittent areas of preferred habitat. Results illustrated that 77% of the surveyed stations comprised mud content in excess of 4%, rendering the much of the sediments within the Morgan Array Area outside of preferred sandeel habitat composition.

1.7.2.3 The 2022 survey of 26 stations within the Morgan Generation Assets and ZoI (Gardline, 2023) indicated the presence of unsuitable, marginal and preferred habitat for sandeel habitation and spawning. Specifically, 15 stations (57.7%) were classified as marginal habitat, with five stations (19.2%) classified as preferred habitat, and six stations classified as unsuitable habitat for sandeel.

1.7.2.4 Figure 1.32 illustrates the site-specific survey data alongside EMODnet seabed substrate data which can also be used to assign broadscale habitat suitability for sandeel. Gravelly sand, (gravelly) sand, and sand in the EMODnet substrate data were classified as preferred habitat and sandy gravel as marginal habitat. Where no shading is present, the habitat in that area is considered unsuitable for sandeel. These results are in line with the EMODnet seabed substrate data within the Morgan Array Area, as these are broadscale datasets. Overall, the EMODnet data broadly aligns with the site-specific survey findings in terms of expected spawning ground suitability. Preferred (prime) habitats resulting from the site-specific surveys are located within or on the periphery of the sandeel preferred EMODnet seabed substrates. It is worth noting, that the EMODnet seabed substrate data is of lower resolution and accuracy than the results of the site-specific survey and so should be interpreted with caution due to not accounting well for local scale variance, but provide a broadscale regional picture of the general surrounding substrate.

1.7.2.5 Further site-specific survey results from grab samples can provide incidental data on the presence of sandeel within the Morgan Array Area, however no sandeel were captured during the 2021 and 2022 surveys within the Morgan Array Area (see Figure 1.33). It should be noted that this data collection method does not target sandeel specifically, therefore these results should be regarded as opportunistic and the absence of any recovered sandeel specimens within grab samples withing the Morgan Array Area should not be interpreted as low abundance or an absence of sandeel. The desktop data indicate that sandeels may be present across the Morgan Generation Assets, although the habitats recorded within the Morgan Array Area were largely assessed to be unsuitable or marginal.

Table 1.6: Sandeel habitat sediment classifications derived from Latto *et al.* (2013).

%Contribution (mud = <63 µm)	Habitat sediment preference (Latto *et al.*, 2013)	Habitat sediment classification (Latto *et al.*, 2013)
<1% mud, >85% sand	Prime	Preferred
<4% mud, >70% sand	Sub-prime	Preferred
<10% mud, >50% sand	Suitable	Marginal
>10% mud, <50% sand	Unsuitable	Unsuitable

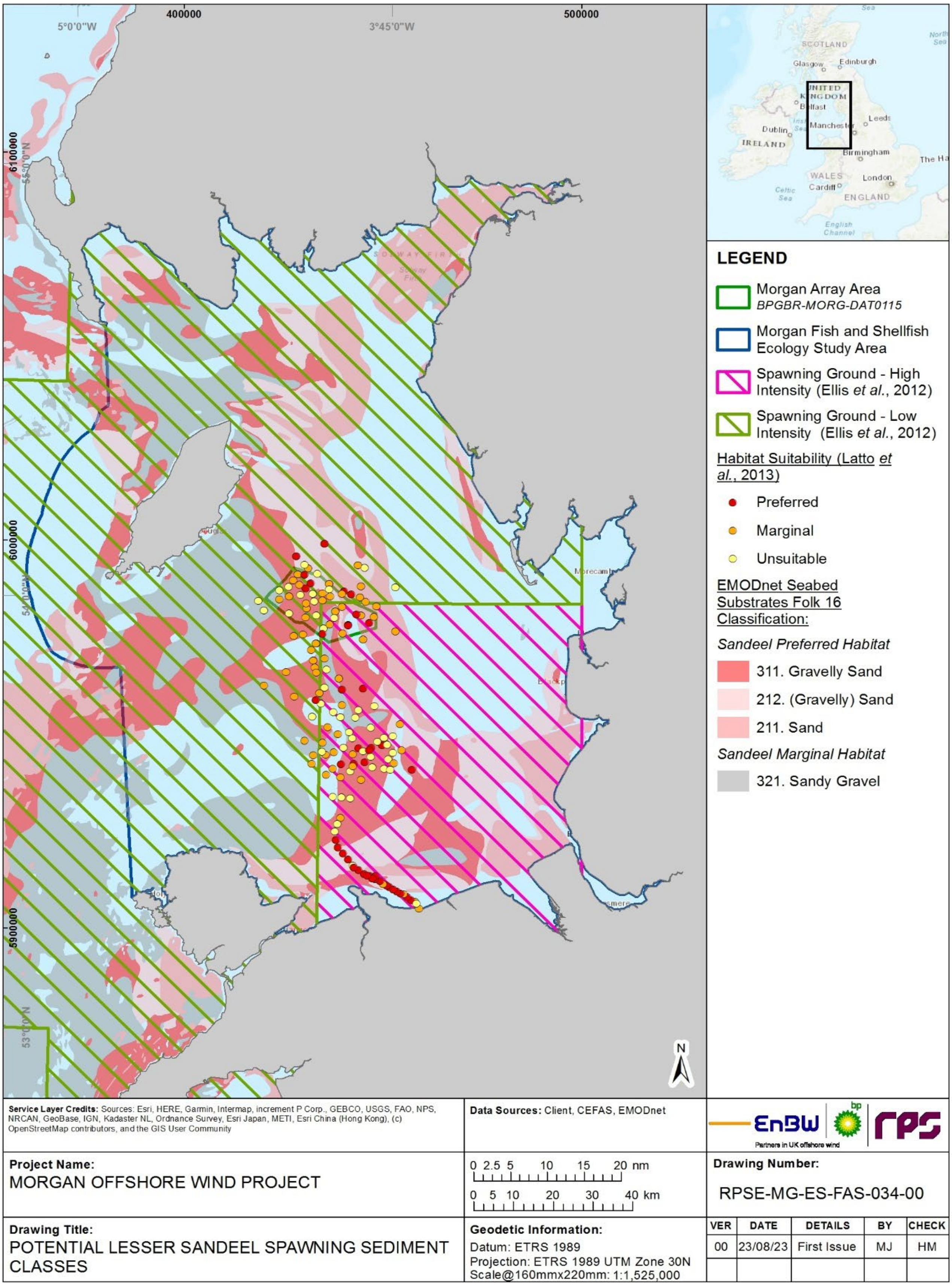
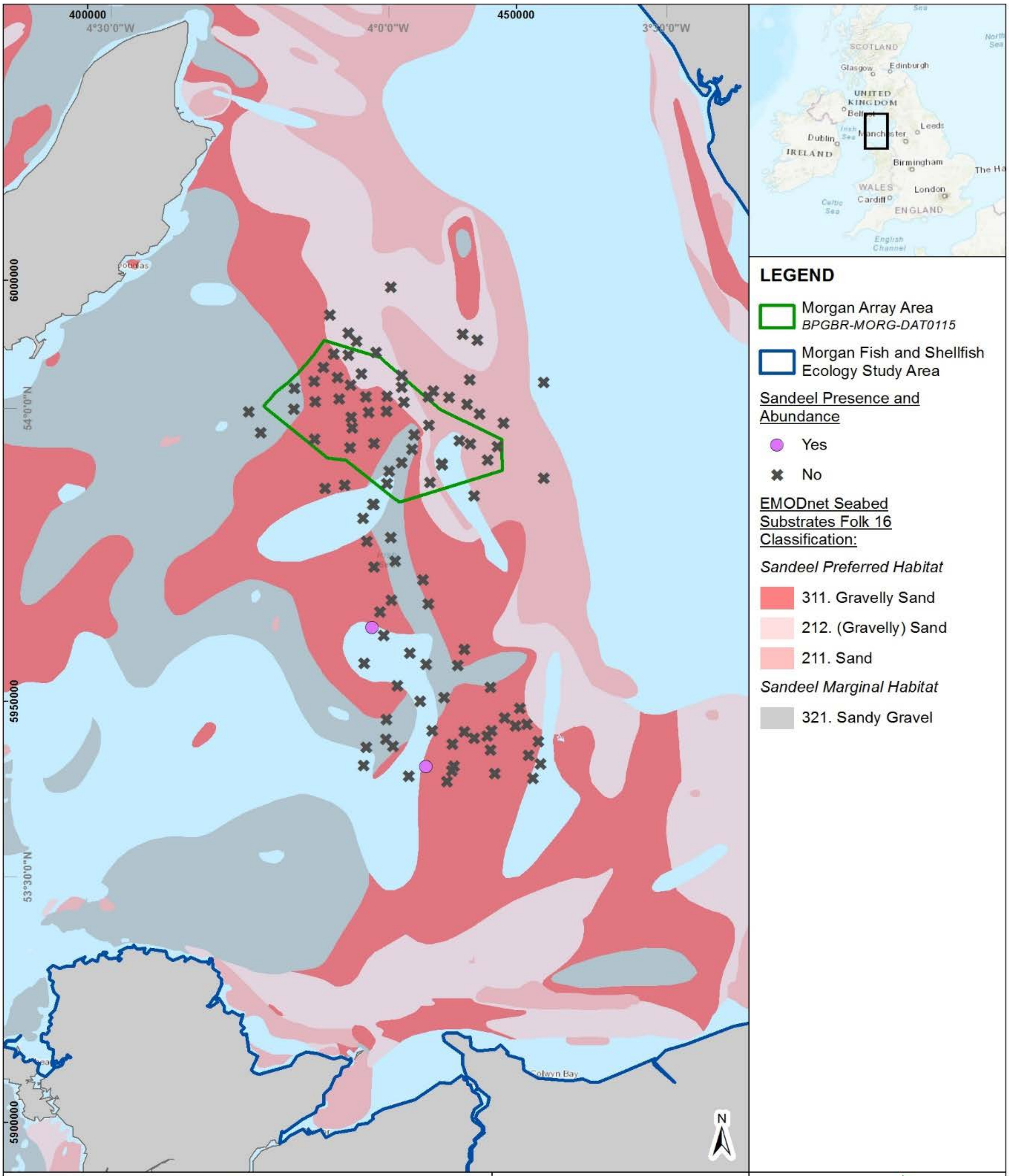


Figure 1.32: Sandeel habitat preference classifications from EMODnet and site-specific survey data.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS, EMODnet

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 nm
0 5 10 20 km

Drawing Number:
RPSE-MG-ES-FAS-032-00

Drawing Title:
SANDEEL PRESENCE DATA BASED ON SITE-SPECIFIC SURVEYS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:750,000

VER	DATE	DETAILS	BY	CHECK
00	23/08/23	First Issue	MJ	HM

Figure 1.33: Sandeel habitat preference classifications with site-specific abundance data.

1.8 Elasmobranchs

1.8.1.1 Elasmobranchs are a cartilaginous fish group that comprises sharks, rays and skates. Over 71 elasmobranch species have been recorded in the Irish Sea; about half the number that live in European waters, with habitats supporting taxa ranging from sedentary to highly migratory (Clarke *et al*., 2016). The most common elasmobranch species found in the Irish Sea are rays, including thornback ray, blonde ray *Raja brachyura*, cuckoo ray and spotted ray, with common shark species including spurdog, lesser spotted dogfish and tope shark. Since 2005, many species of skates and rays have exhibited long-term declines, however, there are signs of recovery and increased biomass in recent years that may be attributed to reduced fishing effort and effort changes in the region (from whitefish to *Nephrops* fishing; ICES, 2019b).

1.8.1.2 Species expected to be present in the fish and shellfish ecology study area include tope, spurdog, common skate *Dipturus batis*, spotted ray and thornback ray. Some species of elasmobranchs have nursery grounds within or in close proximity to the Morgan Generation Assets (Ellis *et al*., 2012; see section 1.5).

1.8.1.3 Thornback ray are known to support an important commercial and recreational fishery within Liverpool Bay. Monthly landing data occurring from the North Western Inshore Fisheries and Conservation Authority (IFCA) District in North Wales and within Liverpool Bay illustrated that ray species were landed year-round, with August being the predominant month of targeted catch (Moore *et al*., 2020). Based on the context of historic declines within UK waters, thornback ray abundance in the Irish Sea is currently thought to be increasing (ICES, 2018b).

1.8.1.4 Skates and rays are known to represent one of the more vulnerable fish communities in the Irish Sea, often being data poor in comparison to other commercially exploited fish species (Dedman *et al*., 2015). Within the Irish Sea, the species distribution for skate and ray species was found to be driven by a general preference for both sand and coarser substrates, as well as higher salinities, current speeds, and surrounding temperatures (Dedman *et al*., 2015). Blonde ray, thornback ray, cuckoo ray and lesser-spotted dogfish were observed within the Morgan Generation Assets during site-specific benthic subtidal surveys (Morgan Offshore Wind Ltd, 2023).

1.8.1.5 The Irish Sea population of spotted and thornback ray are stable throughout their ranges, despite being commonly landed in fisheries. These small-bodied species have a wide geographic distribution throughout the northeast Atlantic and Mediterranean and are some of the most common ray species recorded from Irish Sea waters. There is an inshore to offshore partition in habitat preference illustrated in spotted ray between adults and juveniles, with adults occurring offshore on sand and coarse sand-gravel substrates and juveniles illustrating a preference for inshore, sheltered sandy substrates. Abundant juveniles and egg cases have been found in the east Irish Sea, around Cardigan Bay and Anglesey, as well as their continued presence in previous surveys, suggesting that these are important nursery areas for the spotted ray (Ellis *et al*., 2010; see section 1.5).

1.8.1.6 The cuckoo ray is widely distributed throughout the northeast Atlantic and Mediterranean and Moriarty *et al.* (2015) suggests that the population in the Irish/Celtic Seas is separate to the population in the west and north of Ireland. Cuckoo ray is a small bodied species that typically occurs offshore on the continental shelf and slope at depths of 20 m to 500 m. In the Irish Sea, the habitat preferences of cuckoo ray are coarse sand or gravel substrates, but the scarcity of egg cases recovered on the coast suggests that nurseries for this species are in deeper, offshore waters (Moriarty *et al*., 2015).

1.8.1.7 Lesser spotted dogfish, present within the east Irish Sea, have a broad habitat preference and are commonly found on a variety of substrates including sand, coralline algae, and gravelly or muddy bottoms (Clarke *et al*., 2016). These findings were further reflected in in the similar findings of nearby benthic and sediment surveys of regional wind farms which illustrated this species to be common in trawl surveys (NBDC, 2019). Lesser spotted dogfish is an oviparous species that lays its young in egg cases deposited on macroalgae in shallow coastal waters or on sessile invertebrates (such as sponges, hydroids and soft corals) in deeper waters (Ellis *et al*., 1996). The population trend of lesser spotted dogfish in the UK is stable and is listed on Europe's Red List for cartilaginous fish as Least Concern (IUCN, 2022).

1.8.1.8 Angel shark *Squatina* are a Critically Endangered demersal elasmobranch (Morey *et al*., 2019) with a preference for relatively shallow coastal and continental shelf soft sediment habitats for feeding (Lawson *et al*., 2019), and historical evidence shows the use of stony reef habitats as juvenile nursery grounds around Wales (Moore and Hiddink, 2022). This habitat preference has caused them to be highly susceptible to demersal fishing activities (Ellis *et al*., 2020), with significant decreases in population historically related directly to these activities within the Irish Sea (Quigley, 2006; Hiddink *et al*., 2019). Most recently, the majority of sightings in the Irish Sea were between Bardsey Island and Strumble Head, but this was outside of the fish and shellfish ecology study area. Within the southwest of the fish and shellfish ecology study area, up to 100 individuals in total were historically and recently sighted within Conwy Bay (Barker *et al*., 2022), indicating a potentially significant population concentration approximately 40 km from the Morgan Generation Assets, although this population is only present intermittently throughout spring and summer for feeding.

1.8.1.9 Basking shark *Cetorhinus maximus* are known to migrate throughout the fish and shellfish ecology study area and therefore have the potential to be encountered within the Morgan Generation Assets (Cotton *et al*., 2005; Shark Trust, 2022; Manx Whale and Dolphin Watch, 2023). The basking shark is a large, filter feeding species that is predominately solitary, but may also occur in aggregations where there is dense zooplankton abundance (Speedie, 1999). The basking shark's unique feeding strategy dominates all aspects of its ecology and life history; the basking shark is an obligate ram filter feeder whereby the flow of water across gill rakers within the mouth is controlled by swimming speed (Sims, 1999; Sims, 2008).

1.8.1.10 Basking shark migration routes cover large distances from north Africa to Scotland, using both the continental shelf and oceanic habitats in the upper 50m to 200m of the water column (Doherty *et al*., 2017). Distribution has been shown to be influenced by a range of environmental conditions (Austin *et al*., 2019); surface sightings of basking sharks are typically reported where sea surface temperatures range between 15°C and 17.5°C (Cotton *et al*., 2005; Skomal *et al*., 2004) where thermal fronts are present (Sims and Quayle, 1998; Jeewoonarain *et al*., 2000) and where zooplankton is in its greatest abundance (Sims and Quayle, 1998; Sims, 1999).

1.8.1.11 Basking shark migrations have been evidenced throughout the Irish Sea, with high numbers of sighting recorded around the Isle of Man (National Biodiversity Network (NBN) Atlas, 2019). This is corroborated by the data available from the Manx Whale and Dolphin Watch (2023), with at least 20 sightings around the Isle of Man within the first half of 2023. Historically, basking sharks have been sighted in a density of 11 to 50 individuals sighted per 0.5 by 0.5 degrees to the north of the Isle of Man, within the fish and shellfish ecology study area (Sims *et al*., 2005). Basking shark have a north to south migration and are expected to occur within and surrounding the Morgan Generation Assets during August to October and during the return migration in March to June (Doherty *et al*., 2017). Basking shark were not sighted and therefore not recorded in the site-specific aerial surveys undertaken for birds and marine mammals across the Morgan Generation Assets.

1.8.1.12 More recently, 28 basking shark tagged off the coast of Scotland and the Isle of Man in summer months over four years (2012 to 2015) illustrated an average post-summer migration distance of 1,057 km (Doherty *et al*., 2017). Some remained in UK and Irish waters but moved further offshore, whilst others migrated as far as the Bay of Biscay and north Africa. The tagging data also demonstrated that several sharks in this study migrated through the fish and shellfish ecology study area and therefore in proximity to the Morgan Generation Assets. In addition, 17 basking shark that migrated outside UK waters returned to the Celtic Sea in March to June (Doherty *et al.,* 2017). In summary, 18% of basking sharks tracked in this study entered the Economic Exclusive Zone of the UK, including the Irish Sea, indicating that this is an important area for overwintering that links foraging grounds in the waters off the west coast of the UK to the south migration destinations (Doherty *et al*., 2017).

1.8.1.13 Mating has not been observed in basking shark and most likely occurs in deep water with courtship-like behaviour as the precursor, particularly where individuals aggregate in food-rich waters (Sims, 2008). Individuals are thought to pair and mate in early summer (Sims *et al.,* 2000) and gestation has been estimated over a range of 12 to 36 months (Parker and Stott, 1965; Sims *et al*., 2008). As an ovoviviparous species, basking shark bear live young, hatched from eggs within the uterus of the female. Basking shark are a slow-growing species with late maturation (at 12 to 20 years of age) and a relatively low fecundity (producing litters of around six pups; Sund, 1943). These characteristics suggest that basking shark would be vulnerable to environmental changes and the population would be slow to recover from any major losses. With a long history of exploitation, this species is listed as a Protected Species in the Isle of Man Wildlife Act 1990; on the International Union for the Conservation of Nature (IUCN) Red List globally as Vulnerable (Fowler, 2009), and on the European Red List for cartilaginous fish as Endangered (IUCN, 2021).

1.9 Diadromous fish

1.9.1 Overview

1.9.1.1 The term diadromous fish is utilised to describe fish that migrate between both freshwater and the marine environments. There is the potential for diadromous fish species to migrate to and from English and Welsh rivers in the vicinity of the Morgan Generation Assets. Therefore, the diadromous fish species have the potential to migrate through the Morgan Generation Assets to rivers during certain periods of the year (NBN Atlas, 2019).

1.9.1.2 The east Irish Sea is home to diadromous fish species, which move between the sea and freshwater at different stages of their life cycle and may migrate through the fish and shellfish ecology study area and therefore the Morgan Generation Assets. Atlantic salmon *Salmo salar* and sea trout are two commercially important diadromous fish species found in the Irish Sea. Sea lamprey *Petromyzon marinus*, river lamprey *Lampetra fluviatilis*, and twaite shad *Allosa fallax* are known to occur in inshore waters off the coasts of England and Wales. Brook lamprey *Lampetra planeri* are also recorded in the north areas of the fish and shellfish ecology study area, although as a purely freshwater species, this species migrates between downstream river habitat to upstream areas to spawn and are therefore not considered further in this report as it is unlikely to interact with offshore components of the Morgan Generation Assets. With the exception of sea trout, all of these diadromous fish species are listed on Annex II of the Habitats Directive (Council Directive 92/43/EEC) which makes provision for their protection through designation of Special Areas of Conservation (SACs). The Solway Firth SAC, Aber Dyfrdwy SAC, River Derwent and Bassenthwaite Lake SAC, River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC, and River Ehen SAC have all been designated for the protection of diadromous fish species (see section 1.9). Allis shad *Alosa alosa*, twaite shad, European eels *Anguilla*, river lampreys, and sea lampreys in Welsh waters are also protected under Section 7 of the Wales Biodiversity Partnership (Welsh Government, 2016).

1.9.1.3 Fish and epibenthic surveys carried out in 2013 for the Walney offshore wind farm and in 2012 for the West of Duddon Sands offshore wind farm recorded sea trout, a diadromous species of relevance within the fish and shellfish ecology study area (Brown and May Marine Ltd., 2012b).

1.9.1.4 Sea trout, European eel, river lamprey, and Atlantic salmon have been recorded in the estuaries of rivers across the northwest coast of England, within the fish and shellfish ecology study area. Twaite shad and allis shad have only been recorded at the mouth of the river Esk, north of the Morgan Generation Assets (NBN Atlas, 2019).

1.9.1.5 Sea lamprey have been recorded in the estuaries of the River Dee and the River Mersey however these records are from the 1960s and 1970s (NBN Atlas, 2019).

1.9.1.6 No site-specific surveys were undertaken to inform the baseline characterisation for diadromous fish species. For the purposes of the impact assessment, it will be assumed that the aforementioned species have the potential to occur within both the Morgan Array Area, during key migration periods (e.g. adult migration to spawning rivers and smolt migration from natal rivers in the vicinity) and surrounding the Morgan Generation Assets. Depending on the key migration periods of the diadromous fish species discussed, there will be both a greater or lesser likelihood of fish being present within the Morgan Generation Assets during all phases of the project, depending on the timings of particular activities.

1.9.1.7 Timings of diadromous fish species migrations are presented in Table 1.7, which displays the key migration times of diadromous fish species, and the length of time each species spends in fresh water and at sea. Uncertainty exists in the exact timings and routes of migrations due to the wide range of factors influencing these, and a precautionary approach has therefore been adopted where species may be present in the areas surrounding the Morgan Generation Assets year-round. This approach is supported by evidence from the NIGFS (ICES, 2022b), which indicated the presence of European eel, trout and sea lamprey within the fish and shellfish ecology study area throughout the year, outside of the specific spawning periods. Peak migration periods for some species are documented and it is assumed that most individuals will migrate during the timeframe outlined in Table 1.7, however acknowledgement of the degree of uncertainty thereby warrants application of a precautionary approach to baseline characterisation, which is taken forward into the assessment as described above (i.e. assuming the presence of diadromous fish within the fish and shellfish ecology study area year-round).

Table 1.7: Overview of life histories for diadromous fish relevant to the Morgan Generation Assets (based on Seagreen Wind Energy Ltd., 2019).

Species	Time spent in freshwater	Timing of downstream migration	Time spent at sea before first return	Timing of upstream migration
Atlantic salmon	2 to 3 years	April to May	1, 2 or 3 years	All year round with peak in late summer early autumn
Sea trout	2 to 3 years	Spring	2 or more	April to June
European eel	Males 7 to 20 years Females 9 to 50 years	Late spring	Many do not return to fresh water	January to June
Sea lamprey	3 to 4 years	July to September to open sea	18 to 24 months	April to May spawning in May/June
River lamprey	5 years or more. Remain in burrow in river silt beds until adults	July to September to feed in estuaries	2 years spent in estuaries	Winter and spring when temperatures are <10°C
Allis and Twaite shad	Short period	N/A	2 years spent in estuaries and marine areas do not return to fresh water until they are sexually mature.	April to May spawning in freshwater
Sparling (European smelt)	Short period	N/A	Estuarine	February to April spawning in freshwater

1.9.2 Atlantic salmon

1.9.2.1 Atlantic salmon is of considerable cultural and conservation importance (Hindar *et al*., 2010) and in both England and Wales, represents an ecologically and economically important diadromous fish species in the UK (Parry *et al*., 2018). However, in recent decades, and especially the past thirty or so years, there have been declines in rod catch data across much of the species' range (Parry *et al*., 2018). There are many pressures on Atlantic salmon stocks in both marine and freshwater environments, including commercial and recreational exploitation of stocks, disease, impacts related to farmed salmon and climate change (ICES, 2017). Atlantic salmon is an Annex II species under the EU Habitats and Species Directive and is a feature of various SACs.

1.9.2.2 The UK salmon population is increasingly important as it has influenced the overall selection of various SACs and the site selection process has focused on the identification and designation of rivers holding significant Atlantic salmon populations across the geographical range of species within the UK (JNCC, 2022a).

1.9.2.3 There are 49 rivers in England and 31 rivers in Wales that are known to regularly support Atlantic salmon, however, it is worth noting that some of these stocks are relatively small and support minimal catches overall. Of these 80 rivers located in England and Wales, 64 of them have been designated as 'principal salmon rivers' and are further utilised to give annual advice on stock status and assess the need for management and conservation measures.

1.9.2.4 The Atlantic salmon is considered a Priority Species under the UK Post-2010 Biodiversity Framework. The species is known to be a relatively large-bodied fish that can be encountered in clean and healthy rivers throughout the UK. Like other salmon species, the Atlantic salmon spends most of its life at sea, returning to spawn in the same stretch of river or stream in which it was born.

1.9.2.5 Following spawning by adult Atlantic salmon in English and Welsh rivers, the ova mature into fry and then parr before migrating to sea as smolts. At sea, the smolts grow rapidly and after one to three years they return as adults to spawn, most commonly to their natal river. Many Atlantic salmon die after spawning, but some return to sea as kelts and may return again to rivers to spawn (Mills, 1989). Atlantic salmon are known to migrate in relation to diurnal cues. Evidence provided by Smith and Smith (1997) suggests that Atlantic salmon upstream migration into rivers is related to tidal phase and time of day. Up-estuary movements leading to river entry were found to be predominantly nocturnal and occur during ebb tides, with entry into nontidal reaches of rivers also being nocturnal, however significantly associated with tidal phase (Smith and Smith, 1997). Smolts migrating downstream/offshore have also been found to increase migratory activity nocturnally, with daytime utilised more for prey detection and predator avoidance (Hedger *et al*., 2008). Dempson *et al*. (2011) also found a small but significant increase in migratory movements nocturnally when compared to daytime, which suggests a slight preference for nocturnal migration.

1.9.2.6 An Environment Agency report on salmonid fisheries statistics for England and Wales (Environment Agency, 2022) summarised Atlantic salmon rod catches within a 5-year period between 2017 to 2021 based on completed fisheries returns. Results illustrated that there were 5,815 Atlantic salmon caught in 2021, 11,566 caught in 2020 and 9,163 caught in 2019. Additionally, the 5-year mean (2017 to 2021) catch number was found to be 9,580. These results further illustrate a -50.7% change from 2020 to 2021 Atlantic salmon rod catches and a -29.3% change from the 5-year mean (Environment Agency, 2022).

1.9.2.7 Atlantic salmon net catches in England and Wales reported 592 caught during 2021, 900 Atlantic salmon caught during 2020, 453 caught during 2019, and a five-year mean of 9,580 (2017 to 2021). This accounted for a -34% change from 2020 to 2021 and a very significant -93% change from the 5-year mean (2017 to 2021, when catches typically exceeded averaged 9,580) to 2020 (Environment Agency, 2022). Since 1993, when released Atlantic salmon started being recorded, a continuous increase in released rate was observed with almost all fish released in 2021 (95% Atlantic salmon released, 87% for 5-year average 2016 to 2020; Environment Agency, 2022).

1.9.2.8 Data analysed from multiple acoustic telemetry studies along the west coast of England has illustrated that Atlantic salmon smolts have been evidenced to use a northward migration pathway through the Irish Sea to reach feeding grounds (Green *et al*., 2022).

1.9.2.9 Atlantic salmon is subject to many pressures in Europe, including pollution, the introduction of non-native salmon stocks, physical barriers to migration, exploitation from netting and angling, physical degradation of spawning and nursery habitat, and increased marine mortality (Cefas, 2019).

1.9.3 Sea trout

1.9.3.1 Sea trout are known to be found in rivers, streams, and lakes, often preferring cold and well oxygenated waters. Sea trout spawn in rivers and streams that have swift currents, which are usually characterised by the downward movement of water into gravel, favouring large streams and mountainous areas that have adequate cover resulting from submerged rocks, undercut banks, and overhanging vegetation (Fishbase, 2021a). While there is limited information regarding sea trout migration patterns identified from the Celtic Sea Trout Project (CSTP), the information available suggests preferences are primarily limited to inshore and local waters within the marine environment (Malcolm *et al*., 2010; CSTP, 2016). Findings illustrate that sea trout migrate to and from a number of rivers in the vicinity of the Morgan Generation Assets. Sea trout, like salmon, are also known to be a host species for freshwater pearl mussel *Margaritifera margaritifera*, see section 1.9.7 for additional detail on the freshwater pearl mussel.

1.9.3.2 Wales is widely acclaimed for the quality of its sea trout fisheries due to the larger than average weight of individual fish, numerical abundance, and innate potential to reach weights in excess of 5 kg (CSTP, 2016).

1.9.3.3 An Environment Agency report on salmonid fisheries statistics for England and Wales (Environment Agency, 2022) summarised sea trout rod catches within a 5-year period between 2017 to 2021 based on completed fisheries returns. Results illustrated that there were 12,533 sea trout caught in 2021, 19,277 caught in 2020 and 21,330 caught in 2019. Additionally, the 5-year mean number of sea trout caught (2017 to 2021) was found to be 17,777. These results further illustrate a -35% change from 2020 to 2021 sea trout rod catches and a -29.5% change from the 5-year mean (Environment Agency, 2022).

1.9.3.4 Sea trout net catches in England and Wales reported 5,482 caught during 2021, 12,703 caught during 2020, 14,599 caught during 2019 and 18,729 caught in the 5-year mean (2017 to 2021), with catches consistently decreasing annually from 36,778 in 2017 to 5,482 in 2021). This accounted for a -56% change from 2020 to 2021 and a -71% change from the 5-year mean (2017 to 2021; Environment Agency, 2022).

1.9.4 European eel

1.9.4.1 European eels are classified as critically endangered (IUCN, 2022) inhabit various benthic habitats that range from streams, shores, rivers, lakes, and ultimately migrates to the Sargasso Sea to spawn. Eel larvae are brought to European waters by the Gulf Stream and transform into glass eel, followed by elvers which migrate up estuaries around the English, Welsh, and Irish coasts, colonising rivers and lakes. When the European eel reaches sexual maturity, the species leaves the river and migrates to sea, covering vast distances during their spawning migration (Fishbase, 2021b). It is a possibility that European eel will pass through the vicinity of the Morgan Generation Assets and therefore, given their critically endangered status, will be considered as an IEF.

1.9.5 Sea lamprey

1.9.5.1 The sea lamprey is a primitive, jawless fish that resembles an eel. It is the largest of the lamprey species found within the UK and occurs in estuaries and accessible rivers and is an anadromous species that spawns in freshwater environments, but completes its lifecycle in the sea (JNCC, 2021a). Similar to the other species of lamprey found within UK waters, sea lamprey require clean gravel for spawning, and marginal silt or sand is utilised by burrowing juveniles (ammocoetes). Sea lampreys are known to spend most of their adult life at sea and are parasitic on other fish species and marine fauna. Sea lamprey (and river lamprey) have both been recorded in the Dee Estuary and in fish traps on the River Dee, near Chester Weir (Morgan Generation Assets

Consultation Report submitted with the application - Document Reference E3). It is a possibility that sea lamprey will be present in the vicinity of the Morgan Generation Assets and therefore will be considered as an IEF.

1.9.6 River lamprey

1.9.6.1 The river lamprey is found in coastal waters, estuaries and accessible rivers, but some populations are permanent freshwater residents, however the species is normally anadromous (i.e. spawning in freshwater but completing part of its life cycle in the sea; JNCC, 2021b). River lamprey live on hard bottoms or attached to larger fish like cod and herring due to their parasitic feeding behaviours, with spawning taking place in pre-excavated pits within riverbeds. Due to their preference for estuarine and nearshore coastal waters, such as the Dee Estuary SAC (see above for sea lamprey), it is unlikely that river lamprey will be encountered within the Morgan Array Area.

1.9.7 Freshwater pearl mussel

1.9.7.1 The freshwater pearl mussel is an endangered species of freshwater mussel. Freshwater pearl mussel are similar in shape to common marine mussels but grow much larger and live far longer. They can grow as large as 20 cm and live for more than 100 years, making them one of the longest-lived invertebrates (Skinner *et al*., 2003). These mussels live on the beds of clean, fast flowing rivers, where they can be buried partly of wholly in coarse sand or fine gravel. Mussels have a complex life cycle, living on the gills of young Atlantic salmon or sea trout, for their first year, without causing harm to the fish (Skinner *et al*., 2003). Freshwater pearl mussel is fully protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) and is also listed on Annexes II and V of the Habitats Directive and Appendix III of the Bern Convention. The conservation status of the species is reflected in its listing as Endangered on the IUCN Invertebrate Red List. While there is no potential for direct impacts on this species from the Morgan Generation Assets (as this is an entirely freshwater species), indirect impacts may occur due to effects on their host species (i.e. Atlantic salmon and sea trout) during their marine phase.

1.9.8 Allis and twaite shad

1.9.8.1 The allis and twaite shad are both members of the herring family and are difficult to distinguish between one another in the field (JNCC, 2021c; JNCC, 2021d). The habitat requirements of twaite shad are not decisively understood. On the River Usk and the River Wye, twaite shad are known to spawn at night in shallow areas near deeper pools, in which the species congregate. Their eggs are then released into the water column, sinking into the interstices between coarse gravel and cobble substrates (JNCC, 2021c). The allis shad also has poorly understood habitat requirements. It grows in coastal waters and estuaries, spending most of its adult phase in the marine environment, but migrates into rivers to spawn, swimming up to 800 km upstream in continental Europe. Both species have been heavily researched in their freshwater life phases which has subsequently resulted in scarce understanding of their spatial ecology during the species marine life-phases (Davies *et al*., 2020). Adult allis shad spawn at night with the eggs released into the current where they settle among gaps in gravelly substrates. Spawning sites tend to be shallow gravelly areas adjacent to deep pools (JNCC, 2021d). NRW reported that twaite shad have been recorded in fish trap data in the River Dee, although no evidence exists of a spawning population of this species in this area (Morgan Generation Assets Consultation Report submitted with the application - Document Reference E3).

1.9.9 Sparling (European smelt)

1.9.9.1 Sparling or European smelt are known to inhabit estuaries and large lakes, spending much of their life in the estuarine zone, with short incursions into the littoral zone. Sparling have been evidenced to enter rivers to spawn on both sandy and gravelly substrates, predominantly in fast flowing waters of lake tributaries or shallow shores of lakes and rivers (Fishbase, 2021c). Due to their preference of inhabiting estuarine waters upon entering the marine environment, it is unlikely that sparling will be found within the Morgan Array Area, however they could be encountered in the wider vicinity due to the relatively close proximity of the Morgan Generation Assets to inshore waters, with potential populations noted in the River Ribble and River Wyre estuaries (Ribble Rivers Trust, 2021; Natural England, 2017). This species has also been recorded in the River Dee and also the River Conwy (Morgan Generation Assets Consultation Report submitted with the application - Document Reference E3).

1.10 Shellfish

1.10.1 Overview

1.10.1.1 Shellfish is a colloquial and fisheries term for exoskeleton bearing aquatic invertebrates used as food, including various species of molluscs, crustaceans and echinoderms. Shellfish communities contribute to the biodiversity of the benthic ecosystem and are an important link in the food chain, both as predators and prey. As described previously, there are a number of commercially important shellfish species within the fish and shellfish ecology study area. Edible crab, cockles *Cerastoderma edule*, *Nephrops*, king scallop and whelks are the most commonly occurring shellfish in the Irish Sea, with higher proportions of *Nephrops* and scallops observed to the north (ICES, 2018b). Commercial landings data can be used as a proxy for identifying species present in the vicinity of the Morgan Generation Assets, which include *Nephrops*, edible crab, European lobster, velvet swimming crab, king scallop and squid.

1.10.1.2 The 2021 and 2022 site-specific survey results from grab/DDV samples within the Morgan Array Area provided incidental data on the presence of shellfish species, such as commercially important king and queen scallops, crabs, and razor clam species. However, the sampling methodology did not specifically target any shellfish species, and therefore any results should be regarded as opportunistic and only indicate presence or absence data of the relevant shellfish at the time of sampling.

1.10.2 King and queen scallop

Overview

1.10.2.1 Both king scallops and queen scallop show a preference for areas of clean firm sand, fine or sandy gravel and may occasionally be found on muddy sand, often in high densities (Carter, 2022). While king scallop are generally found in sandy, gravelly substrates, they can additionally be found on rougher ground. King scallop achieve reproductive maturity between three to five years, live upwards of 15 years, and are evidenced to be most abundant in depths of 20 m to 70 m (Cappell *et al*., 2018; Howarth and Stewart, 2014; Salomonsen *et al*., 2015). Queen scallop are known to have particularly important commercial grounds located around the Isle of Man and can be found in depths of up to 100m and are specifically protected against unlicenced towed gear fishing under Isle of Man bylaws (Isle of Man Government - SD 2018/0186, 2018). Similarly, king scallop are protected by a range of measures, such as the Isle of Man King Scallop Long-Term Management Plan 2021, which specified alterations to fishing rights and technical specifications of dredges and tow-bars to minimise damage where possible. A key physical difference between king and queen scallop is that the queen scallop possess two distinctive curved shells, while the upper shell of the king scallop is predominantly flat and king scallops are typically larger overall. Queen scallop stocks are known to be more highly mobile than king scallops, especially within the summer months when queen scallops are actively swimming (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement for additional information).

1.10.2.2 King and queen scallop recruitment is generally understood to be unpredictable, due to the recruitment's dependency on larval production and spawning, in addition to the requirement for transportation of larvae to areas optimum for development (Delargy *et al*., 2019). Therefore, king and queen scallop fisheries in the UK are strictly regulated through the utilisation of gear restriction measures, minimum legal landing sizes, effort controls, and seasonal closures further described in Volume 2, Chapter 6: Commercial fisheries of the Environmental Statement. Protected sites with designations for these scallop species have been identified in section 1.11.

1.10.2.3 Distribution of both of these species is invariably patchy (Carter, 2008; Marshall and Wilson, 2009; Duncan *et al*., 2016) but the areas with greatest abundance tend to be areas of little mud and with good current strength. In general, within the same sea basins, king scallop populations are well connected, although localised currents can lead to isolated populations that become dependent on self-recruitment (Hold *et al.*, 2021). In English and Welsh waters, scallops spawn for the first time in the autumn of their second year, and subsequently spawn each year in the spring or autumn. Modelling has found that larvae travel on residual currents, dispersing up to 100 km away from spawning grounds within a five-week period, with the spawning grounds being most abundant in areas closed to bottom-gear fishing activity (Neill and Kaiser, 2008). After settlement, scallops grow until their first winter, during which growth usually ceases. Thereafter, growth resumes each spring and ceases each winter, causing a distinct ring to be formed on the external surface of the shell.

1.10.2.4 Scallops (both king and queen) were the most valuable wild-caught seafood landed in Wales in 2012. However, both their value and quantity of scallop landed have decreased since 2012. Despite this decrease in associated value, scallops are economically important and as of 2017, were the third most valuable wild-caught seafood in Wales (Delargy *et al*., 2019). Similarly, king and queen scallops are the most important fisheries by sale values in Manx waters, around the Isle of Man (Murray *et al*., 2009; Duncan and Emmerson, 2018). However, since 2011, the stock assessment within the Manx waters indicates a decreasing trend of queen scallop biomass which is also illustrated by lower commercial landings (ICES, 2019c). In Northern Irish waters, catch per unit effort for king scallop has been decreasing from a peak between 2012 and 2014 and landings of queen scallop have dropped after a peak in 2011 which is in line with the continuous decrease of the estimated abundance of queen scallop (ICES, 2019c).

1.10.2.5 Generally, queen scallop are more mobile than king scallop, which influences the gear type used to target them, as discussed further in Volume 2, Chapter 6: Commercial fisheries of the Environmental Statement.

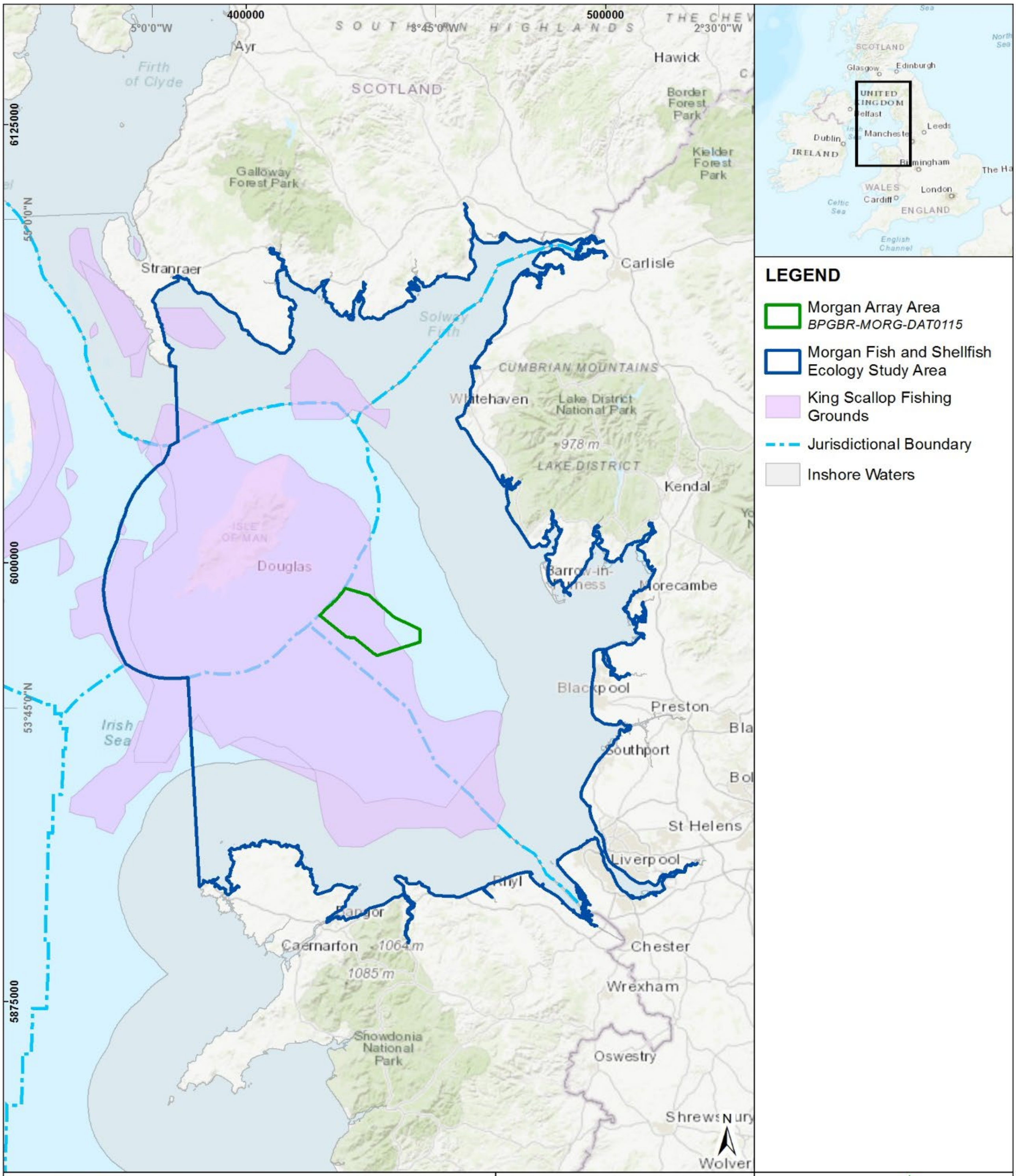
1.10.2.6 King scallop have historically been targeted commercially through dredge fisheries within the vicinity of the Morgan Generation Assets, with the majority of the activity concentrated along the west of the Morgan Array Area and around the Isle of Man

(Figure 1.34). as indicated from VMS data provided by local fisheries. This data, which indicated a wide distribution of this species was supported by surveys performed by the NIGFS, which confirmed the presence of king scallop in this same area at relatively stable population levels in the 2013 to 2021 survey period. Further details are provided within Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement.

1.10.2.7 While the value of landings has fluctuated over the last 10 years, the west-most section of the Morgan Array Area has yielded some of the highest outputs of shellfish landings over the last five years. This is consistent with the consultation feedback showing higher intensity queen scallop fishing in the west-most corner of the Morgan Array Area (Figure 1.35). Other areas around the Morgan Generation Assets and within the Morgan Array Area are rarely fished as they are considered important spawning grounds for the overall queen scallop stock. Specifically, these areas are located within the east half of the Morgan Array Area (Figure 1.35) and extend more widely throughout the fish and shellfish ecology study area. Further consultation has been undertaken in autumn 2023 with relevant fishing industry stakeholders to support broader characterisation of areas of importance to queen scallop beyond the Mona Array Area boundaries. The NIGFS data also indicates the presence of adult specimens of this species within the broader fish and shellfish ecology study area in surveys from 2013 to 2022.

1.10.2.8 King scallop landings by weight within the fish and shellfish ecology study area were found to be greatest from November to May, with an overall landed weight range across these months ranging from 1,394 t to 2,997 t (Bloor, 2019; see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement for additional information). The landed weight of king scallop illustrated relatively similar seasonal trends across the 2020 to 2021 period. Additionally, there is known to be limited dredging occurring from July to October, due to king scallop seasonal due to king scallop seasonal closures. Around the Isle of Man, king scallop fisheries are usually inshore and mostly undertaken using dredges (Beukers-Stewards *et al*., 2005).

1.10.2.9 Queen scallop landings by weight within the fish and shellfish ecology study area were found to be greatest during the months of July, August and September. Landings across these months ranged from 6,721 t to 8,999 t and illustrated varying seasonal trends similar to that of the aforementioned king scallop, with an estimated density in the Isle of Man waters directly north west of the Morgan Generation Assets of 1-11 individuals per 100 m^2 during peak landings period for the area (Bloor *et al*., 2019). A notable lack of queen scallop landings can be observed between April and June, resulting from seasonal closures of the species within the east Irish Sea (Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement).



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, ICES

EnBW bp Partners in UK offshore wind rps

Project Name:
MORGAN OFFSHORE WIND PROJECT

0 2.5 5 10 15 20 25 nm
0 5 10 20 30 40 50 km

Drawing Number:
RPSE-MG-FAS-027-00

Drawing Title:
KING SCALLOP FISHING GROUNDS

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,800,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.34: Historical king scallop fishing grounds confirmed through north Irish, Irish, and UK vessel VMS data (adapted from ICES, 2020).

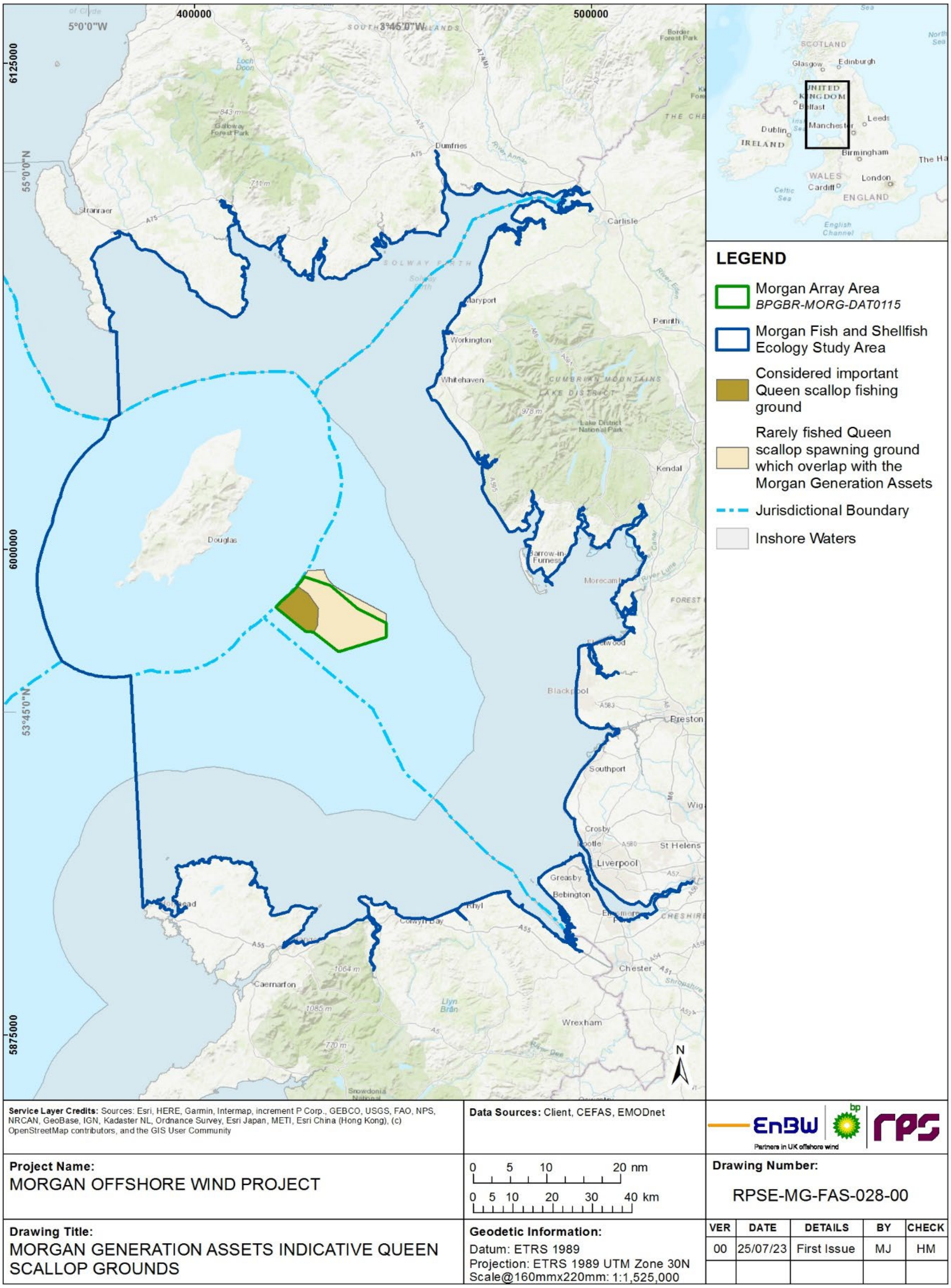


Figure 1.35: Indicative queen scallop grounds as evidenced through stakeholder consultation and VMS data (Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement).

1.10.3 European lobster

1.10.3.1 The European lobster can be found throughout the British coasts on rocky substrata, down to depths of 60 m. European lobster are actively fished in areas within the vicinity of the Morgan Generation Assets as the species is generally caught close to the shore, predominantly by inshore vessels operating out of Anglesey (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement).

1.10.4 Edible crab

1.10.4.1 Edible crab is a relatively long-lived species that are found on all coasts around Britain from the intertidal zone down to depths of 100 m, preferring seabed temperatures of 11 to 15^{o}C in Welsh and Isle of Man waters (Jenkins, 2018). They live on rocky, gravelly substrate which they bury into. Following spawning there is a larval dispersal phase of around 30 to 50 days. Like European lobster, edible crab are actively fished in areas within the vicinity of the Morgan Generation Assets using potting gear (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement).

1.10.5 Velvet swimming crab

1.10.5.1 Velvet swimming crab can be found around the coast of Britain and are found on stony and rocky substrates intertidally and down to depths of 100 m (Howson and Picton, 1997). Velvet swimming crab are targeted by commercial fisheries with higher commercial values available in continental Europe and they are often caught alongside European lobster and edible crab (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement). Velvet swimming crab were recorded in historic surveys undertaken by other offshore wind projects in the vicinity on the Morgan Generation Assets and therefore, are assumed to be present within the Morgan Array Area.

1.10.5.2 Baited static trap and pot fishery independent surveys conducted around the Isle of Man in the Irish Sea evidenced that velvet swimming crab, were the dominant bycatch species in the bottom gear fisheries using pots (Öndes, *et al*., 2018). Peak bycatch rates were found to occur in the spring months, declining into autumn and winter.

1.10.6 Squid

1.10.6.1 Squid species are reported to be found over sand and muddy bottoms (Wilson, 2006) and are mostly demersal in nature and therefore often captured as bycatch in demersal fisheries (Bellido *et al*., 2001). Research on squid indicates that they are probably batch spawners, however, this can vary dependant on species, with some species utilising hard substrate for spawning purposes (Guerra and Rocha, 1994). In Scottish waters, squid exhibit a distinct seasonal migration pattern, travelling up to 500 km from the west coast of Scotland to the east coast in the winter months (Hastie *et al*., 2009). Squid are targeted by commercial fisheries, although main areas of fishing activity are concentrated within coastal waters and do not directly overlap the Morgan

Array Area (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement).

1.10.7 Whelk

1.10.7.1 The common whelk is an epibenthic mobile gastropod, inhabiting muddy sand, sand and mixed sediments from depths of 0 m to 50 m. This species is widely distributed from Iceland in the north to the Bay of Biscay, including throughout the Irish Sea and on all Irish and British coasts. Stocks are likely to be locally discrete due to the absence of a pelagic larval phase and therefore whelk in the Irish Sea comprises a number of populations with limited connectivity. The region immediately to the north west of the Morgan Generation Assets is regularly assessed for whelk populations, with 37 scientific pots in 2017 finding individuals with an average shell length of 70 mm, well over the 45 mm minimum conservation reference size (Emmerson *et al*., 2017), with densities recorded of up to 2.68 (± 1.10) individuals/m^{-2} (Robinson, 2015). Potting for whelk is common across the Morgan Generation Assets and has expanded over the last two decades. Whelk are landed year-round and vessels are known to operate across the Morgan Array Area. Whelk fishers are known to operate out of both English and Welsh ports in proximity to the Morgan Generation Assets (see Volume 4, Annex 6.1: Commercial fisheries technical report of the Environmental Statement).

1.10.8 Nephrops

1.10.8.1 *Nephrops*, known variously as the Norway lobster, Dublin Bay prawn, langoustine or scampi, 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). *Nephrops* are exploited throughout their geographic range, from Icelandic waters to the Mediterranean and the Moroccan coast.

1.10.8.2 *Nephrops* are opportunistic predators, primarily feeding on crustaceans, molluscs and polychaete worms. The species grows incrementally, by moulting their hardened exoskeleton and forming a larger, new one (NWIFCA, 2022). They inhabit muddy seabed sediments and show 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 cm to 30 cm in depth (Dybern and Hoisaeter, 1965). Due to strong habitat preferences, distribution patterns of *Nephrops* are determined by the presence of suitable habitats, with higher abundances found on more favourable substrates.

1.10.8.3 Female *Nephrops* usually mature at three years of age and reproduce each year thereafter. After mating in early summer, *Nephrops* spawn in September, and carry 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). Unspecified intensity nursery and spawning grounds for *Nephrops* are present within the Morgan Array Area, extending west towards the Isle of Man and north towards Northern Ireland (Figure 1.22).

1.10.8.4 *Nephrops* has been consistently recorded across the Walney offshore wind project with the highest number of individuals (3,296) in a single otter trawl recorded in 2009. Otter trawl surveys for the Walney offshore wind project post-construction monitoring recorded *Nephrops* as the most abundant shellfish species and subsequently, *Nephrops* was identified as a species of key commercial importance in the area (Brown and May Marine Ltd., 2013a). Additionally, *Nephrops* were found to be important to the trawling fishery near the Cumbria coast (Walmsley and Pawson, 2007).

1.10.8.5 As previously discussed, *Nephrops* display a strong preference for muddy sediments (silt and clay), therefore the majority of the Morgan Generation Assets is considered unsuitable habitat for *Nephrops* as sand, gravels, and coarser sediments with shell fragments dominate the Morgan Array Area.

1.10.8.6 Incidental observations were made of *Nephrops* from DDV deployments and grab sampling conducted within and adjacent to the Morgan Generation Assets. Environmental sampling was undertaken at 97 locations within and around the Morgan Array Area in 2021, and an addition 26 in the same broad area and ZoI in 2022. *Nephrops* were encountered through DDV survey analysis in the north-most part of the Morgan Array Area. This area was found to comprise gravelly, muddy sand according to survey data (see Volume 4, Annex 2.1: Benthic subtidal ecology technical report of the Environmental Statement).

1.10.8.7 The location of *Nephrops* identified through site-specific surveys, correlated strongly with results of the biotope mapping, with all recordings of *Nephrops* through DDV surveys occurring within areas found to have gravelly muddy sands. *Nephrops* abundances were found to be very low and the biotope they are typically associated with (sea pen and burrowing megafauna communities) was not found to be present across the Morgan Array Area (see Volume 4, Annex 2.1: Benthic subtidal ecology technical report of the Environmental Statement). As such, the Morgan Array Area is unlikely to be important for this species. Further site-specific survey data was collected around the Morgan Array Area and Z0I in 2022 (Morgan Offshore Wind Ltd., 2023), but no *Nephrops* were encountered during this survey.

1.11 Designated Sites

1.11.1 Overview

1.11.1.1 There are a number of sites of nature conservation importance, which are designated for fish and shellfish features within the fish and shellfish ecology study area. Designated sites with relevant fish and shellfish qualifying features and which occur within the fish and shellfish ecology study area are described in Table 1.8, and the locations of the SACs, Marine Conservation Zones (MCZs) and Marine Nature Reserves (MNRs) are illustrated in Figure 1.36. Other sites, including SACs, Sites of Special Scientific Interest (SSSIs), MCZs and Ramsar sites, which are designated for benthic features are examined in Volume 4, Annex 2.1: Benthic subtidal ecology technical report of the Environmental Statement.

1.11.1.2 Note that features such as Ocean quahog *Arctica islandica*, dog whelk *Nucella lapillus,* horse mussel *Modiolus modiolus* beds, spiny scallop *Chlamys hastata,* blue mussel *Mytilus edulis* beds and flame shell *Limaria hians,* which are features of interest of some MNRs, are considered benthic subtidal and intertidal ecology features and are therefore characterised in Volume 4, Annex 2.1: Benthic subtidal ecology technical report of the Environmental Statement and assessed within Volume 2, Chapter 2: Benthic subtidal ecology of the Environmental Statement. These species are not considered further within the fish and shellfish ecology technical report of the Environmental Statement.

1.11.1.3 While brook lamprey is listed as a qualifying feature of some of the identified designated sites, it is not considered further, as it is a wholly freshwater species.

Table 1.8: Summary of designated sites within the fish and shellfish ecology study area and relevant qualifying fish and shellfish ecology features.

* Note that references to scallops within Table 1.8 are collectively to the species within the family Pectinidae, and do not reflect a specific genus or species within this group. References within the same table to sandeel refer to the family Ammodytidae and do not reflect a specific genus or species within this group.

Designated site	Closest distance from the Morgan Generation Assets (km)	Relevant features of interest
Langness MNR	16.74	• European eel • Basking shark • Lobster nursery ground • Cod spawning and nursery ground
Little Ness MNR	20.41	• Basking shark • European eel • Scallops* • Whelk
Douglas Bay MNR	22.22	• European eel • Scallops* • Whelk
Laxey Bay MNR	22.42	• Atlantic salmon • European eel • Sea trout • Scallops* • Whelk
Ramsey Bay MNR	26.42	• European eel • European seabass nursery • Sandeel* • Scallops* • Whelk
Baie ny Carrickey MNR	30.18	• European eel • Basking shark • Spiny lobster (Paniluridae sp.)

Designated site	Closest distance from the Morgan Generation Assets (km)	Relevant features of interest
Calf of Man and Wart Bank MNR	35.76	• European eel • Basking shark • Sandeel* • Spiny lobster
Niarbyl Bar MNR	36.7	• Basking shark
Port Erin MNR	37.02	• Basking shark • Plaice nursery
West Coast MNR	38.7	• European eel • Basking shark • Sandeel* • European seabass nursery • Scallops* • Whelk
Wyre Lune MCZ	47.06	• Sparling
Ribble Estuary MCZ	58.44	• Sparling
River Ehen SAC	62.77	• Atlantic salmon • Freshwater pearl mussel
Dee Estuary SAC/Aber Dyfrdwy SAC	70.09	• Sea lamprey • River lamprey
River Derwent and Bassenthwaite Lake SAC	71.28	• Sea lamprey • River lamprey • Atlantic salmon • Brook lamprey
Solway Firth SAC	84.32	• Sea lamprey • River lamprey
River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC	91.60	• Sea lamprey • River lamprey • Atlantic salmon • Brook lamprey
Solway Firth MCZ	98.90	• Sparling

1.11.2 Langness MNR

1.11.2.1 Langness MNR is located to the southeast of the Isle of Man, in the Irish Sea. The MNR covers 88.67 km^2 and is designated for marine mammal protection, but acts as a feeding ground for basking shark, and a habitat for ocean quahog.

A bed of *Zostera marina* is also present from Langness Gully to the southwest corner of Ramsey Bay, Garwick and Gansey Point (Howe *et al*., 2018; Thomas *et al*., 2018). A series of sea caves are a listed feature of this MNR, comprising two main circular chambers with some roof openings; in areas with roof openings kelp and other seaweeds can be found, along with migrating European eel (Isle of Man Government, 2019a). The sea caves are considered an important nursery area for European lobster (Isle of Man Government, 2019a), and the wider area supports cod spawning and nursery habitats.

1.11.3 Little Ness MNR

1.11.3.1 Little Ness MNR is located on the east coast of the Isle of Man, in the Irish Sea. The MNR covers 10.15 km^2 and is designated for the presence of diverse horse mussel beds, with up to 296 individual species associated with the beds within this MNR (Isle of Man Government, 2019b) through specific seabed habitat surveys conducted in 2010 (Hinz *et al*., 2010). The MNR also acts as a nursery and protected transition ground for the European eels during their migration period, as well as basking shark, scallop, and whelk species (Howe *et al.*, 2018).

1.11.4 Douglas Bay MNR

1.11.4.1 Douglas Bay MNR is located on the southeast coast of the Isle of Man, in the Irish Sea. The MNR covers 4.64 km^2 and is designated to protect king and queen scallop populations, with the Sea Fisheries (Douglas Bay Closed Area) Byelaws 2008 prohibiting the use of towed gear in the area, as well as for the protection of European eel and whelk populations. In the south section of the MNR, a dense and highly diverse horse mussel bed was discovered (Hanley *et al*., 2013), with a bed coverage of approximately 0.22 km^2 present, with up to 240 individuals per m^2 noted, with the main bed running parallel to the coast for 780 m at a distance of 800 m offshore (Perry and Roriston, 2009). An annual closure to protect spawning herring populations is also active within and extending east from this MNR.

1.11.5 Laxey Bay MNR

1.11.5.1 Laxey Bay MNR is located on the east coast of the Isle of Man, in the Irish Sea. The MNR covers 3.97 km^2, and is designated for the presence of ocean quahog, which is listed as an OSPAR regionally threatened/declining species, and thus the site has been closed to bottom-towed scallop dredging activities (Hanley *et al*., 2013). The MNR also provides protection for the Annex II protected European eel, Atlantic salmon and sea trout in their anadromous spawning migrations, and whelk and scallop species (Isle of Man Government, 2019c).

1.11.6 Ramsey Bay MNR

1.11.6.1 Ramsey Bay MNR is located on the northeast cost of the Isle of Man, in the Irish Sea. The MNR covers 94.4 km^2 and is designated for the protection of horse mussel *Modiolus* reefs[2] (Gell *et al*., 2014), with at least five separate areas of high biodiversity reef habitats located in a designated area of 13.9 km^2 in the north section of the MNR (Kennington, 2011). Otherwise, the site is designated for protection of eelgrass, which is understood to be an important nursery habitat for commercially important fish and shellfish species such as European seabass, sandeel, scallops, whelks, or blue mussels *Mytilus edulis* (Heck *et al*., 1995). Overall biomass estimates for fish and shellfish populations in a 2017 dredge survey show a 10% decrease from the 2011 survey (Jenkins, 2018).

1.11.7 Baie ny Carrickey MNR

1.11.7.1 Baie ny Carrickey MNR is located on the southwest of the Isle of Man, in the Irish Sea. The MNR covers 11.37 km^2 and is designated primarily for seabird protection, but also acts as an area in which basking sharks feed and European eels are known to migrate, as well as being closed to mobile fishing gear to prevent damage to the habitats and crustacean stock such as the spiny lobster Paniluridae sp. (Thomas *et al*., 2018; Isle of Man Government, 2019d).

1.11.8 Calf of Man and Wart Bank MNR

1.11.8.1 Calf of Man and Wart Bank MNR is located to the southwest of the Isle of Man, in the Irish Sea. The MNR covers 20.15 km^2 and is designated for primarily the protection of birds and marine mammals, but also basking shark and sandeel species (Isle of Man Government, 2019e). These are protected by prohibition of use of mobile fishing gear, seabed extraction and any other activities which might damage important habitats relevant to fish and shellfish populations, such as kelp forests, and the species which utilise these habitats such as spiny lobster (Thomas *et al*., 2018).

1.11.9 Niarbyl Bay MNR

1.11.9.1 Niarbyl Bay MNR is located to the west of the Isle of Man, in the Irish Sea. The MNR covers 5.66 km^2 and is designated for protection of feeding basking shark and king scallop (Isle of Man Government, 2019f). Specifically, the designation helps with the protection of relatively low-density king scallop populations in the gravelly sediment to the south of the MNR, up to a density of 4 per 100 m^2, with individuals measuring from 24 to 186 mm in length and 54% of individuals being above the minimum landing size of 110 mm (Garratt *et al*., 2022a).

1.11.10 Port Erin MNR

1.11.10.1 Port Erin MNR is located to the southwest of the Isle of Man, in the Irish Sea. The MNR covers 4.34 km^2 and is designated for the presence of feeding basking shark, ocean quahog and flame shells; the area is also listed to support a nursery ground for plaice (Isle of Man Government, 2019g). Benthic

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[2] Note: Mussel reefs (both horse mussels and blue mussels) and ocean quahog are, for the purposes of the Environmental Statement, considered under the benthic subtidal and intertidal ecology topic and are therefore discussed in detail in Volume 4, Annex 2.1: Benthic subtidal ecology technical report of the Environmental Statement.

surveying of this area indicated the widespread presence of king scallops, with 777 individuals noted throughout the surveys area, providing a density of up to 27 individuals per 100 m^2 (Garratt *et al*., 2022b).

1.11.11 West Coast MNR

1.11.11.1 West Coast MNR is located to the west of the Isle of Man, in the Irish Sea. The MNR covers 184.82 km^2 and is designated for basking shark, European bass, blue mussel, scallop, and whelk (Isle of Man Government, 2019h). European bass have been conserved with specific measures in this site since 2016 due to the presence of nursery habitats (Thomas *et al*., 2018) due to the use of this MNR and other nearby sites around the Isle of Man as nursery habitats.

1.11.12 Wyre Lune MCZ

1.11.12.1 The Wyre Lune MCZ is located on the west coast of Britain, in Lancashire, in the south part of Morecambe Bay. The MCZ covers 92 km^2 and is designated for the protection of sparling, with the management goal of returning the population to a favourable condition (DEFRA, 2019a). Data on local sparling populations exist from 1963 in the Lune River, and 1981 in the Wyre River, with the Environment Agency taking responsibility for data collection from 2004, recording 21 sparling datasets in the 2004 to 2014 region, suggesting regular usage of the site as a spawning ground, usually in the February to March period (Natural England, 2017).

1.11.13 Ribble Estuary MCZ

1.11.13.1 The Ribble Estuary MCZ is located on the west coast of Britain, on the northwest coast of England, near Preston and Blackpool. The MCZ covers 15 km^2 and is designated for the protection of sparling, with the management goal of returning the population to a favourable condition (DEFRA, 2019b). Sparling congregate in the lower estuary in early spring, when water temperatures are approximately 5 to 6^{o}C, before transitioning to the river freshwater habitats upstream for spawning upstream in the east of the main river channel, and approximately halfway upstream of the river’s south tributary. Further data on more exact spawning locations and population numbers have been and are being regularly collected in an ongoing and recurring sparling study by the Ribble Rivers Trust (2021). However, at the time of writing, this was not published and has therefore not been used.

1.11.14 River Ehen SAC

1.11.14.1 The River Ehen SAC is an oligotrophic river located in west Cumbria. The designated stretch of the river, between Ennerdale Water and the confluence with the River Keekle at Cleator Moor, meanders across a narrow floodplain with areas of riparian woodland and trees.

1.11.14.2 This site supports England’s largest population of the freshwater pearl mussel which is listed on the IUCN Red List of Protected Species as critically endangered in Europe. Atlantic salmon whilst designated in its own right as a feature of this site, is an important host for the larvae (glochidia) of freshwater pearl mussel. Glochidia attach to juvenile salmon in late summer and over-winter in the fish's gills. Juvenile mussels drop-off of their fish host in spring where they burrow in to the river gravels, where they remain for several years. This buried stage within the life cycle is particularly susceptible to changes in river flow regime, siltation, excess algal biomass and eutrophication. The river has shown some juvenile mussel recruitment within the last 20 years, but not at levels capable of sustaining the population (Natural England, 2019a).

1.11.14.3 The River Ehen SAC is designated due to its Annex II qualifying species, the freshwater pearl mussel and Atlantic salmon. The River Ehen supports the largest freshwater pearl mussel population in England. The freshwater pearl mussel grows to around 150 mm in length and can live to be over 130 years old (Bauer, 1992; Skinner *et al*., 2003). Freshwater pearl mussel require clean, fast flowing, highly oxygenated rivers and burrows into sand/gravel substrates, often between boulders and pebbles (Geist and Auerswald, 2007).

1.11.14.4 The mussel requires a salmonid fish host for its larval (glochidial) stage; it is thought that the appropriate host fish in the Ehen is Atlantic salmon. As this species does not reach reproductive maturity until at least 12 years old and may live for over 130 years (Bauer, 1992), population age-structure is vitally important when assessing viability. The presence of juveniles (a feature essential to the long-term sustainability of mussel populations) is a clear indicator of the structural and functional features of the habitat required for the survival and reproduction of the species (Natural England, 2019a).

1.11.14.5 Exceptionally high densities (greater than 100 m^2) are found at some locations, with population estimates for the entire river exceeding 500,000 during the spawning period, including adults and juveniles. The conservation importance of the site is further enhanced by the presence of juvenile pearl mussels, indicating recruitment in recent years. Worryingly, juvenile recruitment over the past decade has been poor indicating unsustainable pressures on the population which could lead to its extinction within a lifetime (Natural England, 2019a).

1.11.14.6 In the River Ehen SAC, the population has declined because of factors such as habitat modification and associated impacts on natural flow regimes, pollution, nutrient enrichment, aggravated erosion of riverbanks and declining salmonid stocks. The freshwater pearl mussel is classified critically endangered across Europe (Cuttelod *et al*., 2011) and in the UK it is protected under Schedule 5 of the Wildlife and Countryside Act (1981).

1.11.14.7 Additionally, the River Ehen holds a significant population of Atlantic salmon, and the Environment Agency classifies the population as "probably at risk" based on the 2017 assessment and was predicted to remain in that status over the following five years. This potential downward trend in the salmonid population has been a long term issue for this river, with catch and individual counts decreasing over a period of several decades (Marshall, 1977, McCubbing, 1997). This decreasing trend was considered when the site was designated, and potentially acted as a factor in the designation of the Cumbria Coast MCZ which the river flows into (Defra, 2020) in order to improve connectivity between these protected areas. October through to the end of January is the key time for salmon migration into the River Ehen SAC.

1.11.15 Dee Estuary SAC/Aber Dyfrdwy SAC

1.11.15.1 The Dee Estuary/Aber Dyfrdwy SAC comprises both the Dee Estuary SPA and Aber Dyfrdwy SAC. The area lies on the boundary between England and Wales, and the estuary itself is large, sheltered, and funnel shaped, supporting extensive areas of intertidal sandflats, mudflats, and saltmarsh (NRW, 2018; MMO, 2019).

1.11.15.2 The Dee Estuary is one of the largest estuaries in the UK, with an area of over 14,000 ha (140 km^2). The Dee Estuary is hyper-tidal with a mean spring tidal range of 7.7 m at the mouth. The estuary historically stretched as far inland as Chester and its form has been modified considerably over the past 300 years as a direct result of human intervention. The intertidal area is currently dominated by mudflats and sandflats with the remainder being largely saltmarsh. At low water spring tides, over 90% of the estuary dries out. The extensive intertidal flats of the Dee Estuary form the fifth largest such area within an estuary in the UK (NRW, 2018).

1.11.15.3 The Dee Estuary SAC/Aber Dyfrdwy SAC has been designated as a SAC due to supporting a significant presence of both sea and river lamprey (MMO, 2019). Freshwater populations of river lamprey were found to be favourable while the associated marine habitat was denoted unfavourable. The activities that were found to directly impact the condition of the river lamprey feature at this site were found to be water quality issues (NRW, 2018). Regarding sea lamprey data, both the freshwater population and marine habitat were found to be unfavourable; similarly, water quality issues were found to have a direct impact upon this qualifying feature (NRW, 2021).

1.11.16 River Derwent and Bassenthwaite Lake SAC

1.11.16.1 The River Derwent and Bassenthwaite Lake SAC is a large water body with an extensive catchment area subject to rapid through-flows of water and nutrients. The SAC is a designated site due to the Annex II species present, which include sea lamprey, brook lamprey, river lamprey, and Atlantic salmon (JNCC, 2015).

1.11.16.2 Furthermore, the River Derwent and Bassenthwaite Lake SAC has extensive occurrences of gravels and silts in the lower to middle reaches of the river which subsequently results in the ability for the SAC to support a large population of sea lamprey. The SAC also has features that are known to provide necessary conditions for both spawning and nursery areas (extensive gravel shoals, good water quality, and areas of marginal silt) of brook lamprey.

1.11.16.3 Additionally, the Derwent is utilised by river lamprey and is considered an oligotrophic lake in northwest England. River lamprey are known to occur within this area as the river holds features that provide necessary conditions for spawning and nursery areas, which are comprised of good water quality, extensive gravel shoals, and areas of marginal silt (JNCC, 2015).

1.11.16.4 Atlantic salmon is also represented within the River Derwent with populations that take advantage of the surrounding water quality and presence of extensive gravel shoals which help to create a particularly suitable river for breeding which subsequently enables the river to support a larger population of this species (JNCC, 2015).

1.11.17 Solway Firth SAC

1.11.17.1 The Solway Firth SAC is a large, complex estuary on the west coast of Britain. It is known to be one of the least industrialised, yet largest and most natural estuaries in Europe (JNCC, 2014). The sediment habitats are predominantly comprised of dynamic sandflats and subtidal sediment banks that are separated by river channels that continually change their patterns of erosion and accretion (JNCC, 2014).

1.11.17.2 Additionally, the Solway Firth SAC is representative of sublittoral sandbanks on the coast of northwest England, where they are predominantly comprised of gravelly, clean sands. Dominant species of infaunal communities include annelid worms, crustaceans, molluscs, and echinoderms (JNCC, 2014).

1.11.17.3 The conservation objectives for the Solway Firth SAC are to maintain favourable conservation conditions for each of the Annex I habitats and Annex II species that are designated features of the site. The sea lamprey and river lamprey within the Solway Firth SAC are provided migratory passage to and from spawning and nursery grounds in a number of rivers, including the Eden (JNCC, 2014).

1.11.18 River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC

1.11.18.1 The River Dee and Bala Lake SAC crosses the border between England and Wales. The River Dee has its source in Snowdonia at the outflow of Llyn Tegid and it includes the Ceiriog, Meloch, Tryweryn and Mynach tributaries. Its catchment contains a wide spectrum of landscape from high mountains around Bala, rugged peaks near Llangollen, steep sided wooded valleys, and the plains of Cheshire, Flintshire, north Shropshire and Wrexham. There is a tidal influence as far upstream as Farndon and high tides regularly exceed the Chester weir crest level (Natural England, 2019b).

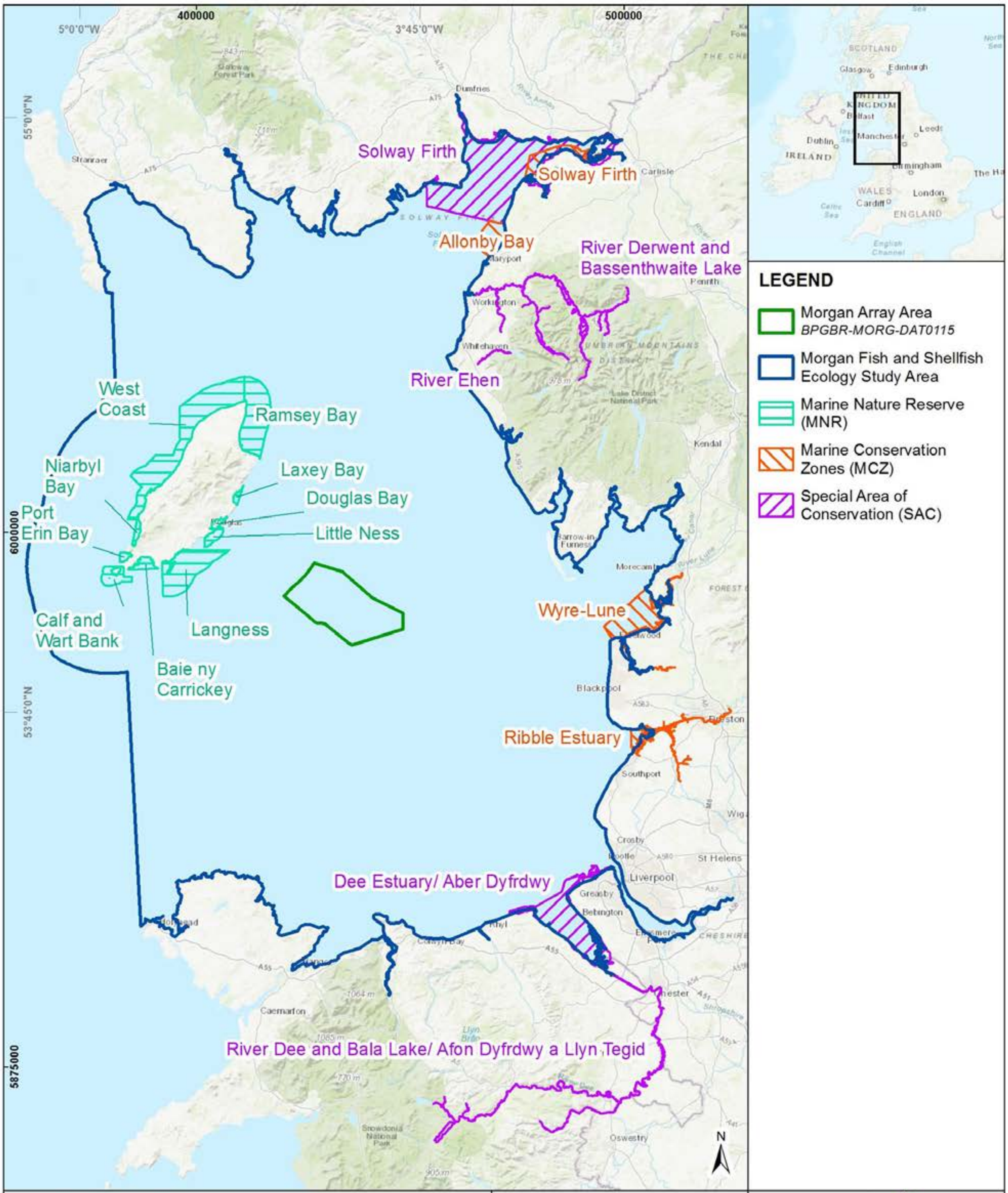
1.11.18.2 The River Dee is recognised as one of North Wales’s premier rivers for Atlantic salmon. The Mynach, Meloch and Ceiriog tributaries are the most important Atlantic salmon spawning tributaries in the Dee catchment. Other diadromous fish utilising the river system include river lamprey and sea lamprey. The Dee also supports important populations of non-migratory fish including brook lamprey (Natural England, 2019b). At least one record of twaite shad has been noted (Morgan Generation Assets Consultation Report submitted with the application - Document Reference E3), although there is no evidence of a spawning population of this species in this designated site.

1.11.18.3 The SAC is underpinned by two Sites of Special Scientific Interest (SSSI) divided by the national boundary; the Afon Dyfrdwy (River Dee) SSSI and the River Dee (England) SSSI. The Welsh SSSI includes the upper part of the main stem Dee, Afon Mynach, Afon Meloch, Afon Tryweryn and the upper part of the River Ceiriog (except the headwaters). The English SSSI includes the lower part of the main stem Dee and the lower part of the River Ceiriog (Natural England, 2019b).

1.11.18.4 The River Dee and Bala Lake SAC has received designation status due to the Atlantic salmon, which is an Annex II species and was the primary reason for the site selection. Additionally, Brook lamprey, sea lamprey, and river lamprey are Annex II species which are qualifying features, however, not the primary reason behind the site selection of this specific SAC (JNCC, 2022b).

1.11.19 Solway Firth MCZ

1.11.19.1 The Solway Firth MCZ is located on the west coast of Britain, in Cumbria, within the Solway Firth estuary. The MCZ covers 45 km^2 within this estuary and is designated specifically for the protection of sparling, with the goal of this management being to recover the population traversing the estuary for spawning behaviour to favourable condition (DEFRA, 2019c). Historically, sparling were abundant in this environment (Lyle and Maitland, 1997), but overfishing and pollution pressures are believed to have caused a significant localised decline in population (Maitland and Lyle, 1996), although this is not replicated at a wider scale, with currently sparling being a species of Least Concern on the IUCN Red List.



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Data Sources: Client, CEFAS, EMODnet

Partners in UK offshore wind

Project Name:
MORGAN OFFSHORE WIND PROJECT

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

Drawing Number:
RPSE-MG-ES-FAS-029-00

Drawing Title:
DESIGNATED SITES

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,500,000

VER	DATE	DETAILS	BY	CHECK
00	25/07/23	First Issue	MJ	HM

Figure 1.36: Designated sites with relevant fish and shellfish features in proximity to the Morgan Generation Assets.

1.12 Summary

1.12.1 Overview

1.12.1.1 The following sections provide a summary of the fish and shellfish baseline characterisation and detail the IEFs to be considered in the EIA, as informed by the baseline characterisation.

1.12.2 Baseline

1.12.2.1 The fish assemblages within the Morgan Generation Assets are typical of the east Irish Sea. This is confirmed through site-specific survey and baseline data available from other offshore wind projects in the vicinity of the Morgan Generation Assets, with a mix of both demersal and pelagic species. There are known spawning and nursery grounds for nine fish and shellfish species, including cod, herring, lemon sole, mackerel, *Nephrops*, plaice, sandeel, sole and whiting, along with a range of elasmobranchs including tope and spurdog. Herring spawning grounds were further investigated, the results showing that while there is some spawning activity in the vicinity of the Morgan Generation Assets, the majority of herring spawning occurs to the north and northwest of the Morgan Generation Assets. The site-specific PSA data supports very low proportions of the Morgan Array Area being suitable for herring spawning activity. Habitat suitability for sandeel was assessed, with the majority of the Morgan Array Area considered marginal and unsuitable habitat, with limited sparse areas of preferred habitat.

1.12.2.2 Eight species of diadromous fish were identified as having the potential to be present within the fish and shellfish ecology study area: Atlantic salmon, sea trout, sea lamprey, river lamprey, European eel, allis and twaite shad and sparling. All eight species were deemed to have the potential to be present within the Morgan Generation Assets. Five SACs designated for diadromous fish species (Solway Firth SAC, Aber Dyfrdwy SAC, River Derwent and Bassenthwaite Lake SAC, River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC, and River Ehen SAC) are present within a range of 62.77 to 91.6 km from the Morgan Generation Assets and within the fish and shellfish ecology study area.

1.12.2.3 Shellfish known to occur in the fish and shellfish ecology study area and therefore with potential to occur within the Morgan Generation Assets boundaries include *Nephrops*, European lobster, edible crab, velvet swimming crab, squid, whelk, king scallop and queen scallop, which are targeted by commercial fisheries in the locality.

1.12.2.4 Basking sharks migrate through the Irish Sea during spring and summer and migration routes are known to cover large distances from the north of Scotland to North Africa. Basking sharks have been recorded moving through the Irish Sea between March to June, indicating that this is an important area for overwintering that links foraging grounds in the waters surrounding the west coast of Ireland and the UK to migration destinations in the south.

1.12.3 Important Ecological Features

1.12.3.1 IEFs are habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Morgan Generation Assets. Guidance from the Chartered Institute of Ecology and Environmental Management (CIEEM) was used to assess IEFs within the area (CIEEM, 2022). IEFs can be attributed to individual species (such as plaice) or species groups (for example other flat fish species). Each IEF is assigned a value or importance rating which are based on commercial, ecological and conservation importance, including Species of Principal Importance (SPI) and features of SACs. SPIs are those species most threatened, in greatest decline, or where England and Wales hold a significant proportion of the world's total population in some cases, as outlined in Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006. This statutory designation applies to allis shad, twaite shad, lesser sandeel, European eel, herring, cod, anglerfish, European hake, ling, whiting, plaice, mackerel, Dover sole, Atlantic salmon, sea trout, river lamprey, sea lamprey, sparling, basking shark, spurdog and tope shark, which are found within the Irish Sea (Cefas, 2005) and are expected to be found within the fish and shellfish ecology study area. Table 1.9 details the criteria used for determining IEFs and Table 1.10 applies the defining criteria to specific species, providing justifications for importance rankings.

Table 1.9: Defining criteria for IEFs.

Value of IEF	Defining criteria
International	Internationally designated sites. Species protected under international law (i.e. Annex II species listed as qualifying interests of SACs).
National	Nationally designated sites. Species protected under national law. Annex II species which are not listed as qualifying interests of SACs in the fish and shellfish ecology study area. OSPAR List of Threatened or Declining Species, and IUCN Red List species that have nationally important populations within the Morgan Generation Assets, particularly in the context of species/habitat that may be rare or threatened in English and Welsh waters. Priority habitats and species (Species of Principal Importance) have been deemed features characteristic of the English and Welsh marine environment and where nationally important habitats/communities are present in the fish and shellfish ecology study area. Species that have spawning or nursery areas within or in the immediate vicinity of the Morgan Generation Assets that are important nationally (e.g. may be primary spawning/nursery area for that species).
Regional	OSPAR List of Threatened or Declining Species, and IUCN Red List species that have regionally important populations within the Morgan Generation Assets (i.e. are locally widespread or abundant). Priority habitats and species (Species of Principal Importance) have been deemed features characteristic of the English and Welsh marine environment. Species that are of commercial value to the fisheries which operate within the Morgan Generation Assets. Species that form an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages within the Morgan Generation Assets. Species that have spawning or nursery areas within the Morgan Generation Assets that are important regionally (i.e. species may spawn in other parts of English and Welsh waters, but this is a key spawning/nursery area within the Morgan Generation Assets).
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Morgan Generation Assets (e.g. they may be exploited in deeper waters outside the Morgan Generation Assets). The spawning/nursery area for the species are outside the Morgan Generation Assets. The species is common throughout English and Welsh waters but forms a component of the fish assemblages in the Morgan Generation Assets.

Table 1.10: IEF species and representative groups within the Morgan Generation Assets.

IEF	Specific name/ representative species	Importance	Justification
Plaice	*Pleuronectes platessa*	Regional	Listed as a Species of Principal Importance. High intensity spawning and low intensity nursery grounds identified throughout the Morgan Generation Assets. Plaice is an important commercial species throughout the Morgan Generation Assets and within the surrounding east Irish Sea.
Lemon sole	*Microstomus kitt*	Local	Spawning and nursery grounds are undetermined and unspecified within the Morgan Generation Assets and wider east Irish Sea. It is an important and abundant commercial fish species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the wider east Irish Sea).
Dover sole	*Solea*	Regional	Listed as a Species of Principal Importance. High intensity spawning and nursery grounds identified throughout the Morgan Generation Assets. Dover sole is an important commercial species throughout the Morgan Generation Assets and within the surrounding east Irish Sea.
Other flatfish species		Local	Other flatfish species including common dab, solenette, and flounder are likely to occur within the Morgan Generation Assets. These species either have no known spawning or nursery grounds or low intensity/undetermined spawning and nursey grounds within the area.
Cod	*Gadus morhua*	Regional	Listed as a Species if Principal Importance. Listed by OSPAR as threatened or declining and listed as vulnerable on the IUCN Red List. High intensity spawning and nursery grounds are present throughout the Morgan Generation Assets. It is an important commercial fish species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the wider east Irish Sea) following the collapse of the stock and subsequent poor recovery.
Haddock	*Melanogrammus aeglefinus*	Regional	Nursery ground of unspecified intensity marginally overlaps the Morgan Array Area in its north section. Listed as vulnerable on the IUCN Red List.
Whiting	*Merlangius merlangus*	Regional	Listed as a Species of Principal Importance. Low intensity spawning and high intensity nursery grounds identified throughout the Morgan Generation Assets. Whiting is an important commercial species throughout the Morgan Generation Assets and within the surrounding east Irish Sea.
Other demersal species		Local to Regional	Species including anglerfish *Lophius piscatorius,* ling *Molva molva,* hake *Merluccius merluccius* and European seabass *Dicentrarchus labrax* are common throughout English and Welsh waters and are likely to be in the Morgan Generation Assets. The first three species listed are also Species of Principal Importance.

IEF	Specific name/ representative species	Importance	Justification
			They are important commercial species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the east Irish Sea).
Sandeel species	Ammodytidae spp.	Regional	There are five species of sandeel found in UK waters with lesser sandeel *Ammodytes tobianus* and larger sandeel *Hyperoplus lanceolatus* being the most commonly found species in British waters. Sandeel are important prey species for fish, birds and marine mammals. High intensity spawning grounds and low intensity nursery grounds are present throughout the Morgan Generation Assets. Identified as likely to be present in the Morgan Generation Assets based on historic data and habitat preference. Raitt's sandeel *Ammodytes marinus* is listed as a Species of Principal Importance.
Herring	*Clupea harengus*	National	Listed as a Species of Principal Importance. Low intensity spawning grounds present immediately outside of the Morgan Generation Assets and within the fish and shellfish ecology study area. High intensity nursery grounds present within the Morgan Generation Assets. Although herring spawning grounds do not directly overlap the Morgan Array Area, this specific area of the Irish Sea has been denoted as key spawning habitat for the species. Herring is an important commercial species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the wider east Irish Sea).
Mackerel	*Scomber scombrus*	Regional	Listed as a Species of Principal Importance. Important prey species for larger fish, birds and marine mammals. Low intensity spawning and nursery grounds throughout the Morgan Generation Assets and the wider east Irish Sea. Mackerel is an important commercial species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the wider east Irish Sea).
Sprat	*Sprattus sprattus*	Regional	Important prey species for larger fish, birds and marine mammals. Unspecified intensity spawning and nursery grounds within the Morgan Generation Assets. Sprat is an important commercial species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the wider east Irish Sea).
Basking shark	*Cetorhinus maximus*	International	The northeast Atlantic population are classed as Endangered on the IUCN Red List. Additionally, they are listed under Convention on International Trade in Endangered Species (CITES) Appendix II and classified as a Priority Species under the UK Post-2010 Biodiversity Framework. Protected in the UK under the Wildlife and Countryside Act. Listed as a Species of Principal Importance.

IEF	Specific name/ representative species	Importance	Justification
			Basking shark likely to be present in low abundances if present at all near the Isle of Man and in proximity to the Morgan Generation Assets.
Tope	*Galeorhinus galeus*	Regional	Listed as a Species of Principal Importance. Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Morgan Generation Assets.
Spurdog	*Squalus acanthias*	Regional	Listed as a Species of Principal Importance. Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. High intensity nursery grounds within the Morgan Generation Assets.
Rays		Regional	Ray species including spotted ray *Raja montagui*, and thornback ray *Raja clavata*. These species either have low intensity nursery grounds and no known spawning grounds within the Morgan Generation Assets.
Shellfish IEF Species			
Edible crab	*Cancer pagurus*	Regional	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets.
Norway lobster	*Nephrops norvegicus*	Regional	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets. *Nephrops* have undetermined intensity spawning and nursery grounds within the Morgan Array Area.
European lobster	*Homarus gammarus*	Regional	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets.
King scallop	*Pecten maximus*	Regional	Commercially important species. Identified as being present within the Morgan Generation Assets.
Queen scallop	*Aequipecten opercularis*	Regional	Commercially important species. Identified as being present within the Morgan Generation Assets.
Velvet swimming crab	*Necora puber*	Local	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets.
Other crustaceans		Local	Other crustaceans including, swimming crabs, spider crabs and shrimp have been identified as being likely to occur within the Morgan Generation Assets. They are all important commercial species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the wider east Irish Sea).
Diadromous Fish IEF Species			
Sea trout	*Salmo trutta*	National	Listed as a Species of Principal Importance. Listed as a species of Least Concern by the IUCN Red List. Listed as an OSPAR threatened/declining species.

IEF	Specific name/ representative species	Importance	Justification
			Likely to migrate through the Morgan Generation Assets. Not a feature of any designated sites in the vicinity of the Morgan Generation Assets.
European eel	*Anguilla anguilla*	National	Listed as a Species of Principal Importance. Listed as Critically Endangered by the IUCN Red List. Listed as an OSPAR threatened/declining species. Likely to migrate through the Morgan Generation Assets. This species is a qualifying feature of multiple MNRs in the vicinity of the Morgan Generation Assets.
Sea lamprey	*Petromyzon marinus*	International	Listed as a Species of Principal Importance. Listed as a species of Least Concern by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets.
River lamprey	*Lampetra fluviatilis*	International	Listed as a Species of Principal Importance. Listed as a species of Least Concern by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets, although only in coastal/estuarine areas.
Twaite shad	*Alosa fallax*	National	Listed as a Species of Principal Importance. Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Likely to migrate through the Morgan Generation Assets.
Allis shad	*Alosa alosa*	National	Listed as a Species of Principal Importance. Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Likely to migrate through the Morgan Generation Assets.
Atlantic salmon	*Salmo salar*	International	Listed as a Species of Principal Importance. Listed as Vulnerable by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets.
Sparling/ European smelt	*Osmerus eperlanus*	National	Listed as a Species of Principal Importance. Listed as a species of Least Concern by the IUCN Red List. This species is a qualifying feature of multiple MCZs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets, although only in coastal/estuarine areas.
Freshwater pearl mussel	*Margaritifera margaritifera*	International	Listed in Annexes II and V of the EU Habitats and Species Directive and Appendix III of the Bern Convention. Listed as Endangered on the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets.

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Appendix B: Morecambe Offshore Windfarm Generation Assets fish and shellfish chapter baseline

10.5 Existing environment

10.62 The characterisation of the existing environment is undertaken using data sources listed in **Table 10.5**, plus other relevant literature.

10.5.1 Overview

10.63 The north Irish Sea (ICES division VIIa) is composed of a deep channel, about 300km long, with shallower bays to the east. The waters to the east of the Isle of Man are generally less than 50m deep. Regional and local data sources have been used to describe the fish and shellfish ecology baseline, with a focus on the local study area defined by ICES rectangle 36E6. Regional data includes MMO landings, used to identify commercially important species; and the International Bottom Trawl Survey (IBTS), which provides information about demersal species present locally that are effectively sampled by beam trawls, including non-commercial species.

10.64 The local fish community includes commercially important species for local fleets such as plaice *Pleuronectes plattessa*, cod *Gadhus morhua* and common sole *Solea solea,* characteristic of inshore, coastal waters (<50m deep); as well as typical smaller demersal species, including whiting *Merlangius merlangus* and sandeels *Ammodytidae sp.*, which are an important prey species for many kinds of fish, birds, and marine mammals (Teal, 2011). Other fish species common to the North Irish Sea include mackerel *Scomber scombrus,* ling *Molva molva,* herring *Clupea Harengus,* and anglerfish *Lophius pisccatorius.*

10.65 There are records of several species of conservation importance in the study area (as described in the below sections). Potential spawning and nursery grounds of sandeel, common sole, plaice, cod, whiting, and mackerel overlap with the study area. The nearest herring spawning grounds are located approximately 40km northwest of the Project (Coull *et al*. 1998 and AFBI NINEL[6]).

10.66 The Irish Sea area also supports populations of elasmobranchs (sharks, skates and rays). Of particular note for conservation importance are basking sharks *Cetorhinus maximus*, which are protected under Appendix III of the Bern Convention and the Wildlife and Countryside Act (1981). Basking shark are also listed under the Convention on International Trade in Endangered Species (CITES). Thornback ray *Raja clavata,* which are of national significance, are also present in the Irish Sea. There are estimated to be

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[6] The most recent 10 years (2012-2021) of the Irish Sea Herring larvae survey (NINEL) run by the Agri-food and Biosciences Institute (AFBI)

around 23 species of elasmobranchs commonly found in the Irish Sea (Niels, 2005).

10.67 The wider fish and shellfish ecology study area is commercially important for Norway lobster *Nephrops norvegicus* (hereafter referred to as *Nephrops*), queen scallops *Aequipecten opercularis,* king scallops *Pecten maximus*, common whelks *Buccinum undatum*, European lobster *Homarus gammarus* and brown crab *Cancer pagurus*. Lockwood (2005) shows two shellfish resources within the Irish Sea. These comprise a large scallop ground, across the whole Eastern Irish Sea, and a *Nephrops* resource, located to the north of Liverpool Bay, between the Isle of Man and the Cumbrian coast (this finding is supported by similar findings by the Northern Ireland Ground Fish Survey (NIGFS)).

10.5.2 Commercial species

10.68 Commercial fisheries data can provide a useful additional insight into the species found in the vicinity of the study area. **Table 10.11** highlights the annual average landings over 0.5 tonnes (2018-2022) by species, in terms of quantity (landed weight) and value, for ICES rectangle 36E6. Catches within this rectangle were dominated by shellfish, with queen scallops representing 37.9% of all landings, whelks 37.5% and king scallops 19.2%. The top two fish species by landed weight were thornback ray, representing 1.7% of all landings, and common sole, representing 1.2%.

Table 10.11 Mean annual fisheries landings data between 2018 – 2022 by species (over 0.5 tonne) in ICES rectangle 36E6 (National Statistics, 2023)

Species	Quantity (tonnes)	Percentage of total
Fish		
Thornback ray *Raja clavata*	23.4	1.7%
Common sole *Solea solea*	17.2	1.2%
Plaice *Pleuronectes platessa*	9.9	0.7%
Sea bass *Dicentrarchus labrax*	7.8	0.5%
Lesser spotted dogfish *Scyliorhinus canicula*	2.5	0.2%
Flounder *Platicthys flesus*	2.3	0.2%
Brill *Scophthalmus rhombus*	1.0	0.1%
Unidentified dogfish	0.6	<0.05%
Shellfish		
Queen scallops *Aequipecten opercularis*	533.7	37.9%

Species	Quantity (tonnes)	Percentage of total
Whelks *B. undatum*	528.4	37.5%
King Scallops *Pecten maximus*	270.0	19.2%
European lobster *Homarus Gammarus*	3.2	0.2%
Brown crab *Cancer pagurus*	3.0	0.2%
Norway lobster *Nephrops norvegicus*	1.9	0.1%
Brown shrimp *Crangon crangon*	0.93	0.1%

10.5.3 Spawning and nursery grounds

10.69 Spawning and nursery grounds, defined by Coull *et al*. (1998), Ellis *et al*. (2012) have been used to indicate which species may have spawning and nursery grounds within the study area. Due to the broad scale of these spawning and nursery maps, the use of these data sources can be considered to represent conservative estimates of the geographical extent of spawning and nursery grounds. It is acknowledged that data sources such as Ellis *et al*. (2012) are over 10 years old and so may not reflect current species composition and abundance. However, further information regarding nursery areas is provided in Aires *et al.* (2014). The study assessed evidence of aggregations of '0 group fish' (fish in the first year of their lives) around the UK coastline. These data were ascertained from species distribution modelling combining observations of species occurrence or abundance with environmental data (Aires *et al.*, 2014). The outputs of this process have been suggested to be used as a guide for the most likely locations of aggregations of 0 group fish. Modelling based on collated survey data in the Isle of Man territorial waters (Campanella and van der Kooij, 2021) provides evidence to support the distribution of the previously identified spawning and nursery grounds for a range of foraging species, with any slight changes in mapped species distribution likely being due to natural interannual variation. Broadly, these studies all describe the same patterns of spawning and nursery habitat within the fish and shellfish ecology study area, and thus the maps available from Coull *et al.* (1998) and Ellis *et al.* (2012) data can be considered reliable.

10.70 In addition, site specific data and recent herring larvae data have been used to further inform the baseline for sandeel and herring (see Section 10.5.4), showing low herring larvae counts in the study area.

10.71 The windfarm site overlaps, or is in close proximity to, a number of fish spawning and nursery grounds, including sandeel, common sole, plaice, cod, whiting and mackerel (see **Figures 10.2 a-c** and **10.3 a-d** and **Table 10.12**). **Table 10.12** highlights the hearing group of each species (as defined by

Popper *et al*. (2014)), with an overlapping spawning or nursery ground (as defined by Coull *et al*. (1998) and Ellis *et al*. (2012)). It is also noted that herring spawning grounds, whilst not overlapping the windfarm site, are found approximately 44km to the northwest of the windfarm site (Coull *et al*. 1998) and have been considered further, due to their particular sensitivity to noise impacts (Popper *et al*., 2014).

10.72 Spawning grounds for elasmobranch species, such as thornback ray, and spurdog, are not defined by Coull *et al*. (1998) or Ellis *et al*., (2012). However, it has been reported that adult thornback rays occur in shallow inshore waters during summer months, potentially for spawning and mating (Walker *et al*, 1997; HOW03, 2018), before returning to deeper offshore waters, leaving juveniles in the shallows. Thornback ray spawning grounds are poorly defined, but are thought to generally coincide with nursery areas (Ellis *et al*., 2012).

Table 10.12 Spawning and nursery areas

Species	**Hearing group**[1]	**Areas overlapping the windfarm site**[2]		**Conservation designation**
		Spawning	**Nursery**	
Sandeel spp.	Group 1: Fish with no swim bladder or other gas chamber	Y (high intensity)	Y (low intensity)	The lesser sandeel *Ammodytes tobianus* is a Priority Species under the UK Post-2010 Biodiversity Framework
Common sole *Solea solea*	Group 1: Fish with no swim bladder or other gas chamber	Y (high intensity)	Y (high intensity)	International Union for Conservation of Nature (IUCN): data deficient
Plaice *Pleuronectes plattessa*	Group 1: Fish with no swim bladder or other gas chamber	Y (high intensity)	Y (low intensity)	IUCN (least concern)
Mackerel *Scomber scombrus*	Group 1: Fish with no swim bladder or other gas chamber	Y (low intensity)	Y (low intensity)	Species of Principle Importance in England (SPII, IUCN (least concern)
Spurdog *Squalus acanthias*	Group 1: Fish with no swim bladder or other gas chamber	N	Y (high intensity)	SPII, OSPAR, IUCN (vulnerable)
Anglerfish *Lophius pisccatorius*	Group 1: Fish with no swim bladder or other gas chamber	N	Y (low intensity)	SPII

Species	Hearing group[1]	Areas overlapping the windfarm site[2]		Conservation designation
		Spawning	Nursery	
Tope shark *Galeorhinus galeus*	Group 1: Fish with no swim bladder or other gas chamber	N	Y (low intensity)	SPII, IUCN (vulnerable)
Thornback ray *Raja clavata*	Group 1: Fish with no swim bladder or other gas chamber	N	Y (low intensity)	OSPAR, IUCN (near threatened)
Spotted ray *Raja montagui*	Group 1: Fish with no swim bladder or other gas chamber	N	Y (low intensity)	SPII, IUCN (least concern)
Cod *Gadhus morhua*	Group 3: Fish in which hearing involves a swim bladder or other gas volume	Y (high intensity)	Y (high intensity)	IUCN Status Global: VU (Vulnerable) Europe: LC (Least Concern)
Whiting *Merlangius merlangus*	Group 3: Fish in which hearing involves a swim bladder or other gas volume	Y (low intensity)	Y (high intensity)	SPII, IUCN (least concern)
Ling *Molva molva*	Group 3: Fish in which hearing involves a swim bladder or other gas volume	Y (low intensity)	N	SPII
Herring *Clupea harengus*	Group 4: Fish that have special structures mechanically linking the swim bladder to the ear	N	Y (high intensity)	SPII, IUCN (least concern)

[1] As defined by Popper et al. (2014); [2]As defined by Coull et al., (1998) and Ellis et al., (2010)

10.73 **Table 10.13** shows the fish and shellfish species with spawning and nursery grounds that overlap with the windfarm site, and the intensity and annual timings of these activities.

Table 10.13 Species with spawning and/or nursery grounds in the windfarm site (Coull et al., 1998; Ellis et al., 2012)

Orange = spawning/nursery ground, ● = peak spawning, Hatched = unknown/lack of data *For these species there is no known spawning ground overlap, however, they are within proximity (<40km) to the windfarm site.

	Spawning season in the windfarm site												**Nursery grounds**
Species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Study area**
Plaice	🟧 ●	🟧 ●	🟧									🟧	🟧
Common sole			🟧	🟧 ●	🟧								🟧
Cod	🟧	🟧 ●	🟧 ●	🟧									🟧
Anglerfish	🟧	🟧	🟧	🟧	🟧	🟧							▨
Whiting		🟧	🟧	🟧	🟧	🟧							🟧
Mackerel					🟧 ●	🟧 ●	🟧 ●	🟧					🟧
Ling		🟧	🟧	🟧	🟧								▨
Sandeel sp.	🟧	🟧									🟧	🟧	🟧
Sprat					🟧 ●	🟧 ●	🟧	🟧					N/A
Herring*								🟧	🟧				🟧
Thornback ray		🟧	🟧	🟧 ●	🟧 ●	🟧 ●	🟧 ●	🟧 ●	🟧				🟧
Spotted ray					🟧	🟧	🟧						🟧
Spurdog	Gravid females present year round												🟧
Tope	Gravid females present year round												🟧

10.5.4 Sandeel and herring spawning habitat

10.74 Various desk-based benthic characterisation surveys for the Project have been utilised, as well as site-specific surveys, to provide particle size analysis (PSA) of the existing sediment in the windfarm site. This data has been used to assess the suitability of the seabed for demersal spawning species sandeel spp and Atlantic herring *Clupea harengus* . Both species are thought to be particularly sensitive to disturbance, due to highly specific sandy substrate requirements.

10.5.4.1 Sandeel

10.75 Sandeels are found in close association with sandy substrate throughout their life cycles, which results in tight zoning of their spawning grounds.

10.76 Sandeel are a group of shoaling fish, which lie buried in seabed sediments at night, and feed on planktonic prey, such as copepods and crustacean larvae, in mid-water during daylight hours. The most abundant sandeel species in the Irish Sea is the lesser sandeel *Ammodytes tobianus*. There are a total of five sandeel species in the UK, all found in shallow, turbulent areas of suitable sediment. Sandeel show a preference for medium and coarser (0.25 to <2.0mm diameter) sandy sediments and avoid areas of fine sediment and silt/clay (Lynam *et al.*, 2013). Sandeel rarely occur in sediments where the mud content (particle size <0.63µm) is greater than 4%, and they are absent in substrates with a mud content greater than 10% (Holland *et al*., 2005; Wright *et al.*, 2000).

10.77 Due to high substrate specificity and limited larval exchange between sandeel populations, sandeel are particularly vulnerable to overfishing and other pressures. Whilst no large-scale fisheries exist for sandeel in the Irish Sea, they are an important trophic link in the region's food chain, between zooplankton and sandeel predators, including piscivorous fish, seabirds and mammals. As many marine predators rely on sandeel, coupled with their vulnerability to changes in habitat, sandeel are of increasing conservation interest and listed as a species of principal importance in the UK and designated as a nationally important marine feature.

10.78 No sandeel were recorded in any of the 50 grab sample stations across the survey area (**Appendix 9.1**), although it should be noted that grab samples are not an optimal sampling method for sandeel.

10.79 Based on the Folk 1954 sediment classifications, the study area was predicted to comprise of a mixture of sand, and sandy mud (DigSBS250, British Geological Survey (BGS) 2015), shown in **Figure 10.4**. However, site-specific PSA surveys found that the predominant sediment type across the survey area (reflecting the Agreement for Lease Area (AfL)) is fine sand (see **Chapter**

7 Marine Geology, Oceanography and Physical Processes and **Appendix 9.1**). The distribution of Project benthic grab samples, their analysed suitability for sandeel habitat, and the broader BGS sediment map showing coarse modelled sandeel habitat suitability, is shown in **Figure 10.5**. This shows the broad lack of suitable sandeel habitat within the windfarm site (largely to due to sediment mud content that is higher than preferred by the species), with a small area of potential suitable habitat in the southwest portion of the windfarm site.

10.80 Average mud (particle size <0.63µm) content across all samples in the survey area is 18.5% (and therefore too high, on average, to support significant sandeel assemblages (Holland *et al*., 2005, Wright *et al*., 2000)), and mud content is less than 30% in 76% of samples and less than 10% in 30% of samples. Only nine of the 50 sample stations within the survey area had sediment with less than 4% mud content, again suggesting that the area is generally unsuitable for sandeel (Holland *et al*., 2005, Wright *et al*., 2000). Given that sandeel rarely occur in sediments where the mud content (particle size <0.63µm) is greater than 4%, this data suggests that the majority of the windfarm site is unlikely to represent significant suitable habitat for sandeel.

10.81 A review of larvae data collected in UK waters from the Continuous Plankton Recorder was compared to dedicated larval samples collected by ICES in 2004 and 2009. Findings suggest that the sandeel spp. abundance in the wider study area is relatively low, ranging from <0.1 to a maximum of <0.2 individuals per m^3 (Lynam *et al.,* 2013).

10.5.4.2 Herring

10.82 The preferred sediment habitat for herring spawning is gravel, with some tolerance of more sandy sediments, although these are primarily on the edge of any spawning grounds (Stratoudakis *et al.* 1998). Atlantic herring spawning beds are typically small, localised features. Actual spawning habitat, or habitat that could be used for spawning activity, likely comprises relatively small seabed features, with discrete spatial extents, although these may be spread across a wide area of suitable seabed spawning habitat at a regional scale. Eggs are laid on the seabed, usually in water 10-80m deep, in areas of gravel, or similar coarse habitats (e.g., coarse sand, shell and maerl), with well oxygenated waters (Ellis *et al*., 2012; Bowers, 1980; de Groot, 1980; Rakine, 1986, Aneer, 1989; Stratoudakis *et al*., 1998).

10.83 Based on the Folk 1954 sediment classifications, the study area was predicted to comprise of a mixture of sand, and sandy mud (DigSBS250, British Geological Survey (BGS) 2015), shown in **Figure 10.4**. However, the predominant sediment type across the survey area (reflecting the Agreement for Lease Area (AfL)) is fine sand. Site-specific PSA surveys found that average gravel content is 0.1% across 98% of samples in the survey area, with only one station comprising a higher gravel content (20.6%) (see **Chapter 7 Marine Geology, Oceanography and Physical Processes** and **Appendix 9.1**), meaning that the windfarm site is generally unsuitable for herring spawning (Stratoudakis *et al.* 1998). For context, sediment is considered unsuitable for herring spawning if it has >5% mud content and <10% gravel content (Reach *et al.*, 2013). As mentioned for sandeel, average mud (particle size <0.63µm) content across all samples in the survey area is 18.5% (and therefore too high, on average, to support herring spawning (Reach *et al.*, 2013), and mud content is less than 30% in 76% of samples and less than 10% in 30% of samples. Only nine of the 50 sample stations within the survey area had sediment with less than 4% mud content, again suggesting that the area is generally unsuitable for herring spawning (Reach *et al.* 2013).Herring do not spawn in areas without gravel, so this data suggests that the windfarm site is unlikely to represent significant suitable habitat for spawning herring.

10.84 Atlantic herring is widespread in UK and Irish waters and is an important stock commercially and as a forage species. Herring are benthic spawners, normally preferring gravel, stones and/or rock, on which to lay their eggs (O'Sullivan *et. al,*. 2013).

10.85 The main spawning grounds for Irish Sea herring stock are shown to be close to the east coast of the Isle of Man, 44km away from the Project (**Figure 10.6,** Marine Scotland 2022, Coull *et al.* 1998). There are also spawning grounds off the east coast of Northern Ireland at Mourne (Dickey-Collas *et al.*, 2001). This data, combined with recent PSA analysis (**Figures 10.5** and **10.7**), demonstrates that there is a low likelihood of suitable habitat for herring spawning existing within the windfarm site itself. Herring fecundity (ability to produce offspring) ranges from 10,000 – 60,000 eggs per spawning. Newly hatched herring larvae are dependent on reserves in the yolk sac and, as a result, stay on the seabed for a period between 3 and 20 days, until the yolk is absorbed. The yolk sac absorption rate is dependent on sea temperature (Russell, 1976). Once the yolk sac is absorbed, the larvae then become pelagic, drifting with ocean currents. The Northern Irish Herring Larvae Survey (NINEL) has been carried out annually in November, since 1993, with the latest ICES published results being from 2020 (ICES, 2022), demonstrating that the vast majority of larvae are found in the vicinity of the Douglas bank spawning ground, and to the north of the Isle of Man, diminishing significantly closer to the windfarm site (**Plate 10.1**).

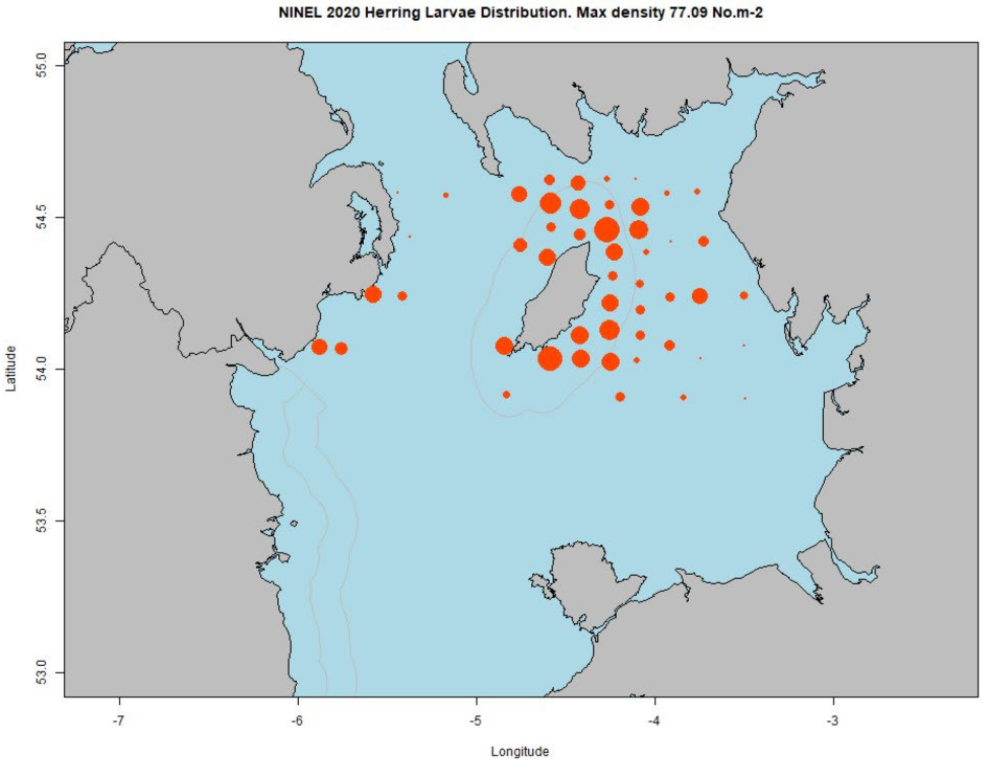

Plate 10.1 Distribution of herring larvae captured during 2020 north Irish Sea herring larvae survey (ICES, 2022)

10.86 The most recent 10-years of Northern Irish Herring Larvae Survey data has been provided by AFBI and these have been used to produce a heatmap of herring larvae distribution in the northern Irish Sea using kernel density interpolation in GIS, as agreed at the Marine Ecology ETG on 11th October 2023. This recent data shows that the likely present day extent of the IoM herring spawning ground maps onto the historical spawning ground extent defined by Coull *et al*., (1998) well (**Figure 10.6**). Given this appraisal of recent data, there is no reason to consider that the location and extent of the known herring spawning ground at the IoM, located 44km away from the Project, has meaningfully shifted in recent years.

10.5.5 Demersal fish

10.87 Demersal fish live on, or in close association with, the seabed. This category therefore includes flatfish, that rest on the sea floor, and benthopelagic fish, such as Atlantic cod (referred to as 'cod' hereafter), which occupy the water column immediately above the seabed. Demersal fish are predominantly 'bottom-feeders' – foraging for food on, within, or in close association with, the substrate. The distribution of demersal fish is generally driven by abiotic factors, such as sediment type and hydrodynamic regimes, although predator-prey interactions and interspecific competition is also important.

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10.88 Based on landings data, the key (>1% of total landings from ICES rectangle 36E6) demersal species found in the vicinity of the study area are plaice, common sole, European bass, and flounder (National Statistics, 2023).

10.89 **Table 10.14** shows the demersal fish species likely to occur in the study area as part of the wider fish assemblage.

Table 10.14 Summary of demersal species likely to be present in the study area

Species	**Northern Irish Priority List**	**OSPAR Annex V[1].**	**IUCN[2] Red List**	**SPII[3]**
Anglerfish/sea monkfish *(Lophius piscatorius)*	✓		LC	
Atlantic cod *(Gadus morhua)*	✓	✓	VU	✓
Common sole *(Solea solea)*	✓			✓
European hake *(Merluccius merluccius)*	✓		LC	✓
European plaice *(Pleuronectes platessa)*			LC	✓
Haddock *(Melanogrammus aeglefinus)*			VU	
Lemon sole *(Microstomus kitt)*	✓		LC	
Ling *(Molva molva)*	✓			✓
Sandeel *(Ammodytes spp)*	✓			✓
European bass (*Dicentrarchus labrax*)			LC	
Whiting *(Merlangius merlangus)*	✓		LC	✓

VU = vulnerable, LC = least concern

[1] OSPAR – Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic – Threatened or declining species

[2] IUCN – International Union for the Conservation of Nature – Red-listed species

[3] SPII – Species of Principle Importance in England

10.90 The Cefas-run C-BASS tracking project, tracked the movements of adult European bass in UK waters using electronic tags[7] over the period 2013-2020 (Cefas, 2020). Results of recaptured tagged fish suggest that bass make extensive migrations through UK waters, including movements of some individuals from the Celtic Sea during winter, up to Morecambe Bay through the spring/summer, then moving back down the coast towards the Celtic Sea

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[7] https://marinescience.blog.gov.uk/2016/01/18/c-bass-on-the-move/

once again into the autumn/winter months (Cefas, 2020). Individuals appeared to associate with coastal migratory routes, moving into the Irish sea in Q1, and leaving to the deeper waters of the Celtic Sea in Q4. They may pass through the ZoI of the Project in relation to longer distance noise effects as they move through the Irish Sea (Cefas, 2020; de Pontual *et al.,* 2023).

10.5.6 Pelagic fish

10.91 Pelagic fish inhabit the water column, and are not closely associated with the seabed, unlike demersal fish. Hydrographic factors influence the distribution of pelagic fish, through the direction and distance of drift of larvae and eggs in ocean currents. Bathymetry is also important in the selection of spawning and nursery grounds, whilst biotic factors, such as food availability, influence migration patterns between spawning and feeding grounds (Maravelias, 1999). The environmental factors that drive pelagic fish distribution are highly variable; when combined with the high level of mobility displayed by many pelagic species, this causes the temporal and spatial distribution and abundance of pelagic species to vary significantly interannually. The pelagic fish species set out in **Table 10.15** are likely to occur in the study area (National Statistics, 2021; Coull *et al.*, 1998; Ellis *et al.*, 2012).

Table 10.15 Summary of pelagic fish with the potential to utilise the study area

Species	**Northern Irish Priority List**	**NERC 2006**[1]	**IUCN Red List**	**SPII**
Atlantic herring	✓	✓	LC	✓
Atlantic mackerel	✓	✓	LC	✓
European sprat		✓	LC	

LC = Least Concern

[1] NERC – Natural Environment Research Council

10.5.7 Elasmobranchs

10.92 There are over 71 different elasmobranch species (sharks, skates, and rays) that have been recorded in the Irish Sea, about half the number that live in European waters, with habitats supporting taxa ranging from sedentary to highly migratory (Clarke *et al*., 2016). The most common elasmobranch species found in the Irish Sea are rays, including thornback ray *Raja clavata*, blonde ray *Raja brachyuran*, cuckoo ray *Leucoraja naevus* and spotted ray *Raja montagui,* with common shark species including spurdog (*Squalus sp*.), dogfish (*Scyliorhinus sp.)* and tope *Galeorhinus galeus*. Since 2005, many species of skates and rays have exhibited long-term declines, however, there are signs of recovery and increased biomass in recent years that may be attributed to reduced fishing effort, and effort changes in the region (from whitefish to *Nephrops* fishing) (ICES 2019).

10.93 Thornback rays are abundant in the Irish Sea and have the potential to be present in the fish and shellfish ecology study area. These are listed as near threatened under the IUCN Red List of Threatened Species, owing to declines caused by fishing and exacerbated by their life history parameters (late maturation and low fecundity).

10.94 Basking shark *Cetorhinus maximus* may be present within the fish and shellfish ecology study area. Basking sharks, subject to a targeted fishing effort until 2007, are now protected under Appendix III of the Bern Convention, the Wildlife and Countryside Act (1981), and the Wildlife Act of the Isle of Man (1990). They are also listed under the CITES. They are known to be highly migratory, with tagged individuals moving between southern Morocco and the northwest of Scotland within a year, and most likely to be found in the Irish Sea during summer months (Doherty *et al.* 2017, Austin *et al.* 2019). It should be noted that a Project site-specific digital aerial survey campaign, undertaken over the period March 2021 to February 2023, identified no basking shark in the study area.

10.95 Data records provide data for basking shark sightings between 1987 to 2021 (with a hotspot occurring off the coast of the Isle of Man). Sightings were recorded year-round, but the majority occurred between the months of May to August (Ocean Biodiversity Information System 2021, Marine Conservation Society, NBN Atlas, 2022). Sightings peaked in 2006 (2,162 sightings), then dropped off significantly in 2014 (103 sightings) and have remained at a lower level since then.

10.5.8 Diadromous fish

10.96 Diadromous fish are those which spend part of their life at sea and part in freshwater, undergoing migrations between the two environments at key points in their life cycles.

10.97 A number of migratory fish species, such as Atlantic salmon *Salmo salar*, sea trout *Salmo trutta,* smelt *Osmerus eperlanus* and European eel *Anguilla anguilla*, may pass through the wider fish and shellfish ecology study area, after leaving rivers in the area, during their more vulnerable life stage in March, April and early May (Atlantic salmon and sea trout); early spring (smelt) and autumn/winter (adult European eels) (Maitland and Campbell, 1992; Malcolm *et al.*, 2010). Most of these species are protected under a range of international protections (see **Table 10.16**).

10.98 Atlantic salmon smolts along the west coast of England have been shown to use a northward migratory route through the Irish Sea to reach feeding grounds (Barry *et al.* 2020, Green *et al.* 2022). Similarly, Atlantic salmon smolts from the east coast of Ireland migrate northwards out of the Irish Sea after leaving their natal rivers (COMPASS, 2022). In 2021, 1,008 wild and 60 ranched Atlantic salmon smolts were tagged with acoustic transmitters in 12 rivers in England, Scotland, Northern Ireland and Ireland. The tracking showed a strong preference for Irish Sea smolts to migrate in a north westerly direction out of the Irish Sea to the North East Atlantic after exiting their natal rivers (Lilly *et al*., 2023). Adult Atlantic salmon are observed to commence entry into the Leven, Kent, Lune, and Wyre rivers during early spring, whilst sea trout commence entry in June (through until the autumn), although the upstream migration of sea trout is not considered as extensive.

10.99 Other diadromous species recorded from rivers and estuaries (Eden, Dee, Morecambe Bay, Conwy and Solway Firth) in the Eastern Irish Sea include allis shad *Alosa alosa*, twaite shad *Alosa fallax*, sea lamprey *Petromyzon marinus* and river lamprey *Lampetra fluivatilis* (Biological Records Centre, 2022). These species are unlikely to be encountered in the windfarm site, as (except in the case of sea lamprey) they remain in close association with estuarine environments during the marine phase of their life cycle. They are likely, however, to pass through the study area during migratory periods.

10.100 Little is known about the distribution of sea lamprey during the marine phase of their lifecycle, as reports are varied, suggesting a wide range and use of habitats (Maitland, 2004).

10.101 The current understanding is that European eels spawn in the Sargasso Sea, but there are potentially other, more distant, spawning grounds, and the routes to and from these spawning grounds for European eels remain unclear. Migrating adult European eels are thought to leave (escape) European rivers in autumn and the early stages of winter (predominantly at night); however, very little is known about their behaviour at this time (Orpwood *et al.*, 2015). Studies have reported that eels have been found swimming at depths of 1-17m (averaging around 10m depth), with individuals spending very little time on the seabed. It is thought that eels spend very little time low down in the water column due to water temperature below the thermocline being too low. Spring and summer seasonal thermoclines in the Irish Sea will generally fall between 15 – 25m depth. Elvers or young eels generally enter the inland waters of the UK between February and April (also predominantly at night) (Bruijs and Durif, 2009). The young eels (elvers) may also enter the rivers around Morecambe Bay in spring (English Nature, 2000).

10.102 The marine distribution and migration routes of the river lamprey, sea lamprey or European eel remains largely unknown, however, these species are known to utilise rivers on the western coast of England for spawning and foraging or, in the case of European eel, foraging only (Malcolm *et al.*, 2010). It is therefore likely that these species may be present within the wider study area during marine migration or residency. Brook lamprey, whilst present in some SACs considered in **Section 10.5.10**, remain resident in freshwater rivers for their entire lifecycle, so are not diadromous fish and there is no pathway for impact on this species. **Table 10.16** lists the diadromous species with the potential to interact with the study area during the marine migration period in their life cycles.

Table 10.16 Diadromous fish species of conservation interest that may be present in the study area

Species	Conservation status								
	SPII	OSPAR[8]	NASCO[9]	NERC 2006[10]	ICUN Red List[11]	Bern Convention	CITES	W&C 1981[12]	Habitats Directive
European eel	✓	✓	-	✓	Critically Endangered	-	✓	-	-
Allis shad	✓	✓	-	✓	Least Concern	✓	-	✓	✓
Twaite shad	✓	✓	-	✓	Least Concern	✓	-	✓	✓
Sea lamprey	✓	✓	-	✓	Least Concern	✓	-	-	✓
River lamprey	✓	✓	-	✓	Least Concern	✓	-	-	✓
Sea trout	✓	✓	-	✓	Least Concern	-	-	-	-
Atlantic salmon	✓	✓	✓	✓	Vulnerable	✓	-	-	✓
Smelt	✓	✓	-	✓	Least Concern	-	-	-	-

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[8] OSPAR - Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic – Threatened or declining species

[9] NASCO - North Atlantic Salmon Conservation Organization, established by the UN Convention for the Conservation of Salmon in the North Atlantic Ocean

[10] NERC Act 2006

[11] IUCN - International Union for the Conservation of Nature – Red-listed species

[12] Wildlife and Countryside Act 1981

10.5.9 Shellfish (crustaceans and molluscs)

10.103 The wider fish and shellfish ecology study area is important for a number of commercially exploited shellfish, specifically benthic crustaceans and bivalve/gastropod molluscs; taxa that play a key role in the ecological food web, have commercial value, and conservation interest. For the purposes of this assessment, these have been grouped into:

- Crustaceans: arthropod taxon, including decapods and isopods. Typically, mobile species with segmented exoskeleton
- Molluscs: Large marine phylum, containing bivalves, gastropods and cephalopods

10.104 The commercial species found in the study area include queen scallops, whelks, king scallops, brown crab, European lobster, *Nephrops*, and brown shrimp.

10.105 Lockwood (2005) showed two broadscale shellfish resources within the Irish Sea. This includes a large scallop ground across the whole Eastern Irish Sea that overlaps with the windfarm site, and a *Nephrops* resource, located to the north of Liverpool Bay, between the Isle of Man and the Cumbrian coast. This finding is supported by commercial landings data (see **Section 10.5.2**), and the ICES Working Group for the Celtic Seas Ecoregion (WGCSE) Report in 2018, which highlights the main fishing grounds for *Nephrops* being concentrated to the north of the Project (**Plate 10.2**).

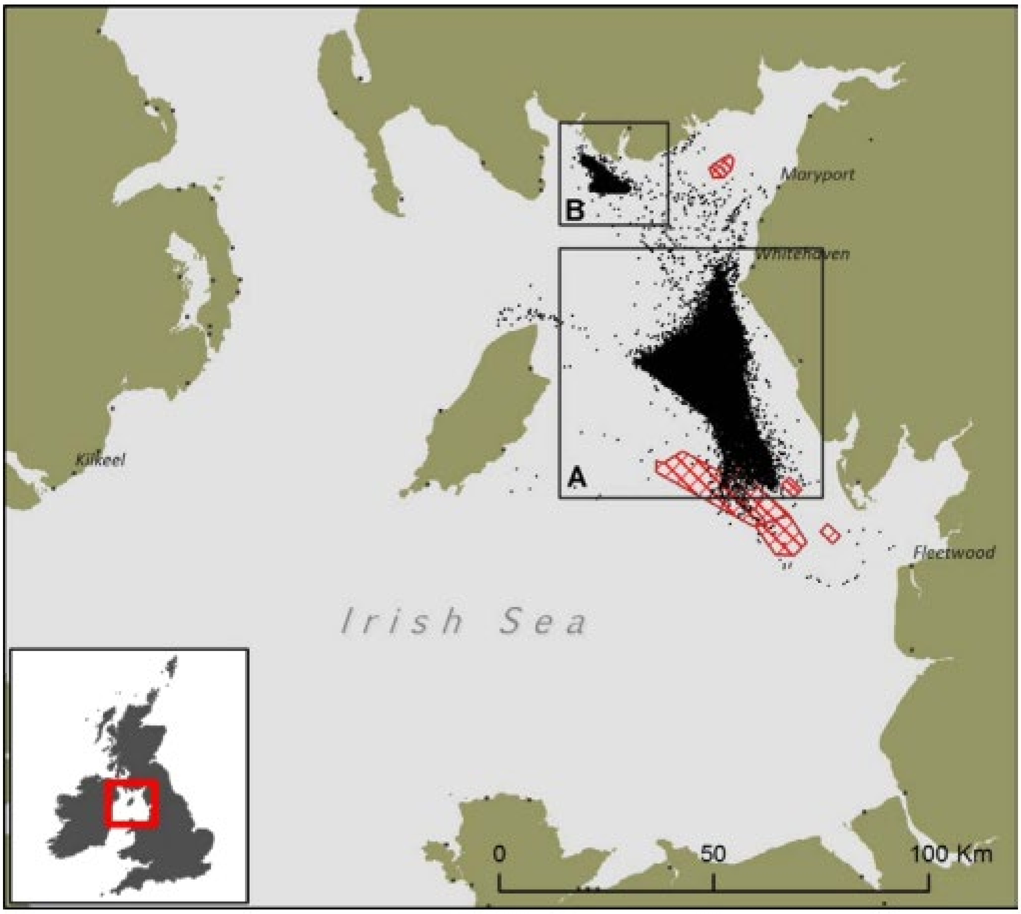

Plate 10.2 East Irish Sea Nephrops fishing grounds: A= Main fishing ground; B= Wigtown bay area. Existing windfarms represented by red polygons (Source: ICES, 2015)

10.106 Reported landings of shellfish within ICES rectangle 36E6 between 2018 and 2022 also includes brown shrimp, cuttlefish sp., velvet crab *Necora puber*, squid sp. and octopus sp. By weight, queen scallops and whelks constituted the highest landings, with lobster and crab species considerably lower (MMO, 2023). Queen scallops are highly abundant in the Study Area (**Table 10.11**) and form important fisheries in the wider study area in the territorial waters of the Isle of Man (Bloor *et al*., 2022) and Wales (Delargy *et al*., 2019).

10.107 Evidence suggests that adult brown crab undertake wide-ranging migrations over considerable distances to offshore overwintering grounds where eggs are hatched, moving back to coastal areas around May (Edwards, 1979; Bennett, 1995; Tonk and Rozemeijer, 2019). The findings of tagging studies suggest that mature females undertake long-distance migrations with preference for direction of travel, whilst the movements of males and immature females is in more random directions, and constrained within local areas (Edwards, 1979; Bennett, 1995).

10.108 Brown crab mating occurs in spring and summer with activity peaking between July and September, after females have moulted. Females are 'berried' (carrying eggs under the abdomen) for 6-9 months after copulation. They do not feed, remaining in pits dug in the sediment or under rocks over the winter period and are unlikely to be caught in a baited pot (Thompson *et al*., 1995; Fahy *et al.,* 2008). Data is lacking for the northwest English coast to suggest the extent and direction of local female brown crab migration, although it is likely that any female migrations will occur in a counter-current direction (Hunter *et al*., 2013), which would result in a migration of Irish Sea crab in a more coast-parallel direction, rather than a coast-perpendicular direction directly offshore and towards the windfarm site (Hunter *et al.*, 2013).

10.109 Other non-commercial shellfish species to note include:

- Ocean quahog *Arctica islandica* – found on sublittoral firm sediments in sand and muddy sand, distributed all around British and Irish coasts and offshore (Tyler-Walters and Sabatini, 2017). Currently listed as OSPAR Annex V and a Feature of Conservation Importance (England and Wales)
- Freshwater pearl mussel (FWPM) *Margaritifera margaritifera* – widely distributed in Europe and found in fast flowing rivers and streams, the mussel spends its larval stage attached to the gills of salmonid fish as they migrate upstream (this is a key component of the FWPM life cycle). Therefore, impacts upon migratory salmon at sea, can indirectly impact FWPM populations. Currently listed as 'Vulnerable' by IUCN, the species is declining in both range and total population in the UK. It should be noted that there is no direct pathway for impacts of offshore activities on FWPM, only indirectly via impacts on salmonids. Therefore, significant effects on FWPM may only be found if significant effects on Atlantic salmon or sea trout are found.

10.5.10 Designated sites

10.110 The below review has been undertaken to identify designated sites in proximity to the fish and shellfish ecology study area, which are either designated for fish and shellfish interest, or habitats/species which are dependent on, or associated with, fish or shellfish. It should be noted that European Sites and MCZs are also subject to assessment, as part of the HRA and MCZA processes for the Project.

10.111 The Project does not directly overlap with any designated sites. Within 50km (encompassing any potential noise or suspended sediment impacts) are the following relevant sites for fish and shellfish:

- Morecambe Bay SAC, designated for sandbanks, which may represent spawning habitats for sandeel

- Shell Flat and Lune Deep SAC, designated for sandbanks, which may represent spawning habitats for sandeel
- Fylde MCZ, designated for subtidal sand and subtidal mud, which represents productive areas for crustacean, mollusc and flatfish species
- Wyre Lune MCZ, designated for smelt
- Ribble Estuary MCZ, designated for smelt
- West of Walney MCZ, which is designated for subtidal sand and subtidal mud, which represent highly productive areas for crustacean, mollusc and flatfish species
- West of Copeland MCZ, which supports an array of species, including crabs, sea mats and bivalve molluscs (such as venus clams *Chamelea gallina* and razor clams *Ensis ensis*)
- North Anglesey Marine SAC, the primary reason for this site’s designation is harbour porpoise *Phocoena phocoena*, of which herring and sandeel are key prey species
- Y Fenai a Bae Conwy/Menai Strait and Conwy Bay is designated for sandbanks, which may represent spawning habitats for sandeel
- Liverpool Bay SPA abuts the eastern boundary of the windfarm site. This site is principally designed for the protection of marine/coastal ornithological features (further information on which is provided in **Chapter 12 Offshore Ornithology**) but habitats also support fish and shellfish species which are prey species

10.112 As noted in **Section 10.5.8**, there is potential for Annex II species to pass through the fish and shellfish ecology study area from various rivers associated with SACs. Within the wider study area are the following:

- Dee Estuary/Aber Dyfrdwy SAC - Sea lamprey and river lamprey present as qualifying features
- River Ehen SAC - FWPM as a primary reason for selection of the site and Atlantic salmon as a qualifying feature
- River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC – Atlantic salmon as a primary reason for selection of the site and sea lamprey, river lamprey and brook lamprey present as qualifying features
- Afon Gwyrfai a Llyn Cwellyn SAC – Atlantic salmon as a primary reason for selection of the site
- Afon Eden – Cors Goch Trawsfynydd SAC – FWPM as a primary reason for selection of the site and Atlantic salmon as a qualifying feature
- River Eden SAC – Atlantic salmon, sea lamprey, brook lamprey and river lamprey as primary reasons for selection of the site

- River Derwent and Bassenthwaite Lake SAC (Atlantic Salmon, Sea lamprey, River lamprey)
- Solway Firth Solway Firth SAC (Sea lamprey, River lamprey).

10.113 Further detail on relevant SACs (and SPAs), and assessments of potential effects on site integrity, is provided within the accompanying RIAA. Similarly, effects on MCZs are assessed fully in the accompanying MCZA Report.

10.5.11 Climate change and future trends

10.114 The existing baseline conditions within the fish and shellfish study area described above are considered to be relatively stable. The fish and shellfish baseline environment of the Irish Sea is primarily influenced by global environmental factors and by commercial fishing activity.

10.115 The baseline will continue to evolve as a result of global trends which include the effects of climate change, such as increasing sea levels and sea surface temperature, as well as trends at the regional and European level such as changes in fisheries regulations and policies.

10.5.12 Species taken forward to assessment

10.116 Key species identified, and the rationale for their inclusion within the fish and shellfish ecology assessment, are provided in **Table 10.17** of **Section 10.6.** Note that, for some impacts, species are not considered on an individual basis, but by functional group (e.g., fin fish, shellfish, elasmobranchs or migratory fish), unless there is a specific sensitivity for a specific species (e.g., herring and underwater noise) for assessment.

10.6 Assessment of effects

10.6.1 Impact receptors

10.117 The principal receptors with respect to fish and shellfish ecology are spawning and nursery grounds, diadromous fish, pelagic fish, demersal fish, elasmobranchs, shellfish (crustaceans and molluscs), and designated sites.

10.118 The specific features defined within these receptors as requiring further assessment are listed in **Table 10.17**.