MONA OFFSHORE WIND PROJECT

Preliminary Environmental Information Report

Volume 6, annex 8.1: Fish and shellfish ecology technical report

Image of an offshore wind farm

April 2023
FINAL

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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.
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.
shellfish	For the purposes of this assessment, shellfish is considered a generic term to define molluscs and crustaceans.
spawning grounds	Spawning grounds are the areas of water or seabed where fish spawn or produce their eggs.
Special Area of Conservation (SAC)	A site designation specified in the Habitats Directive (Council Directive 92/43/EEC). Each site is designated for one or more of the habitats and species listed in the Directive. The Directive requires that a management plan be prepared and implemented for each SAC to ensure the favourable conservation status of the habitats or species for which it was designated. In combination with SPAs, these sites contribute to the 'Natura 2000' or 'European' Sites network.
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.

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
DCO	Development Consent Order
DDV	Drop Down Video
EIA	Environmental Impact Assessment
EEZ	Exclusive Economic Zone
EMODnet	European Marine Observation and Data Network
EMP	Environmental Management Plan
IBTS	International Bottom Trawl Survey
ICES	International Council for Exploration of the Sea
IEF	Important Ecological Feature
IFCA	Inshore Fisheries Conservation Authority
IHLS	International Herring Larval Survey
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

Acronym	Description
MMO	Marine Management Organisation
MNR	Marine Nature Reserve
MPA	Marine Protected Area
NBN	National Biodiversity Network
NIGFS	Northern Irish Ground Fish Trawl Survey
NINEL	Northern Irish Herring Larvae Survey
NRW	Natural Resources Wales
PEIR	Preliminary Environmental Information Report
PMF	Priority Marine Feature
PSA	Particle Size Analysis
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
SPI	Species of Principal Importance
UK	United Kingdom
UKOOA	United Kingdom Offshore Operators Association

Units

Unit	Description
%	Percentage
km^2	Square kilometres
km	Kilometres (distance)
m	Metre (distance)
mm	Millimetre
m^2	Square metres

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 Mona Offshore Wind Project. The Mona Offshore Wind Project is 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 Mona Offshore Wind Project 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 Mona Offshore Wind Project and within the wider fish and shellfish ecology study area, in line with published Environmental Impact Assessment guidelines (CIEEM, 2018).

1.1.1.4 This technical report is structured as follows:

- Section 1.2: Study Area – Overview of the 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 1.5.2: Herring – A description of herring habitats and ecology (focussing on spawning)
  - Section 1.6: Sandeel – A description of sandeel habitats and ecology
  - Section 1.7: Elasmobranchs – A description of elasmobranch fish ecology
  - Section 1.8: Diadromous Fish – A description of diadromous fish ecology and designated sites associated with them
  - Section 1.9: Shellfish – A description of shellfish habitats and ecology
  - Section 1.10: Designated sites – A description of designated sites within the east Irish Sea which may be affected by the Mona Offshore Wind Project
- Section 1.11: Summary – A summary of the information provided in the report
  - Section 1.11.1: Baseline – A summary of the fish and shellfish ecology baseline characterisation
  - Section 1.11.2: 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 western tip of Anglesey, following the territorial waters 12nm limit 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 noise over a wider area) associated with the Mona Offshore Wind Project on the identified receptors.

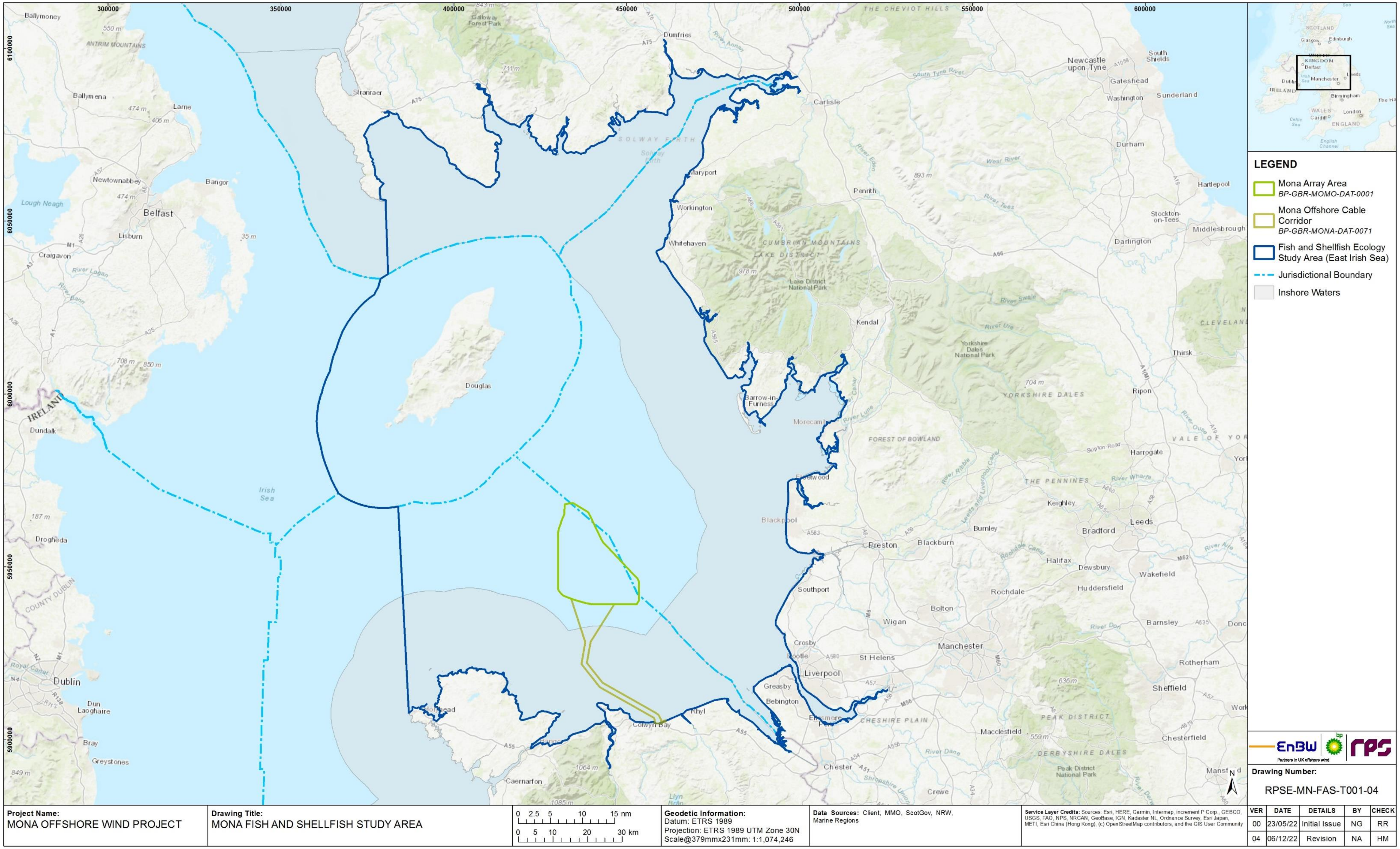

Figure 1.1: Fish and shellfish ecology study area extending across the east Irish Sea, including the Mona Offshore Wind Project.

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 6, appendix 11.1: Commercial fisheries technical report of the PEIR 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
Herring larvae surveys of the northern Irish Sea	The Agri-Food and Biosciences Institute (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 to2006	Coastal Fisheries Conservation and Management
Walney and West of Duddon Sands Offshore Wind Farms, Baseline Benthic Survey – Epifaunal Beam Trawl Results	Marine Data Exchange	2005	Titan Environmental Surveys Ltd.
Burbo Bank Offshore Wind Farm, Pre-construction Commercial Fish Survey (2m Beam Trawl)	Marine Data Exchange	2006	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	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
Celtic Array (Zone 9) Autumn Fish Trawl Survey	Marine Data Exchange	2010, 2013	CMACS
Gwynt y Mor Offshore Wind Farm, Pre-construction Baseline Beam Trawl Data	Marine Data Exchange	2011	Centre for Marine and Coastal Studies Ltd. (CMACS)
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	Cefas	2012	Ellis *et al.*
Northern Irish Ground Fish Trawl Survey (NIGFS)	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 offshore wind farm preliminary environmental information chapter 10: fish and shellfish ecology	Marine Data Exchange	2013	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*.
Celtic Seas ecoregion fisheries overview	Summary of commercial fisheries in the Celtic Sea	2018	ICES
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*.
JNCC MPA Mapper	JNCC	2019	JNCC
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)	2020	MMO
SeaLifeBase	https://www.sealifebase.ca/	2021	Palomares and Pauly
International council for the exploration of the sea (ICES) working group on surveys on ichthyoplankton in the North Sea and adjacent seas	ICES	2021	ICES
Fisheries & Conservation Science Group	Bangor University	2022	Bangor University
Marine Recorder Public UK Snapshot	Joint Nature Conservation Committee (JNCC)	2022	JNCC
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 targeting fish and shellfish receptors were not proposed in order to inform the EIA for the Mona Offshore Wind Project. However, the results from site-specific surveys primarily designed to inform the benthic subtidal and intertidal ecology baseline characterisation (see volume 6, appendix 7.1: Benthic subtidal and intertidal ecology technical report of the PEIR), which include records of small demersal fish species and shellfish species, have been used to additionally inform the baseline characterisation for fish and shellfish ecology.

1.3.2.3 Site-specific subtidal benthic surveys were undertaken across the fish and shellfish ecology study area to characterise the benthic habitats in the vicinity of the Mona Offshore Wind Project 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 Mona Array Area (and surrounding area) benthic subtidal survey was undertaken by Gardline Limited (Gardline) in June to September 2021 and the survey was conducted onboard the multi-role service vessel MV *Ocean Resolution.*

1.3.2.4 Combined grab and Drop-down video (DDV) sampling were undertaken across 97 sampling stations, with 60 located in the vicinity of the Mona Offshore Wind Project, and 52 located within the Mona Array Area, with particle size analysis (PSA) data obtained from grabs used to inform habitat characterisation for sandeel *Ammodytidae* spp. and potential spawning grounds of 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. As outlined in Table 1.2, additional site-specific sampling within the Mona Array Area, offshore cable corridors, and zone of influence were undertaken in 2022 by Gardline, however data is not available for inclusion at this time and will instead be presented in the Environmental Statement submitted with the application for consent.

1.3.2.5 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 prime, subprime, suitable, 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 demonstrate herring spawning habitats in line with guidelines published by Boyle and New (2018). The abundances of larvae ≤10mm 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 (as noted above, from the Mona Array Area), were used to determine where key potential spawning habitats were located within the vicinity of the Mona Array Area (see section 1.5, Figure 1.14 to Figure 1.17).

1.3.2.6 Sandeel habitat characterisation was also completed, using a similar method as above where samples were categorised into prime, subprime, suitable 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 abundance data were collated from the benthic surveys to inform presence/absence data of individual sandeels caught by grab samples. The data was plotted into maps and reviewed alongside additional desktop data sources to further characterise nearby sandeel habitats (see section 1.6 for results).

1.3.2.7 Norway lobster *Nephrops norvegicus* (hereafter referred to as *Nephrops*) presence within the vicinity of the Mona Array Area 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 6, appendix 7.1 (see section 1.9.8 for additional results).

1.3.2.8 The site-specific digital aerial surveys would have recorded basking shark *Cetorhinus maximus*, if sighted. However they were recorded in the aerial surveys although they are known to inhabit the area which has further informed the fish and shellfish baseline characterisation.

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

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., 2021
Benthic Subtidal Survey	Morgan and Mona Offshore Cable Corridors, Array Areas and zone of influence.	Grab samples, Visual survey outputs (DDV sampling) and laboratory testing	Gardline Limited.	2022	These findings will be further reported within the final technical report and will be submitted as part of the final Development Consent Order (DCO) application.

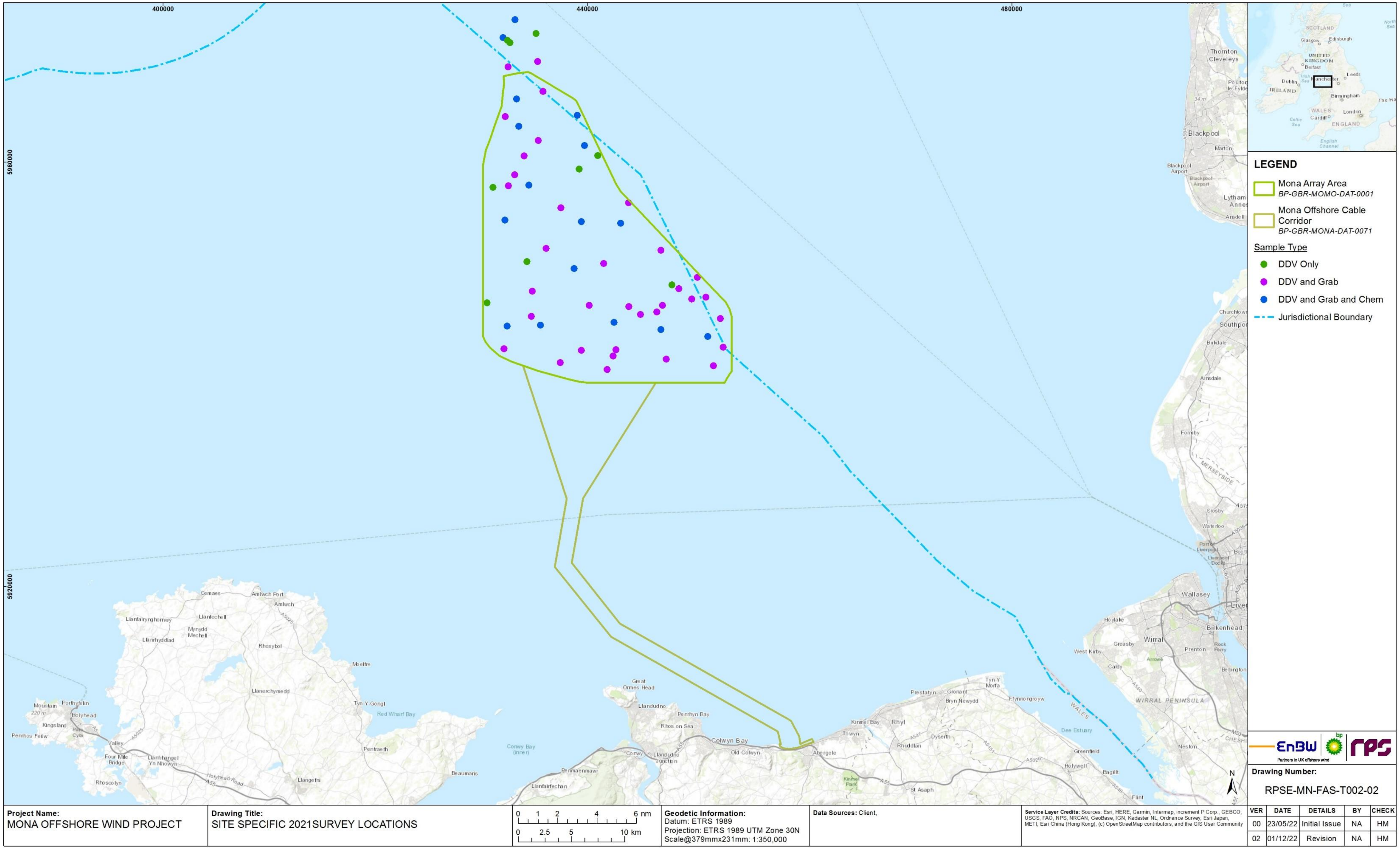

Figure 1.2: Site-specific subtidal survey locations.

1.4 Baseline characterisation

1.4.1 East Irish Sea

1.4.2 Desktop study

1.4.2.1 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 1.9.

1.4.2.2 The fish and shellfish ecology study area is additionally classified as comprising the Strategic Environmental Assessment (SEA6) area and VIIa ICES Region according to the UK Government. SEA6 corresponds to the eastern 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).

1.4.2.3 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 1.5), 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 scallop and *Nephrops* (ICES, 2021a).

1.4.2.4 The sediments of the Irish Sea can be subdivided into three broad regions: two 'mudbelts' comprising soft muds which occupy the eastern and western inshore areas separated by a central 'gravel belt' which comprises coarser sediment and hard substrate (Mellet *et al.,* 2015). The eastern and western 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 north of the Mona Array Area, in territorial waters within the 12nm limit, the sediment is split between mixed sands to the north, and mixed gravel to the west (Howe *et al*., 2018).

1.4.2.5 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 and substrate type, 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, noise, and marine litter to limit fish and shellfish distributions (van der Kooij et al., 2021).

1.4.2.6 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 solea*, whiting *Merlangius merlangus*, lesser spotted dogfish *Scyliorhinus canicula* and cod *Gadus morhua*, with pelagic species including herring, European seabass *Dicentrarchus labrax*, and mackerel *Scomber scombrus.*

1.4.2.7 Dominant shellfish species in the Irish Sea include blue mussel *Mytilus edulis*, European lobster *Hommarus 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 squid *Loligo sp*. As key components of the shellfish community, these species are also commercially valuable within this region (see volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information).

1.4.2.8 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 eastern and western portions of the Irish Sea are typically dominated by flatfish including plaice, dab and Dover sole (Ellis *et al*., 2000). In coarse substrates further offshore, abundant species include common hermit crabs *Pagurus prideaux* and 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.

1.4.2.9 The International Bottom Trawl Survey (IBTS) is an 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 Mona Offshore Wind Project 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 (IBTS, 2021).

1.4.2.10 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 20mm 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). Groundfish surveys in the area were 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).

1.4.2.11 Several species of both commercial and ecological importance are known to be present within the east Irish Sea. These species include 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).

1.4.2.12 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).

1.4.2.13 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 100m 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 <50m. 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).

1.4.2.14 Herring, European hake *Merluccius merluccius*, whiting, blue whiting *Micromesistius poutassou*, 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. Georges Channel (at the southern 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.

1.4.2.15 European hake is focused within the northeast 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 35cm and females at 50cm 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, 2019b).

1.4.2.16 Whiting is abundant throughout the northeast Atlantic, Mediterranean, and European Seas. They are most commonly found in depths of 10m to 100m, 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).

1.4.2.17 Similar to whiting, blue whiting is distributed throughout the north Atlantic and found on continental shelves at depths of 300m to 400m but have been found at depths exceeding 1,000m. 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).

1.4.2.18 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. 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).

1.4.2.19 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 50m to 200m (FishBase, 2020e). An omnivorous species, cod feed on invertebrates and fish, including young cod.

1.4.2.20 European seabass are 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 peak landings between July and (Moore *et al*., 2020).

1.4.2.21 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 6, appendix 11.1: Commercial fisheries technical report of the PEIR).

1.4.2.22 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 Mona Offshore Wind Project.

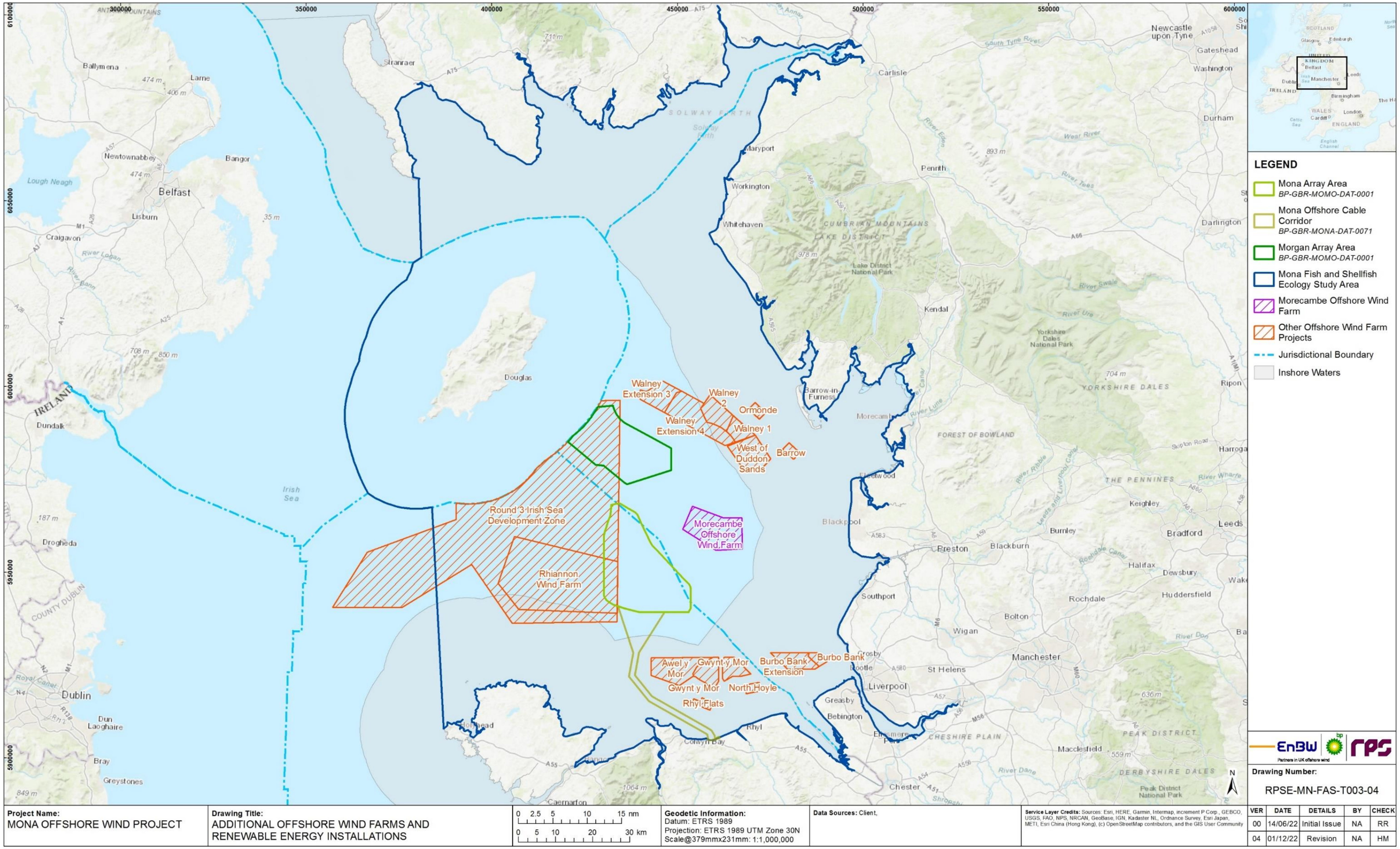

Figure 1.3: Locations of other offshore wind projects in the fish and shellfish ecology study area[1].

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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

1.4.2.23 Beam trawl surveys were undertaken in the autumn of both 2010 and 2011 across the Irish Sea Round 3 development zone which overlaps the western portion of the Mona Offshore Wind Project. In terms of the fish and shellfish ecology study area, the Irish Sea Round 3 Development Zone is located within the southwestern corner of the area (Figure 1.3).

1.4.2.24 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. The most common commercially valuable fish species was plaice, followed by thickback sole and lemon sole (CMACS, 2010; Celtic Array Ltd., 2013).

1.4.2.25 Furthermore, seven elasmobranch species were recorded, including lesser spotted dogfish, cuckoo ray *Raja naevus*, spotted ray, thornback ray, nursehound *Scyliorhinus stellaris*, starry smoothhound *Mustelus asterias* and starry ray *Raja 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

1.4.2.26 The Gwynt y Môr offshore wind project is located approximately 18km southeast of the Mona Offshore Wind Project (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.

1.4.2.27 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 20m to 30m (CMACS, 2011).

1.4.2.28 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).

1.4.2.29 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).

1.4.2.30 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).

1.4.2.31 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

1.4.2.32 Beam and otter trawl surveys were conducted in September 2012 for the West of Duddon Sands offshore wind project pre-construction surveys, located approximately 31km northeast of the Mona Offshore Wind Project in inshore waters (Figure 1.3).

1.4.2.33 The West of Duddon Sands offshore wind project found that plaice, dab, and lesser spotted dogfish were the most abundant species encountered and the total catch rates (catch per unit of effort; CPUE) were highest along the export cable corridor (Brown and May Marine Ltd., 2012). Additionally, it was found that plaice and dab represented the majority of the catch at most of the 23 otter trawl sampling stations.

1.4.2.34 Otter trawl catch rates within the West of Duddon Sands offshore wind project evidenced abundances as high as 2,886 individuals per hour and 3,712 individuals per hour from surveys taking place in the wind farm and along the export cable corridor, respectively. Between the wind farm and export cable corridor, plaice, dab lesser spotted dogfish, whiting, grey gurnard, tub gurnard, thornback ray, Dover sole, sprat, starry smoothhound, common dragonet, nursehound, poor cod, cod, lemon sole, herring, tope, anglerfish *Lophius piscatorius*, bib, mackerel and brill were the fish species observed in order of abundance. The shellfish species that were found to be present within the wind farm and export cable corridor included edible crab, whelk, velvet swimming crab, lobster, spiny spider crab *Maja brachydactyla* and *Nephrops* (Brown and May Marine Ltd., 2012).

1.4.2.35 Beam trawl surveys found a total of 10 species of fish within the aforementioned wind farm and along the export cable corridor during sampling. Overall, solenette was the most abundant species caught, followed by plaice and undetermined species of goby *Gobiidae sp*. within the areas. Beam trawl catch rates illustrated abundances as high as 422 individuals per hour from within the wind farm boundary and 281 individuals per hour from along the export cable corridor. West of Duddon Sands offshore wind project beam trawl monitoring was specifically undertaken to sample fish species within the area and included solenette, dab, goby (Gobiidae spp.), scaldfish *Arnoglossus laterna*, sand goby, plaice, whiting, Dover sole, common dragonet, pogge *Agonus cataphractus*, lesser spotted dogfish, poor cod, lesser pipefish *Syngnathus rostellatus* and grey gurnard (Brown and May Marine Ltd., 2012).

Walney offshore wind project

1.4.2.36 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 summer of each survey year. The Walney offshore wind project is located approximately 30km northeast of the Mona Offshore Wind Project (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., 2013).

1.4.2.37 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., 2013).

1.4.2.38 Walney 1 pre- and post- construction surveys found that Dover sole had 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., 2013). *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 seasonality (Brown and May Marine Ltd., 2013) 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 in Walney 1 evidenced abundances as high as 3,900 *Nephrops* individuals per hour trawled.

1.4.2.39 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 a only snapshot of highly mobile species at the time of sampling (Brown and May Marine Ltd., 2013). Otter trawl catch rates during the survey recorded abundances as high as 1,700 individuals per hour trawled.

1.4.2.40 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., 2013). 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., 2013).

1.4.2.41 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 of 293 (Brown and May Marine Ltd., 2013). Solenette was found to be the most abundant species encountered within both of these survey areas during the months of April and June. At 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., 2013).

Awel y Môr offshore wind project

1.4.2.42 The Awel y Môr offshore wind project is located approximately 12km south of the Mona Offshore Wind Project (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 Celtic Array to better inform and undertake their 2021 Preliminary Environmental Information Report (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.

1.4.2.43 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 Awel y Mor offshore wind project which could also be found within the Mona Offshore Wind Project. These species include Atlantic salmon, cod, whiting, plaice, Dover sole, herring, mackerel, lesser sandeel (*Ammodytes tobianus*), spotted and thornback ray (MacNab and Nimmo, 2021).

1.4.2.44 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 Mona Offshore Wind Project (ICES, 2010; MacNab and Nimmo, 2021).

1.4.2.45 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 Mona Offshore Wind Project 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).

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) is 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). This 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 Mona Offshore Wind Project, including high intensity spawning areas for cod, plaice, sole, sandeel and herring. Species with known spawning periods and nursery habitats identified within the Mona Array Area have been summarised in Table 1.3, Table 1.4 and Figure 1.4 to Figure 1.13.

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 Mona Offshore Wind Project and have been utilised to characterise herring and sandeel habitats in later sections of this Technical Report (section 1.5.3 and section 1.6.2).

1.5.1.5 Subtidal benthic sediments across the Mona Array Area were found to range from gravelly sand to muddy sandy gravel, with gravelly muddy sand (52% of samples), gravelly sand (21%) and muddy sandy gravel (19%), representing the three most common sediment types reported. All sediment samples classified as slightly gravelly sand were detected in the southeast section of the Mona Array Area. The sediments within the east of the Mona Array Area were dominated by gravelly muddy sand with areas of muddy sandy gravel in the north and south, and gravelly sand in the north. The sediments within the west of the Mona Array Area were typically slightly coarser and characterised by gravelly muddy sand in addition to muddy sandy gravel (see volume 6, appendix 7.1: Benthic subtidal and intertidal ecology technical report of the PEIR 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, haddock, cod, whiting and *Nephrops* are found within the Irish Sea (Figure 1.4 to Figure 1.13). A large proportion of the east Irish Sea, including the environment around the Mona Offshore Wind Project, 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 Mona Array Area, and all of the Mona offshore cable corridor (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 Mona Offshore Wind Project (Figure 1.4). There are no haddock spawning grounds denoted within the Mona Array Area (Coull *et al*., 1998). The lack 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 Mona Offshore Wind Project.

1.5.1.9 Ling were found to have a low intensity spawning ground located across most of the Mona Array Area and the associated Mona Offshore Cable Corridors, extending north towards Solway Firth and west to Ireland (Figure 1.5; Ellis *et al*., 2012). Ling are known to spawn in March to July (Cohen *et al*., 1990), 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 Mona Array Area coincides with high intensity spawning and nursery grounds for whiting, while the Mona Offshore Cable Corridor is located within high intensity nursery grounds and low intensity spawning grounds (Figure 1.6).

1.5.1.11 Herring have high intensity nursery grounds found primarily within the areas inshore of the Mona Array Area, with both high and low intensity spawning grounds located near the Isle of Man (Figure 1.6; 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. 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 zero group herring found inshore and near the Isle of Man. A further review of herring spawning has been included in section 1.5. The Agri-Food and Biosciences Institute (AFBI) in Northern Ireland has undertaken herring larvae surveys of the northern 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, 2021).

1.5.1.13 Sprat spawning grounds (unspecified intensity) coincide with the Mona Offshore Wind Project and the whole of the east Irish Sea (Figure 1.7). 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.

1.5.1.14 Mackerel have low intensity spawning grounds which coincide with the entirety of the Mona Array Area and low intensity nursery grounds across the Mona Array Area and Mona Offshore Cable Corridor (Figure 1.7; 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.

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 Mona Offshore Wind Project, specifically within the northern portion of the Mona Array Area (Figure 1.8; Coull *et al*., 1998). These findings are supported by outputs from Aires *et al*. (2014). Lemon sole are known to spawn primarily in April to September (Smith, 2014), although evidence exists of spawning in October to November dependent on 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 10m to 50m. Plaice have high intensity spawning grounds within the Mona Array Area and the Mona Offshore Cable Corridor, with high intensity nursery grounds occurring in the eastern portions of the Mona Array Area and the Mona Offshore Cable Corridors (Figure 1.9; Ellis *et al*., 2012).

1.5.1.17 Sole spawning and nursery grounds are similar to those presented above for plaice, with similar spawning behaviour to the lemon sole in the April to June period annually (Savina *et al*., 2010). High intensity spawning and nursery grounds were found to be concentrated along the eastern portions of the Mona Array Area and the entirety of the Mona Offshore Cable Corridor, located in inshore waters (Figure 1.9). 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 Mona Offshore Wind Project with both sandeel spawning and nursery grounds (Figure 1.10). Low intensity nursery grounds are present amongst the eastern portions of the Mona Array Area and across the entirety of the Mona Offshore Cable Corridor. High intensity spawning grounds are denoted as being present within the majority of the Mona Array Area, and along Mona Offshore Cable Corridor (Figure 1.10; 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 Mona Offshore Wind Project including spotted ray, tope, and thornback ray (Figure 1.11 and Figure 1.12). Additionally, the offshore areas which comprise the Mona Array Area has been classified as a high intensity nursery ground for spurdog (Figure 1.11; Ellis *et al*., 2012). This classification is 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 2 to 3 years and they have an annual reproductive cycle. *Nephrops* spawning and nursery grounds (unspecified intensity) coincide with a small area of the northernmost portion of the Mona Array Area (Figure 1.13). It is worth noting that no part of the Mona Offshore Cable Corridor is located within the unspecified intensity areas for *Nephrops* spawning and nursery grounds (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 Mona Offshore Wind Project, queen scallop are known to spawn in the region. VMS data and feedback from commercial fisheries stakeholders indicated that the eastern portions of the Mona Array Area are known to be important queen scallop spawning areas (further discussed in section 1.9.2).

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

Common Name	Species Name	Spawning (Mona)	Nursery (Mona)
Anglerfish	*Lophius piscatorius*		✓
Cod	*Gadus morhua*	✓	✓
Herring	*Clupea harengus*		✓
Horse Mackerel	*Trachurus trachurus*	✓	
Lemon Sole	*Microstomus kitt*	✓	✓
Ling	*Molva molva*	✓	
Mackerel	*Scomber scombrus*	✓	✓
Nephrops	*Nephrops norvegicus*	✓	✓
Plaice	*Pleuronectes platessa*	✓	✓
Sandeels	Ammodytidae spp.	✓	✓
Dover Sole	*Solea solea*	✓	✓
Spotted Ray	*Raja montagui*		✓
Sprat	*Sprattus sprattus*	✓	
Spurdog	*Squalus acanthias*		✓
Thornback Ray	*Raja clavata*		✓
Tope	*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; 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	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning					
Cod	Spawning	Peak	Peak	Spawning								
European Hake	Spawning	Peak	Peak	Spawning	Spawning	Spawning						
Haddock		Peak	Peak	Peak	Spawning							
Herring*									Spawning	Spawning		
Horse Mackerel			Spawning	Spawning	Peak	Peak	Spawning	Spawning				
Lemon Sole			Spawning	Peak	Spawning							
Ling		Spawning	Spawning	Spawning	Spawning							
Mackerel			Spawning	Spawning	Peak	Peak	Spawning					
Nephrops	Spawning	Spawning	Spawning	Peak	Peak	Peak	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning
Plaice	Peak	Peak	Spawning									Spawning
Sandeels	Spawning	Spawning									Spawning	Spawning
Sole		Spawning	Peak	Spawning								
Spotted Ray					Peak	Peak	Peak					
Sprat					Peak	Peak	Spawning	Spawning				
Spurdog	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning
Thornback Ray		Spawning	Spawning	Peak	Peak	Peak	Peak	Peak	Spawning			
Tope	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning
Whiting		Spawning	Spawning	Spawning	Spawning	Spawning						

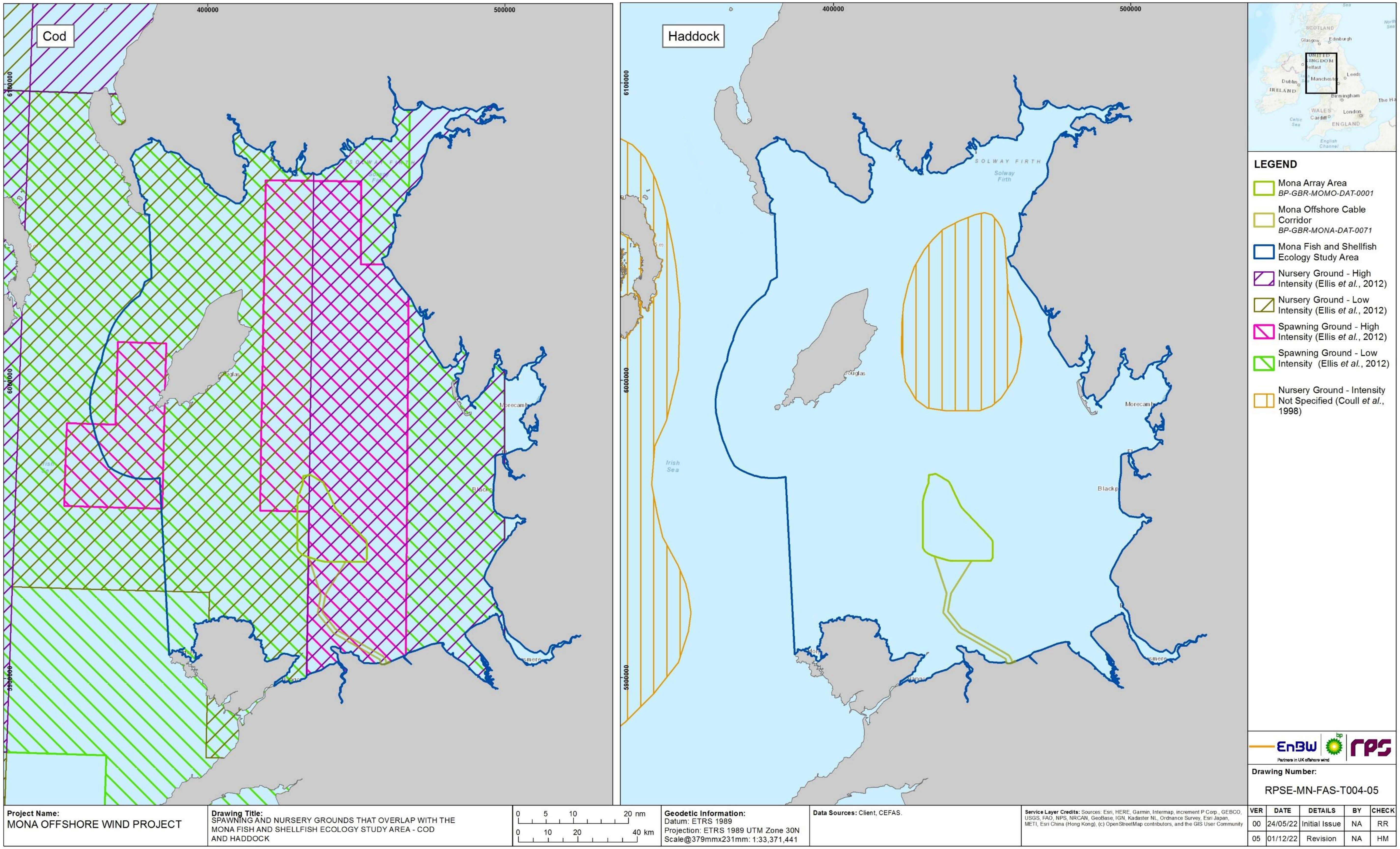


Figure 1.4: Cod and haddock spawning and nursery grounds overlapping the Mona Offshore Wind Project.

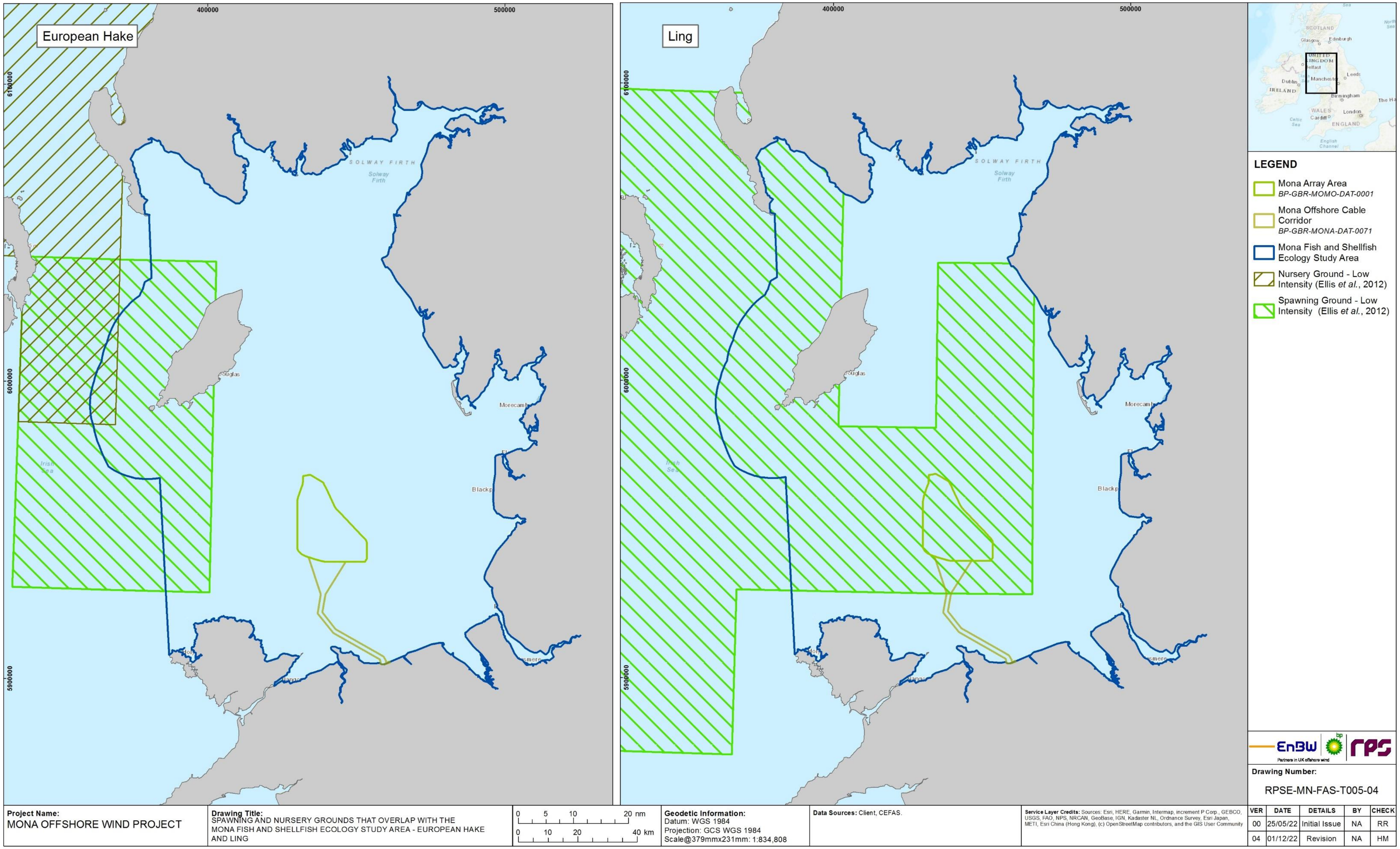


Figure 1.5: European hake and ling spawning and nursery grounds overlapping the Mona Offshore Wind Project.

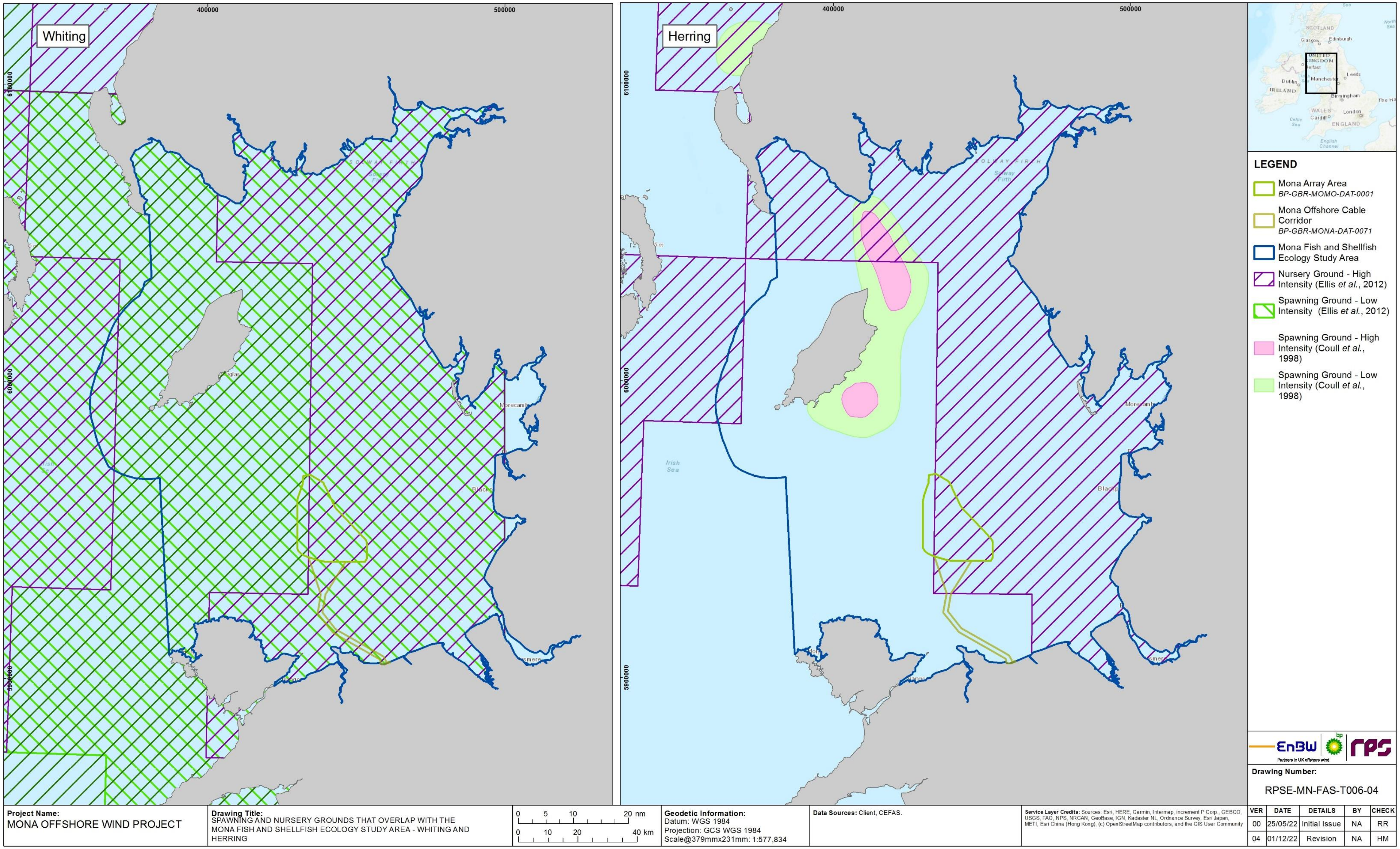
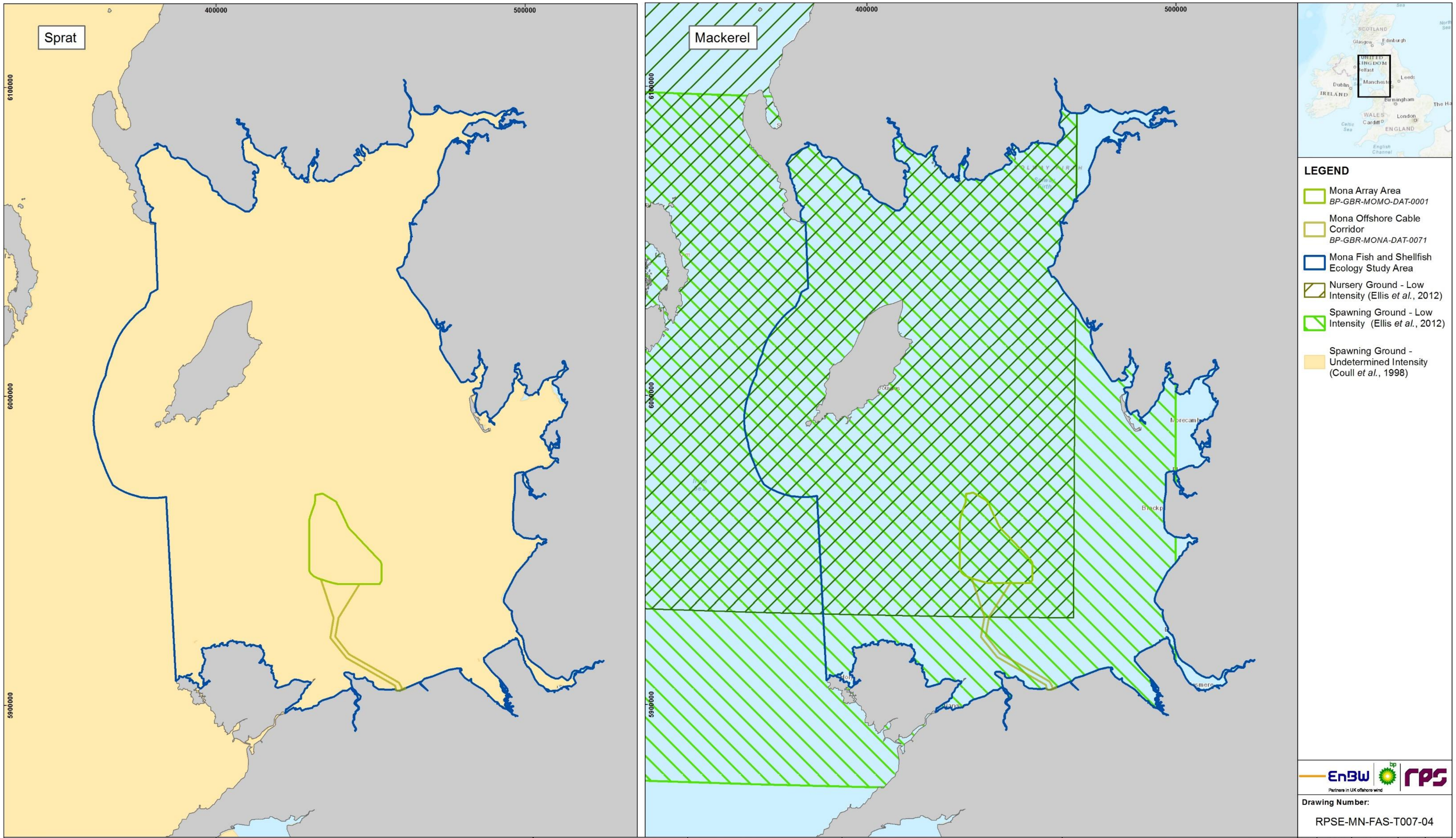


Figure 1.6: Whiting and herring spawning and nursery grounds overlapping the Mona Offshore Wind Project.



Project Name:	Drawing Title:	Scale	Geodetic Information:	Data Sources:	Service Layer Credits:
MONA OFFSHORE WIND PROJECT	SPAWNING AND NURSERY GROUNDS THAT OVERLAP WITH THE MONA FISH AND SHELLFISH ECOLOGY STUDY AREA - SPRAT AND MACKEREL	0 5 10 20 nm; 0 10 20 40 km	Datum: WGS 1984; Projection: GCS WGS 1984; Scale@379mmx231mm: 1:600,000	Client, CEFAS.	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

VER	DATE	DETAILS	BY	CHECK
00	26/05/22	Initial Issue	NA	RR
04	01/12/22	Revision	NA	HM

Figure 1.7: Sprat and mackerel spawning and nursery grounds overlapping the Mona Offshore Wind Project.

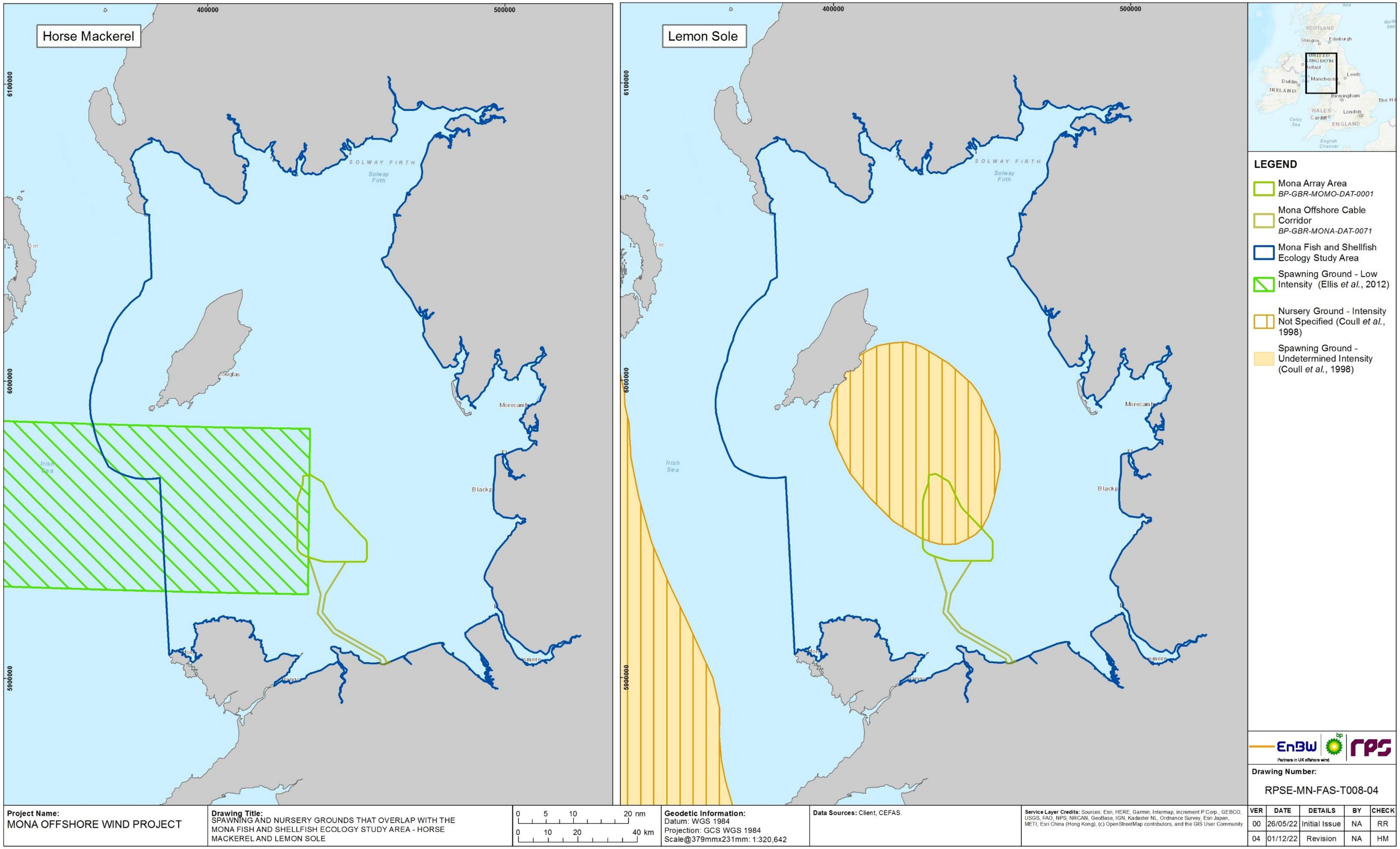


Figure 1.8: Horse mackerel and lemon sole spawning and nursery grounds overlapping the Mona Offshore Wind Project.

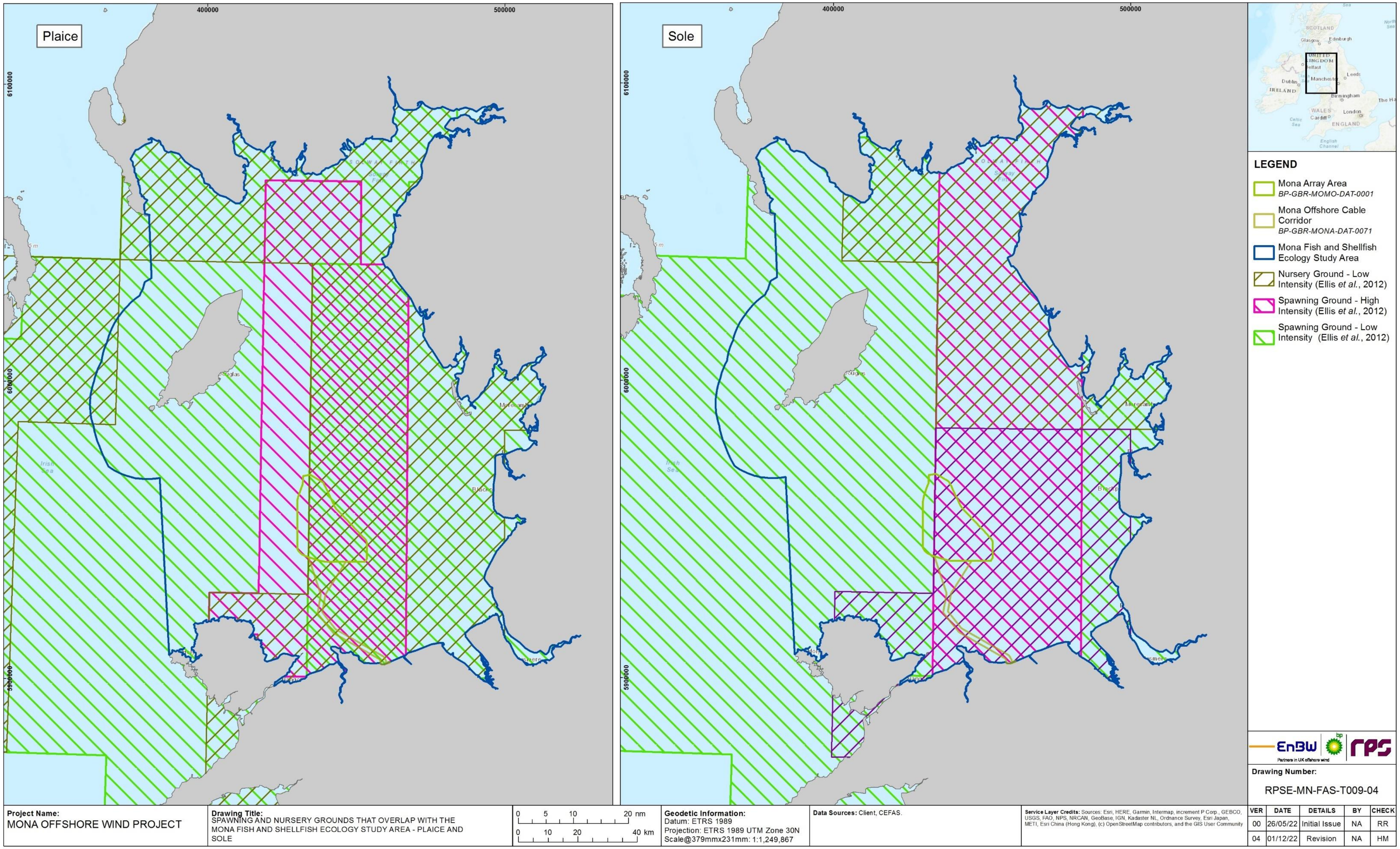


Figure 1.9: Plaice and sole spawning and nursery grounds overlapping the Mona Offshore Wind Project.

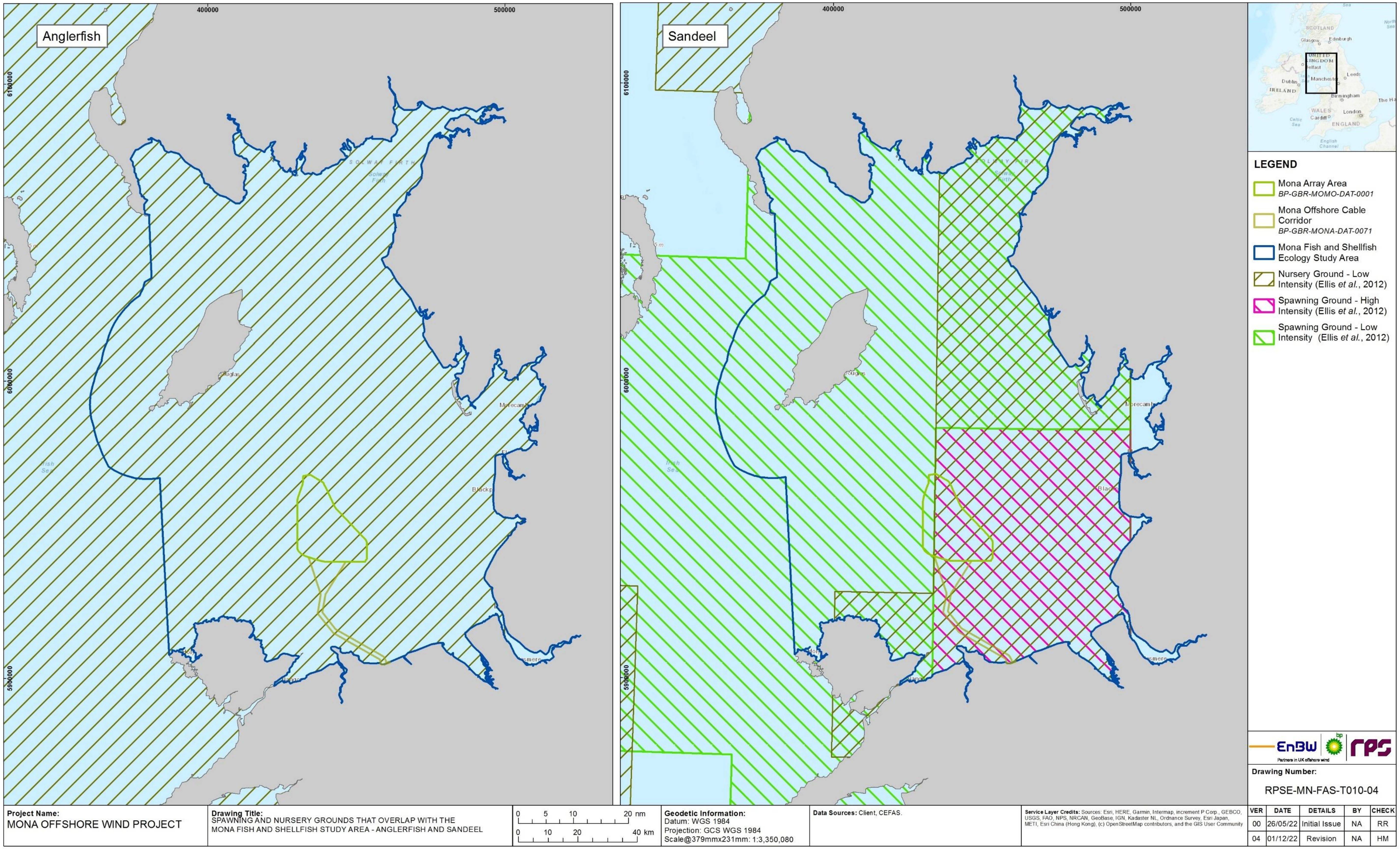


Figure 1.10: Anglerfish and sandeel spawning and nursery grounds overlapping the Mona Offshore Wind Project.

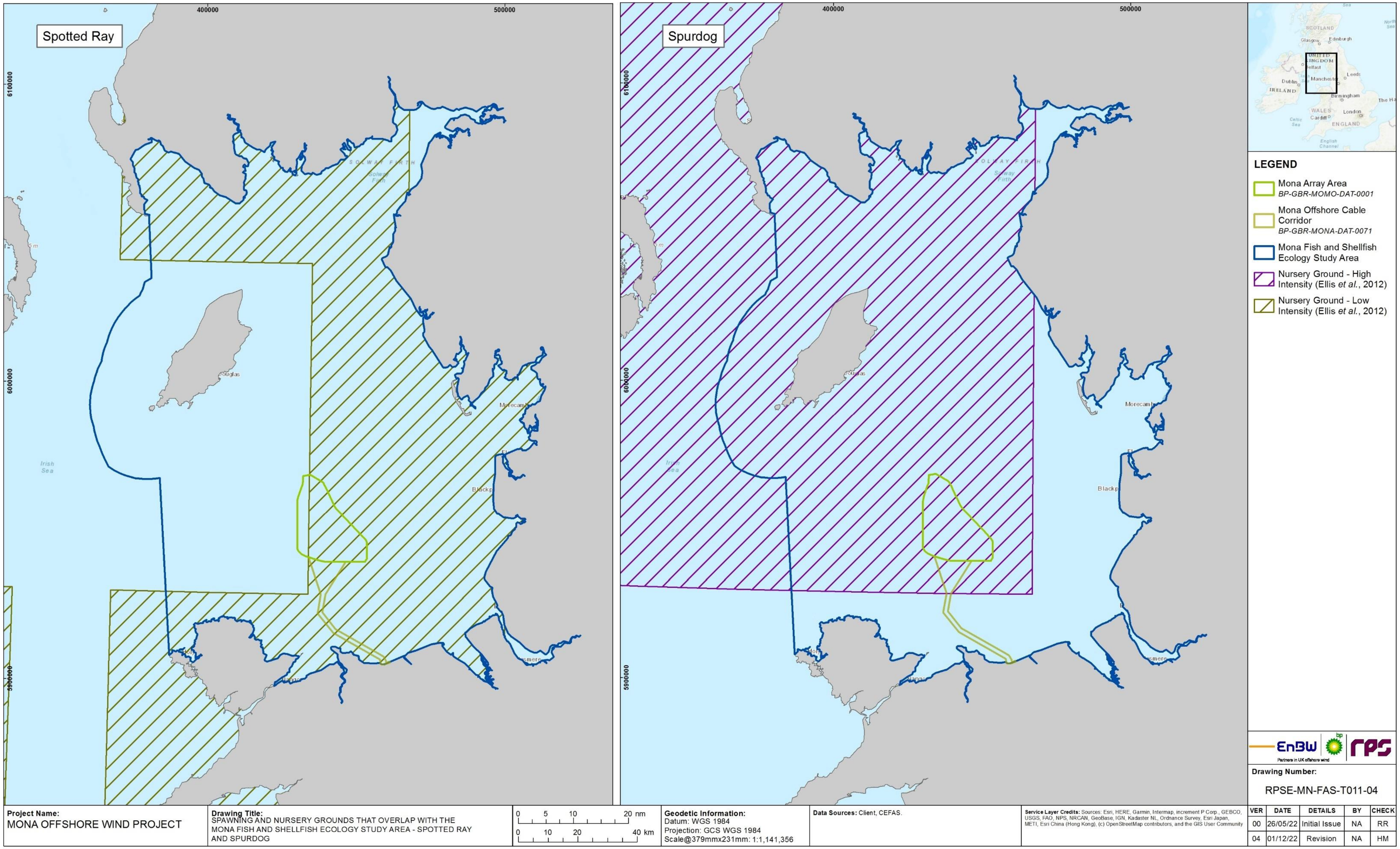


Figure 1.11: Spotted ray and spurdog spawning and nursery grounds overlapping the Mona Offshore Wind Project.

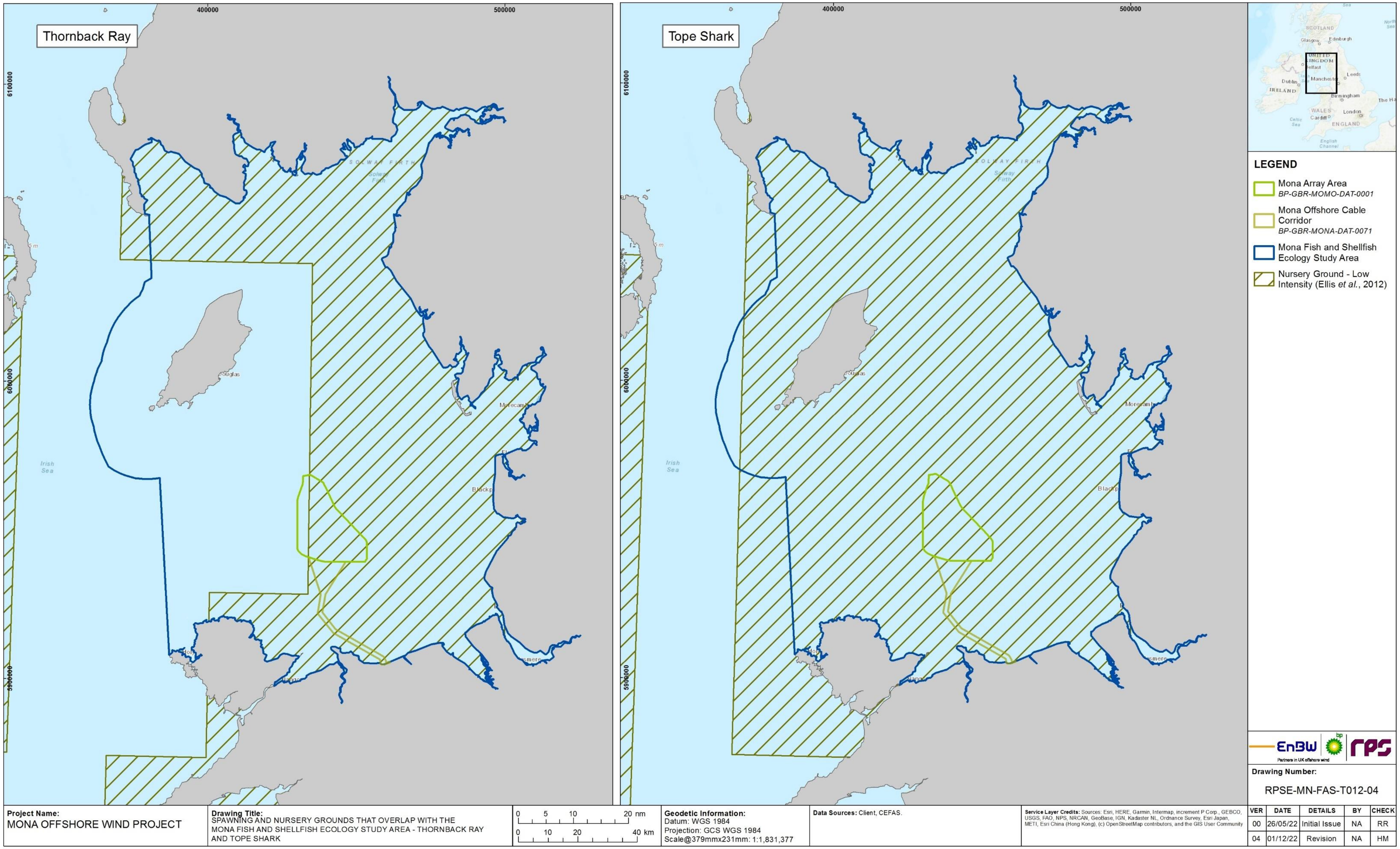


Figure 1.12: Thornback ray and tope spawning and nursery grounds overlapping the Mona Offshore Wind Project.

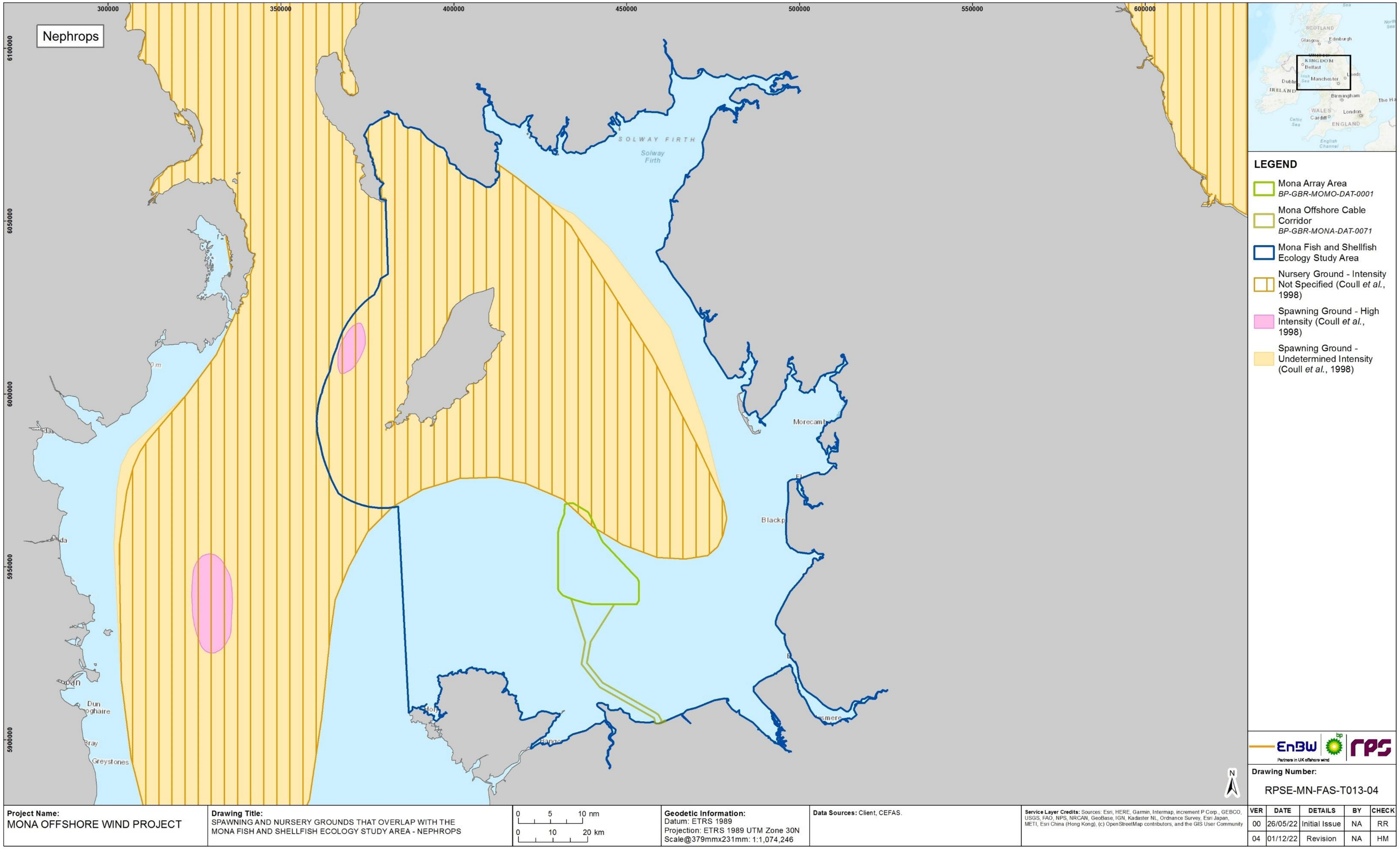


Figure 1.13: *Nephrops* spawning and nursery grounds overlapping the Mona Offshore Wind Project.

Herring

1.5.2 Desktop study

1.5.2.1 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).

1.5.2.2 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. Georges Channel (at the southern 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 northern Bay of Biscay to Greenland and into the Barents Sea.

1.5.2.3 Adult herring can be found on continental sea shelfs to depths of 200m, 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).

1.5.2.4 Herring nursery grounds, as described in section 1.5 and shown in Figure 1.6, are also concentrated inshore of the Mona Offshore Wind Project, within the vicinity of the Mona Offshore Cable Corridor (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).

1.5.2.5 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 noise. 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. Once spawning has taken place (the peak spawning months being September and October for the Mourne stock), the eggs take approximately three weeks to hatch after which the larvae drift in the plankton (Dickey-Colas *et al.,* 2010; Ellis *et al*., 2012).

1.5.2.6 A detailed review of herring spawning has been undertaken following guidelines set out by Boyle and New (2018) considering seabed sediment type and herring larval abundances.

1.5.3 Site-specific surveys

Particle size data

1.5.3.1 As outlined in section 1.3.2, site-specific survey data were collected in 2021 alongside desktop studies to assess the extent of potential suitable spawning habitat within the Mona Array Area. Grab sampling surveys were 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

1.5.3.2 Habitat suitability classifications for herring spawning, based on site-specific data, illustrated that the overwhelming majority of the Mona Array Area has unsuitable sediment composition for herring spawning. Within the Mona Array Area, out of 48 successfully sampled stations, a total of four were assessed as suitable habitat for herring spawning and just one station was classified as sub-prime spawning habitat based on the criteria outlined above (Gardline, 2022). Stations classed as suitable habitat were located in the south of the Mona Array Area, with one suitable target positioned along the northeast flank adjacent to the sub-prime station. Outside of the Mona Array Area, three further stations were classified as suitable spawning habitat, and one station as sub-prime; these were located due north and north northwest of the Mona Array Area (Gardline, 2022).

1.5.3.3 Although the Mona Array Area was found to predominantly comprise 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 Mona Array Area as unsuitable for this purpose.

1.5.3.4 Figure 1.14 illustrates 2021 site-specific survey data 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. Overall, the majority of the Mona Array Area is considered unsuitable habitat for herring spawning, with sparse patches of marginal (suitable) habitat and one area denoted as sub-prime habitat. These results are in line with the EMODnet broadscale seabed substrate data within the Mona Array Area.

1.5.3.5 Additionally, based on the broadscale EMODnet substrate data, the Mona Offshore Cable Corridor contains predominantly unsuitable habitat without any patches described as potential marginal habitat. It is worth noting that the EMODnet seabed substrate data is of lower resolution and accuracy than the results of the site-specific survey data, but provide an overall picture of the surrounding substrate. Further site-specific survey data has been collected along the Mona Offshore Cable Corridor in

2022, and these findings will be presented in the final Fish and Shellfish Technical Report to be submitted as part of the DCO application.

1.5.4 Northern Irish Herring Larvae Survey

1.5.4.1 As outlined above in section 1.5.2, 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, 2022). 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 <10mm long used as a cut off point for recently spawned larvae (in line with standard International Herring Larvae Survey (IHLS) practice).

1.5.4.2 It should be noted that the NINEL datasets, despite being useful indicators of specific herring spawning locations, are considered to underestimate he 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 have 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.

1.5.4.3 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 1.15 to Figure 1.17 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).

1.5.4.4 These data show that the spawning area directly northwest of the Mona Array Area 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 indicates 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, 2021). 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.

1.5.4.5 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 south-east and north-east of the Isle of Man, matches the high intensity grounds identified by Coull *et al*. (1998) (Figure 1.14), with a broad distribution of low intensity spawning surrounding these areas in all years from 2012-21. Figure 1.14 shows the area of high intensity spawning south-east of the Isle of Man, and north-east of the Mona Array Area, 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).

1.5.4.6 No high intensity spawning grounds identified by Coull *et al*. (1998) overlap with any part of the Mona 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 1.14. The large patches of gravelly sand and >5% mud content reported provide unsuitable spawning habitat throughout much of the Mona Array Area, with only four areas of suitable spawning habitat, and one sub-prime habitat identified out of a total of 48 stations.

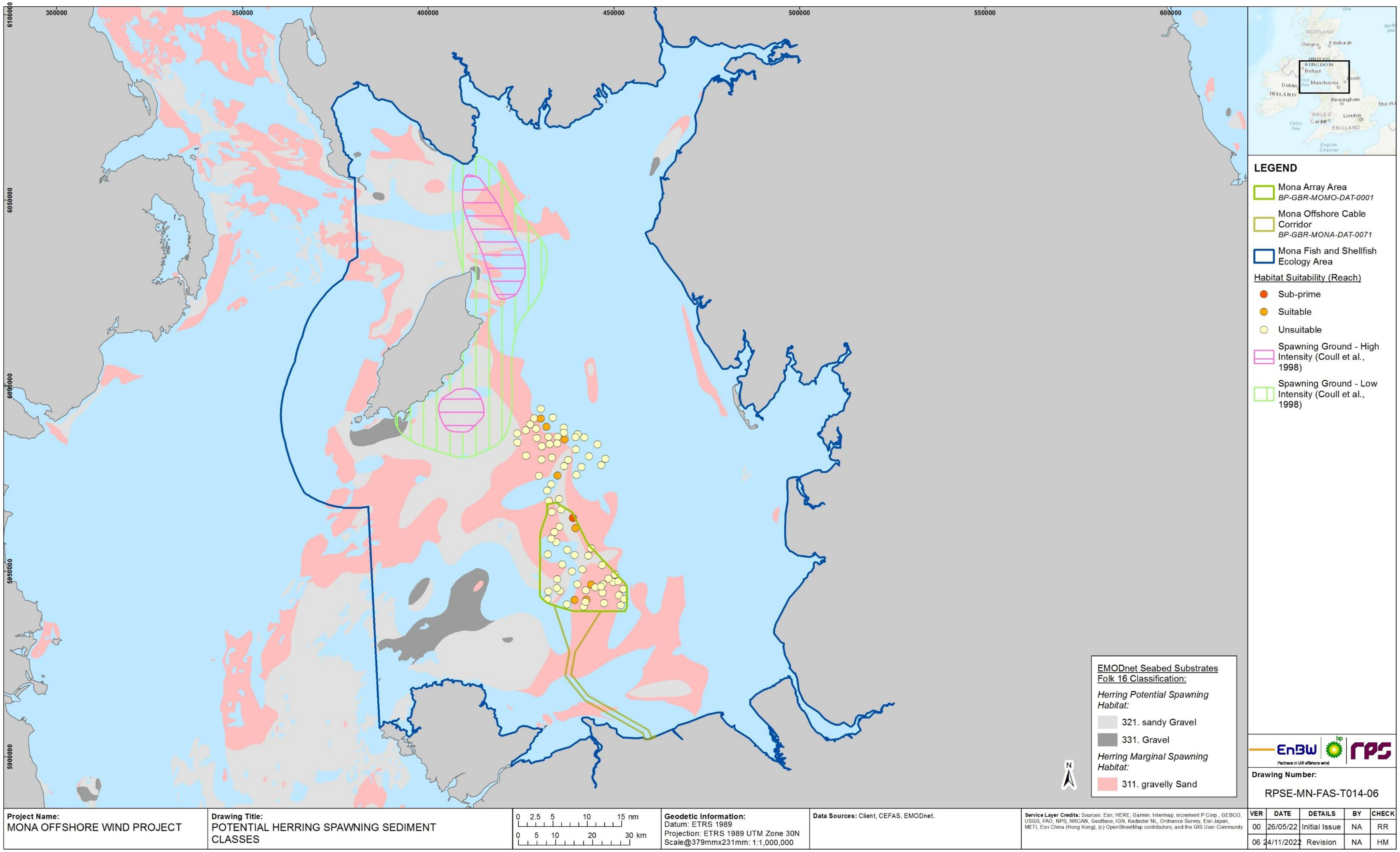


Figure 1.14: Herring spawning habitat preference classifications from EMODnet and site-specific survey data.

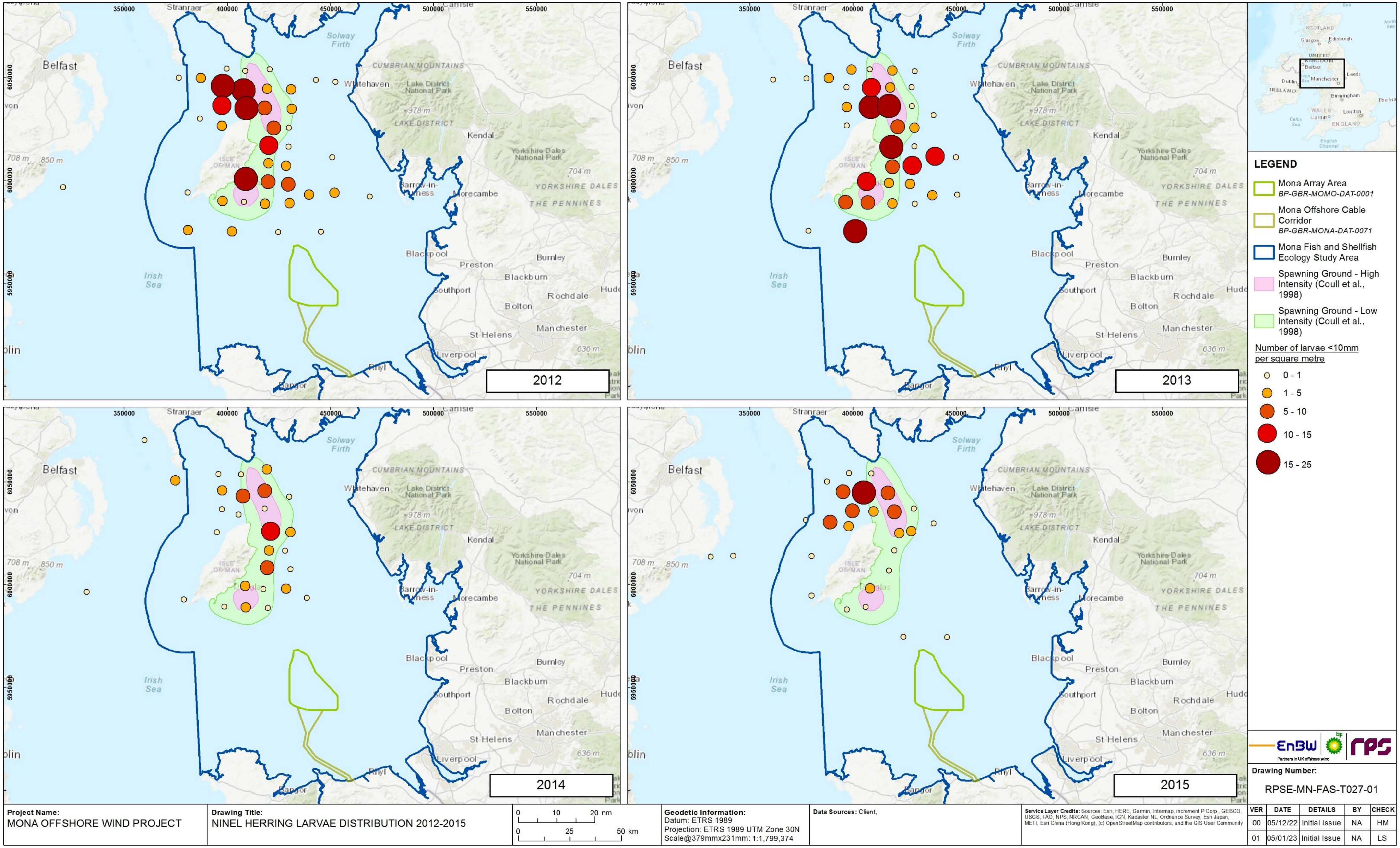


Figure 1.15: NINEL Herring Larvae population densities (larvae/m²) in 2012-2015.

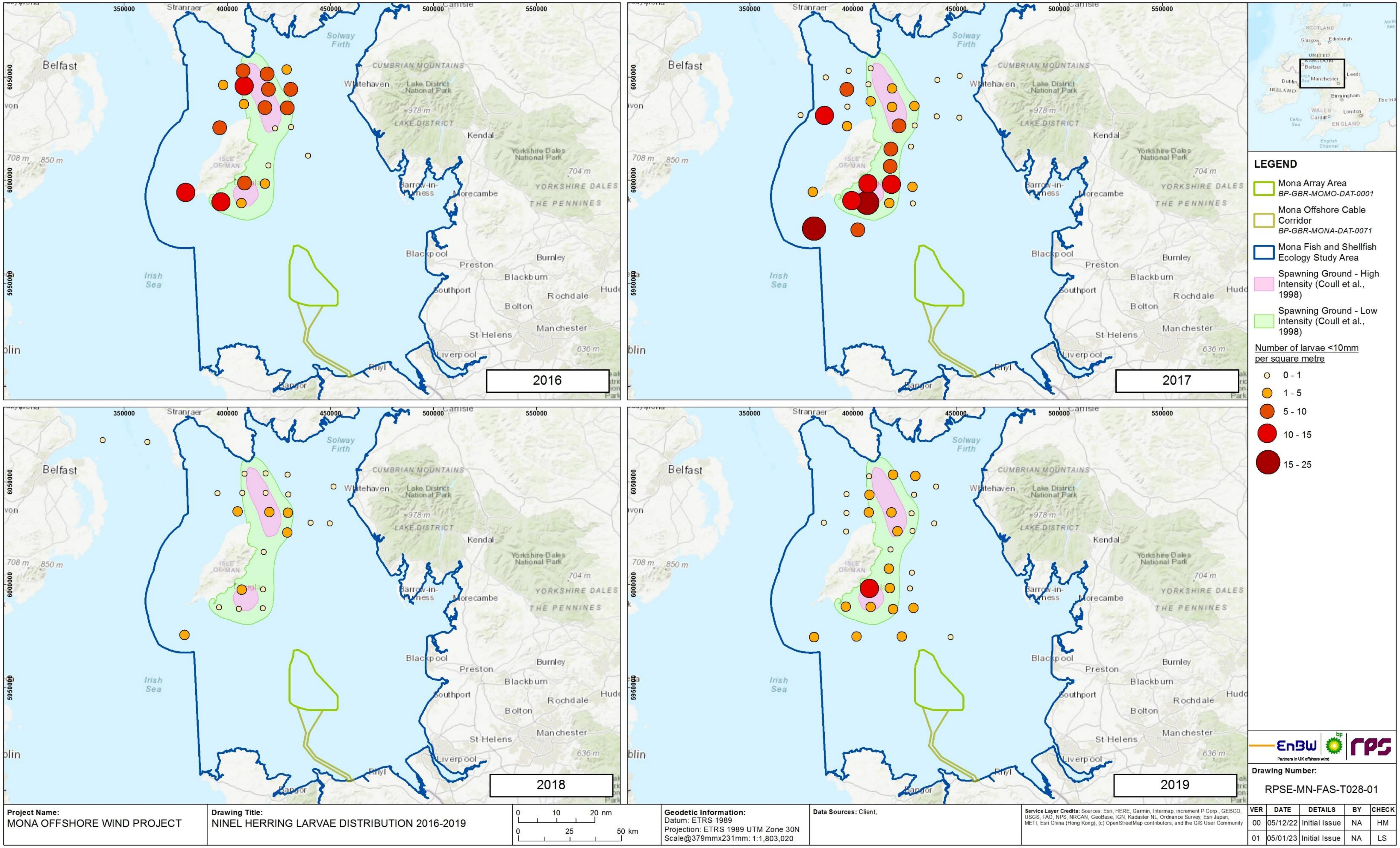


Figure 1.16: NINEL Herring Larvae population densities (larvae/m²) in 2016-2018.

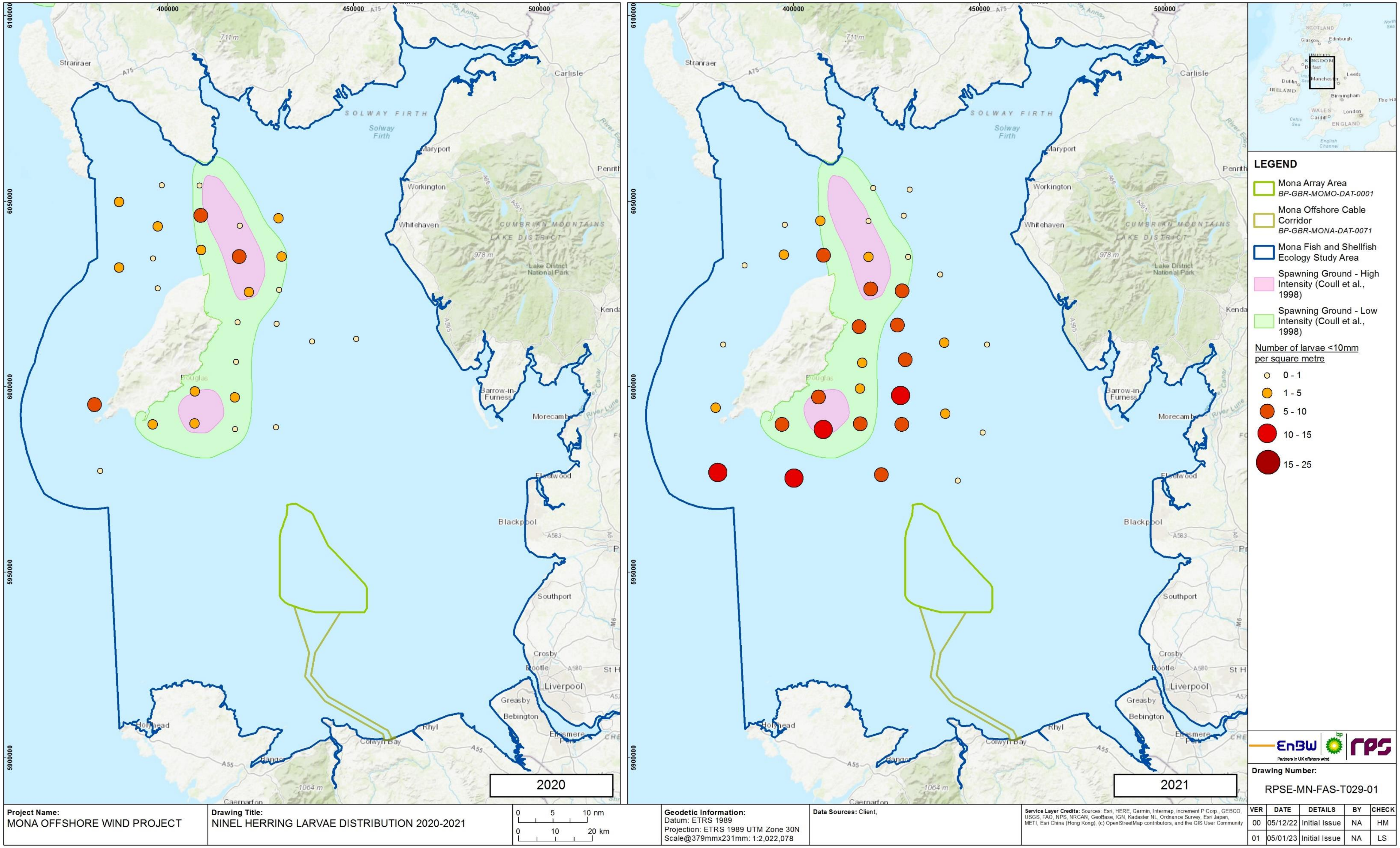


Figure 1.17: NINEL Herring Larvae population densities (larvae/m²) in 2020-2021.

1.6 Sandeel

1.6.1 Desktop study

1.6.1.1 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.

1.6.1.2 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).

1.6.1.3 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).

1.6.1.4 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.

1.6.1.5 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 0.25mm to 2mm), and avoided sediment containing >4% silt (particle size <0.063 mm) and >20% fine sand (particle size 0.063mm to 0.25mm). 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 0.25mm to 2.0mm) increased, sandeel showed an increased preference for this substrate.

1.6.1.6 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 investigated by MarineSpace Ltd (2013), to produce four sandeel sediment preference categories, which were defined as; Prime, Sub-Prime, Suitable and Unsuitable (see Table 1.6).

1.6.2 Site-specific survey

1.6.2.1 As outlined in section 1.3.2, site-specific survey data were collected and reviewed alongside desktop studies to assess the extent of suitable sandeel habitat within the Mona Offshore Wind Project. Grab sampling was undertaken (see section 1.3.2) and PSA completed on the sediment samples collected in 2021 in the Mona Array Area which allowed classification of the sediment types according to Latto *et al*. (2013), as described in section 1.3.2. 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.

1.6.2.2 Figure 1.18 illustrates the results of this site-specific analysis with sandeel habitat preference classifications of prime, sub-prime, suitable and unsuitable denoted, presented with high intensity spawning grounds (Ellis *et al*., 2012). The distribution of habitat suitability shows that the Mona Array Area is largely classified as both unsuitable (40.38%) and suitable (25%) habitat, with intermittent areas of prime and sub-prime habitat (Gardline, 2022).

1.6.2.3 Results illustrate that 46% (22) of stations comprised over 10% mud content; these stations are considered unsuitable habitat for sandeel. A further 37.5% (18) of stations revealed suitable or marginal habitat with between 4% and 10% mud content, and just two and six stations within the Mona Array Area were found to comprise prime and sub-prime sandeel habitat, respectively. These results highlight the patchiness of the substrate composition within the Mona Array Area, and demonstrate the low favourability of the site for sandeel, with over 80% of the site classified as unsuitable or marginal habitat.

1.6.2.4 Figure 1.18 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. Overall, the EMODnet data broadly aligns with the site-specific survey findings in terms of expected spawning ground suitability. 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 are 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 do provide a broadscale regional picture of the general surrounding substrate.

1.6.2.5 Further site-specific survey results from grab samples from the 2021 survey, as shown in Figure 1.19, have provided incidental data on the presence of sandeel within the Mona Offshore Array, where grab samples captured sandeel individuals. A total of eight individual lesser sandeel were captured in grab samples within the Mona Array Area at two stations out of a total of 48; these coincided with stations assessed to be prime and sub-prime sandeel habitat in the south and west of the site. However, it should be noted that this data collection method does not target sandeel specifically, therefore these results should be regarded as opportunistic, demonstrating consistency between the PSA results and faunal observations. 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 site-specific survey data and desktop data indicate that sandeels may be present across the Mona Offshore Wind Project, although the habitats recorded within the Mona 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

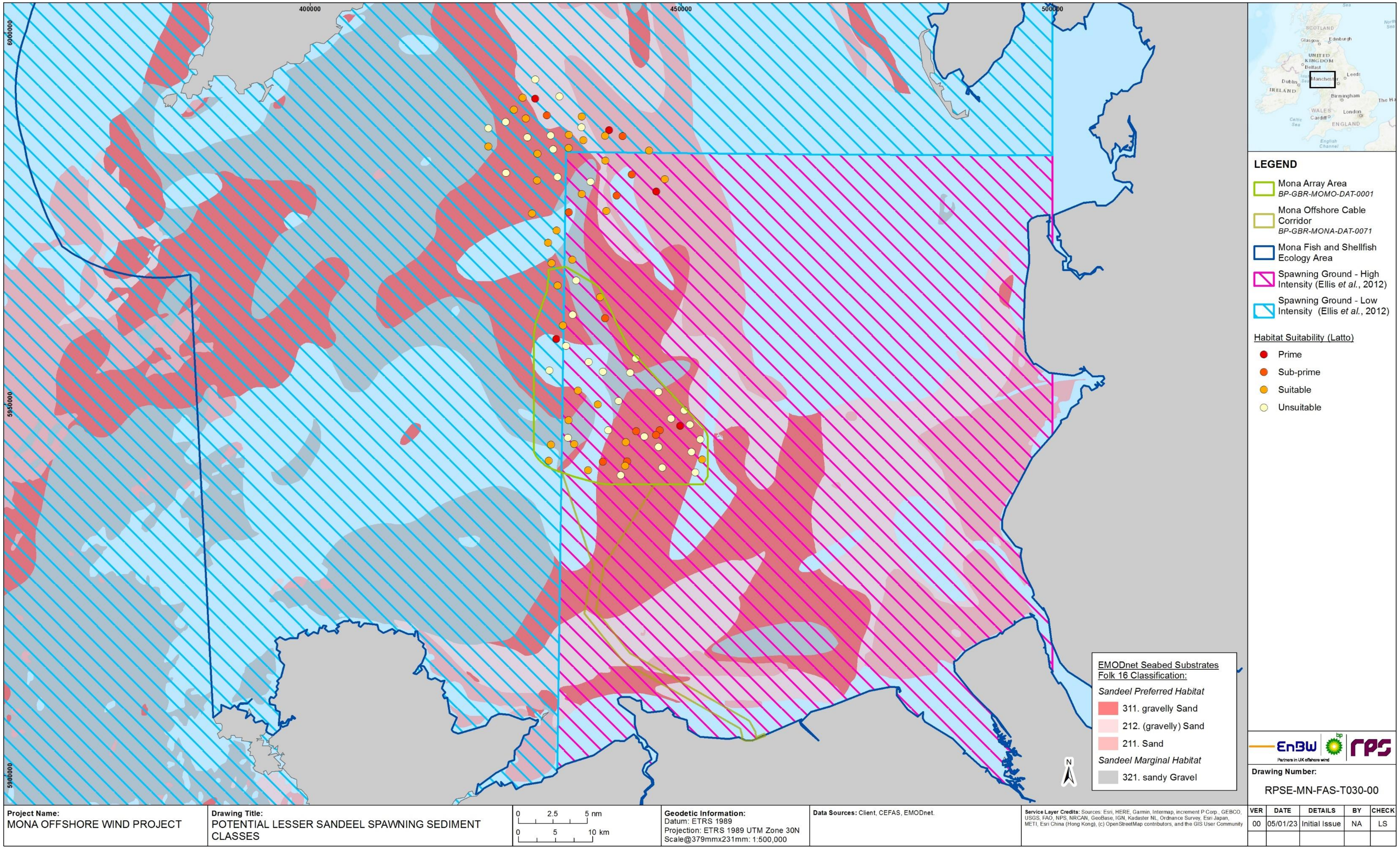


Figure 1.18: Sandeel habitat preference classifications from EMODnet and site-specific survey data.

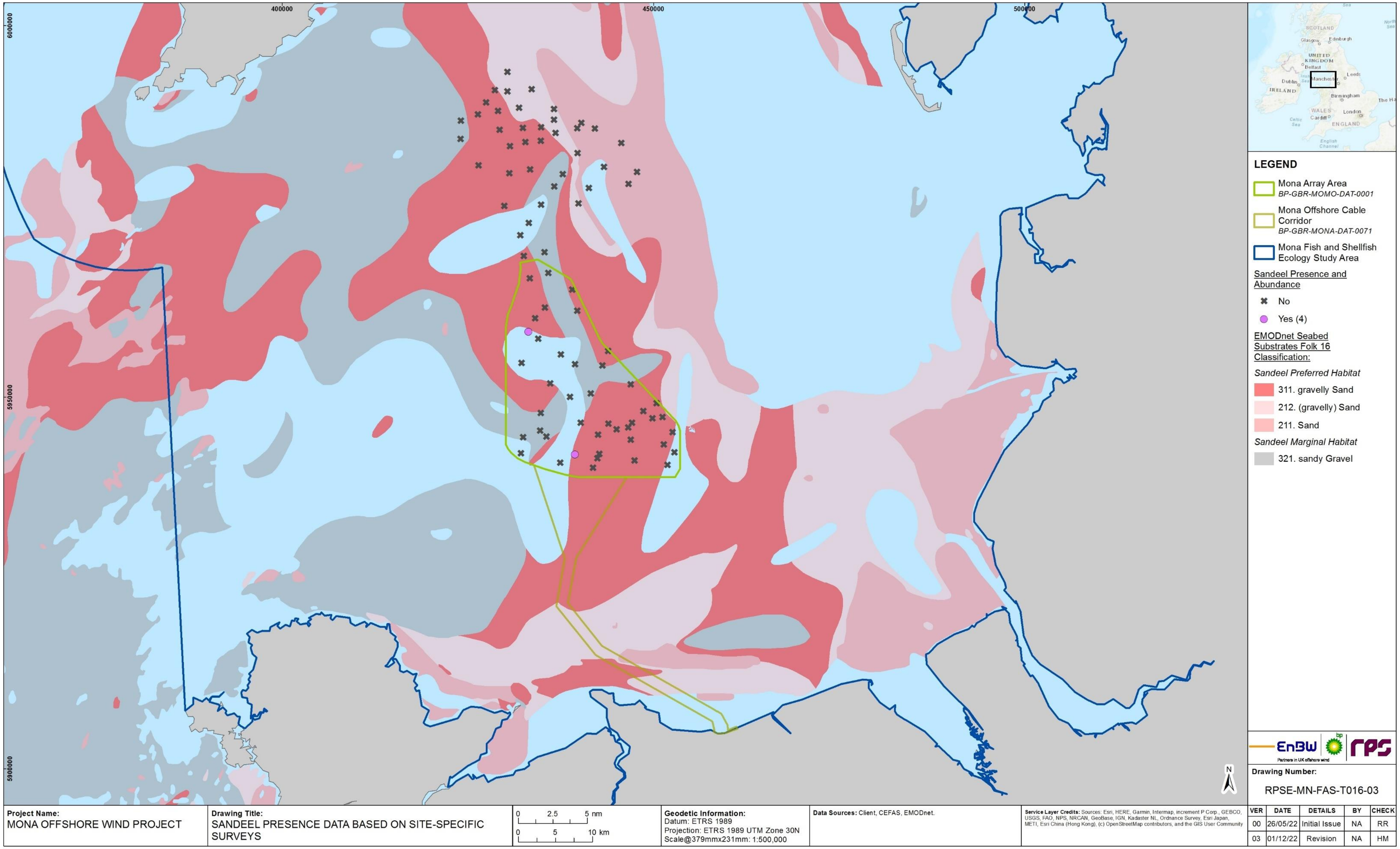


Figure 1.19: Sandeel habitat preference classifications with site-specific abundance data.

1.7 Elasmobranchs

1.7.1.1 Elasmobranchs are a cartilaginous fish group that comprises sharks, rays and skates, with species expected to be present in the fish and shellfish ecology study area including 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 Mona Offshore Wind Project (Ellis *et al*., 2012; see section 1.5).

1.7.1.2 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).

1.7.1.3 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, 2018).

1.7.1.4 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).

1.7.1.5 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 20m to 500m. 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).

1.7.1.6 Both spurdog and tope are known to occur throughout the Irish Sea, around the Isle of Man territorial waters and therefore within the fish and shellfish ecology study area (Stone *et al*., 2013). This study identified the presence of 28 tope and six spurdog, indicating relatively low adult population densities within this area, although Ellis *et al*. (2012) provides evidence of high intensity spurdog nursery grounds, and low intensity tope nursery grounds within the fish and shellfish ecology area, highlighting the potential importance of this area to these species.

1.7.1.7 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 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 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, 2021).

1.7.1.8 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 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 30km from the Mona Array Area, although this population is reportedly only present intermittently throughout spring and summer for feeding.

1.7.1.9 Basking sharks *Cetorhinus maximus* are known to migrate throughout the fish and shellfish ecology study area and therefore have the potential to be encountered within the Mona Offshore Wind Project. 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).

1.7.1.10 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).

1.7.1.11 Basking shark migrations have been evidenced throughout the Irish Sea, with high numbers of sighting recorded around the Isle of Man (NBN Atlas, 2019). Historically, basking sharks have been sighted in a density of 11-50 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 Mona Offshore Wind Project 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 Mona Offshore Wind Project.

1.7.1.12 More recently, twenty-eight 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 1,057km (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 Mona Offshore Wind Project. 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 (EEZ) 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 southern migration destinations (Doherty *et al*., 2017).

1.7.1.13 Mating has not been observed in basking sharks 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 sharks 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).

1.8 Diadromous Fish

1.8.1.1 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 Mona Offshore Wind Project. Therefore, the diadromous fish species have the potential to migrate through the Mona Offshore Wind Project to rivers during certain periods of the year (National Biodiversity Network (NBN) Atlas, 2019).

1.8.1.2 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 Mona Offshore Wind Project. Atlantic salmon *Salmo salar* and sea trout *Salmo trutta* 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 northern 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 Mona Offshore Wind Project. 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 1.8). Allis shad *Alosa alosa*, twaite shad, European eel *Anguilla anguilla*, river lamprey, and sea lamprey in Welsh waters are also protected under Section 7 of the Wales Biodiversity Partnership (Welsh Government, 2016).

1.8.1.3 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., 2013).

1.8.1.4 Sea trout, European eel, river lamprey, and Atlantic salmon have been recorded in the estuaries of rivers across the northwest coast of England, in the vicinity of the Mona Offshore Cable Corridor and within the inshore area of 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 Mona Array Area (NBN Atlas, 2019).

1.8.1.5 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).

1.8.1.6 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 the Mona Array Area and the Mona Offshore Cable Corridor, during key migration periods (e.g. adult migration to spawning rivers and smolt migration from natal rivers in the vicinity and surrounding the Mona Offshore Wind Project). Depending on the key migration periods of the diadromous fish species discussed, there will be both a greater and lesser likelihood of these species being present within the Mona Offshore Wind Project during all phases of the project, depending on the timings of particular activities.

1.8.1.7 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.

Table 1.7: Overview of life histories for diadromous fish relevant to the Mona Offshore Wind Project.

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

Species	Time Spent in Freshwater	Timing of Downstream Migration	Time Spent at Sea Before First Return	Timing of Upstream Migration
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°
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

1.8.2 Atlantic salmon

1.8.2.1 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 Atlantic salmon and climate change (ICES, 2017). Atlantic salmon is an Annex II species of the EU Habitats and Species Directive and is a feature of various SACs.

1.8.2.2 The UK Atlantic 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, 2022).

1.8.2.3 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.

1.8.2.4 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.

1.8.2.5 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.

1.8.2.6 An Environment Agency report on salmonid fisheries statistics for England and Wales (Environment Agency, 2021) summarised Atlantic salmon rod catches within a 5-year period between 2015 to 2019 based on completed fisheries returns. Results illustrated that there were 11,566 Atlantic salmon caught in 2020 and 9,163 caught in 2019. Additionally, the 5-year mean number of Atlantic salmon caught (2015 to 2019) was found to be 11,051. These results further illustrate a 26% change from 2019 to 2020 Atlantic salmon rod catches and a 5% change from the 5-year mean compared to 2020 data (Environment Agency, 2021).

1.8.2.7 Atlantic salmon net catches in England and Wales reported 900 Atlantic salmon caught during 2020, 453 caught during 2019, and 11,734 caught in the 5-year mean (2015 to 2019). This accounted for a 99% change from 2019 to 2020 and a very significant -92% change from the 5-year mean (2015 to 2019, when catches typically exceeded 10,000) to 2020 (Environment Agency, 2021).

1.8.2.8 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).

1.8.2.9 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).

1.8.3 Sea Trout

1.8.3.1 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 Mona Offshore Wind Project. Sea trout, like Atlantic salmon, are also known to be a host species for freshwater pearl mussel *Margaritifera margaritifera*, see section 1.8.7 for additional detail on the freshwater pearl mussel.

1.8.3.2 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 5kg (CSTP, 2016).

1.8.3.3 An Environment Agency report on salmonid fisheries statistics for England and Wales (Environment Agency, 2021) summarised sea trout rod catches within a 5-year period between 2015 to 2019 based on completed fisheries returns. Results illustrated that there were 19,277 sea trout caught in 2020 and 21,330 caught in 2019. Additionally, the 5-year mean number of sea trout caught (2015 to 2019) was found to be 21,728. These results further illustrate a -10% change from 2019 to 2020 sea trout rod catches and a -11% change from the 5-year mean to 2020 (Environment Agency, 2021).

1.8.3.4 Sea trout net catches in England and Wales reported 12,703 caught during 2020, 14,599 caught during 2019, and 35,555 caught in the 5-year mean (2015 to 2019, with catches consistently decreasing annually from 64,468 in 2015 to 14,599 in 2019). This accounted for a -13% change from 2019 to 2020 and a -64% change from the 5-year mean (2015 to 2019) to 2020 (Environment Agency, 2021).

1.8.4 European Eel

1.8.4.1 European eels are classified as critically endangered (IUCN, 2022) and inhabit various benthic habitats that range from streams, shores, rivers, lakes, and ultimately migrate to the Sargasso Sea to spawn. European 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 Mona Offshore Wind Project and therefore, given their critically endangered status, will be considered as an Important Ecological Feature (IEF).

1.8.5 Sea Lamprey

1.8.5.1 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 lamprey 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). It is a possibility that sea lamprey will be present in the vicinity of the Mona Offshore Wind Project and therefore will be considered as an IEF.

1.8.6 River Lamprey

1.8.6.1 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 Mona Array Area, however they could occur near the Mona Offshore Cable Corridor as they can be found in the vicinity of estuarine environments.

1.8.7 Freshwater Pearl Mussel

1.8.7.1 The freshwater pearl mussel is an endangered species of freshwater mussel. Freshwater pearl mussels are similar in shape to common marine mussels but grow much larger and live far longer. They can grow as large as 20cm 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 or 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 International Union for Conservation of Nature (IUCN) Invertebrate Red List. While there is no potential for direct impacts on this species from the Mona Offshore Wind Project (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. This species will therefore be considered as an IEF.

1.8.8 Allis and Twaite Shad

1.8.8.1 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 800km 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. Optimal 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).

1.8.9 Sparling (European Smelt)

1.8.9.1 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 Mona Array Area, however they could be encountered in vicinity of the Mona Offshore Cable Corridor. This species has also been recorded in the River Dee and also the River Conwy (NRW, Scoping Opinion).

1.9 Shellfish

1.9.1.0 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 king scallops observed to the north (ICES, 2018). Commercial landings data can be used as a proxy for identifying species present in the vicinity of the Mona Offshore Wind Project, which include *Nephrops*, edible crab, European lobster, velvet swimming crab, king scallop and squid.

1.9.2 King and Queen Scallop

1.9.2.1 Both king scallop 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 in coarser sediments. King scallop achieve reproductive maturity between three to five years of age, live upwards of 15 years, and are evidenced to be most abundant in depths of 20m to 70m (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 (SD 2018/0186, 2018). A key physical difference between king and queen scallop is the queen scallop's two distinctive curved shells, while the king scallop's upper shell is predominantly flat and are typically larger overall. Queen scallop are known to be more highly mobile than king scallop, especially within the summer months when queen scallop are actively swimming (Volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information).

1.9.2.2 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 transportation of larvae to areas optimal 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 6, chapter 11.1: Commercial fisheries technical report of the PEIR.

1.9.2.3 Distribution 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 English and Welsh waters, scallop 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 100km 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, scallop 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.

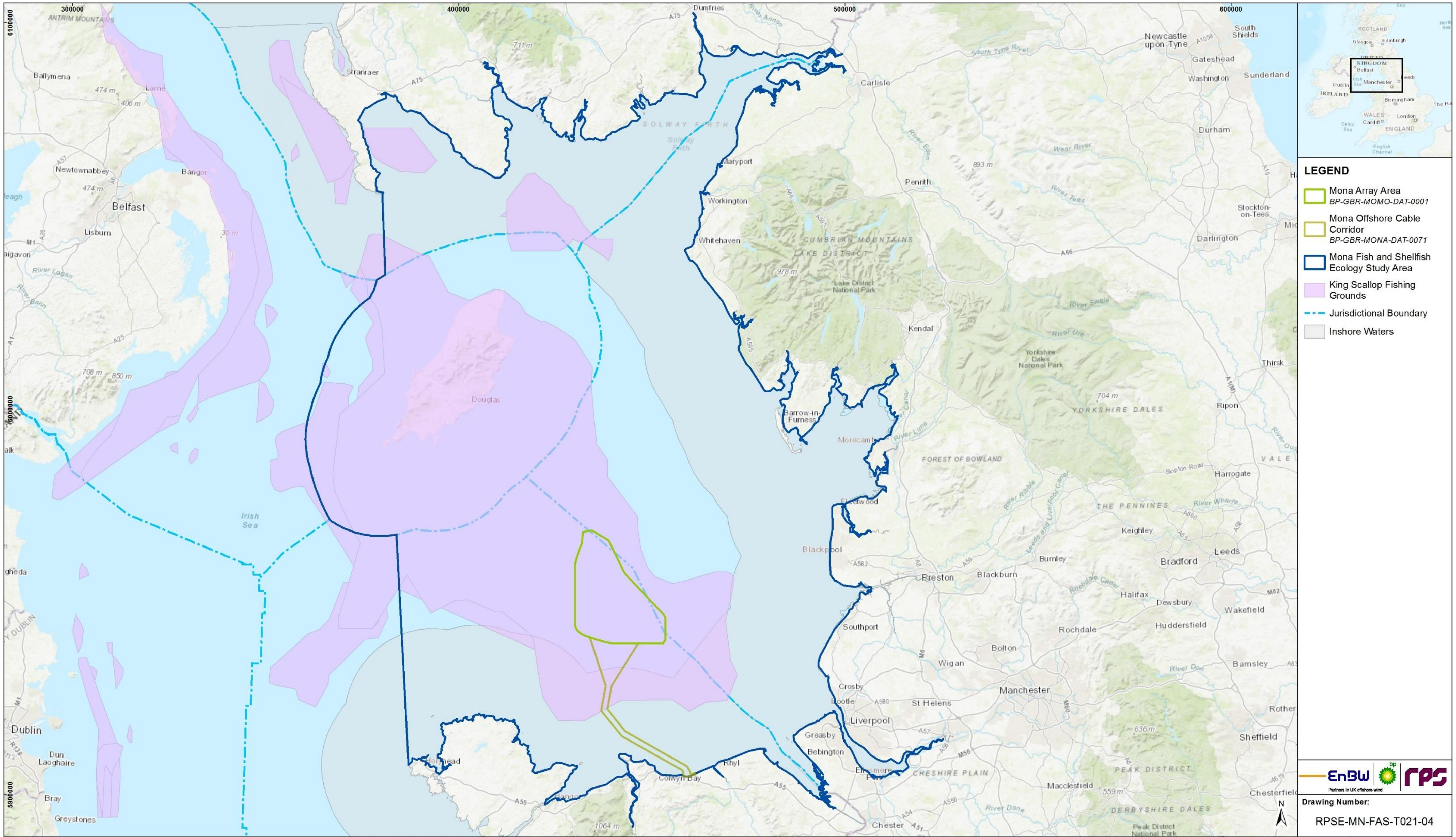
1.9.2.4 Scallop (both king and queen) were the most valuable wild-caught seafood landed in Wales in 2012. However, both their value and quantity of scallop within landings have decreased since 2012. Despite this decrease in associated value, scallop are economically important and as of 2017, were the third most valuable wild-caught seafood in Wales (Delargy *et al*., 2019). Generally, queen scallop are more mobile than king scallop, which influences the gear type used to target them, as discussed further in volume 6, chapter 11.1: Commercial fisheries technical report of the PEIR.

1.9.2.5 King scallop have historically been targeted commercially through dredge fisheries within the vicinity of the Mona Offshore Wind Project, with the majority of the activity concentrated along the western portions of the Mona Array Area and around the Isle of Man (Figure 1.20).

1.9.2.6 While the value of landings has fluctuated over the last 10 years, high intensity scallop dredging is present along the western-most corner and through the middle of the Mona Array Area (Figure 1.21). Other areas around and within the Mona Offshore Wind Project and Mona Array Area are rarely fished as they are considered important spawning grounds for the overall stock. Specifically, these areas are located within the western and easternmost portions of the Mona Array Area (Figure 1.21).

1.9.2.7 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 1,394t to 2,997t (Bloor, 2019; see Volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information). The landed weight of king scallops 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 closures.

1.9.2.8 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 6,721t to 8,999t and illustrated varying seasonal trends similar to that of the aforementioned king scallop, with an estimated density in the Isle of Man waters far northeast of the Mona Array Area of 1-11 individuals per 100m2 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 fishing closures of the species within the east Irish Sea (Volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information).



Project Name:	Drawing Title:	Geodetic Information:	Data Sources:
MONA OFFSHORE WIND PROJECT	KING SCALLOP FISHING GROUNDS	Datum: ETRS 1989 Projection: ETRS 1989 UTM Zone 30N Scale@379mmx231mm: 1:1,000,000	Client, ICES.

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

VER	DATE	DETAILS	BY	CHECK
00	01/06/22	Initial Issue	NG	RR
04	01/12/22	Revision	NA	HM

Figure 1.20: Historical king scallop fishing grounds confirmed through northern Irish, Irish, and UK vessel VMS data (adapted from ICES, 2020).

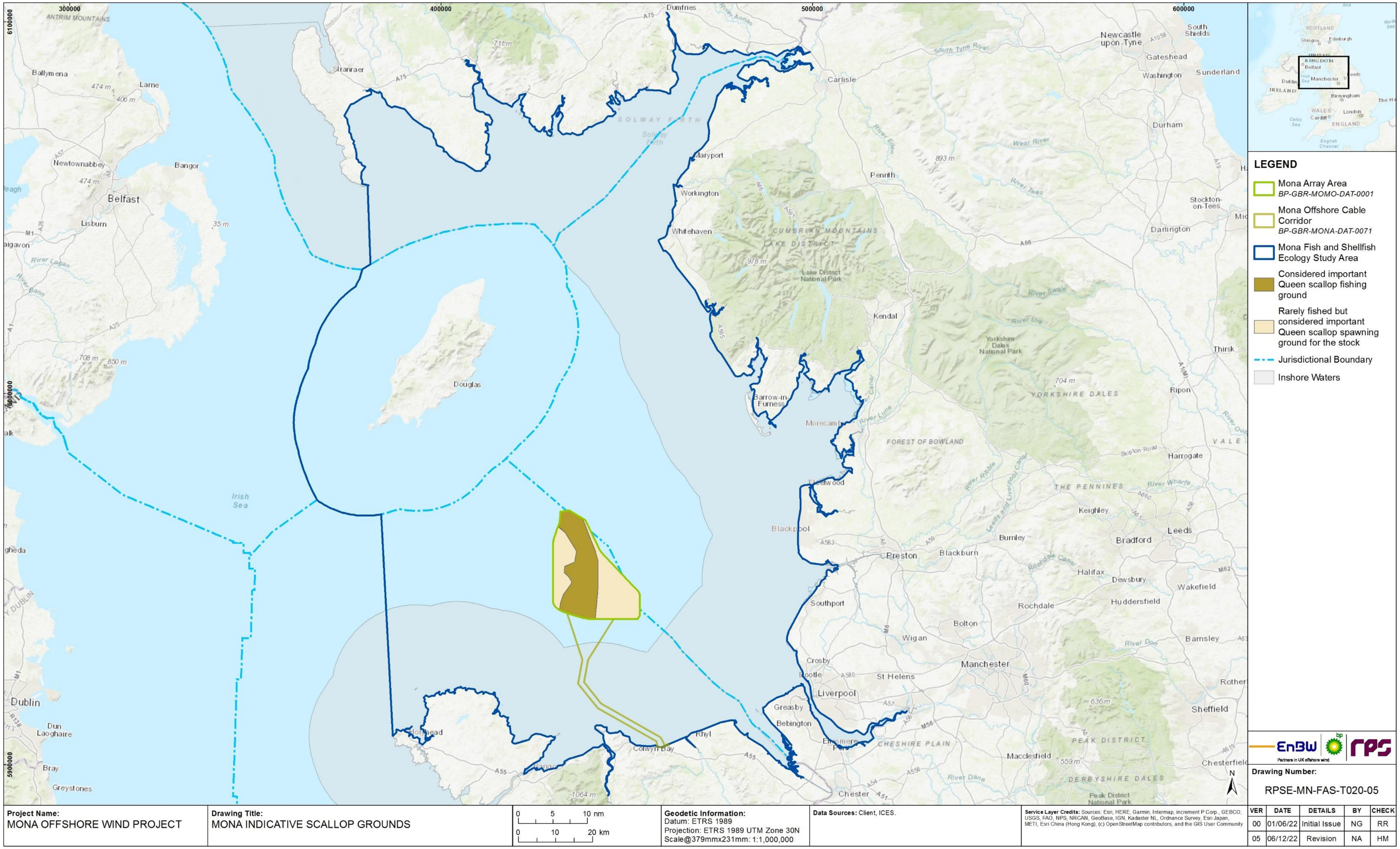


Figure 1.21: Indicative queen scallop grounds as evidenced through stakeholder consultation and VMS data (Volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information).

1.9.3 European Lobster

1.9.3.1 The European lobster can be found throughout the British coasts on rocky substrata, down to depths of 60m. European lobster are actively fished in areas within the vicinity of the Mona Offshore Cable Corridors as the species is generally caught close to the shore, predominantly by inshore vessels operating out of Anglesey (see volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information).

1.9.4 Edible Crab

1.9.4.1 Edible crab is a relatively long-lived species that are found on all coasts around Britain from the intertidal zone down to depths of 100m, preferring seabed temperatures of 11-15ºC in Welsh and Isle of Man waters (Jenkins, 2018). They live on rocky, gravelly substrates 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 Mona Offshore Cable Corridor, as well as the Mona Array Area using potting gear (see volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information).

1.9.5 Velvet Swimming Crab

1.9.5.1 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 100m (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 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information). Velvet swimming crab were recorded in historic surveys undertaken by other offshore wind projects in the vicinity on the Mona Array Area and therefore, are assumed to be present within the Mona Offshore Wind Project.

1.9.5.2 Independent baited static trap and pot fishery 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 such a pots (Öndes, *et al*., 2018). Peak bycatch rates were found to occur in the spring months, declining into autumn and winter.

1.9.6 Squid

1.9.6.1 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 500km 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 only overlap the Mona Offshore Cable Corridor (see volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR for additional information).

1.9.7 Whelk

1.9.7.1 The common whelk is an epibenthic mobile gastropod, inhabiting muddy sand, sand and mixed sediments from depths of 0m to 50m. 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 to the northeast of the Mona Array Area is regularly assessed for whelk populations, with 37 scientific pots in 2017 finding individuals with an average shell length of 70mm, well over the 45mm 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 Mona Offshore Wind Project and has expanded over the last two decades. Whelk are landed year-round and vessels are known to operate across the Mona Array Area and Mona Offshore Cable Corridor. Whelk operators are known to operate out of both English and Welsh ports in proximity to the Mona Offshore Wind Project (see volume 6, appendix 11.1: Commercial fisheries technical report of the PEIR additional information).

1.9.8 Nephrops

1.9.8.1 *Nephrops*, known variously as the Norway lobster, Dublin Bay prawn, langoustine or scampi, is a slim, orange pink lobster which grows up to 25cm 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.

1.9.8.2 *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), which tends to limit their potential distribution. They build and spend significant amounts of time in semi-permanent burrows which vary in structure and size but typically range from 20cm to 30cm 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.

1.9.8.3 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 predominantly located to the north of the Mona Array Area, extending west towards the Isle of Man and north towards Northern Ireland (Figure 1.13).

1.9.8.4 *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., 2013). Additionally, *Nephrops* were found to be important to the trawl fishery near the Cumbria coast (Walmsey and Pawson, 2007).

1.9.8.5 As previously discussed, *Nephrops* display a strong preference for muddy sediments (silt and clay), therefore the majority of the Mona Offshore Wind Project area is considered unsuitable for *Nephrops* as sand, gravels, and coarser sediments with shell fragments dominate the Mona Array Area, and broadscale substrate data by EMODnet indicates these substrata extend along the majority of the Mona Offshore Cable Corridor (Gardline, 2022).

1.9.8.6 Incidental observations were made of *Nephrops* from DDV surveys and combined grab and DDV sampling conducted within the Mona Offshore Wind Project. Environmental sampling was undertaken at 97 locations within the Mona Array Area and surrounding local area. *Nephrops* were encountered through DDV survey analysis at one location in the southwest of the Mona Array Area. This area was denoted as having gravelly, muddy sand according to survey data (see Volume 6, appendix 7.1: Benthic subtidal ecology technical report of the PEIR for additional information).

1.9.8.7 The location of *Nephrops* identified through site-specific surveys, correlated strongly with results of the biotope mapping, with all recordings of *Nephrops* through DDV deployments 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 Mona Array Area (Volume 6, appendix 7.1: Benthic subtidal and intertidal ecology technical report of the PEIR). As such, the Mona Array Area is unlikely to be important for this species. Further site-specific survey data was collected along the Mona Offshore Cable Corridor in 2022, and the EIA technical report will be updated to incorporate the results of these surveys, including *Nephrops* habitats.

1.10 Designated Sites

1.10.1.0 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 1.22.

Table 1.8: Summary of designated sites within the fish and shellfish ecology study area and relevant qualifying interest features.

Designated Site	Closest Distance from the Mona Offshore Wind Project (km)	Relevant Features of Interest
Little Ness MNR	40.66	• European eel (*Anguilla anguilla*) • Flame shell (*Limaria hians*)[2] • Horse mussel beds (*Modiolus modiolus*)[3] • Icelandic clam/Ocean quahog (*Arctica islandica*)[4] • Spiny lobster (*Palinuridae*) • Scallops (*Pectinidae*)
Douglas Bay MNR	42.66	
Laxey Bay MNR	44.4	
Ramsey Bay MNR	51.95	
Wyre Lune MCZ	52.61	• Sparling (*Osmeridae*)
Ribble Estuary MCZ	48.39	• Sparling (*Osmeridae*)
River Ehen SAC	83.01	• Atlantic salmon (*Salmo salar*) • Freshwater pearl mussel (*Margaritifera margaritifera*)
Dee Estuary SAC/Aber Dyfrdwy SAC	34.51	• Sea lamprey (*Petromyzon marinus*) • River lamprey (*Lampetra fluviatilis*)
River Derwent and Bassenthwaite Lake SAC	95.06	• Sea lamprey (*Petromyzon marinus*) • River lamprey (*Lampetra fluviatilis*) • Atlantic salmon (*Salmo salar*) • Brook lamprey (*Lampetra planeri*)
Solway Firth SAC	109.46	• Sea lamprey (*Petromyzon marinus*) • River lamprey (*Lampetra fluviatilis*)
River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC	59.13	• Sea lamprey (*Petromyzon marinus*) • River lamprey (*Lampetra fluviatilis*) • Atlantic salmon (*Salmo salar*) • Brook lamprey (*Lampetra planeri*)
Solway Firth MCZ	122.71	• Sparling (*Osmeridae*)

[2] Flame shell *Limaria hians* is further considered within the Benthic Subtidal and Intertidal Ecology Technical Report.

[3] Horse mussel beds *Modiolus modiolus* is further considered within the Benthic Subtidal and Intertidal Ecology Technical Report.

[4] Icelandic clam *Arctica islandica* is further considered within the Benthic Subtidal and Intertidal Ecology Technical Report.

1.10.1 Solway Firth SAC

1.10.1.1 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).

1.10.1.2 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).

1.10.1.3 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).

1.10.2 Dee Estuary SAC/Aber Dyfrdwy SAC

1.10.2.1 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).

1.10.2.2 The Dee Estuary is one of the largest estuaries in the UK, with an area of over 14,000ha (140km^2). The Dee Estuary is hyper-tidal with a mean spring tidal range of 7.7m 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).

1.10.2.3 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).

1.10.3 River Derwent and Bassenthwaite Lake SAC

1.10.3.1 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).

1.10.3.2 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.

1.10.3.3 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).

1.10.3.4 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).

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

1.10.4.1 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, 2019a).

1.10.4.2 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, 2019a).

1.10.4.3 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, 2019a).

1.10.4.4 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, 2022).

1.10.5 River Ehen SAC

1.10.5.1 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.

1.10.5.2 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 Atlantic 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, 2019b).

1.10.5.3 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 150mm in length and can live to be over 130 years old (Bauer, 1992; Skinner *et al*., 2003). Freshwater pearl mussel requires clean, fast flowing, highly oxygenated rivers and burrows into sand/gravel substrates, often between boulders and pebbles (Geist and Auerswald, 2007).

1.10.5.4 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, 2019b).

1.10.5.5 Exceptionally high densities (greater than 100m^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).

1.10.5.6 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).

1.10.5.7 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. October through to the end of January is the key time for Atlantic salmon migration into the River Ehen SAC.

1.10.6 Solway Firth MCZ

1.10.6.1 The Solway Firth MCZ is located on the west coast of Britain, in Cumbria, within the Solway Firth estuary. The MCZ covers 45km^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, 2019a). 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.

1.10.7 Wyre Lune MCZ

1.10.7.1 The Wyre Lune MCZ is located on the west coast of Britain, in Lancashire, in the southern part of Morecambe Bay. The MCZ covers 92km^2 and is designated for the protection of sparling, 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 2004-2014 region, suggesting regular usage of the site as a spawning ground, usually in the February-March period (Natural England, 2017).

1.10.8 Ribble Estuary MCZ

1.10.8.1 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 15km^2 and is designated for the protection of sparling, with the management goal of returning the population to a favourable condition (DEFRA, 2019c). Sparling congregate in the lower estuary in early spring, when water temperatures are approximately 5-6^{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 southern 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.

1.10.9 Ramsey Bay MNR

1.10.9.1 Ramsey Bay MNR is located on the north-east cost of the Isle of Man, in the Irish Sea. The MNR covers 94.4km^2 and is designated for the protection of horse mussel *Modiolus modiolus* reefs[5] (Gell *et al*., 2014), with at least five separate areas of high biodiversity reef habitats located in a designated area of 13.9km^2 in the northern portion 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 scallop or blue mussels *Mytilus edulis*

[5] Note: Mussel reefs (both horse mussels and blue mussels) and ocean quahog are, for the purposes of the PEIR, considered under the benthic subtidal and intertidal ecology topic and are therefore discussed in detail in volume 6, aannexx 7.1: Benthic subtidal and intertidal ecology technical report of the PEIR.

(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).

1.10.10 Laxey Bay MNR

1.10.10.1 Laxey Bay MNR is located on the east coast of the Isle of Man, in the Irish Sea. The MNR covers 3.97km^2, and is designated for the presence of Iceland clams *Arctica islandica*, 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; and Atlantic salmon and sea trout in their anadromous spawning migrations (Isle of Man Government, 2009).

1.10.11 Douglas Bay MNR

1.10.11.1 Douglas Bay MNR is located on the south-east coast of the Isle of Man, in the Irish Sea. The MNR covers 4.64km^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. In the southern portion of the MNR, a dense and highly diverse horse mussel bed was discovered (Hanley *et al*., 2013), with a bed coverage of approximately 0.22km^2 present, with up to 240 individuals per m^2 noted, with the main bed running parallel to the coast for 780m at a distance of 800m offshore (Perry and Roriston, 2009). An annual closure to protect spawning herring populations is also active within and extending east from this MNR.

1.10.12 Little Ness MNR

1.10.12.1 Little Ness MNR is located on the west coast of the Isle of Man, in the Irish Sea. The MNR covers 10.15km^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, 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).

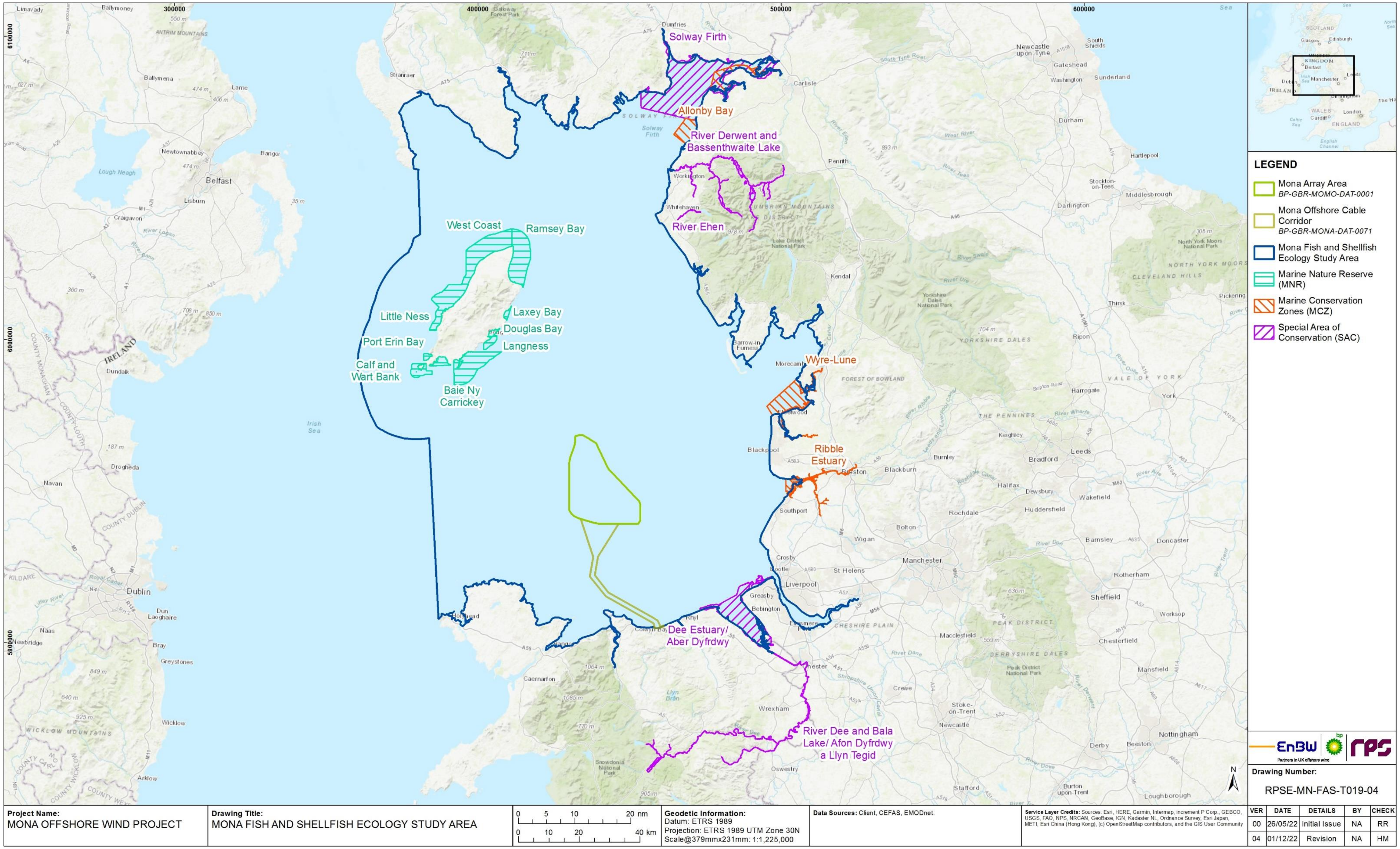


Figure 1.22: Designated sites in proximity to the Mona Offshore Wind Project.

1.11 Summary

1.11.1.0 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.

1.11.1 Baseline

1.11.1.1 The fish assemblages within the Mona Offshore Wind Project 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 Mona Offshore Wind Project, with a mix of both demersal and pelagic species. There are known spawning and nursery grounds for nine 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 Mona Offshore Wind Project, the majority of herring spawning occurs to the north and northwest of the site, and site-specific PSA data supports low proportions of the Mona Array Area being suitable for spawning activity. Habitat suitability for sandeel was assessed, with the majority of the Mona Array Area considered marginal and unsuitable habitat, with limited sparse areas of prime and sub-prime habitat.

1.11.1.2 Eight species of diadromous fish were identified as having the potential to be present within and in proximity to the fish and shellfish ecology study area. Of these eight species, Atlantic salmon, sea trout, sea lamprey, river lamprey, European eel, allis and twaite shad and sparling were deemed to have the potential to be present within the Mona Offshore Wind Project. 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 the vicinity of the Mona Offshore Wind Project.

1.11.1.3 Shellfish known to occur in the fish and shellfish ecology study area and therefore with potential to occur within the Mona Offshore Wind Project 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.

1.11.1.4 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 southern migration destinations.

1.11.2 Important Ecological Features

1.11.2.1 IEFs are habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Mona Offshore Wind Project. Guidance from the Chartered Institute of Ecology and Environmental Management (CIEEM) was used to assess IEFs within the area (CIEEM, 2018). IEFs can be attributed to individual species (such as plaice) or species groups (for example other flatfish 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. 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 study area. OSPAR List of Threatened or Declining Species, and IUCN Red List species that have nationally important populations within the Mona Offshore Wind Project, 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 Mona Offshore Wind Project 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 Mona Offshore Wind Project (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 Mona Offshore Wind Project. 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 Mona Offshore Wind Project. Species that have spawning or nursery areas within the Mona Offshore Wind Project 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 Mona Offshore Wind Project).
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Mona Offshore Wind Project (e.g. they may be exploited in deeper waters outside the Mona Offshore Wind Project). The spawning/nursery area for the species are outside the Mona Offshore Wind Project. The species is common throughout English and Welsh waters but forms a component of the fish assemblages in the Mona Offshore Wind Project.

Table 1.10: IEF species and representative groups within the Mona Offshore Wind Project.

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 Mona Offshore Wind Project. Plaice is an important commercial species throughout the Mona Offshore Wind Project and within the surrounding east Irish Sea.
Lemon Sole	*Microstomus kitt*	Local	Spawning and nursery grounds are undetermined and unspecified within the Mona Offshore Wind Project and wider east Irish Sea. It is an important and abundant commercial fish species, but not in the immediate vicinity of the Mona Offshore Wind Project (i.e. in the wider east Irish Sea).
Dover Sole	*Solea solea*	Regional	Listed as a Species of Principal Importance. High intensity spawning and nursery grounds identified throughout the Mona Offshore Wind Project. Dover sole is an important commercial species throughout the Mona Offshore Wind Project 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 Mona Offshore Wind Project. 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 Mona Offshore Wind Project. It is an important commercial fish species, but not in the immediate vicinity of the Mona Offshore Wind Project (i.e. in the wider east Irish Sea).
Whiting	*Merlangius merlangus*	Regional	Listed as a Species of Principal Importance. Low intensity spawning and high intensity nursery grounds identified throughout the Mona Offshore Wind Project. Whiting is an important commercial species throughout the Mona Offshore Wind Project and within the surrounding east Irish Sea.
Other demersal species		Local	Species including anglerfish *Lophius piscatorius,* ling *Molva Molva* and European hake *Merluccius merluccius* are common throughout English and Welsh waters and are likely to be in the Mona Offshore Wind Project. They are important commercial species, but not in the immediate vicinity of the Mona Offshore Wind Project (i.e. in the east Irish Sea).
Sandeel species		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 Mona Offshore Wind Project. Identified as likely to be present in the Mona Offshore Wind Project based on historic data and habitat preference. 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 Mona Offshore Wind Project and within the fish and shellfish ecology study area. High intensity nursery grounds present within the Mona Offshore Wind Projects. Although herring spawning grounds do not directly overlap the Mona 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 Mona Offshore Wind Project (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 Mona Offshore Wind Project and the wider east Irish Sea. Mackerel is an important commercial species, but not in the immediate vicinity of the Mona Offshore Wind Project (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 Mona Offshore Wind Project. Sprat is an important commercial species, but not in the immediate vicinity of the Mona Offshore Wind Project (i.e. in the wider east Irish Sea).

IEF	Specific Name/ Representative Species	Importance	Justification
Basking Shark	*Cetorhinus maximus*	National	The north-east Atlantic population are classed as Endangered on the IUCN Red List. Additionally, they are listed under 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. Basking shark likely to be present in low abundances if present at all near the Isle of Man and in proximity to the Mona Offshore Wind Project.
Tope	*Galeorhinus galeus*	Regional	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 Mona Offshore Wind Project.
Spurdog	*Squalus acanthias*	Regional	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 Mona Offshore Wind Project.
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 Mona Offshore Wind Project.
Shellfish IEF Species			
Edible crab	*Cancer pagurus*	Regional	Commercially important species. Identified as being likely to be present within the Mona Offshore Wind Project.
Norway lobster	*Nephrops norvegicus*	Regional	Commercially important species. Identified as being likely to be present within the Mona Offshore Wind Project.
European lobster	*Homarus gammarus*	Regional	Commercially important species. Identified as being likely to be present within the Mona Offshore Wind Project.
King scallop	*Pecten Maximus*	Regional	Commercially important species. Identified as being present within the Mona Offshore Wind Project.
Queen scallop	*Aequipecten opercularis*	Regional	Commercially important species. Identified as being present within the Mona Offshore Wind Project.
Velvet swimming crab	*Necora puber*	Local	Commercially important species. Identified as being likely to be present within the Mona Offshore Wind Project.

IEF	Specific Name/ Representative Species	Importance	Justification
Other crustaceans		Local	Other crustaceans including, swimming crabs, spider crabs and shrimp have been identified as being likely to occur within the Mona Offshore Wind Project. They are all important commercial species, but not in the immediate vicinity of the Mona Offshore Wind Project (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. Likely to migrate through the Mona Offshore Wind Project. Not a feature of any designated sites in the vicinity of the Mona Offshore Wind Project.
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 Mona Offshore Wind Project. This species is a qualifying feature of multiple MNRs in the vicinity of the Mona Offshore Wind Project.
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 Mona Offshore Wind Project. Likely to migrate through the Mona Offshore Wind Project.
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 Mona Offshore Wind Project. Likely to migrate through the Mona Offshore Wind Project, although only in coastal/estuarine areas nearer the Mona Offshore Cable Corridor.
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 Mona Offshore Wind Project.
Allis shad	*Alosa alosa*	National	Listed as a Species of Principal Importance.

IEF	Specific Name/ Representative Species	Importance	Justification
			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 Mona Offshore Wind Project.
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 Mona Offshore Wind Project. Likely to migrate through the Mona Offshore Wind Project.
Sparling	*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 Mona Offshore Wind Project. Likely to migrate through the Mona Offshore Wind Project, although only in coastal/estuarine areas, nearer the Mona Offshore Cable Corridor.
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 Mona Offshore Wind Project.

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