Appendix 9-1:
Fish and Shellfish Ecology Technical Report

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

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ORIEL WIND FARM PROJECT

Environmental Impact Assessment Report
Appendix 9-1: Fish and Shellfish Ecology Technical Report

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Glossary

Term	Meaning
Anadromous fish	Fish species that regularly migrate from sea to fresh water to spawn.
Area of Special Scientific Interest	Areas of Special Scientific Interest (ASSIs) are protected areas designated under The Environment (Northern Ireland) Order 2002 for their species, habitat and/or geological features.
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.
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).
Elasmobranchs	Elasmobranchs like sharks, rays and skates have a skeleton composed entirely of cartilage.
Natural Heritage Area	An area considered important for the habitats present or which holds species of plants and animals whose habitat needs protection. Under the Wildlife Amendment Act (2000) , NHAs are legally protected from damage from the date they are formally proposed for designation.
Pelagic fish	Fish species that inhabit open water. Examples in Irish waters include herring, mackerel and sprat.
Redds	‘Nests’ of spawning fish.
Special Area of Conservation	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.
Viviparity	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.

Acronyms

Term	Meaning
AFBI	Agri-Food & Biosciences Institute
ASSI	Areas of Special Scientific Interest
BIM	Bord Iascaigh Mhara
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CIEEM	Chartered Institute of Ecology and Environmental Management
COMPASS	Collaborative Oceanography and Monitoring for Protected Areas and Species
CSTP	Celtic Sea Trout Project
DAERA	Department of Agriculture, Environment and Rural Affairs (Northern Ireland)
DAFM	Department of Agriculture, Food and the Marine
DAHG	Department of Arts, Heritage and the Gaeltacht
DAOWFL	Dublin Array Offshore Wind Farm Limited
DECC	Department of Energy & Climate Change (UK)
Defra	Department for Environment, Food and Rural Affairs
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EU	European Union
EUNIS	European Nature Information System
FU	Functional Units
IBTS	International Bottom Trawl Surveys
ICES	International Council for the Exploration of the Sea
IEF	Important Ecological Feature
IFI	Inland Fisheries Ireland
JNCC	Joint Nature Conservation Committee
LBM	Live Bivalve Molluscs
MAGIC	Multi-Agency Geographic Information for the Countryside
MarLIN	Marine Life Information Network
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
NHA	Natural Heritage Area
OREDP	Offshore Renewable Energy Development Plan
OSPAR	The Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic
QI	Qualifying Interest
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SNH	Scottish Natural Heritage
UWTV	Underwater Television
ZoI	Zone of Impact

Units

Unit	Description
g	Grams
°C	Degrees Centigrade
km	Kilometres
m	Metres
cm	Centimetres

1 FISH AND SHELLFISH ECOLOGY TECHNICAL REPORT

1.1 Introduction

This Fish and Shellfish Ecology Technical Report provides a detailed baseline characterisation of the fish and shellfish ecology (i.e. species, communities and habitats) for the Oriel Wind Farm Project (hereafter referred to as "the Project").

The Project is located in the Irish Sea, off the coast of County Louth (approximately 22 km east of Dundalk town centre and 18 km east of Blackrock) (Figure 1-1). The closest wind turbine will be approximately 6 km from the closest shore on the Cooley Peninsula. The offshore cable corridor extends approximately 16 km southwest from the wind farm area to the landfall south of Dunany Point. The onshore cable route extends for approximately 20 km to a substation location 3 km east of Ardee

The aim of this Technical Report is to provide a baseline characterisation of fish and shellfish ecological resources within a defined Fish and Shellfish Ecology Study Area (see section 1.2). Within this characterisation, fish and shellfish species, or groups of species, are categorised as Important Ecological Features (IEFs), based on their conservation, ecological and commercial importance, for consideration in the Environmental Impact Assessment (EIA).

The details and competencies of the specialist who prepared this report can be found in volume 2A, chapter 1: Introduction.

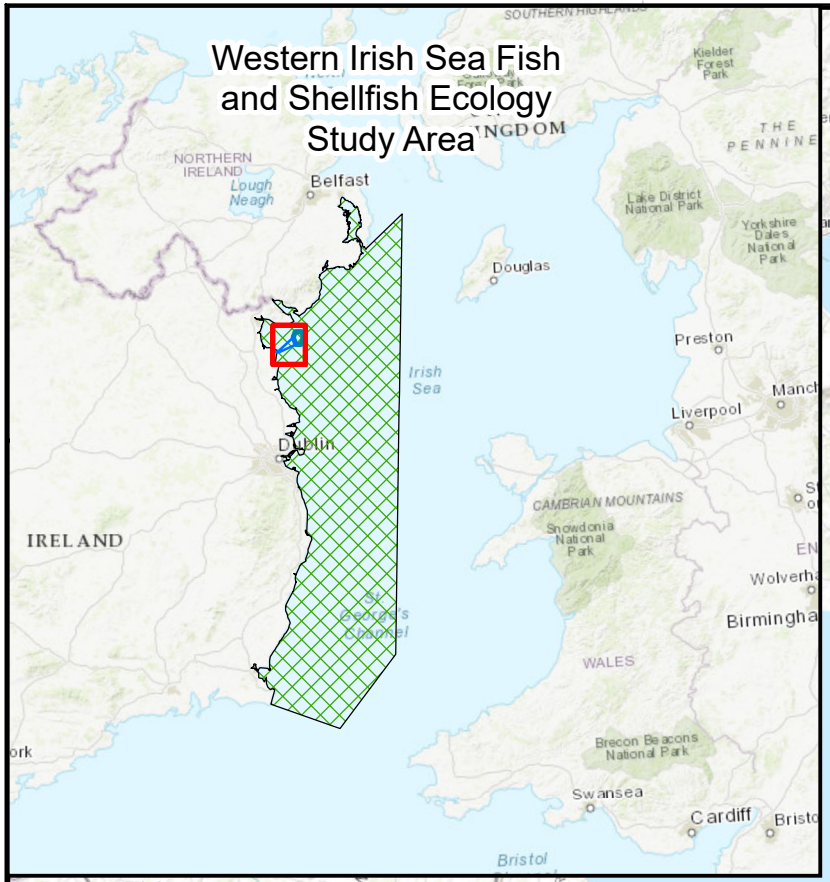
1.2 Study area

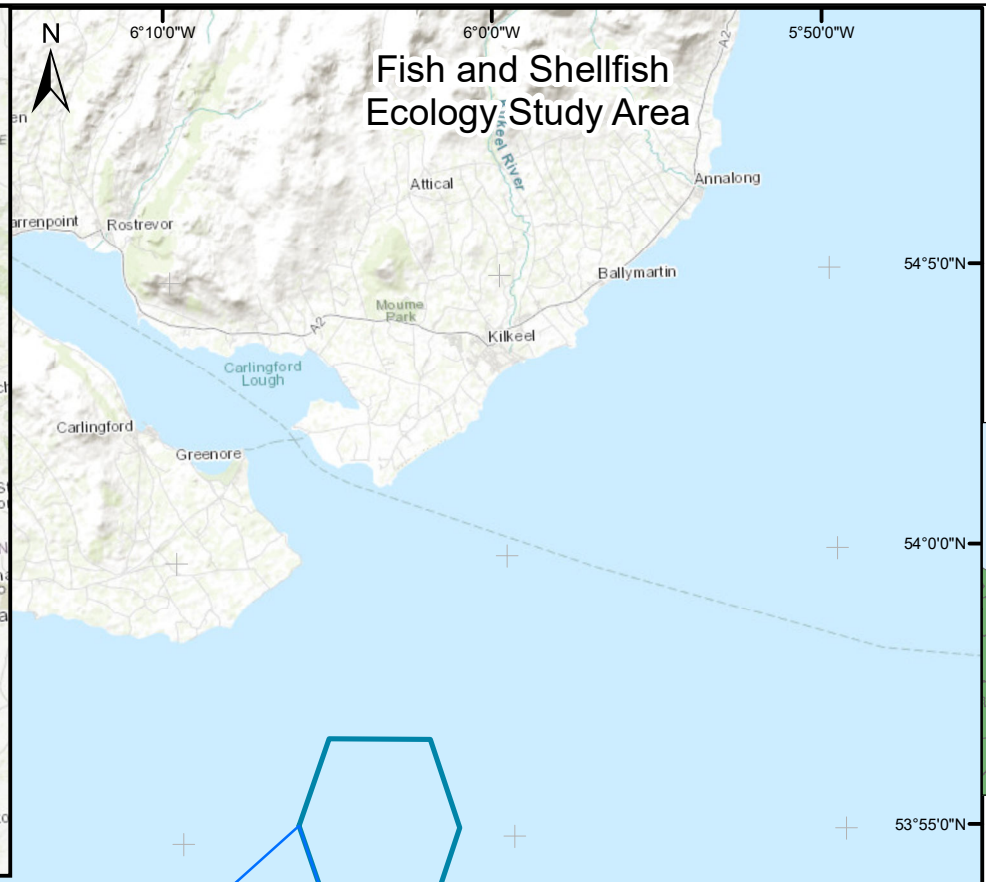
Fish and shellfish are spatially and temporally variable, therefore for the purposes of the fish and shellfish ecology characterisation, two appropriate study areas were defined through professional judgement and author experience of offshore wind farm impact assessment:

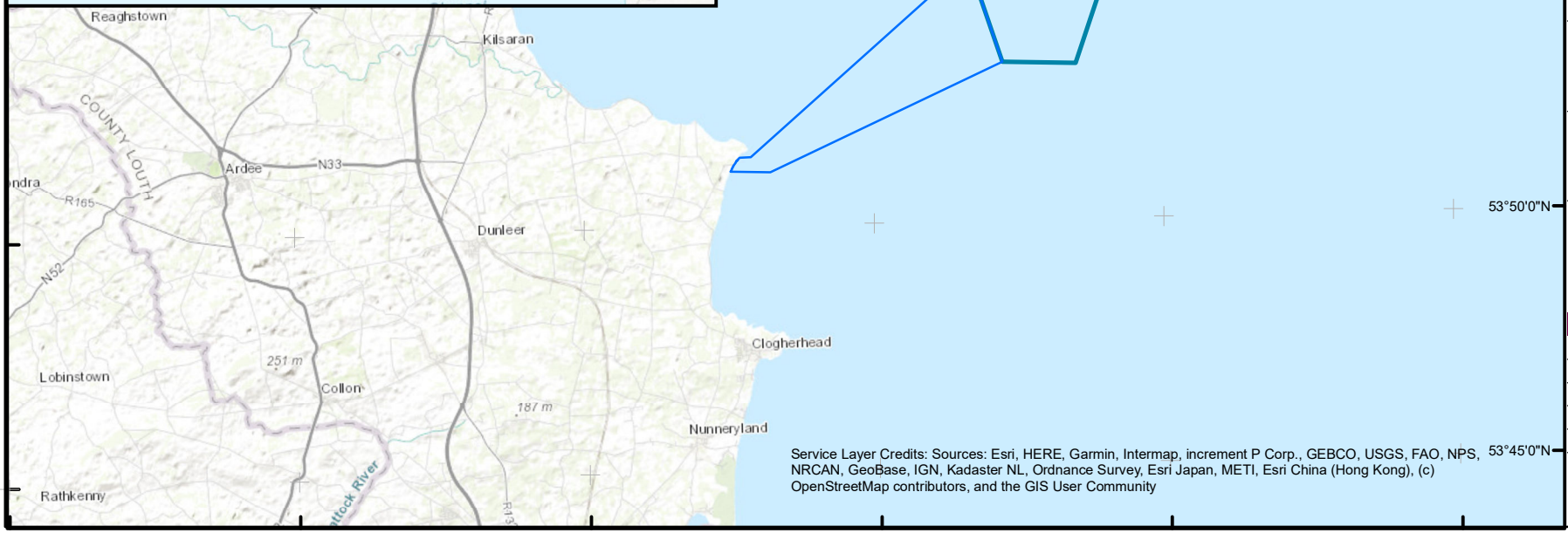
- **The Fish and Shellfish Ecology Study Area:** The area encompassing the offshore wind farm area, approximately 27.7 km^2 and the offshore cable corridor, approximately 25.4 km^2 which includes the intertidal area (Figure 1-1); and

- **The Western Irish Sea Fish and Shellfish Ecology Study Area:** Defined as the western Irish Sea region (Figure 1-1) and based on professional judgement. This area includes the western portion of the Irish Sea[1] along the east coast of Ireland, from Ballyquintin Point (55.5 km northeast of the offshore wind farm area) to Carnsore Point (191.5 km south of the offshore wind farm area). The western Irish Sea Fish and Shellfish Ecology Study Area provides a wider context for the fish species and populations identified within the Fish and Shellfish Ecology Study Area and informs assessments of those impacts affecting fish and shellfish receptors over a larger scale (e.g. underwater noise).

[1] Delineated by the continental shelf, and artificially extended to the centre point between Ballyquintin Point (Northern Ireland) and the Mull of Galloway peninsula (Scotland).





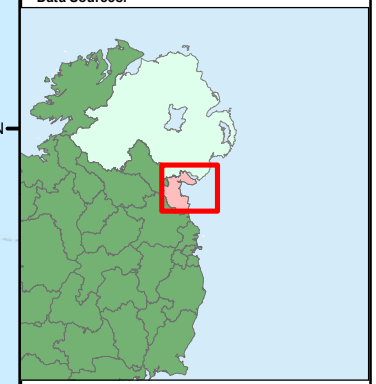


Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Western Irish Sea Fish and Shellfish Ecology Study Area

Data Sources:



Client

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Project

Oriel Wind Farm Project

Title

Figure 1-1
Fish and Shellfish Ecology Study Areas

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Issue Details

Drawn By: NA	**Project No.** EOR0822 (MDR1520B)
Checked By: KL	**File Ref:** EOR0822_FAS_T_1251_FINAL
Approved By: KL	
Scale: 1:250,000 @ A4	**Projection:** ITM (IRENET95)
Date: 08/03/2024	Geographic Co-ordinates: ETRS89

1.3 Methodology

1.3.1 Desktop review

The Project is located off the east coast of the Republic of Ireland, for which extensive data and knowledge regarding fish and shellfish ecology is already available. This data/information has been acquired through:

- Publicly available journals;
- Academic studies;
- Commissioned reports by local interest groups;
- Published reports including other Environmental Impact Assessment Reports;
- Fisheries data and reports from Inland Fisheries Ireland (IFI), Bord Iascaigh Mhara (BIM) and the Marine Institute;
- Historical characterisation studies undertaken for the Project; and
- Nature conservation designations occurring within the western Irish Sea Fish and Shellfish Ecology Study Area.

Information on Fish and Shellfish Ecology within the Fish and Shellfish Ecology Study Area and the western Irish Sea Fish and Shellfish Ecology Study Area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 1-1 below. Where reports and data date back to the 1990s, up-to-date data and information have been used to ensure these sources are still valid.

Table 1-1: Summary of key desktop reports.

Title	Year	Author
Offshore Wind Farm, Environmental Impact Statement, Main EIS, Volume 2 of 3	2007	Oriel Windfarm Limited
A report on fishing in the waters between Carlingford and Clogher Head based on published data, appendix VIII within Oriel Windfarm Limited, Offshore Wind Farm, Environmental Impact Statement, Appendices, Volume 3 of 3	2003	Roden and Ludgate
An Offshore Wind Farm on the Kish and Bray Banks. Environmental Statement. January 2012 – Revision 1. Section 8: Marine Ecology	2012	Dublin Array Offshore Wind Farm Limited (DAOWFL)
Offshore Wind Farm at Codling Bank: Non-Technical Summary. Volume 2 of 3	2002	Codling Wind Park
River Boyne and River Blackwater Special Area of Conservation (SAC). Site Synopsis (Site Code: 002299)	2014	Department of Arts, Heritage and the Gaeltacht (DAHG)
Slaney River Valley SAC. Site Synopsis (Site Code: 000781)	2015	Department of Arts, Heritage and the Gaeltacht (DAHG)
Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREDP) in the Republic of Ireland	2010	AECOM and Metoc
Ireland Red List No.11: Cartilaginous Fish	2016	Clarke *et al*.
Ireland Red List No.5: Amphibians, Reptiles and Freshwater Fish	2011	King *et al*.
Spawning and nursery grounds of selected fish species in UK Waters	2012	Ellis *et al*.
Fisheries Sensitivity Maps in British Waters	1998	Coull *et al*.
An Inventory of Irish Herring Spawning Grounds	2013	O'Sullivan *et al*.
Celtic Sea Trout Project – Technical Report	2016	Celtic Sea Trout Project (CSTP)

Title	Year	Author
Western Irish Sea Nephrops Grounds (FU15) 2019 Underwater Television (UWTV) Survey Report and Catch options for 2020	2019	Lundy *et al*.
Fifty years of marine tag recoveries from Atlantic salmon. International Council for the Exploration of the Sea (ICES) Cooperative Research Report No. 343	2018	Ó Maoiléidigh *et al*.
Atlas of Commercial Fisheries for Shellfish around Ireland	2017	Tully (Marine Institute)
Shellfish Stocks and Fisheries Review 2022: An assessment of selected stocks	2023	Marine Institute and BIM
Shellfish Stocks and Fisheries Review 2021: An assessment of selected stocks	2022	Marine Institute and BIM
Shellfish Stocks and Fisheries Review 2020: An assessment of selected stocks	2021	Marine Institute and BIM
Shellfish Stocks and Fisheries Review 2019: An assessment of selected stocks	2020	Marine Institute and BIM
Shellfish Stocks and Fisheries Review 2018: An assessment of selected stocks	2019	Marine Institute and BIM
Sampling Fish in Rivers 2018 - Fane, Factsheet No. 3. National Research Survey Programme	2019a	Matson *et al*.
Sampling Fish in Rivers 2018 - Flurry, Factsheet No. 4. National Research Survey Programme	2019b	Matson *et al*.
Assessment, Monitoring and Management of the Dundalk Bay and Waterford Estuary Cockle (*Cerastoderma edule*) Fisheries in 2007	2008	Hervas *et al*.
All fisheries landings from ICES rectangle 38E3 from 2016-2019	2016-2019	Department of Agriculture, Environment and Rural Affairs (Northern Ireland) (DAERA) personal comms.
Cumulative Impact Assessment: Aquaculture activities within and adjacent to Natura 2000 designated sites in Carlingford Lough	2015a	Agri-Food & Biosciences Institute (AFBI)
Marine Institute provided benthic survey raw data from Dundalk Bay and the western Irish Sea	2021	Marine Institute
Pot Fishing In Northern Ireland	2015b	AFBI
Biodiversity maps [Accessed February 2023]	Various	https://maps.biodiversityireland.ie/# https://atlas.marine.ie/#?c=53.9000:-15.9000:6
ICES Division VIIa technical reports series [Accessed February 2023]	Various	Centre for Environment, Fisheries and Aquaculture Science (Cefas) (https://www.cefas.co.uk/cefas-data-hub/) International Bottom Trawl Surveys (IBTS) Survey Data (ICES, 2022)
Spawning and nursery grounds of forage fish in Welsh and surrounding waters	2021	Campanella and van der Kooij
Ireland's Marine Atlas [Accessed November 2023]	2023	Marine Institute and The Department of Agriculture, Food, and the Marine (https://atlas.marine.ie/)
Ecological Sensitivity Analysis of Irish Sea to inform future designation of Marine Protected Areas (MPA) – Main Report & Appendices	2023	Department of Housing, Local Government and Heritage (DHLGH)

1.3.2 Identification of designated sites

All designated sites within the western Irish Sea Fish and Shellfish Ecology Study Area that could be affected by the construction, operation and maintenance, and decommissioning phases of the Project were identified using the three-step process described below:

- **Step 1:** All designated sites of international, national and local importance within the western Irish Sea Fish and Shellfish Ecology Study Area were identified using a number of sources. These included international, national and local designations including SACs, Natural Heritage Areas (NHAs), and Areas of Special Scientific Interest (ASSIs) identified by examining Ireland's Marine Atlas interactive map application (http://atlas.marine.ie/) and the National Parks and Wildlife Service (NPWS) website, the European Nature Information System (EUNIS) designated site database, and for sites in Northern Ireland, the Joint Nature Conservation Committee (JNCC) website and the UK Department for Environment, Food and Rural Affairs (Defra) Multi-Agency Geographic Information for the Countryside (MAGIC) interactive map applications (http://magic.defra.gov.uk/);

- **Step 2:** Information was compiled on the relevant fish and shellfish Qualifying Interests (QIs) of an SAC or features of a national or local designated site (hereinafter referred to as "features"), for each of these sites. The known occurrence of species within the Fish and Shellfish Ecology Study Area was based on the relevant desktop information on the fish communities of the western Irish Sea Fish and Shellfish Ecology Study Area; and

- **Step 3:** Using the above information and expert judgement, sites were included for further consideration if:

  - A designated site directly overlaps with the western Irish Sea Fish and Shellfish Ecology Study Area;

  - Sites and associated QIs or features were located within the potential Zone of Impact (ZoI) (i.e. the western Irish Sea Fish and Shellfish Ecology Study Area) for impacts associated with the Project (e.g. habitat loss/disturbance, underwater noise during the construction phase);

  - QIs or features of a designated site were either recorded as present during historic surveys within the area, or identified during the desktop study as having the potential to occur within the western Irish Sea Fish and Shellfish Ecology Study Area;

  - Where national and locally designated sites (e.g. NHAs and ASSIs) fall within the boundaries of an internationally designated site (e.g. SAC), only the international site has been considered, as potential effects on the integrity and conservation status of the nationally designated site are assumed to be inherent within the assessment of the internationally designated site (i.e. a separate assessment for the national site is not undertaken). In some cases, however, where a national site forms a component of an international site, but the latter designation does not list a QI that is present on the NHA/ASSI citation, the individual NHA/ASSI will be taken forward for further assessment for that particular QI; and

  - Where a national site falls outside of an international site, but within the western Irish Sea Fish and Shellfish Ecology Study Area, the national site will be taken forward for further assessment for a particular feature.

1.4 Western Irish Sea fish and shellfish ecology assemblage

The total marine fish fauna of the Irish Sea is estimated to be in the region of 370 species, with a further 30 freshwater species, a number of which are anadromous (Went and Kennedy, 1976; Wheeler, 1992; Parker-Humphreys, 2004; Wheeler, Merrett *et al*., 2004). Around 10% of the Irish Sea species are of significant commercial value including flatfish, gadoids, elasmobranchs and shellfish and as such, their abundance is affected by fishing pressure. The remaining species that occur in the Irish Sea are of little commercial value and so are not directly subject to fishing pressure. However, many of these species are of significant ecological importance as prey items for other marine species (e.g. birds, marine mammals and other fish species) and may be indirectly affected by fishing pressure as bycatch or through habitat degradation.

The Irish Sea is divided east to west by three deep channels, the North Channel, the Western Channel and St George's Channel and it is thought that these deeper areas of water may play a role in fish and shellfish assemblage division (Parker-Humphreys, 2004). The waters in the three channels, that run parallel to the eastern coast of Ireland, are much deeper than the surrounding sediment platforms, reaching 240 m (Mellet *et al*., 2015). Inshore of the channels the waters of the Irish Sea are comparatively shallow, rarely exceeding 60 m.

The sediments of the Irish Sea can be subdivided into three broad regions, two 'Mud Belts' comprising of soft muds occupy the eastern and western inshore areas and these are separated by a central 'Gravel Belt' which comprises of coarser sediment and hard substrate (Mellet, Long *et al*., 2015). The western Irish Sea in particular is known for its muddy sediments that support one of the most valuable fisheries for the Norway Lobster *Nephrops norvegicus (*hereafter referred to as *Nephrops)* (Lundy *et al*., 2019; Parker-Humphreys, 2004). However, seabed sediments within the Fish and Shellfish Ecology Study Area are more complex with large areas of circalittoral rock, sand and coarse sediments (chapter 8: Benthic Subtidal and Intertidal Ecology).

Water flows into and out of the Irish Sea through the North Channel, between Scotland and Northern Ireland, and through St George's Channel to the south, between the Republic of Ireland and Wales, leading to a generally south to north flow in the western Irish Sea. The western Irish Sea front occurs generally in spring, where mixed waters in the southeast begin to separate from the stratified waters to the northwest. The resulting eddies and upwellings may result in increased local productivity and therefore increase fish and shellfish abundance (Le Fèvre, 1986; Durazo *et al*., 1998; Scherer, Gowen and Tett, 2016). Additionally, temperatures in the western Irish Sea are kept relatively warm and consistent, with a surface sea temperature of 13.5°C in summer to 9.5°C in winter, and a bottom sea temperature of 10.5°C in summer to 9°C in winter. These temperatures are due to the warm water entering the Irish Sea from the southwest, which are derived from the Gulf Stream (Parker-Humphreys, 2004).

Several fish and shellfish surveys have previously been undertaken within the western Irish Sea region including Cefas beam trawl surveys undertaken between 1993 and 2001 and baseline characterisation surveys for other proposed offshore wind projects (DAOWFL, 2012; Codling Wind Park, 2002), all of which provide useful information on the fish and shellfish communities present within the western Irish Sea area. While there is likely to be small natural variability in fish and shellfish populations over time and spatially, it is likely that the broad patterns in fish populations discussed below are still valid for the purposes of the Project baseline characterisation.

Cefas beam trawl surveys undertaken in the Irish Sea between 1993 and 2001, recorded more than 100 species of fish (Parker-Humphreys, 2004). Species that were found in the western Irish Sea include flatfish such as plaice *Pleuronectes platessa*, sole *Solea solea*, brill *Scophthalmus rhombus*, dab *Limanda limanda*, lemon sole *Microstomus kitt*, scaldfish *Arnoglossus laterna*, solenette *Buglossidium luteum*, thickback sole *Microchirus variegatus* and witch, *Glyptocephalus cynoglossus*. Gadoids in the area included cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, poor cod *Trisopterus minutus*, and whiting *Merlangius merlangus*. Elasmobranch species include small-spotted catshark *Scyliorhinus canicula* and spotted ray *Raja montagui*. Other fish species found throughout the Irish Sea include anglerfish *Lophius piscatorius*, bull rout *Myoxocephalus scorpius*, common dragonet *Callionymus lyra*, spotted dragonet *Callionymus maculatus*, grey gunnard *Eutrigla gurnardus*, and pogge *Agonus cataphractus*. Shellfish species such as edible crab *Cancer pagurus* and *Nephrops* can also be found on the sea floor of the western Irish Sea.

IBTS have been conducted by ICES in the Irish Sea since 1992. They are conducted biannually, once in March (Quarter 1) and once in October (Quarter 4). The surveys are carried out on a 43.5 m stern trawler using a rock-hopper otter trawl (ICES, 2022). There were 19,797 fish caught during these surveys between 2017 and 2021, with the highest counts of whiting, haddock, cod, and plaice, and low counts of European conger, hake, and pollock. Similar counts of whiting and haddock were recorded in both quarters, while cod counts in Quarter 1 were over four times higher than in Quarter 4. The results of the ICES IBTS for the relevant region of the Irish Sea are presented in Table 1-2 (it should be noted abundances have not been standardised, but these data give an indication of the dominant species and seasonality in this part of the western Irish Sea).

Table 1-2: Summary of counts of fish species caught per year and per quarter between 2017 to 2021 during ICES IBTS in the Irish Sea (dataset available from ICES, 2022).

Common Name	Species	Quarter	Counts Per Year					Total per Quarter	Grand Total
			2017	2018	2019	2020	2021		
Whiting	*Merlangius merlangus*	1	1,359	0	1,124	1,181	1,188	4,852	**10,179**
		4	1,090	1,261	1,093	1,100	783	5,327	
Haddock	*Melanogrammus aeglefinus*	1	1,017	739	901	1,035	911	4,603	**8,226**
		4	746	717	745	782	633	3,623	
Cod	*Gadus morhua*	1	202	170	193	132	141	838	**1,017**
		4	50	77	21	20	11	179	
Plaice	*Pleuronectes platessa*	1	362	0	0	0	0	362	**362**
European Conger	*Conger conger*	1	9	0	0	0	0	9	**9**
Hake	*Merluccius merluccius*	1	3	0	0	0	0	3	**3**
Pollock	*Pollachius pollachius*	1	1	0	0	0	0	1	**1**

The fish ecology characterisation study undertaken as part of the Dublin Array project (located approximately 73 km south of the offshore wind farm area) showed that the fish assemblages in the vicinity of this project had relatively low species diversity and included flatfish such as plaice, dab and lemon sole as well as thornback ray *Raja clavata*, whiting, grey gurnard, lesser weever fish *Echiichthys vipera,* and butterfish *Pholis gunnellus*. In addition, herring *Clupea harengus*, two-spotted clingfish *Diplecogaster bimaculata*, lesser sandeel *Ammodytes tobianus*, greater sandeel *Hyperoplus lanceolatus,* witch and dab were also recorded (DAOWFL, 2012). Fish surveys undertaken as part of the Codling Wind project (located approximately 84 km south of the offshore wind farm area) found fish communities were found to be reflective of those of the western Irish Sea. The fish assemblage was characterised by species including whiting, plaice, dab, lemon sole, herring and sandeel along with other commercially important species including cod and other flatfish species. Elasmobranch species recorded included rays, common skate *Dipturus batis*, and tope *Galeorhinus galeus*. Major commercial activity was centred on the common whelk *Buccinum undatum* and blue mussels *Mytilus edulis*, with their associated mussel seed beds (Codling Wind Park, 2002).

Migratory species likely to transit the western Irish Sea include sea lamprey *Petromyzon marinus*, river lamprey *Lampetra fluviatilis*, twaite shad *Alosa fallax*, and Atlantic salmon *Salmo salar* from rivers located along the east coast of the Republic of Ireland (section1.6.2). Basking sharks *Cetorhinus maximus* have also been found to transit the waters of the Irish Sea (basking shark are fully considered in chapter 10: Marine Mammals and Megafauna).

1.5 Designated sites within the Western Irish Sea Fish and Shellfish Ecology Study Area

Designated sites which have fish and shellfish QIs and which have been considered in the fish and shellfish assessment are described in their locations relative to the Fish and Shellfish Ecology Study Area are shown in Figure 1-2 and Table 1-3.

Table 1-3: Designated sites within the western Irish Sea Fish and Shellfish Ecology Study Area and QIs.

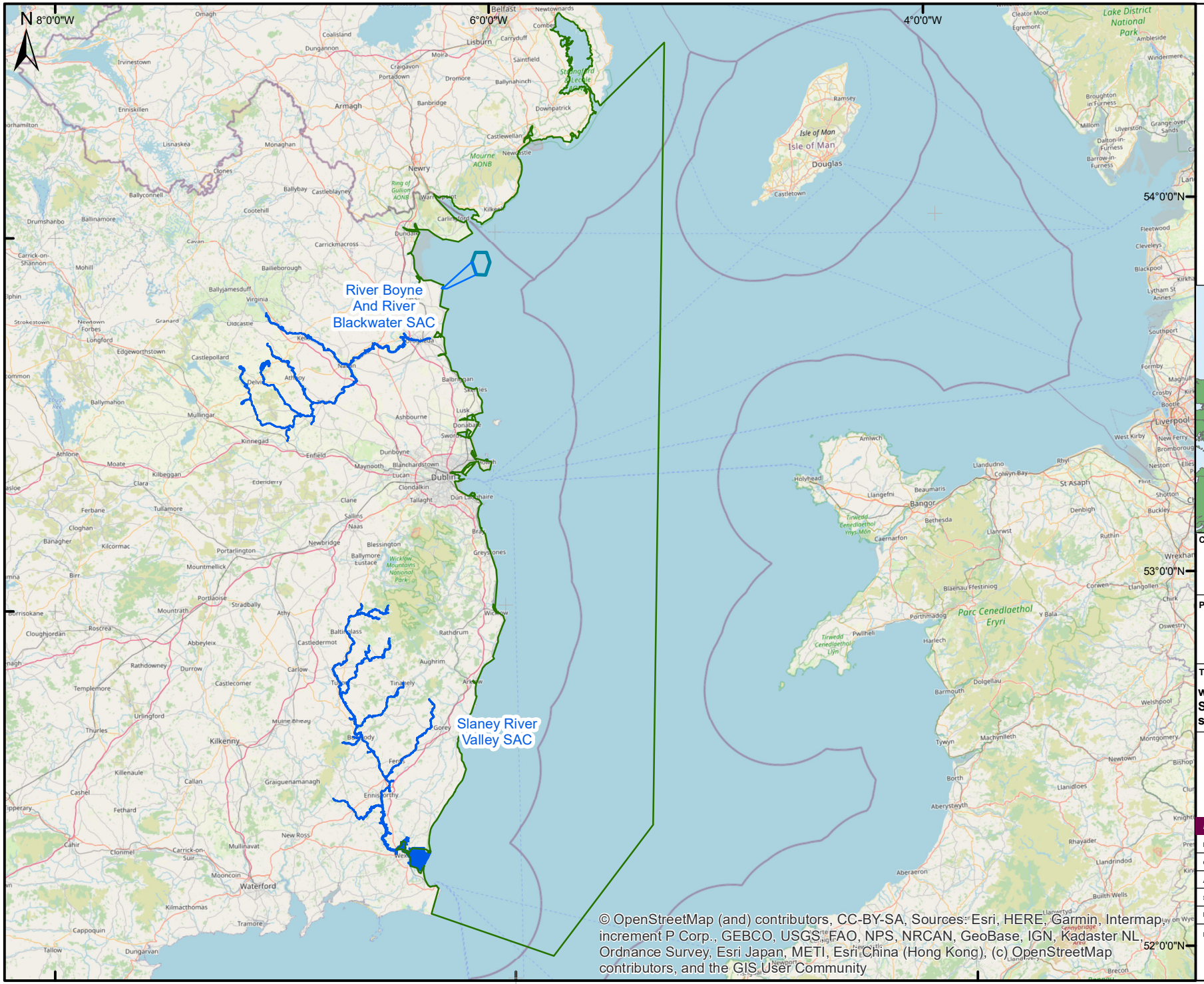
Designated site	Closest distance and direction from the Fish and Shellfish Ecology Study Area (km)	Relevant QIs[2]
River Boyne and River Blackwater SAC (Site Code: 002299)	26.6 southwest	• River Lamprey *Lampetra fluviatilis* • Atlantic Salmon *Salmo salar*
Slaney River Valley SAC (Site Code: 000781)	102.1 south	• Freshwater Pearl Mussel *Margaritifera margaritifera* • Sea Lamprey *Petromyzon marinus* • River Lamprey *Lampetra fluviatilis* • Twaite Shad *Alosa fallax fallax* • Atlantic Salmon *Salmo salar*

In addition to the above identified designated sites, the report released by Department of Housing, Local Government and Heritage (DHLGH, 2023) 'Ecological sensitivity analysis of the western Irish Sea to inform future designation of MPAs' has undertaken an analysis of the best available evidence of the western Irish Sea to determine the potential MPAs within the region. Forty biological and environmental features were identified that have the potential to be recommended for spatial protection in the western Irish Sea under the forthcoming MPA legislation.

As the MPAs have not been determined as of yet (February 2024), fish and shellfish features of concern listed within this report that have high population density and direct overlap with the Oriel have been considered within the baseline, and where relevant have been taken forward for assessment. These include:

- American Plaice *Hippoglossoides platessoides* - Due to high presence within the Oriel area, note no spawning or nursery grounds; and
- Herring *Clupea harengus* – Due to the modelled presence of the herring spawning ground at Mourne.

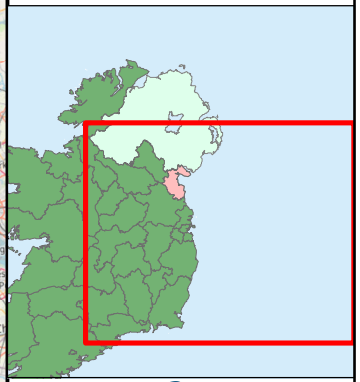
[2] Note: Mammal QIs (e.g. otter and seal) and purely freshwater fish species (e.g. brook lamprey), for which there is no impact pathway, have not been included.



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Western Irish Sea Fish and Shellfish Ecology Study Area
- Special Areas of Conservation (SAC)
- Inshore Waters Boundary

Data Sources:



Client

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Project

Oriel Wind Farm Project

Title

Figure 1-2 Designated sites within the western Irish Sea Fish and Shellfish Study Area with fish and/or shellfish Qualifying Interests

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Issue Details

Drawn By: NG	**Project No.** EOR0822 (MDR1520B)
Checked By: NG	**File Ref:** EOR0822_FAS_T_1250_FINAL
Approved By: AOS	
Scale: 1:1,500,000 @ A4	**Projection:** ITM (IRENET95)
Date: 08/03/2024	Geographic Co-ordinates: ETRS89

1.6 Local fish and shellfish assemblage within the Fish and Shellfish Ecology Study Area

1.6.1 Overview

A fisheries assessment and consultation with stakeholders was carried out for the Project in 2003 (Roden and Ludgate, 2003). This information can be used to provide an indication of the fish and shellfish species present within the Fish and Shellfish Ecology Study Area.

Commercial fisheries in the area concentrate on whitefish (including whiting and mackerel) and shellfish (including edible cockles, *Nephrops* and queen scallops) (see appendix 12-1: Commercial Fisheries Technical Report). The area is also an important spawning and nursery ground for a number of whitefish species and a recovery ground for cod (see section 1.6.4). There are high abundances of cod and plaice eggs recorded from the northwest Irish Sea and in particular due east of Dundalk Bay (Roden and Ludgate, 2003). Consultation with IFI in March 2021 also highlighted that the area was important for a number of recreational fisheries in the area, with Dundalk Bay and the area around known to be important for bass (W. Roche, pers. comms; March 2021).

Fish and shellfish species that are likely to occur within the Fish and Shellfish Ecology Study Area have been presented in Table 1-4, based on Roden and Ludgate (2003), Oriel Windfarm Limited (2007) and DAERA personal comms (2019). These species were identified following a detailed examination of the habitats present and commercial fisheries information, rather than from site-specific survey data, but nevertheless it is considered unlikely that significant changes will have occurred to the fish and shellfish assemblage identified in 2003.

Table 1-4: Fish and shellfish species likely to occur in the Fish and Shellfish Ecology Study Area (based on the data sources detailed in Table 1-1)).

Fish		Shellfish	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Demersal Fish		**Crustaceans**	
Benthic Fish		Lobster	*Homarus gammarus*
Flounder	*Platichthys flesus*	Norway lobster	*Nephrops norvegicus*
Plaice	*Pleuronectes platessa*	Spider crab	*Maja squinado*
American Plaice	*Hippoglossoides platessoides*	Green shore crab	*Carcinus maenus*
Turbot	*Scophthalmus maximus*	Edible crab	*Cancer pagurus*
Megrim	*Lepidorhombus whiffiagonis*	Velvet swimming crab	*Necora puber*
Conger eel	*Conger conger*	Swimming crabs	*Liocarcinus spp*
Brill	*Scphthalmus rhombus*		
Halibut	*Hippoglossus hippoglossus*	**Molluscs**	
Sole	*Soleidae*	Cockle	*Cerastoderma edule*
Lemon Sole	*Microstromus kitt*	Scallop	*Pecten maximus*
Witch	*Glyptocephalus cynoglosus*	Razor clam	*Ensis spp*
		Pacific oyster	*Crassostrea gigas*
Benthopelagic Fish		Blue mussel	*Mytilus edulis*
Cod	*Gadus morhua*		
Ling	*Molva molva*		
Pollack	*Pollachius pollachius*		
Hake	*Merluccius merluccius*		
Haddock	*Melanogrammus aeglefinus*		
Coalfish	*Pollachius virens*		
Anglerfish	*Lophius piscatorius*		
Bass	*Dicentrarchus labrax*		
Other Demersal Species			
Gobies	*Gobiidae*		
Blennies	*Blenniiformes*		
Wrasse species	*Labridae*		
Pelagic Fish			
Mackerel	*Scomber scombrus*		

Fish	Shellfish
Herring	*Clupea harengus*
Elasmobranchs	
Tope	*Galeorhinus galeus*
Rays	*Raja spp.*
Small-spotted catshark	*Scyliorhinus canicula*
Nursehound	*Scyliorhinus stellaris*
Thornback Ray	*Raja clavata*
Blonde Ray	*Raja brachyura*

1.6.2 Migratory fish species

A number of migratory fish species have been designated as QIs of both the River Boyne and River Blackwater SAC and Slaney River Valley SAC (Table 1-3).

They have the potential to occur in the Fish and Shellfish Ecology Study Area, migrating to and from the rivers located along the east coast of the Republic of Ireland and Northern Ireland, which these species use either for spawning habitat or as a nursery area for growth and development into the adult stage. Migratory fish species are of conservation importance as Annex II species protected under European legislation.

Two anadromous migratory fish are QIs of the River Boyne and River Blackwater SAC: river lamprey, and Atlantic salmon. Four anadromous migratory fish are QIs of the Slaney River Valley SAC: River and sea lamprey, twaite shad and Atlantic salmon). Sea trout Salmo trutta and European eel *Anguilla anguilla* are listed as The Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) threatened/declining species and have been found transiting the east coast of the Republic of Ireland and Northern Ireland, however they are not listed as QIs of any designated sites in the western Irish Sea Fish and Shellfish Ecology Study Area.

Atlantic salmon

The juvenile life stage typically lasts between one to four years before migrating to the sea. Following migration to the sea, salmon are known as post-smolts until the spring of the following year and after one winter as grilse. Atlantic salmon that spend one to three years at sea before returning in spring are known as spring salmon (Davies *et al.*, 2004). Adult Atlantic salmon spend the majority of their lives at sea, growing rapidly and only returning to freshwater environments to spawn (Scottish Natural Heritage(SNH), 2017). Due to a highly acute sense of smell, the Atlantic salmon is able to locate the river in which it originated and on maturity migrates back to spawn (Dipper, 2001; Lockwood, 2005). The length of time an Atlantic salmon spends in the sea varies from one to five years (Klemetsen *et al.*, 2003).

Data and information on the movements of salmon during their sea migration is limited. Smolts are believed to school and move to deep-sea feeding areas. Prior to seaward migration, the fish undergo a preparatory smolting process involving morphological, biochemical, physiological and behavioural changes that preadapt them for life within the marine environment (Hoar, 1988; Høgasen, 1998; Thorpe *et al*., 1998; Finstad and Jonsson, 2001). The migration from fresh water through the estuary and into the marine environment is predominantly nocturnal during the early part of the smolt run. During the latter part of the season, a significant proportion of the smolts switch to migration during both day and night (Thorstad *et al.,* 2012). The average total body length of wild smolts is usually 10–20 cm, and they may weigh from 10 to 80 g (Thorstad *et al*., 2011).

Atlantic salmon are widely distributed throughout Ireland and are recognised as an Annex II (European Union (EU) Habitats Directive) species, an OSPAR species and declared as Vulnerable on the Ireland Red List (King *et al.*, 2011). They are currently both nationally and internationally important species and as such the River Boyne and River Blackwater, and the Slaney River Valley have been designated as SACs.

The River Boyne and River Blackwater SAC is located approximately 26.6 km to the southwest of the Project (Figure 1-2). Atlantic salmon are known to run the River Boyne almost every month of the year, with large multi-sea-winter salmon generally arriving in February, with smaller spring salmon in April/May and grilse arriving in July. A later run occurring in late August has also been observed. The River Boyne and River

Blackwater SAC is able to support the full range of salmon life-history types (DAHG, 2014). The Slaney River Valley SAC, located approximately 102.1 km to the south of the Project, is primarily known for its spring salmon which spawn within the upper Slaney and tributary headwaters (Figure 1-2; DAHG, 2015).

Commercial fisheries information provided in Oriel Windfarm Limited (2007) suggests that the majority of watercourses flowing into Dundalk Bay contain salmon. Adult salmon migrate through this area on their way to feeding grounds at sea and when returning to inland rivers. The rivers containing salmon which flow into Dundalk Bay include the River Dee, River Fane, River Glyde, the Ballymascanlan River, Flurry River and the Castletown River. Further to this, the Marine Institute operates a programme to map the migration routes of the Atlantic salmon. There is evidence of a northerly migration route for Irish salmon stocks in the early months of their long migration (Ó Maoiléidigh *et al.,* 2018). From this it can be assumed that salmon migrating from the River Boyne and River Blackwater SAC and Slaney River Valley SAC, as well as other rivers whereby salmon may be present, are likely to pass through the Fish and Shellfish Ecology Study Area, as they migrate from northern Atlantic waters.

Inland Fisheries Ireland (IFI) have placed counters on the rivers Slaney and Boyne, recording throughout 2017. The River Slaney showed the transiting of 329 salmon in the spring and 592 salmon in the late summer. The River Boyne showed the passage of 333 salmon in the spring and 2,042 salmon in the late summer, providing further evidence of salmon using these rivers (IFI, 2018). Salmon are also regularly sampled from the Fane and Flurry river catchments (Matson *et al*., 2019a and 2019b). IFI also have a tagging project for salmon and sea trout called the Collaborative Oceanography and Monitoring for Protected Areas and Species (COMPASS) project. The project aims to investigate marine habitat use by salmon and sea trout as they migrate. They have set up a network of mini-acoustic receivers moored to the seabed along the coast between Dundalk and Larne. This network provides passive telemetry coverage in key areas along the northeast coast for smolts captured by electrofishing, trapping or angling, which are tagged with tiny acoustic transmitters as they migrate downstream. Initial results suggest that salmon smolts travel north towards the North Channel once they leave their natal rivers and can travel up to 250 km in a period of 32 days (Barry *et al*., 2020).

Sea trout

The sea trout has a similar ecology to the Atlantic salmon but is smaller in size. Sea trout has a much wider distribution and remains within nearshore waters rather than undergoing extensive migration offshore (CSTP, 2016; DECC, 2009). Trout spawn in winter from October to January, with the eggs deposited in redds, small deviations in the riverbed, cut by the female in the river gravel.

Similar to the Atlantic salmon, sea trout can be found within Dundalk Bay and its connecting rivers. The sea trout is known to migrate through this area on their way to feeding grounds within the bay area. Records from Biodiversity Maps have indicated that sea trout are present in rivers all along the east coast of the Republic of Ireland and along Northern Ireland. Additionally, counters placed in the River Slaney during 2017 indicated a passage of 182 sea trout (IFI, 2018), with brown trout (not confirmed as sea trout) recorded in both the Fane and Flurry river catchments (Matson *et al.,* 2019a and 2019b). The Boyne, Dee, Glyde, Fane and Castletown rivers have all been identified as principal sea trout rivers (CSTP, 2016).

European eel

The European eel has a complex life history, entering two stages of metamorphosis. Spawning occurs in the Sargasso Sea (mid Atlantic Ocean), after which larval eels cross the Atlantic Ocean. Once eels have reached the continental shelf, they will have metamorphosed into ‘glass eels’. Some remain in the sea and others ascend rivers and move between marine, estuarine and freshwater environments. During this time, the European eel will develop pigmentation and are referred to as ‘yellow eels’. The yellow eel stage can last up to 60 years before they enter a final metamorphosis into ‘silver eels’ and return to the Sargasso Sea for spawning (Malcolm *et al.,* 2010).

Little is known about the migratory routes taken by eels. The timing of migration peaks in Irish waters in August to November as eels are waiting for water levels to rise in August to aid riverine navigation (Sandlund *et al.*, 2017). The European eel has been found throughout the water column (up to 1,000 m deep; Antunes and Tesch, 1997a, 1997b) and can vary with the time of day and state of tide throughout its life cycle (Cresci *et al.,* 2017, 2019, 2020). For example, larvae exhibit diel vertical migration and are found between 100 and 150 m during the day and 50 and 100 m during the night (Castonguay and McCleave, 1987). Upon reaching the European continental slope, they are found between 300 and 600 m during the day and 35 and 100 m

during the night (Tesch, 1980). This diel vertical migration continues throughout the metamorphosis phase, with glass eels showing similar vertical distributions, influenced by light and tides, in coastal water (Creutzberg, 1961, Bardonnet *et al.,* 2005). Diel vertical migration has also been observed in the silver eel life stage, with a mean swimming depth of 344 m during the day and 196 m during the night (Tesch, 1989).

European eels are widely distributed throughout Ireland, however, recruitment to the east coast has declined since the early 1980's and the eel has now been designated as an OSPAR species, is listed on the Ireland Red List as Critically Endangered (King *et al*., 2011), and has a European Union Management Plan. European eel is currently both a nationally and internationally important species.

Records from the Biodiversity Maps have indicated that eel are present along the east coast of the Republic of Ireland and they have also been sampled from the Fane and Flurry river catchments (Matson *et al*., 2019a and 2019b).

Sea lamprey

The sea lamprey is distributed throughout Irish waters. Spawning occurs between May and June, with the eggs deposited in redds excavated in gravel. Upon hatching, juvenile lamprey (ammocoete) will often bury themselves in gravel, silt or sand, to prevent predation. The process of metamorphosis from ammocoete to adult can take four weeks to four months. In Ireland this process appears to be initiated between July and September. After five years in freshwater the lamprey progressively make their way to the open sea to mature (Maitland, 2003; Igoe *et al.,* 2004).

Sea lamprey has been designated as an EU Habitats Directive Annex II species and is listed as Near Threatened on the Ireland Red List (King *et al.*, 2011).

Records of sea lamprey occurring along the east coast of Ireland are limited. The Biodiversity Maps indicates no lamprey sightings, but they are present within the Slaney River Valley SAC (NPWS, 2017a) and lamprey have also been sampled from the Fane and Flurry river catchments (Matson *et al.,* 2019b) although the species was not specified.

River lamprey

The river lamprey can be found throughout Ireland and the western reaches of Europe and shares a similar life cycle to the sea lamprey but is morphologically smaller (Maitland, 2003). They migrate upstream from nearshore feeding grounds (marine or brackish water) into freshwater to spawn in autumn or spring. Spawning occurs in April and May on pebble and gravel substrates (NatureScot, 2022). After four to five years in freshwater, river lampreys migrate to nearshore coastal or estuarine waters, however some populations are freshwater resident and do not undertake this migration to the marine environment (Kelly and King, 2001). Unlike the sea lamprey, river lampreys do not migrate to open sea.

The river lamprey has been identified as a QI for the Slaney River Valley SAC and River Boyne and River Blackwater SAC.

Twaite shad

Twaite shad are in decline in many parts of Europe due to overfishing, pollution and migratory route obstructions. They reach sizes of up to 40 cm in length. Twaite shad return from the sea to spawn in spring, usually between April and June. The habitat requirements are not fully understood. They are known to spawn at night in shallow areas near deeper pools. The eggs are released into the water column, sinking into the interstices between coarse gravel/cobble substrates, with the majority of adults dying after spawning. After hatching the fry develop and slowly drift downstream. Recruitment seems to be highest in warm years, and high flows between May and August may result in fry being washed prematurely out to sea (Howson and Picton, 1997).

Twaite shad have only been confirmed in Barrow, with anecdotal reports pointing to a decline of population in the Slaney River Valley SAC of which twaite shad is a QI. The twaite shad has been categorised under the EU Habitats Directive as an Annex II and V species and Vulnerable on the Ireland Red List (King *et al.*, 2011).

1.6.3 Elasmobranchs

Elasmobranchs are a cartilaginous fish group that comprises sharks, rays and skates. Shark species expected to be present in the western Irish Sea Fish and Shellfish Ecology Study Area include basking shark, blonde ray, spurdog, tope, Small-spotted catshark, porbeagle *Lamna nasus,* Kitefin shark *Dalatias licha*, shortfin *mako Isurus oxyrinchus*, blue shark *Prionace glauca and* nurse hound *Scyliorhinus stellaris (*Maunsell and Metoc, 2007 and MarLIN, 2011). The main species of skate and ray present are thornback ray, cuckoo ray, spotted ray and common skate (Maunsell and Metoc, 2007).

Further information on the basking shark can be found in chapter 10: Marine Mammals and Megafauna. Species accounts of elasmobranchs with spawning and nursery habitats that overlap with the Fish and Shellfish Ecology Study Area are provided within section 1.6.4.

1.6.4 Spawning and nursery habitats

The spawning and nursery habitats present in the Fish and Shellfish Ecology Study Area are summarised in Table 1-5 for all species for which data exist. Nursery and spawning habitats were categorised by Ellis *et al*. (2012) as either high or low intensity dependent on the level of spawning activity or abundance of juveniles recorded. Coull *et al*. (1998) also identified spawning and nursery grounds, though the intensity of nursery grounds is not specified. Spawning grounds identified by Coull *et al.* (1998) are classified as low, high or undetermined, again based on the level of spawning activity.

Campanella and van der Kooij (2021) produced hotspot maps for juveniles and adults of numerous fish species within the Irish and Celtic Seas using survey data from 2008 to 2020. These hotspot maps provided more recent insight into spawning and nursery grounds for some species included in Coull *et al*. (1998) and Ellis *et al*. (2012): cod, herring, mackerel, sandeel, sprat, and whiting. The spawning and nursery areas presented in Campanella and van der Kooij (2021) correspond with Coull *et al*. (1998) and Ellis *et al*. (2012) for the aforementioned species. Furthermore, they identified a potential nursery hotspot for European sardine *Sardina pilchardus* in the northern Irish Sea and illustrated that the consistency of adult poor cod in the central Irish Sea could be representative of spawning areas but was unconfirmed due to limited information on this species. The DHLGH (2023) report identified herring spawning ground at the Mourne area.

Similarly, Ellis *et al.* (2012) and Campanella and van der Kooij (2021) noted the presence of juvenile horse mackerel *Trachurus trachurus* in the western Irish Sea, which could indicate nursery grounds in the wider area. However, information on localised nursery grounds was not available. The spawning and nursery habitats presented in Coull *et al.* (1998), Ellis *et al*. (2012), Campanella and van der Kooij (2021) and DHLGH (2023) have been cross checked with those presented on Ireland's Marine Atlas (2023) and are confirmed to be consistent at the time of writing (December 2023). The species present in Ireland's Marine Atlas with spawning and nursery habitats overlapping with the Project are cod, haddock, herring, mackerel, *Nephrops*, and whiting. Species with spawning or nursery habitats that overlap with the Fish and Shellfish Ecology Study Area have been given individual species accounts, and the extent and classification of these grounds is illustrated in Figure 1-3 to Figure 1-7.

Species that have been found to have nursery and spawning habitats that overlap with the Fish and Shellfish Ecology Study Area include demersal, pelagic and elasmobranch species (Table 1-5). *Nephrops* spawning and nursery habitats also occur in the area, located approximately 2.3 km and 5.8 km from the offshore wind farm area, respectively (Figure 1-8; Coull *et al*., 1998). *Nephrops* represents one of the most important fisheries in the area and as such has been provided with a species account within section 1.6.5.

Table 1-5: Species that have spawning and nursery areas that overlap with the Fish and Shellfish Ecology Study Area, additionally spawning periods have been provided (Ellis *et al.,* 2012; Coull *et al.,* 1998; and DHLGH, 2023).

Common Name	Species	Spawning area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nursery area
Demersal Species															
Anglerfish	*Lophius piscatorius*														Low
Lemon Sole	*Microstomus kitt*	Undetermined													Not specified
Plaice	*Pleuronectes platessa*	Low													Low
Sandeel	*Ammodytidae*	Low													Low
Sole	*Solea solea*	Low													
Whiting	*Merlangius merlangus*	Low													High
Cod	*Gadus morhua*	Low													High
Haddock	*Melanogrammus aeglefinus*														Not specified
Ling	*Molva molva*	Low													
Pelagic Species															
Herring	*Clupea harengus*														High
Mackerel	*Scomber scombrus*	Low													Low
Sprat	*Sprattus sprattus*	Undetermined													
Elasmobranchs															
Spotted ray	*Raja montagui*														Low
Thornback ray	*Raja clavata*														Low
Spurdog	*Squalus acanthias*		Viviparous species (reproduce all year)												High
Tope	*Galeorhinus galeus*		Viviparous species (reproduce all year)												Low

Spawning period
Peak spawning
Anecdotal evidence supports spawning in these months
Overlap with Fish and Shellfish Ecology Study Area

Demersal species

Anglerfish

Anglerfish are distributed all over the coastal waters of Great Britain and Ireland and are found predominantly on the west coast of Ireland and Britain, at depths of 550 m. It is uncommon to see an anglerfish in waters shallower than 18 m. Spawning occurs offshore at depths of around 2,000 m (Reeve, 2008). The high intensity nursery area occurs in the northern North Sea, north of Scotland and Ireland (Ellis *et al.,* 2012). The Fish and Shellfish Ecology Study Area overlaps with an area identified by Ellis *et al*. (2012) as being a low intensity nursery ground for anglerfish, based on the recorded number of juveniles (Figure 1-3).

Lemon sole

Lemon sole are widely distributed demersal species that occur throughout Irish and British waters. Spawning for the lemon sole begins in April through to September when eggs are released in deep water in the pelagic environment. The larvae hatch and occupy progressively deeper water as they develop (Maunsell and Metoc, 2007). The Fish and Shellfish Ecology Study Area overlaps with an area identified by Coull *et al*. (1998) as being a nursery and spawning ground for lemon sole, although the intensity, or relative importance, is unknown (Figure 1-3).

Plaice

Plaice are widely distributed demersal flat fish throughout the Irish and British waters and are found within the intertidal region to depths of 8 m, on sand, gravel and mud (Maunsell and Metoc, 2007). In their first year, plaice live in very shallow waters, after which they migrate into deeper waters (Ruiz, 2007). The Fish and Shellfish Ecology Study Area overlaps with an area identified by Ellis *et al*. (2012) as a low-high intensity spawning ground and low intensity nursery ground.

Sandeel

There are five species of sandeels in the waters around Britain and Ireland. Commercial catch has found that approximately 90% of this catch is lesser sandeel *Ammodytes marinus* (Maunsell and Metoc, 2007). During the winter, sandeel remain in the sediment only emerging to spawn. Sexual maturity is reached at the age of two. The eggs are laid in clumps within sandy substrate until they hatch, after which they enter the water column. Sandeels will then metamorphose and settle in sandy sediments amongst adults (Van Deurs *et al.,* 2009). As a result, there is very little movement between spawning and feeding grounds. The Fish and Shellfish Ecology Study Area overlaps with an area identified by Ellis *et al*. (2012) and Campanella and van der Kooij (2021) as being a low intensity nursery and spawning ground for sandeel (Figure 1-4).

Sole

Sole is distributed widely throughout Irish and British waters and found within sandy, muddy seabeds at depths between 10-60 m. Adult fish are usually 30-40 cm long, however large individuals may grow to 60 cm. They mainly hunt for food at night and feed on thin shelled bivalves, bristle-worms, small crustaceans and fish. During the day they lie on the seabed buried in sand with only the eyes showing. Juveniles are found during the first two to three years in coastal nurseries (bays and estuaries) before migrating to deeper waters (ICES, 2012; Picton and Morrow, 2016). The Fish and Shellfish Ecology Study Area overlaps with an area identified by both Coull *et al*. (1998) and Ellis *et al*. (2012) as being a low intensity spawning ground for sole (Figure 1-4).

Whiting

Whiting is a widely distributed demersal species occurring at depths between 30 and 100 m throughout Irish waters. Whiting has a prolonged spawning period from February to June throughout its range. The eggs and larvae are pelagic, and the young remain pelagic until they attain a length of approximately 10 cm when they adopt a demersal habit. The nursery grounds tend to be located inshore and juveniles will remain in these areas for one or two years (Maunsell and Metoc, 2007). The Fish and Shellfish Ecology Study Area overlaps with an area identified by Coull *et al*. (1998), Ellis *et al*. (2012), and Campanella and van der Kooij (2021) as being a low intensity spawning area and a high intensity nursery area, respectively (Figure 1-4). This is consistent with data presented in Ireland's Marine Atlas at the time of writing (Ireland's Marine Atlas, 2023).

Cod

Cod are widely distributed demersal species that occur throughout Irish and British waters and are found from the shoreline to depths of around 600 m. Spawning occurs between January and April, with peak spawning occurring in February to March, during which time up to six million buoyant eggs are released into the pelagic environment. The eggs hatch after approximately 12 days and the larvae enter the plankton for up to two months before settling on the seabed (Dipper, 2001).

The Fish and Shellfish Ecology Study Area overlaps with an area identified by Coull *et al*. (1998), Ellis *et al*. (2012) and Campanella and van der Kooij (2021) as being a low intensity spawning area, although Ellis *et al.* (2012) also identify a high intensity spawning ground just offshore and to the south of the Project (Figure 1-5). The studies also classify the area as a nursery ground for cod, with Ellis *et al*. (2012) classifying the area as high intensity based on the abundance of juveniles recorded. The nursery area identified in Campanella and van der Kooij (2021) closely resembles those proposed in Coull *et al*. (1998) and Ellis *et al*. (2012) but is slightly further north. The spawning and nursery habitat identified are consistent with data presented in Ireland's Marine Atlas at the time of writing (Ireland's Marine Atlas, 2023).

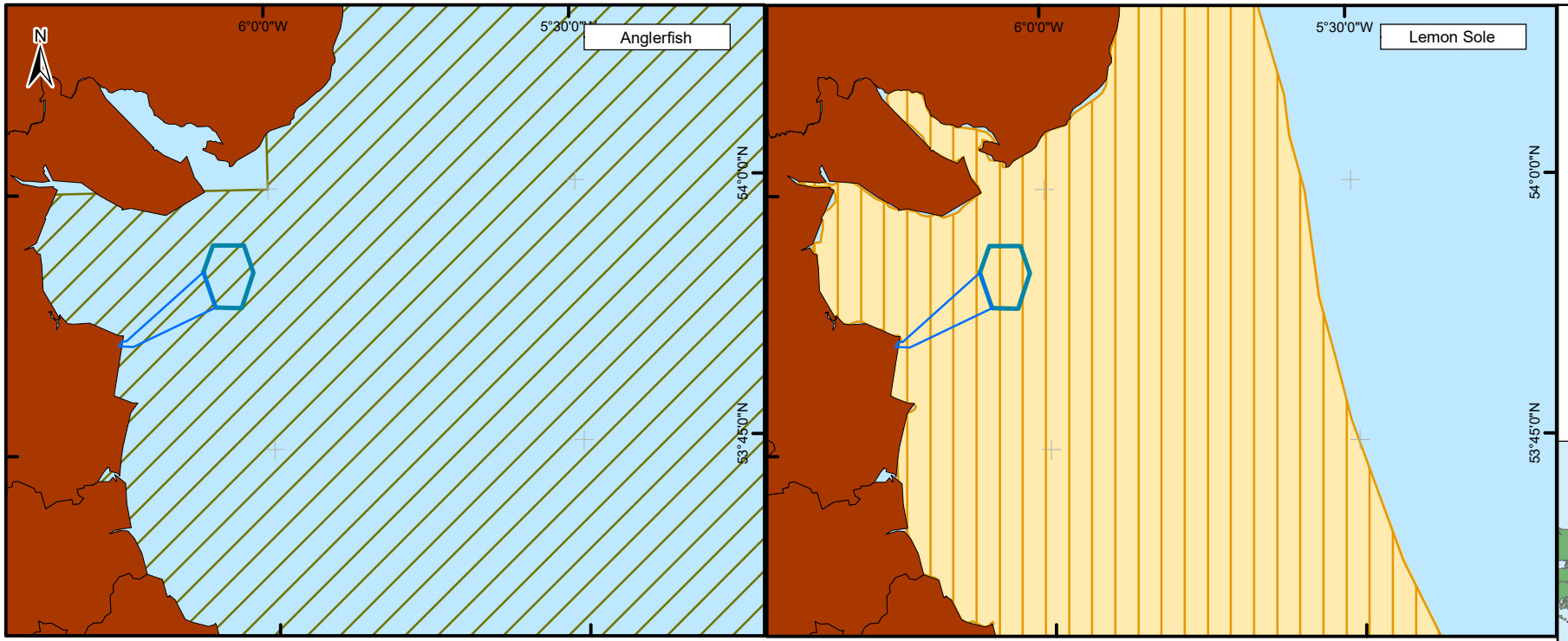
Cod have historically been subject to high levels of commercial fishing leading to concerns about the status of the species. In February 2000 the European Commission established a closed area in the Irish Sea as part of a general recovery plan. The recovery plan was further revised and implemented between 2001 and 2004 but the closure did not result in the anticipated recovery levels. This in-part was due to uncertainty in the model and in the catch data incorporated into it (Kelly *et al*., 2006). Misreporting of commercial catches for this fishery makes its management very difficult (Marine Institute, 2005). However, recent cod tagging efforts by the Marine Institute, Cefas and the Agri-Food and Biosciences Institute (AFBI) have helped to improve understanding of status of cod stocks and the ecology of the species (AFBI, 2019). This, coupled with the work of ICES has led to a more optimistic view of the stocks, putting them above the Maximum Sustainable Yield (MSY) trigger and categorising the stock as being at full reproductive capacity (ICES, 2017).

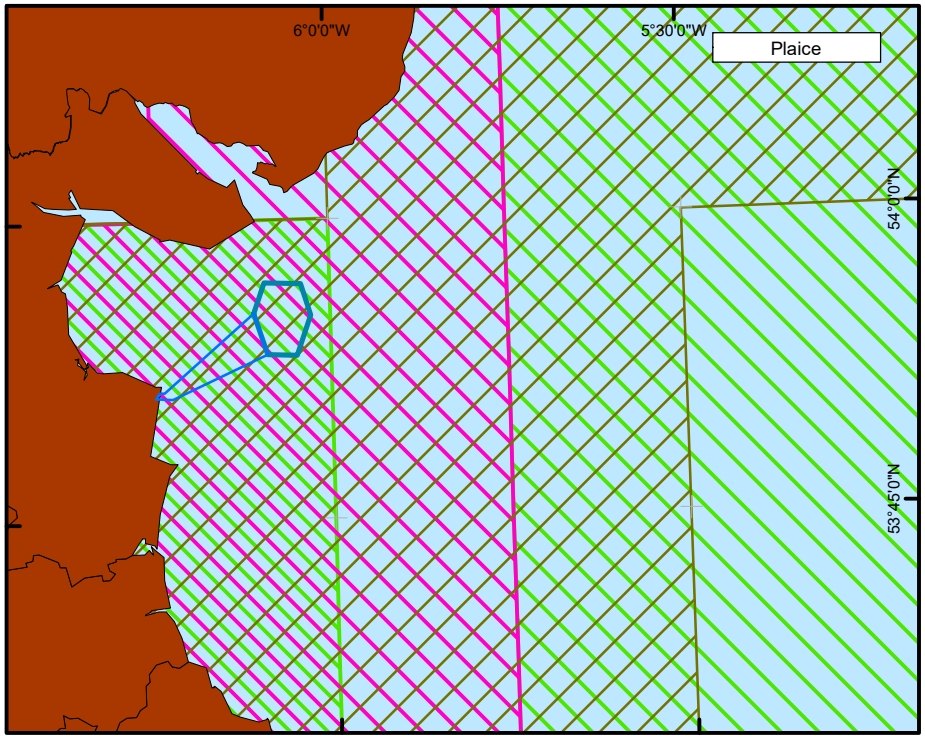
Haddock

Haddock is a widely distributed demersal species that occurs throughout Irish and British waters at depths between 40 m and 300 m (Barnes, 2008). Spawning takes place in deep waters. In their first year, haddock are pelagic and carry out vertical migrations (Maunsell and Metoc, 2007). The Fish and Shellfish Ecology Study Area overlaps with an area identified by Coull *et al*. (1998) as being a nursery ground for haddock (Figure 1-5), which is consistent with the data presented in Ireland's Marine Atlas at the time of writing (Ireland's Marine Atlas, 2023).

Ling

Ling is the largest species of the cod family, and its ecology is very similar to that of cod (described above). The Fish and Shellfish Ecology Study Area overlaps with an area identified by Ellis *et al*. (2012) as being a low intensity spawning ground for ling (Figure 1-5).





Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Nursery Grounds

- High Intensity (Ellis *et al.*, 2012)
- Low Intensity (Ellis *et al.*, 2012)
- Not Specified (Coull *et al.*, 1998)

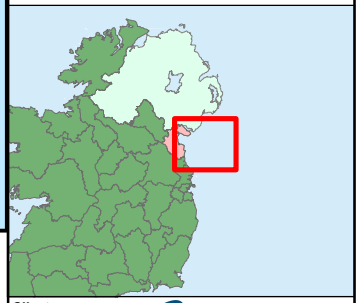
Spawning Grounds (Ellis *et al.*, 2012)

- High Intensity
- Low Intensity

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

- High Intensity
- Low Intensity
- Undetermined Intensity

Data Sources: Ellis *et al.*, 2012, Coull *et al.*, 1998



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-3
Fish Spawning and Nursery Grounds I: Anglerfish, Lemon Sole and Plaice

RPS
A TETRA TECH COMPANY

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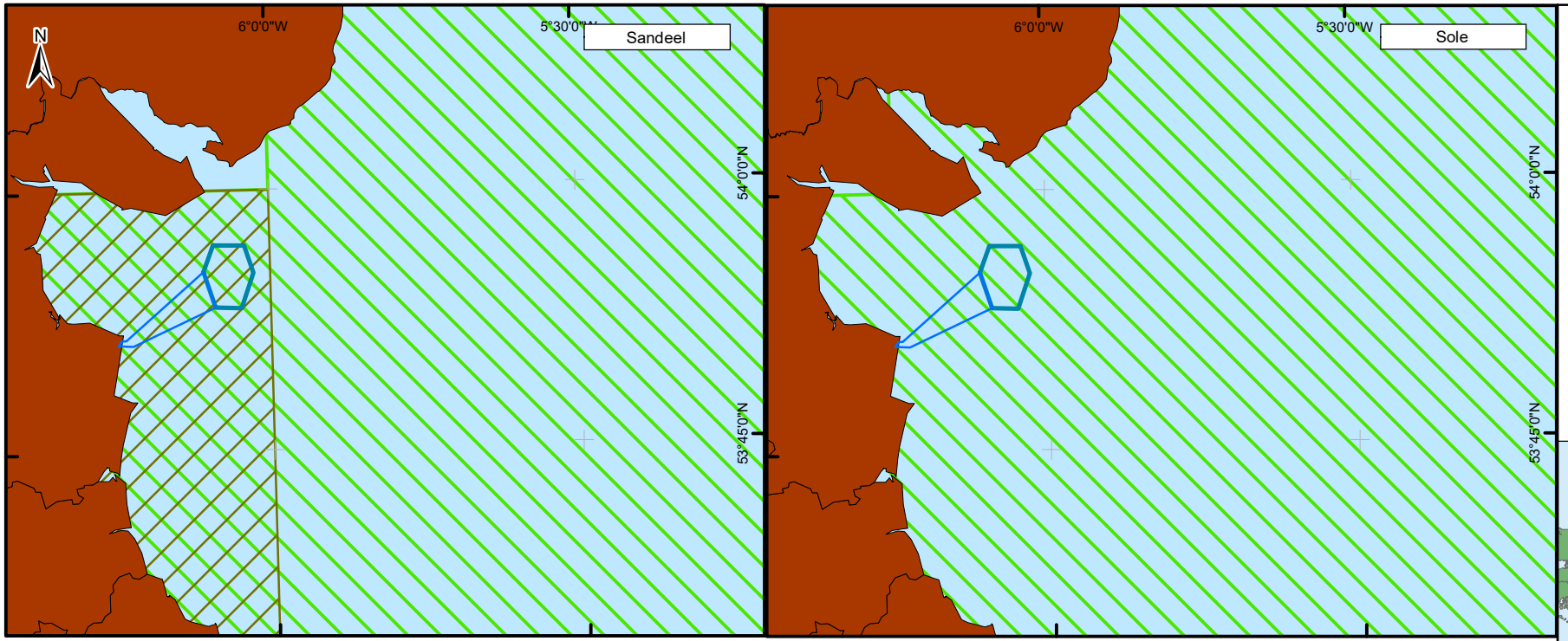
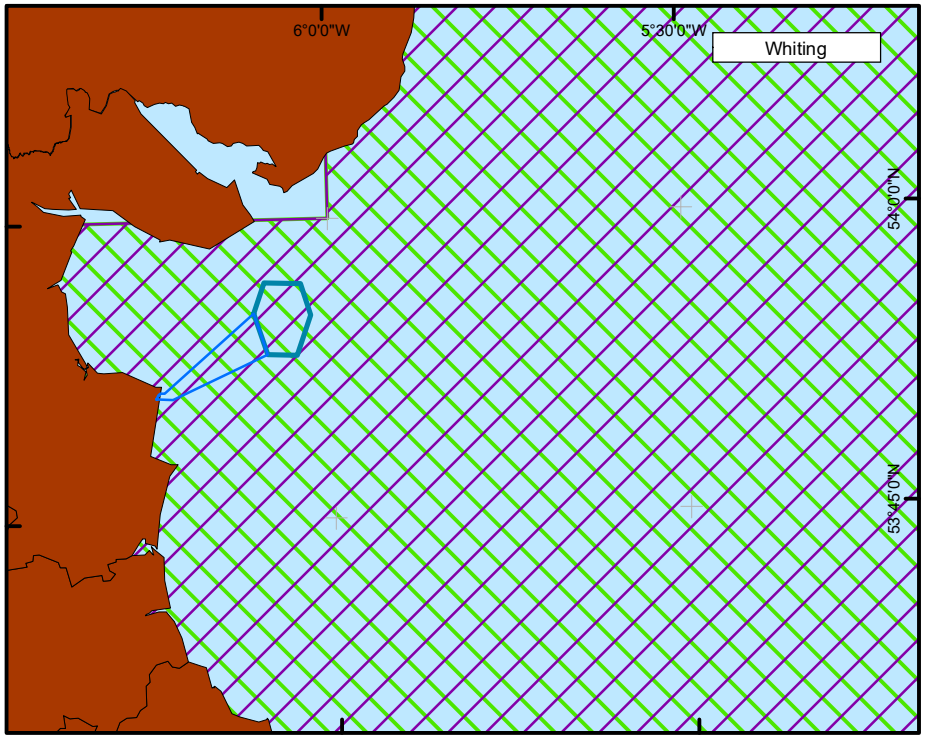
Web Page: rpsgroup.com/ireland

Issue Details

Drawn By: NG	**Project No.** EOR0822 (MDR1520B)
Checked By: NG	**File Ref:** EOR0822_FAS_T_1252_FINAL
Approved By: AOS	
Scale: 1:700,000 @ A4	**Projection:** ITM (IRENET95)
Date: 08/03/2024	Geographic Co-ordinates: ETRS89





Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

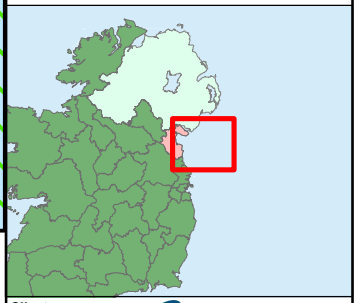
Nursery Grounds

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

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

- Low Intensity

Data Sources: Ellis *et al.*, 2012, Coull *et al.*, 1998



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-4
Fish Spawning and Nursery Grounds II:
Sandeel, Sole and Whiting

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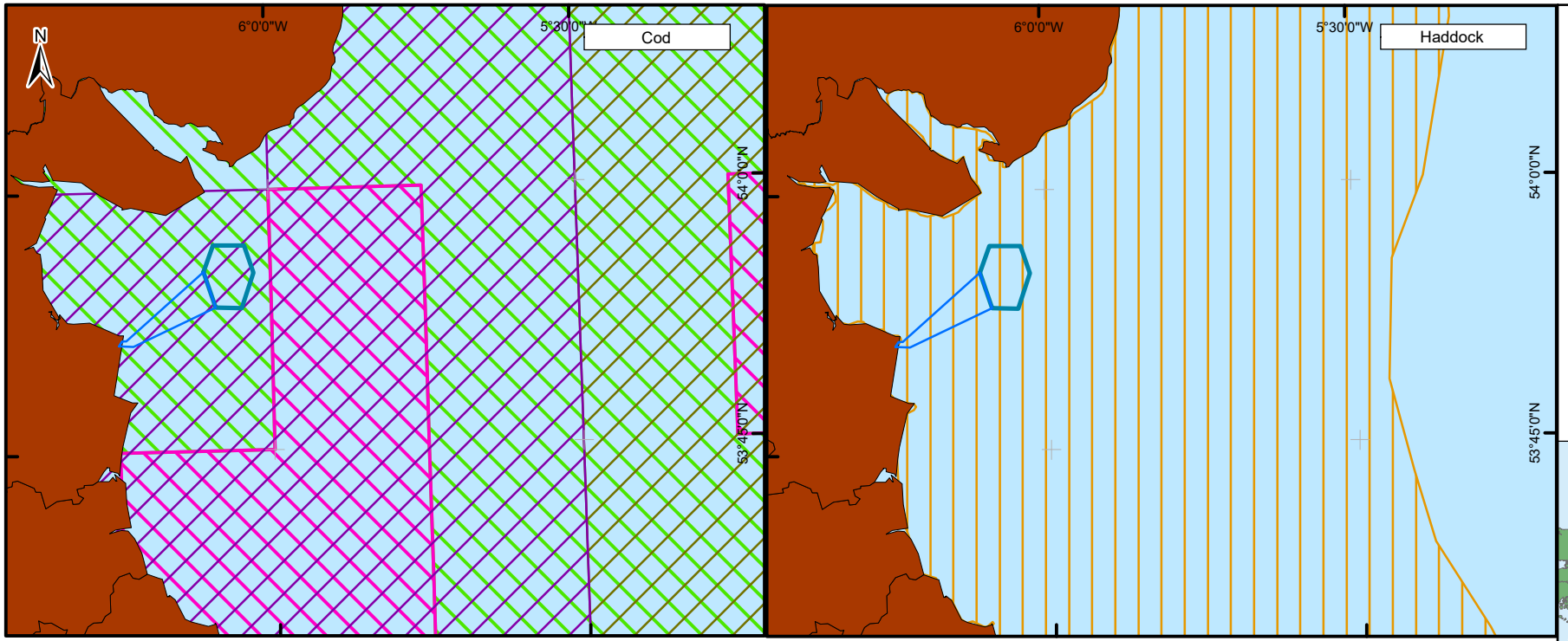
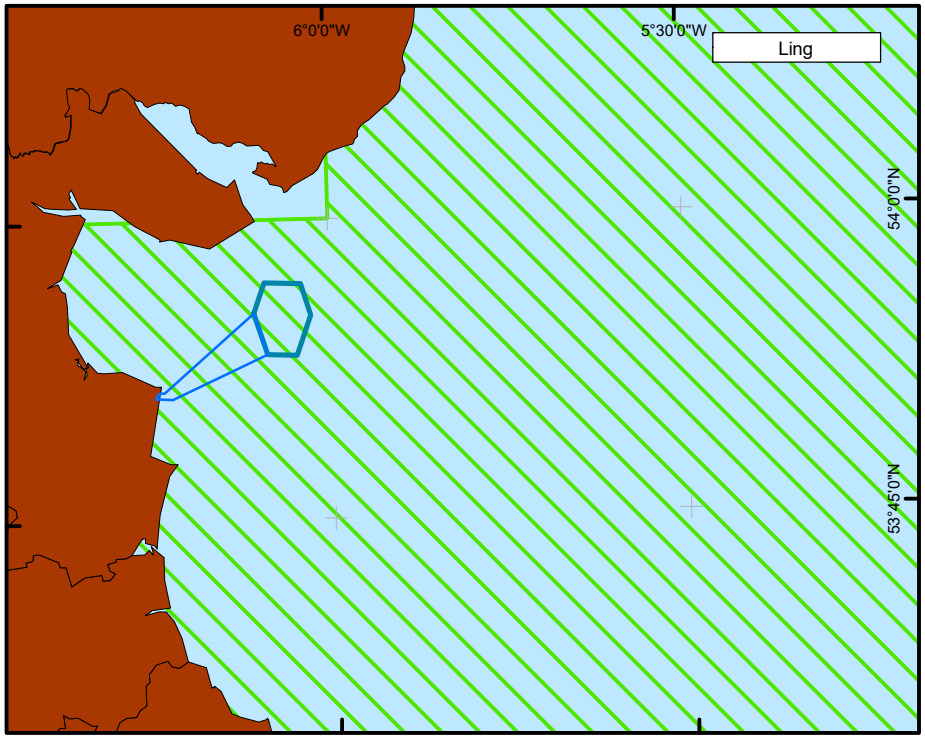




Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

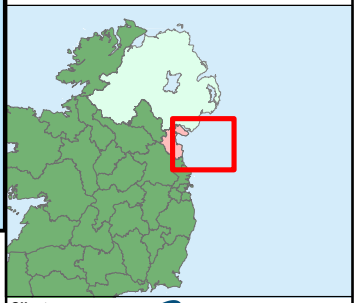
Nursery Grounds

- High Intensity (Ellis *et al.*, 2012)
- Low Intensity (Ellis *et al.*, 2012)
- Not Specified (Coull *et al.*, 1998)

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

- High Intensity
- Low Intensity

Data Sources: Ellis et al 2012, Coull et al., 1998



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-5
Fish Spawning and Nursery Grounds III: Cod, Haddock and Ling

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Pelagic Species

Herring

Herring are widely distributed throughout Irish and British waters and can be found in deep waters to depths of 200 m. Spawning of herring is expected to take place between September to November with anecdotal evidence to support winter/spring spawning from December to March (Appendix 9-2: Herring Spawning – Technical Report). Sticky eggs are deposited on a wide range of substrate types, but preferred substrate type is coarse and rock substrate types (Drapeau, 1973; Rogers and Stocks, 2001). The eggs adhere to the seabed and can form extensive beds. After hatching the larvae enter the plankton and drift with the current until reaching inshore nursery grounds. After a year they migrate further offshore to join adults at feeding grounds.

The Fish and Shellfish Ecology Study Area overlaps with an area identified by Ellis et al. (2012), Campanella and van der Kooij (2021) and DHLGH (2023) as being a herring nursery and spawning ground (Figure 1-6), and classified as high intensity nursery based on the abundance of juveniles caught in the area. This is consistent with data presented in Ireland's Marine Atlas at the time of writing (Ireland's Marine Atlas, 2023).

The DHLGH (2023) report identifies the Mourne herring spawning ground, however, it is important to note that this is based on herring substrate spawning preference on EMODnet benthic broadscale habitat types of course sediments and not specific egg or larval surveys of the area. However, following the precautionary principle and for the purposes of the assessment the area will be assumed to be a potential spawning area for herring.

In response to pre-application consultation with An Bord Pleanála and discussion on the presence of herring spawning grounds, a supplementary herring baseline report has been produced and presented in appendix 9-2: Herring Spawning – Technical Report. This report identifies that in addition to the identified coarse substrate in the DHLGH (2023), that there is rock substrate present within the Fish and Shellfish Ecology Study Area, suggesting a greater area available for herring spawning. In addition, appendix 9-2: Herring Spawning – Technical Report identifies coarse substrate that extends along the coast, northern east, into Northern Irish waters. Likely excluded from the DHLGH (2023) report due to jurisdictional boundaries in designating MPAs.

Mackerel

Mackerel are the most prolific and well-known species in Irish waters. Mackerel are found around the entire coastline in large shoals, although they have been subject to commercial over-fishing. Mackerel are broadcast spawners and once released their eggs float to the surface. Once hatched, larvae enter the plankton until they reach inshore nursery grounds. Nursery grounds are extensive and found off the coast of Britain and Ireland. The Fish and Shellfish Ecology Study Area overlaps with an area identified by Ellis *et al*. (2012) and Campanella and van der Kooij (2021) as being a low intensity spawning and nursery ground for this species (Figure 1-6). This is consistent with data presented in Ireland's Marine Atlas at the time of writing (Ireland's Marine Atlas, 2023).

Sprat

Sprat is a small (<16 cm) oily fish belonging to the genus *Sprattus* in the family Clupeidae and can be found widely distributed through Irish and British waters. Reproduction normally starts when the fish reaches its first or second year depending on growth conditions, feeding on zooplankton. The Fish and Shellfish Ecology Study Area overlaps with an area identified by Coull *et al*. (1998) as being a spawning ground of undetermined intensity for this species (Figure 1-6), which is consistent with Campanella and van der Kooij (2021). In addition, the hotspot maps produced by Campanella and van der Kooij (2021) demonstrate that coastal waters in the vicinity of the Project support persistent and high intensities of juvenile sprat, which could be representative of nursery areas.

Elasmobranchs

Spotted ray

Spotted rays have been found to inhabit inshore waters to depths of 8 m to 283 m. Juveniles tend to occur on sandy sediments, closer inshore, with adults occurring offshore in coarse gravel substrates. The population of spotted ray is stable throughout its range, despite being commonly landed in fisheries, and is

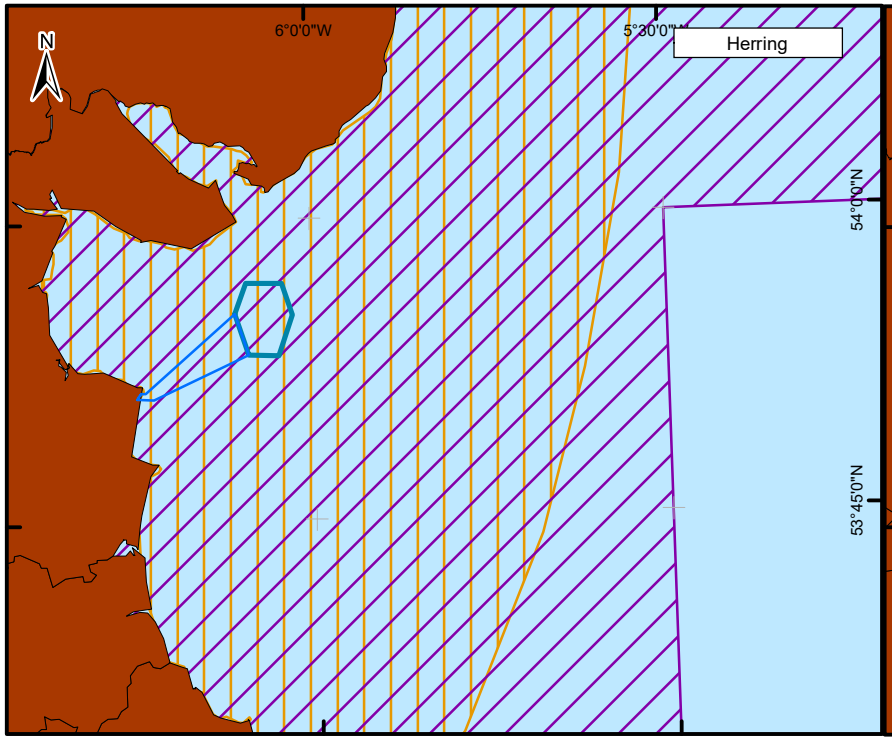
therefore listed on Ireland's Red List for cartilaginous fish as a species of Least Concern (Clarke *et al.,* 2016).

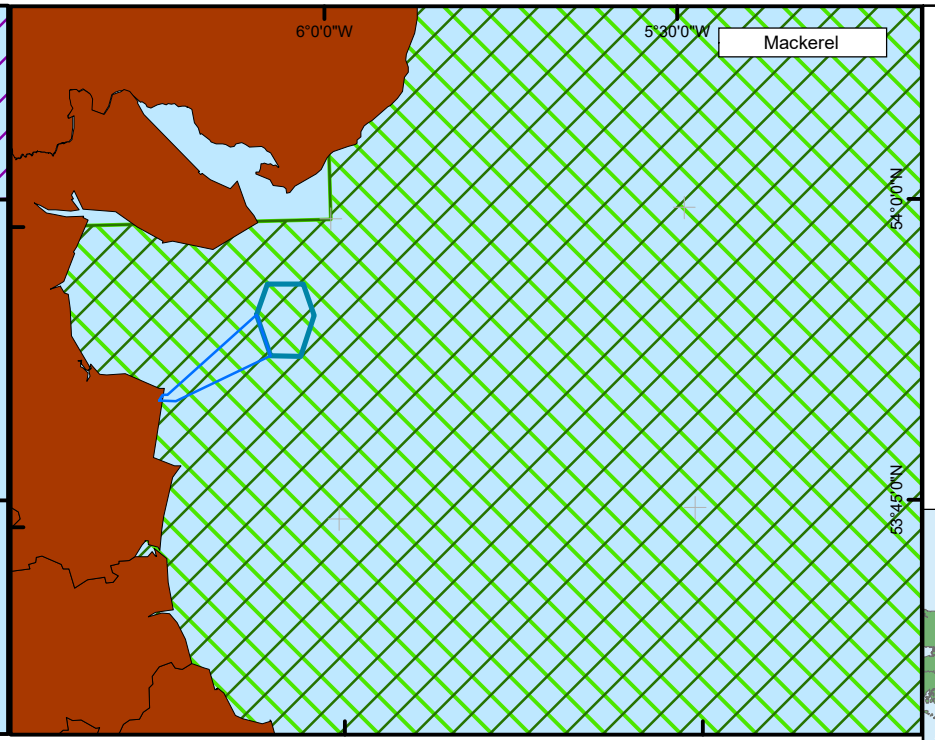
The Fish and Shellfish Ecology Study Area overlaps with an area identified as being a low intensity nursery ground for this species (Figure 1-7).

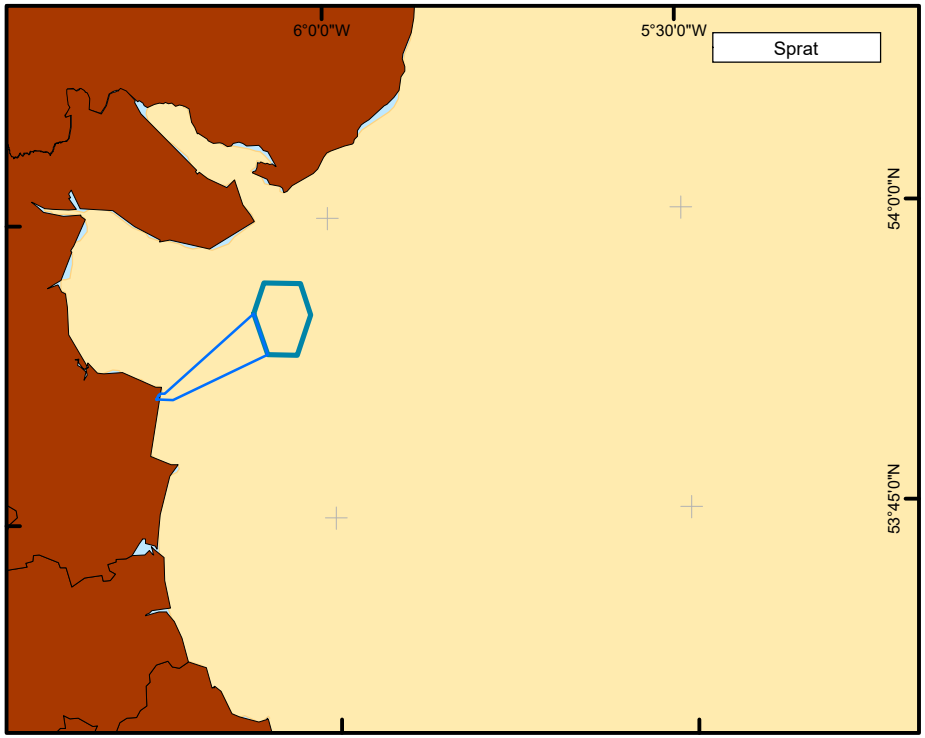
Thornback Ray

Thornback ray are a widely distributed demersal species throughout Irish and British waters and are found at depths of 2 m to 60 m. They are found on a wide variety of seabed types from mud, sand, shingle and gravel. The thornback ray has been listed as an OSPAR species and of Least Concern on the Ireland Red List (Clarke *et al.,* 2016).

The Fish and Shellfish Ecology Study Area overlaps with an area identified as being a low intensity nursery ground for this species (Figure 1-7).







Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Intensity

- High Intensity (Ellis *et al.*, 2012)
- Low Intensity (Ellis *et al.*, 2012)
- Not Specified (Coull *et al.*, 1998)

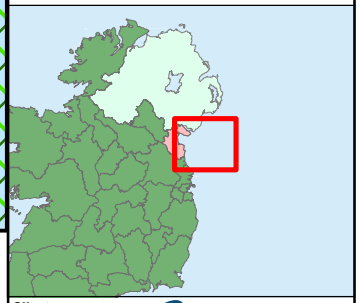
Spawning Grounds (Ellis *et al.*, 2012)

- High Intensity
- Low Intensity

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

- High Intensity
- Low Intensity
- Undetermined Intensity

Data Sources: Ellis *et al.*, 2012, Coull *et al.*, 1998



Client

ORIEL WINDFARM
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Project

Oriel Wind Farm Project

Title

Figure 1-6
Fish Spawning and Nursery Grounds IV: Herring, Mackerel and Sprat

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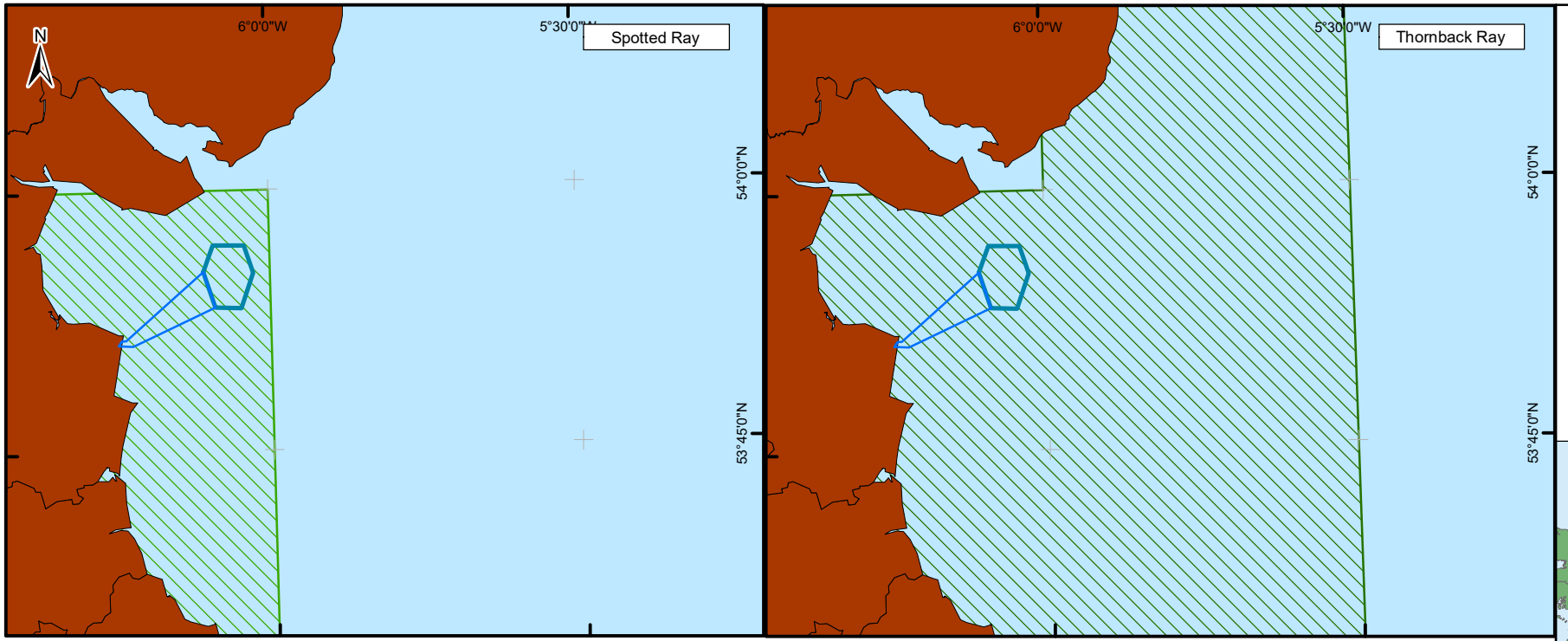
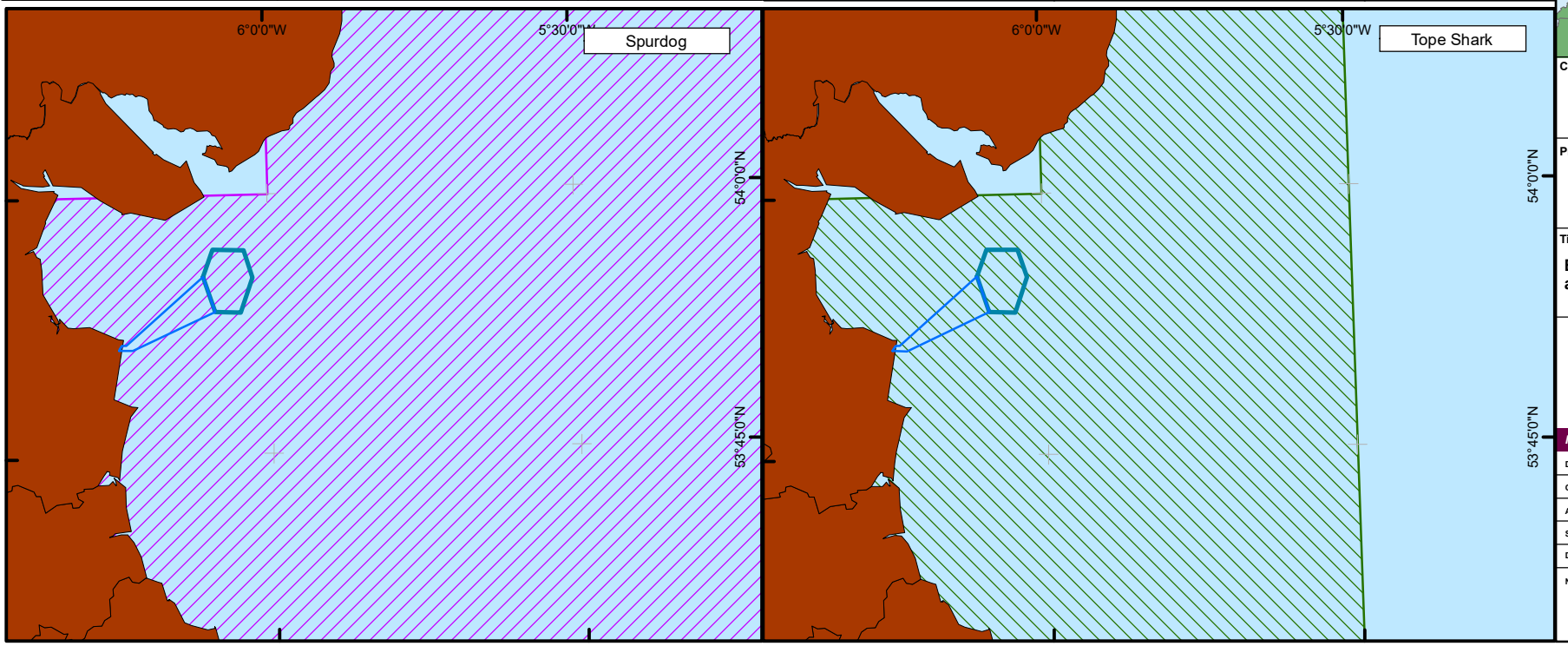




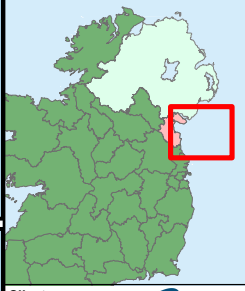
Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

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

- High Intensity
- Low Intensity

Data Sources: Ellis *et al.*, 2012.



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-7
Elasmobranch Spawning and Nursery Grounds

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Date: 08/03/2024	Geographic Co-ordinates: ETRS89

Spurdog

The spurdog is an umbrella term for species in the *Squalus* genus, widely distributed pelagic species, occurring at depths between ten and 100 m. They are viviparous and produce live young, often with females migrating inshore to give birth. Spurdog has been categorised as an OSPAR species and listed on the Ireland Red List as Endangered (Clarke *et al.,* 2016).

The Fish and Shellfish Ecology Study Area overlaps with an area identified as being a high intensity nursery ground for this species (Figure 1-7).

Tope shark

The tope shark is a pelagic species with a widespread distribution at depths to approximately 50 m. They are viviparous, producing live pelagic young. They tend to be solitary, migrating offshore in winter. They arrive in coastal waters in September peaking in October/November before migrating to deep-water in January (Maunsell and Metoc, 2007). Tope are active and strong swimming sharks and are predominantly encountered near the seabed. The tope shark has been listed as a vulnerable species on the Ireland Red List (Clarke *et al.,* 2016).

The Fish and Shellfish Ecology Study Area overlaps with an area identified as being a low intensity nursery ground for this species (Figure 1-7).

1.6.5 Shellfish

Shellfish is a colloquial and fisheries term for exoskeleton-bearing aquatic invertebrates used as food, including various species of molluscs, crustaceans, and echinoderms. Using commercial landing data as a proxy for species present in the western Irish Sea Fish and Shellfish Ecology Study Area, species most commonly caught include the edible crab, European lobster *Homarus gammarus*, *Nephrops*, common whelk, squid and velvet swimming crab *Necora puber*. Other species caught in the area include periwinkles *Littorina* spp., blue mussels, razor clams *Ensis spp.* and cockles *Cerastoderma edule*.

Designated shellfish waters

Dundalk Bay has been designated as shellfish waters (the “Dundalk Bay Production Area”) under Directive 2006/113/EC in 2012 (Figure 1-9). The Dundalk Bay Production Area contains cockles and razor clams, which are classified[3] in accordance with Regulation (EC) No 854/2004 (SFPA, 2019). Due to the high density of shellfish, razor clams and specifically cockles, within Dundalk Bay, the area is subject to a management plan, covering the period 2021 to 2025. The purpose of the plan is to safeguard against over exploitation of the shellfish resource present within the Bay, to ensure the economic viability of the fisheries by applying the precautionary approach to fisheries management (DAFM, 2021). The management plan also aims to preserve the habitat within these Natura designated areas and Dundalk Bay as a whole (DAFM, 2021). The management area covers a total of 77.8 km^2 of intertidal sandflats with a legal landing size of 17 mm shell width. The management plan has put a number of restrictions on the harvest of shellfish to ensure sustainability including:

- Defined harvest rate;
- Closure of the fishery should the catch rate decline to 250 kg per vessel per day;
- Seasonal closer to protect waterbirds and allow recovery of habitats;
- Daily catch allowance (maximum of 1,000 kg per vessel) allowances to ensure equitable distribution of catch;

[3] Regulation (EC) No 854/2004 sets out the requirements for the classification of production and relaying areas, the monitoring of classified relaying and production areas and the recording and exchange of information.

- Gear specification;
- Days per week and time restriction (fishing only allowed on one tide per 24 hour period);
- The provision of access and fisheries Natura permits; and
- Vessel monitoring.

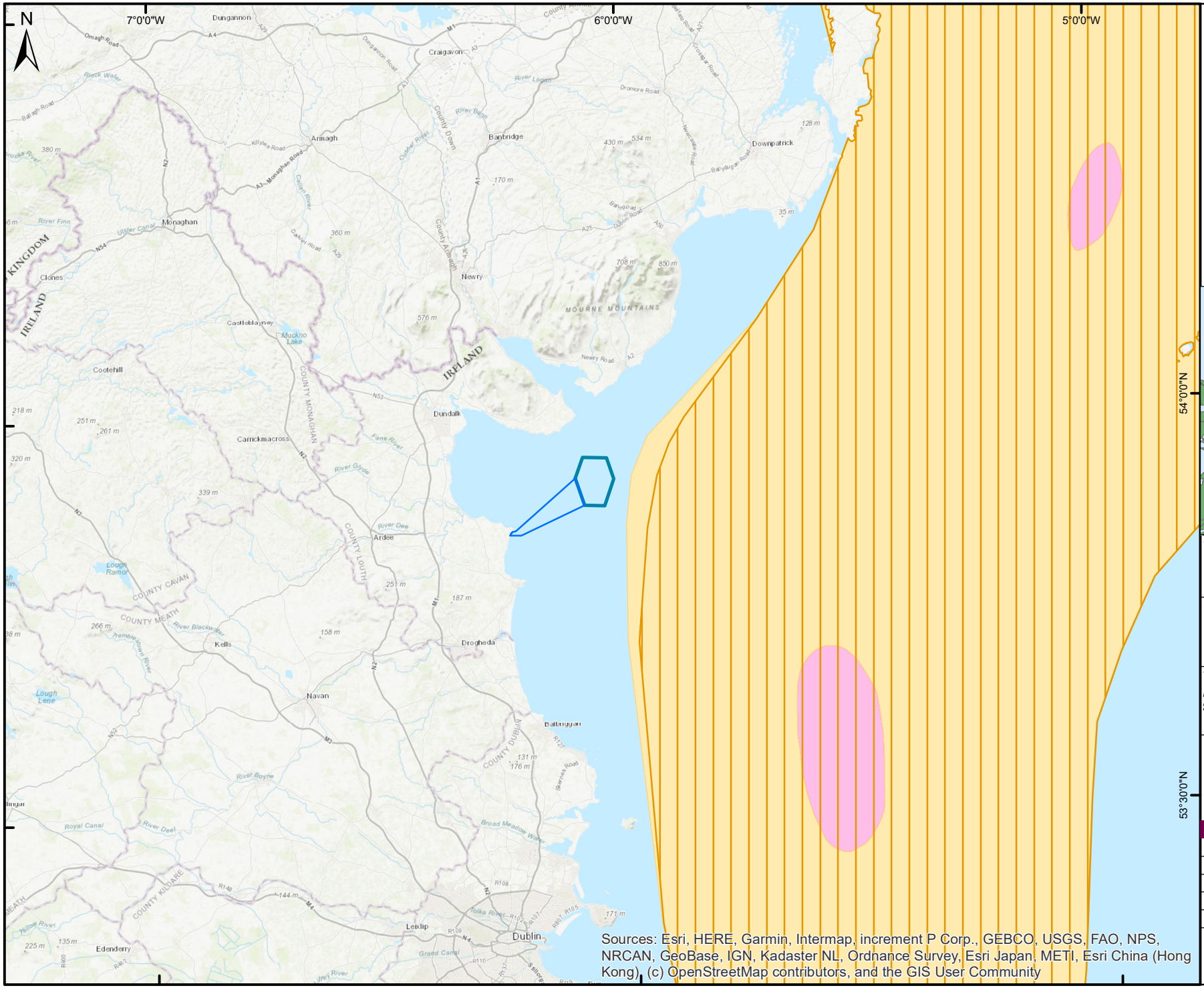
There are known periwinkle grounds located at Carlingford Lough, Rathcor, Corstown Bridge, near Clogherhead and Skerries. Further information on commercial fisheries can be found in chapter 12: Commercial Fisheries.

Nephrops

Nephrops norvegicus, known variously as the Norway lobster, Dublin Bay prawn, langoustine or scampi, is a slim, orange-pink lobster which grows up to 25 cm long, and is considered to be the most commercially important crustacean in Europe (Bell *et al.,* 2006). *Nephrops* is exploited throughout its geographic range, from Icelandic waters to the Mediterranean and the Moroccan coast. However, the western Irish Sea stock is amongst the most productive of all the *Nephrops* stocks currently fished, yielding landings of 5,000-10,000 tonnes annually from a relatively small geographic area (Lundy *et al.,* 2019).

Nephrops inhabit muddy seabed sediments and show a strong preference for sediments with more than 40% silt and clay (Bell *et al.,* 2006). They build and spend significant amounts of time in semi-permanent burrows which vary in structure and size but typically range from 20 to 30 cm in depth (Dybern and Hoisaeter, 1965). *Nephrops* spawning and nursery grounds (of undetermined intensity) are located around 2.3 km and 5.8 km from the offshore wind farm area, respectively (Figure 1-9; Coull *et al.,* 1998). 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).

Within the western Irish Sea and the wider Irish Sea, the Marine Institute carry out underwater video surveys of the *Nephrops* functional units (FU) to independently estimate abundance, distribution and stock sizes of *Nephrops.* The Fish and Shellfish Ecology Study Area falls within FU15 – western Irish Sea. The FU15 stock accounts for >40% of the total landings reported for ICES Sub-area VII (ICES, 2019). The burrow densities typically observed in FU15 are amongst the highest observed of all *Nephrops* stocks but the mean sizes of individuals in the catches are relatively small. It appears that growth is suppressed due to competition and/or recruitment effects (Johnson *et al.,* 2012).



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

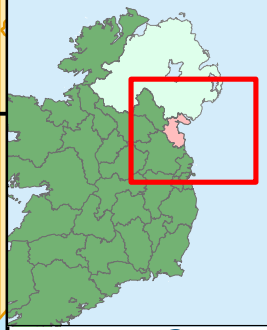
Nursery Grounds

- High Intensity (Ellis *et al.*, 2012)
- Low Intensity (Ellis *et al.*, 2012)
- Not Specified (Coull *et al.*, 1998)

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

- High Intensity
- Low Intensity
- Undetermined Intensity

Data Sources: Ellis *et al.*, 2012, Coull *et al.*, 1998



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ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title **Figure 1-8**

Nephrops norvegicus
Spawning and Nursery Grounds

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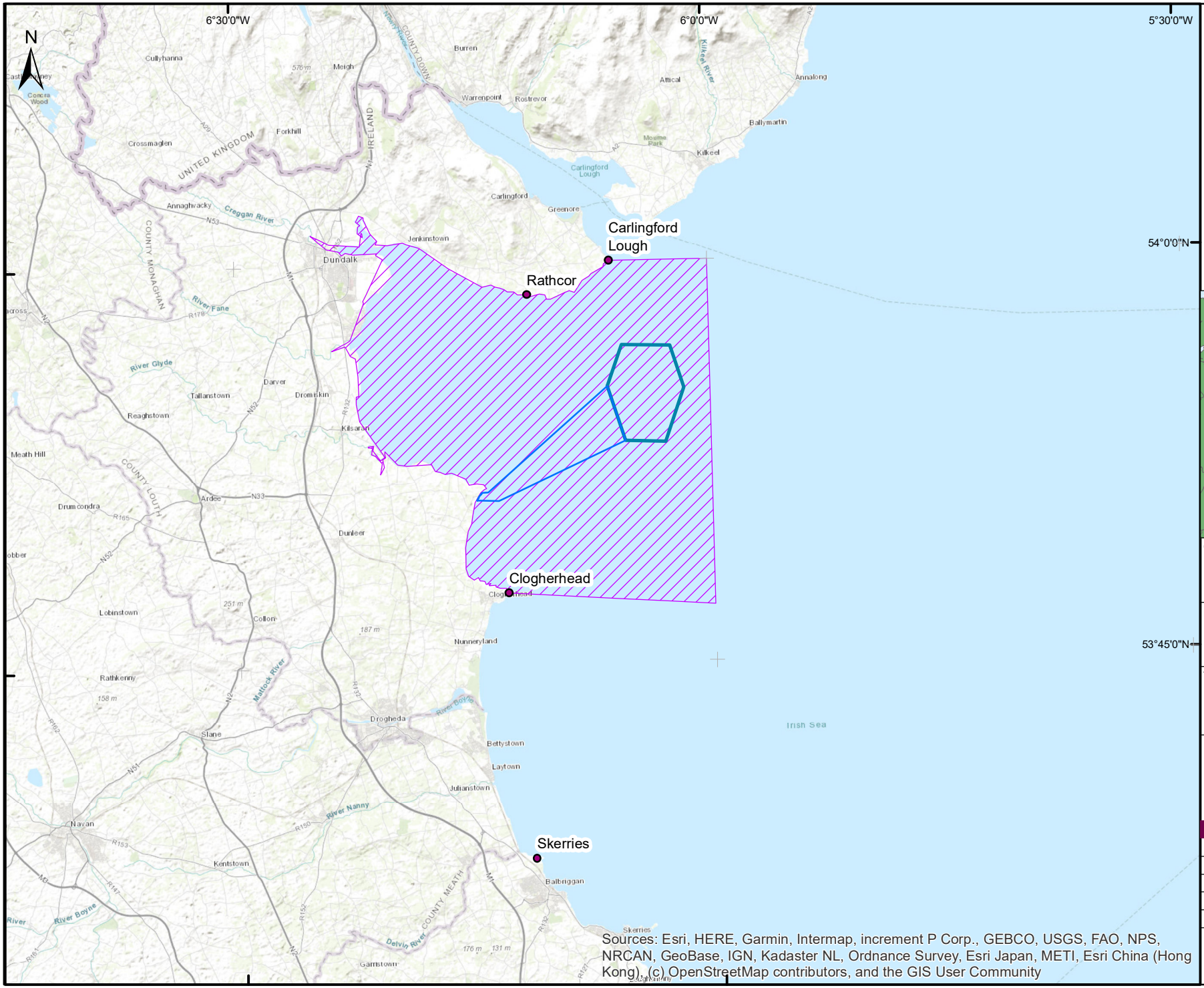
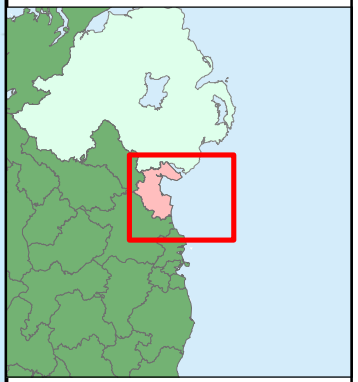


Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Dundalk Bay Live Bivalve Mollusc (LBM) Production Area

Data Sources: SFPA (Sea Fisheries Protection Authority)



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Project

Oriel Wind Farm Project

Title

Figure 1-9
Shellfish Production Areas

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Date: 08/03/2024	

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European lobster

The European lobster can be found throughout the British and Irish coasts on rocky substrata, down to depths of 60 m. Lobsters are actively fished in the area between Dublin and Dundalk (Tully, 2017) and are likely to occur in the Fish and Shellfish Ecology Study Area (see appendix 12-1: Commercial Fisheries Technical Report).

Edible (brown) crabs

Edible crabs (*Cancer pagurus)* which are also known as Brown Crabs are a relatively long-lived species that are found on all coasts around Ireland and Britain from the intertidal zone down to depths of 100 m. They live on rocky, gravelly substrate which they bury into. Following spawning there is a larval dispersal phase of approximately 30-50 days. Like lobster, edible crab are actively fished in the area between Dublin and Dundalk (Tully, 2017) and have been recorded along the coastline adjacent to the Project. In 2010, 25% of pot fishing in Northern Ireland was landed at Kilkeel which is within the Fish and Shellfish Study Area, edible crabs make up a very high percentage of pot fishing in Northern Ireland (AFBI, 2015b). Data provided by the Marine Institute in April 2021 on razor clams and by-catch in the north Irish Sea recorded edible crabs around Dundalk Bay and the east coast of Ireland. Edible crabs are considered likely to occur within the Fish and Shellfish Ecology Study Area (see appendix 12-1: Commercial Fisheries Technical Report).

Freshwater pearl mussel

The freshwater pearl mussel (*Margaritifera margaritifera*) 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 20 cm and live for more than 100 years, making them one of the longest-lived invertebrates (Skinner *et al.,* 2003). These mussels live on the beds of clean, fast-flowing rivers, where they can be buried partly of wholly in coarse sand or fine gravel. Mussels have a complex life cycle, living on the gills of young Atlantic salmon or brown trout, for their first year, without causing harm to the fish (Skinner *et al.,* 2003). The NPWS publish a map of sensitive catchment areas for freshwater pearl mussel, along the east coast of Ireland these include the Avoca, Vartry and Slaney (NPWS, 2017b). Freshwater pearl mussels are a QI of the Slaney River SAC and since there is some evidence of a northerly migration of salmon from the Slaney (Ó Maoiléidigh *et al.,* 2018), it is possible that juveniles may transfer to the Fish and Shellfish Ecology Study area during salmon migration.

Cockles

Cockles are found in the western Irish Sea, with the main beds located in Dundalk Bay. Dundalk Bay is under a Natura 2000 site management regime, which includes a fishery Natura plan for cockles (Marine Institute and Bord Iascaigh Mhara, 2019; Marine Institute and Bord Iascaigh Mhara, 2020). The Project is located within the Dundalk Bay (Live Bivalve Mollusc) LBM Production Area for cockles (Figure 1-8; SFPA, 2019). The Dundalk Bay stock is located west of the Fish and Shellfish Ecology Study Area (Figure 1-8). Other small-scale cockle stocks are distributed on the northwest coast of Ireland (Marine Institute and Bord Iascaigh Mhara, 2019;). Data provided by the Marine Institute in April 2021 on cockle and by-catch in Dundalk Bay reported an increase in average common cockle *Cerastoderma edule* catch density from 2017 to 2019 with a slight decrease in catch density in 2020. Cockle densities ranged between of 11.3-39.1 per m^2 and 5.3-12.7 per m^2 for quadrat and rake respectively, for 2017-2019. By catch data included the bivalves *Macoma balthica*, *Macomangulus tenuis* and the lug worm *Arenicola marina*.

Razor clams

Razor clams (*Ensis siliqua*) are commonly found throughout the Irish and British coasts and can be found in muddy sands from extreme low water to the shallow sublittoral, down to depths of around 60 m. Razor clams occur along the east coast of Ireland in mud and muddy sand sediments from Dundalk to Dublin and from Cahore Point to Rosslare and in numerous areas along the west coast (Marine Institute and Bord Iascaigh Mhara, 2019; Marine Institute and Bord Iascaigh Mhara, 2020). Dundalk Bay has been designated as a shellfish water for its high density of razor clams. Additionally, the Project is located within the Dundalk Bay LBM Production Area for razor clams (Figure 1-8; SFPA, 2019). Data provided by the Marine Institute in April 2021 on razor clams and by-catch in the north Irish Sea reported species of razor calm and by-catch caught from within Dundalk Bay and the east coast of Ireland. The razor clams *Ensis ensis*, *Ensis magnus* and *Ensis siliqua* were all recorded. By catch included the bivalves: the common welk *Buccinum undatum*, the common cockle, the common otter shell *Lutraria lutraria, Chamelea striatula,* the ocean quahog *Artica*

islandica, Pharus legumen, Spisula solida and *Venus senegelensis*. Ocean quahog were only found at seven locations, most of which were just outside Dublin and therefore over 40 km from the Project. Other by-catch included the polychaete *Aphrodita aculeata*, the echinoderms *Astropecten irregularis*, the common star fish *Asterias rubens* and serpent star *Ophiura ophiura* as well as five species of crab: *Cancer pagurus*, *Carcinus maenas*, *Corystes cassivelaunus*, *LIocarcinus depurator* and *Liocarcinus holsatus*.

Blue mussel

Blue mussels are widely distributed throughout the northern hemisphere and all along Ireland's coastline. They are commonly found along the intertidal to the shallow sublittoral regions attached by byssus threads to hard substrate. Subtidal aquaculture involving the bottom culture of blue mussel occurs in Carlingford Lough (AFBI, 2015a; Clyne *et al.,* 2008). Mussel seed is dredged from naturally settled wild seed mussel beds on the east coast of Ireland, including some from Dundalk Bay and re-laid onto licensed aquaculture beds within the Carlingford Lough for growing to harvestable size (AFBI, 2015a; Clyne *et al.,* 2008). Mussels were recorded on areas of rock at the Project landfall location (see appendix 8-1: Intertidal Phase 1 Report).

Pacific oyster

The pacific oyster (*Crassostrea gigas)* is an estuarine species, but it can also be found in intertidal and subtidal zones. They prefer to attach to hard or rocky surfaces in shallow or sheltered waters up to 40 m deep but have been known to attach to muddy or sandy areas when the preferred habitat is scarce. The Pacific oyster can also be found on the shells of other animals. The Pacific oyster is an introduced species native to the Pacific coast of Asia but is now widely cultivated in Ireland (AFBI, 2015a; Clyne *et al.,* 2008). The Pacific oyster is cultivated in the intertidal area, predominantly using off-bottom (trestle) culture, between Carlingford Lough and Greenore (AFBI, 2015a; Clyne *et al.,* 2008).

Common whelk

The common whelk is an opportunistic carnivorous marine gastropod found all around the Irish coast. It provides locally important fisheries, typically being exported to South Korea, Hong Kong, Japan, China and Singapore. Whelk are slow growing and slow to reach maturity, which makes this species vulnerable to disturbance (e.g. fishing pressure or aggregate extraction; MESL 2008). Furthermore, recent studies have shown that there are local differences in growth rates which could mean that this species is being caught before it reaches sexual maturity (Haig *et al.,* 2015; McIntyre *et al.,* 2015).

Breeding in European populations of the common whelk occurs during late autumn. Female whelk will usually delay spawning until the water temperature has dropped to 9°C or less, normally in November (Hancock, 1967). Egg clusters are laid onto hard substratum and consist of a number of egg capsules, each containing up to 3,000 eggs (Hancock, 1967). Cod are one of the most common predators of adult whelk (Turtle, 2014), and as noted above, the Project is located within the Irish cod recovery plan area (ICES, 2017).

Although whelk can be found in the intertidal zone, they will more normally inhabit subtidal areas. Whelk can be recorded on all types of seabed substratum (Haig *et al.,* 2015) including gravel, sand, mud and rock, but are typically found in areas of soft seabed, usually comprising a mixture of sand and mud, in which whelk may spend some of their time buried in the sediment (Hancock, 1967). As mentioned above, spawning requires the presence of hard substratum to which egg clusters are attached as they are laid.

Squid

Squid are commonly found throughout the eastern Atlantic including along the Irish coast. Those in the *Loligo* genus such as the common or European squid (*Loligo vulgaris*) and long finned squid (*Loligo forbesi*) are a neritic and mainly near-bottom species which are carnivorous predators, feeding on small, juvenile fishes, other cephalopods, crustaceans and polychaetes. They present an extended breeding season, from January to May with a peak in February–March (Lum-Kong *et al*., 1992; Pierce *et al*., 1994). Ireland has jurisdiction over the Irish fishery targeting squid in Irish coastal waters. Squid in this region are primarily caught by otter trawl gear (Marine Stewardship Council, 2020).

1.7 Summary

1.7.1 Overview of the fish and shellfish resources

This report has identified the fish and shellfish species likely to occur within the Fish and Shellfish Ecology Study Area and the wider western Irish Sea, including distribution and abundance of key species, spawning and nursery activity, commercial and conservation importance, migratory species and species of ecological importance (e.g. important prey species for other marine species, including other fish species). This section provides a summary of each of the fish and shellfish receptors that have the potential to be impacted by the Project and therefore require consideration in the EIA.

Fish and shellfish identified within the western Irish Sea Fish and Shellfish Ecology Study Area include demersal, pelagic, elasmobranchs and migratory species. It is likely that surface seabed substrate is a determining factor in the fish and shellfish assemblage, with the western Irish Sea Fish and Shellfish Ecology Study Area mainly comprised of muddier sediments, with sands and gravels present further inshore along the offshore cable corridor. These muddy sediments have been found to support a large *Nephrops* fishery, associated predators and fish assemblages, such as gadoids, flatfish and elasmobranchs. Additionally, the literature review of other surveys undertaken within the western Irish Sea found a similar assemblage of fish and shellfish, suggesting limited variability of marine fauna along the east coast of Ireland.

The western Irish Sea is also home to migratory fish species with Atlantic salmon and sea trout identified as the two most commercially important species in the region. The rivers Boyne and Blackwater, and the Slaney further south along the east coast of Ireland, have been designated for migratory fish species, while the rivers Dee, Fane, Glyde, Ballymascanlan, Flurry and Castletown, flowing into Dundalk Bay, are also known to host migratory fish species. The River Boyne and River Blackwater SAC is designated for the protection of the Annex II migratory fish river lamprey and Atlantic salmon, while the Slaney River Valley is a SAC designated for salmon, sea lamprey, river lamprey, brook lamprey and twaite shad.

Elasmobranchs found along the east coast of Ireland include sharks, rays, skates and the larger basking shark (see chapter 10: Marine Mammals and Megafauna).

A large portion of the Irish Sea is considered important as a nursery and spawning area for several species of fish and shellfish. The Project overlaps with spawning and/or nursery grounds for pelagic, demersal and elasmobranch species, with *Nephrops* spawning and nursery grounds found to the east of the offshore wind farm area. Juveniles of many species often favour sheltered inshore waters.

The Fish and Shellfish Ecology Study Area and the surrounding waters also support a diverse shellfish community, some of which are commercially exploited. *Nephrops* is the most commercially important shellfish with mussels identified as the second most important shellfish. The area inshore from the Project is considered to be particularly important for cockles and razor clams and for the settlement of larvae. Other shellfish noted in the region included cockles, scallop, edible crab, European lobster and velvet swimming crab.

1.7.2 Important ecological features

The IEF of an area are those that are considered to be important and potentially affected by a project. The importance of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2018). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g. Annex II species under the Habitats Directive, species listed as threatened and/or declining by OSPAR, or Ireland Red List species). However, only a very small proportion of marine habitats and species are afforded protection under the existing legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species. For example, some features may not have a specific conservation value in themselves but may be functionally linked to a feature of high conservation value (e.g. fish as prey species for protected bird or marine mammal species). Table 1-6 shows the criteria applied to determining the ecological value of IEFs within the geographic frame of reference applicable to the Fish and Shellfish Ecology Study Area.

Table 1-7 identifies the key fish and shellfish species likely to occur within the Fish and Shellfish Ecology Study Area and the wider western Irish Sea, based on the desktop review set out above. This also presents the value/importance as an ecological receptor based on the criteria outlined in Table 1-6. Specific reference is made to each species' commercial, conservation and ecological importance, where this is known. These species will be taken forward for assessment as part of the EIA.

Table 1-6: Criteria used to inform the importance of ecological receptors in the Fish and Shellfish Ecology Study Area.

Value of IEF	Defining criteria
International	Internationally designated sites. Species protected under international law (i.e. Annex II species listed as QIs of SACs).
National	Nationally designated sites. Species protected under national law. Annex II species which are not listed as QIs of SACs in the Fish and Shellfish Ecology Study Area. OSPAR List of Threatened and/or Declining Species or Irish Red List species that have nationally important populations within the Fish and Shellfish Ecology Study Area, particularly in the context of species/habitat that may be rare or threatened in Irish waters. Species that have spawning or nursery areas within the Fish and Shellfish Ecology Study Area that are important nationally (e.g. may be primary spawning/nursery area for that species).
Regional	OSPAR List of Threatened and/or Declining Species or Irish Red List species that have regionally important populations within the Fish and Shellfish Ecology Study Area (i.e. are locally widespread and/or abundant). Species that are of commercial value to the fisheries which operate within the Fish and Shellfish Ecology Study Area. 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 Fish and Shellfish Ecology Study Area. Species that have spawning or nursery areas within the Fish and Shellfish Ecology Study Area that are important regionally (i.e. species may spawn in other parts of Irish waters but this is a key spawning/nursery area within the Fish and Shellfish Ecology Study Area).
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Fish and Shellfish Ecology Study Area (e.g. they may be exploited in deeper waters outside the Fish and Shellfish Ecology Study Area). The spawning/nursery area for the species are outside the Fish and Shellfish Ecology Study Area. The species is common throughout Irish waters but forms a component of the fish assemblages in the Fish and Shellfish Ecology Study Area.

Table 1-7: Summary of Fish and Shellfish IEFs and their value/importance within the Fish and Shellfish Ecology Study Area.

Common Name	Scientific Name	Importance	Justification
Demersal Fish			
Benthic Fish			
Plaice	*Pleuronectes platessa*	Regional	Low intensity nursery and low intensity spawning habitat. Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Commercially important fish species in the region.
American plaice	*Hippoglossoides platessoides*	Regional	Due to high presence within the Oriel area, note no spawning or nursery grounds. IUCN Red List species – least concern. Whilst this species could be

Common Name	Scientific Name	Importance	Justification
			considered within the category as 'other flatfish species', following the precautionary principle, a regional IEF status has been given.
Other flatfish species	-	Local	Other flatfish species including, sole, lemon sole, turbot, flounder and megrim are all commercially important species in the region and are likely to occur within the Project site. These species either have no known spawning or nursery grounds or low intensity/undetermined nursery and spawning grounds.
Conger eel	*Conger conger*	Local	No known spawning or nursery grounds in the area. Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences.
Other small benthic fish species	-	Local	Small demersal species including wrasse, gobies and blennies are likely to be present and likely to be prey items for fish, bird and marine mammal species. No information is available on the spawning or nursery habitats of these species, they have little or no commercial importance and are not listed under any nature conservation legislation.
Benthopelagic Fish			
Cod	*Gadus morhua*	National	Low intensity spawning and high intensity nursery ground. Fish and Shellfish Ecology Study Area coincides with Irish Sea Cod Recovery Plan area. Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Commercially important species. Listed by OSPAR as threatened and/or declining and listed as vulnerable on the IUCN Red List.
Haddock	*Melanogrammus aeglefinus*	Regional	Spawning ground of unspecified intensity. Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Commercially important fish

Common Name	Scientific Name	Importance	Justification
			species in the region. IUCN Status: Vulnerable.
Whiting	*Merlangius merlangus*	Regional	Low intensity spawning and high intensity nursery habitats. Commercially important fish species in the region and a key prey species for other marine species (particularly harbour porpoise). Not identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences but is a target for local fisheries.
Other gadoids	-	Local	Other gadoid species including ling, Pollack, coalfish and hake have been identified as being likely to occur within the Project site and are likely to have some commercial importance in the region. These species either have no known spawning or nursery grounds or low intensity/undetermined nursery and spawning grounds.
Sea bass	*Dicentrarchus labrax*	Regional	Sea bass is a species that is targeted by recreational fisheries in the area. Dundalk Bay is important for this species, with spawning grounds potentially occurring in the area (IFI, pers. comm., 2021)
Anglerfish	*Lophius piscatorius*	Local	Low intensity nursery ground. Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Important commercial species in the Irish Sea, but not in local area.
Lesser sandeel	*Ammodytes tobianus*	Local	Low intensity nursery and spawning ground. Important prey species for fish, birds and marine mammals. Commercially important species. Not identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences.
Greater sandeel	*Hyperoplus lanceolatus*		
Pelagic Fish			
Herring	*Clupea harengus*	National	High intensity nursery, and Mourne spawning ground. Important prey species for larger fish, birds and marine

Common Name	Scientific Name	Importance	Justification
			mammals. Whilst currently not a feature of a designated MPA, the Mourne herring spawning grounds have been identified as a potential feature for consideration for a potential MPA. Therefore, following the precautionary principle, the herring spawning grounds have been given a National IEF value.
Mackerel	*Scomber scombrus*	Regional	Low intensity nursery and spawning ground. Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Important prey species for larger fish, birds and marine mammals.
Sprat	*Sprattus sprattus*	Local	Spawning ground of undetermined intensity. Not identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Important prey species for larger fish, birds and marine mammals.
Migratory Fish			
Sea lamprey	*Petromyzon marinus*	International	Very likely to migrate through the Project site. Annex II species and listed as QIs of a number of SACs within the western Irish Sea Fish and Shellfish Ecology Study Area.
River lamprey	*Lampetra fluviatilis*		
Twaite shad	*Alosa fallax*		
Atlantic salmon	*Salmo salar*		
Sea trout	*Salmo trutta*	National	Very likely to migrate through the Project site. Listed as OSPAR threatened/declining species. Not a QI or feature of any designated sites in the western Irish Sea Fish and Shellfish Ecology Study Area.
European eel	*Anguilla anguilla*	National	Very likely to migrate through the Project site. Listed as an OSPAR threatened/declining species and listed as critically endangered on the IUCN Red List and the Ireland Red List. Not a QI or feature of any designated sites in the western Irish Sea Fish and Shellfish Ecology Study Area.
Elasmobranchs			
Small-spotted catshark	*Scyliorhinus canicula*	Local	Identified as likely to occur within the Project site in the

Common Name	Scientific Name	Importance	Justification
			2007 baseline study, based on habitat preferences. Common and listed as of Least Concern on the IUCN Red List.
Nursehound	*Scyliorhinus stellaris*	Regional	Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Common, but listed as of Near Threatened on the IUCN Red List due to declines in the Mediterranean population.
Tope	*Galeorhinus galeus*	Regional	Low intensity nursery ground. Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Listed on Ireland Red List as Vulnerable.
Spurdog	*Squalus acanthias*	National	Not identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences, but the area has since been identified as a high intensity nursery ground. Listed on Ireland Red List as Endangered.
Rays	-	Local	Rays (most likely including thornback and spotted rays) were identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Low intensity nursery ground. Listed on Ireland Red List as Least Concern.
Skate	*Dipturus batis*	Regional	Not identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences, but has been noted as occurring in the general area. Skate are listed as Critically Endangered on the IUCN Red List.
Pelagic sharks	-	Regional	Large pelagic shark species including the porbeagle, kitefin, shortfin mako and blue shark are likely to be very occasional visitors to this area. Many of these species are listed as threatened on the IUCN Red List.
Shellfish			

Common Name	Scientific Name	Importance	Justification
Crustaceans			
Edible crab	*Cancer pagurus*	Regional	Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Important commercial species.
Norway lobster	*Nephrops norvegicus*	Regional	Spawning and nursery area 2.3 km and 5.8 km from the Project site. Not identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Second most valuable species fished by the Irish fleet and an important fishery in the local area.
European lobster	*Homarus gammarus*	Regional	Identified as likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. Important commercial species.
Other crustaceans	-	Local	Other crustaceans including velvet swimming crab, green shore crab, swimming crabs, spider crabs and brown shrimp have been identified as being likely to occur within the Project site in the 2007 baseline study, based on habitat preferences. They are all important commercial species, but not in the local area.
Molluscs			
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 and is a QI of the Slaney River Valley SAC. This species lives on the gills of salmon and brown trout in the first year of life.
Cockles	*Cerastoderma edule*	National	Main cockle bed found in Dundalk Bay is under a Natura 2000 site management regime and a fishery Natura plan. Main cockle fishery in Ireland.
Razor clams	*Ensis spp.*	Regional	Dundalk Bay is designated as a shellfish water for its high density of razor clams. The Project site is located within a razor clam conservation area.

Common Name	Scientific Name	Importance	Justification
Blue mussel	*Mytilus edulis*	Regional	Important commercial species. Likely to be found along the offshore cable corridor. Cultivated in the Boyne Estuary and Carlingford Lough.
Pacific oysters	*Crassostrea gigas*	Regional	Important commercial species. Cultivated at Carlingford Lough and Annagassan.
Common whelk	*Buccinum undatum*	Regional	Important commercial species. Fished locally. Whilst whelk are not a protected species, there is concern about the fishery in general terms because of recent increases in its commercial value and uncertainties surrounding its size at maturity. Prey species for cod and other large fish and elasmobranchs.
Other mollusc species	-	Local	Other mollusc species are thought likely to occur in the area including the king scallop and queen scallop which are important commercial species. The main fishing grounds for these species are however, further offshore. There are also periwinkle grounds located at Carlingford Lough, Rathcor, Corstown Bridge and Skerries.
Squid	*Loligo*	Local	Important commercial species in the Irish Sea, but not in local area.

References

AECOM and Metoc (2010) Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREDP) in the Republic of Ireland. AECOM and Metoc, Available online: https://www.seai.ie/publications/OREDP-SEA-ER-Volume-2-Main-Report.pdf

AFBI (2015a) Cumulative Impact Assessment: Aquaculture activities within and adjacent to Natura 2000 designated sites in Carlingford Lough. Prepared by AFBI Fisheries and Aquatic Ecosystem Branch for DARD Fisheries and Environment Division. 115pp. Available online at: https://www.daera-ni.gov.uk/sites/default/files/consultations/dard/cumulative-impact-assessment-carlingford-lough-aquaculture-activities-dec%202015.PDF

AFBI (2015b) Pot Fishing in Northern Ireland, Prepared by AFBI Fisheries and Aquatic Ecosystems Branch for DARD Fisheries and Environment Division. Available at: https://www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/%5Bcurrent-domain%3Amachine-name%5D/pot%20fishing%20in%20northern%20ireland.pdf

AFBI (2019) Cod tagging project in the Irish Sea. Agri Food and Biosciences Institute (AFBI) in collaboration with Cefas and the Marine Institute. https://www.afbini.gov.uk/articles/cod-tagging-project-irish-sea

Antunes, C., and Tesch, F. W. (1997a). A critical consideration of the metamorphosis zone when identifying daily rings in otoliths of European eel, Anguilla anguilla (L.). Ecology of Freshwater Fish, 6(2): 102-107.

Antunes, C., and Tesch, F. W. (1997b). Eel larvae (Anguilla anguilla L.) caught by RV “Heincke” at the European continent slope in autumn 1991. Ecology of Freshwater Fish, 6(1): 50-52.

Bardonnet, A., Bolliet, V., and Belon, V. (2005). Recruitment abundance estimation: role of glass eel (Anguilla anguilla L.) response to light. Journal of Experimental Marine Biology and Ecology, 321(2): 181-190.

Barry J., Kennedy R., Rosell R., Roche W. (2020) Atlantic salmon smolts in the Irish Sea: First Evidence of a northerly migration trajectory, Fisheries Management and Ecology, vol 27, Issue 5, p517-522.

Barnes, M.K.S. 2008. Melanogrammus aeglefinus Haddock. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 09-12-2019]. Available from: https://www.marlin.ac.uk/species/detail/79

Bell, M.C., Redant, F. and Tuck, I (2006) Nephrops Species. In Phillips, B.F. (ed.). Lobsters: Biology, Management, Aquaculture and Fisheries. Wiley-Blackwell. pp. 412–461. doi:10.1002/9780470995969.ch13. ISBN 978-1-4051-2657-1.

Campanella, F., and van der Kooij, J. (2021). Spawning and nursery grounds of forage fish in Welsh and surrounding waters. Cefas Project Report for RSPB, 65 pp.

Castonguay, M., and McCleave, J. D. (1987). Vertical distributions, diel and ontogenetic vertical migrations and net avoidance of leptocephali of Anguilla and other common species in the Sargasso Sea. Journal of Plankton Research, 9(1): 195-214.

CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine, September 2018, Version 1.2. Updated April 2022. Available from: https://cieem.net/wp-content/uploads/2018/08/ECIA-Guidelines-2018-Terrestrial-Freshwater-Coastal-and-Marine-V1.2-April-22-Compressed.pdf

Clarke, M., Farrell, E.D., Roche, W., Murray, T.E., Foster, S. and Marnell, F. (2016) Ireland Red List No. 11: Cartilaginous fish [sharks, skates, rays and chimaeras]. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs. Dublin, Ireland.

Clyne, F.J., Garrod, C.J., Jeffs, T.M. and Jenkinson , S.B. (2008) An assessment of aquatic radiation pathways in Ireland, 2008. Environmental Report RL 16./08. Centre for Environment, Fisheries & Aquaculture Science (Cefas), Lowestoft. 101pp. Available online at: https://www.epa.ie/pubs/reports/radiation/RPII_aquatic_radiation_pathways_2008.pdf

Codling Wind Park (2002). Offshore Wind Farm at Codling Bank, Non-Technical Summary, Volume 2 of 3. Produced by Natural Power for Codling Wind park. Page 25. Available at: http://codlingwindpark.ie/wp-content/uploads/2013/01/Codling-Non-Technical-Summary1.pdf

Coull, K.A., Johnstone, R, and Rogers, S.I. (1998) Fisheries Sensitivity Maps in British Waters. UKOOA Ltd: Aberdeen.

Cresci, A., Paris, C. B., Durif, C. M. F., Shema, S., Bjelland, R. M., Skiftesvik, A. B. and Browman, H. I. (2017). Glass eels (*Anguilla Anguilla*) have a magnetic compass linked to the tidal cycle. Science Advances 3, 1–9.

Cresci, A. (2020). A comprehensive hypothesis on the migration of European glass eels (*Anguilla anguilla*). Biological Reviews, 95(5), 1273-1286.

Cresci, A., Durif, C. M., Paris, C. B., Thompson, C. R. S., Shema, S., Skiftesvik, A. B. and Browman, H. I. (2019). The relationship between the moon cycle and the orientation of glass eels (*Anguilla Anguilla*) at sea. Royal Society Open Science 6, 190812.

Creutzberg, F. (1961). On the orientation of migrating elvers (*Anguilla vulgaris Turt*.) in a tidal area. Netherlands Journal of Sea Research, 1(3): 257-338.

CSTP (2016) (Milner, N., McGinnity, P. & Roche, W. Eds) Celtic Sea Trout Project – Technical Report to Ireland Wales Territorial Co-operation Programme 2007-2013 (INTERREG 4A). [Online] Dublin, Inland Fisheries Ireland. Available: http://celticseatrout.com/downloads/technical-report/

DAFM (2021) Fisheries Natura Plan for cockle (Cerastoderma edule) in Dundalk Bay, 2021-2025, Accessed 17 January 2023, Available at: http://www.fishingnet.ie/media/fishingnet/content/fisheriesinnaturaareas/siteassessments/dundalkbay/APP21FinalisedDundalkBayFisheriesPlanforCockle20212025260721.pdf

DAHG (2014). River Boyne and River Blackwater SAC. Site Synopsis (Site Code: 002299). Department of Arts, Heritage and the Gaeltacht. Available online: https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY002299.pdf

DAHG (2015). Slaney River Valley SAC. Site Synopsis (Site Code: 000781). Department of Arts, Heritage and the Gaeltacht. Available online: https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY000781.pdf

DAOWFL (2012). An Offshore Wind Farm on the Kish and Bray Banks, Environmental Impact Statement, January 2012 – Revision 1. Section 8: Marine Ecology. Dublin Array Offshore Wind Farm Ltd. Available at: https://www.housing.gov.ie/sites/default/files/migrated-files/en/Foreshore/ApplicationsSubjecttoEIA/BrayOffshoreWindLtd/SupportingDocumentation/FileDownLoad%2C35120%2Cen.pdf.

Davies, CE, Shelley, J, Harding, PT, McLean, IFG, Gardiner, R, Peirson, G (2004). Freshwater fishes in Britain - the species and their distribution. Harley Books.

DECC (2009). UK Offshore Energy SEA 2 Environmental Report.

DHLGH, (2023). Ecological sensitivity analysis of the western Irish Sea to inform future designation of Marine Protected Areas. Accessed online: https://www.gov.ie/pdf/?file=https://assets.gov.ie/261015/35f09f23-5a32-4492-b470-d9d26ed9eb16.pdf#page=null

Dipper, F. (2001). British sea fishes (2nd edn). Teddington: Underwater World Publications Ltd.

Drapeau, G. 1973. Sedimentology of herring spawning grounds on Georges Bank. ICNF Res. Bull. No 10. P151 -162

Durazo, R., Harrison, N.M. and Hill, A.E., (1998). Seabird observations at a tidal mixing front in the Irish Sea. Estuarine, Coastal and Shelf Science, 47: 153-164

Dybern, B.I. and Hoisaeter, T (1965). The burrows of *Nephrops norvegicus*. Sarsia. 21: 49–55. doi:10.1080/00364827.1965.10409560

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012) Spawning and nursery grounds of selected fish species in UK waters. Scientific Series Technical Report. Cefas Lowestoft, 147: 56 pp

EPA (2022). Guidelines on The Information to be Contained in Environmental Impact Assessment Report (Draft), August 2017. Environmental Protection Agency. Available Online: http://www.epa.ie/pubs/advice/ea/EPA%20EIAR%20Guidelines.pdf

EPA (2015). Advice notes for preparing Environmental impact Statements (draft) September 2015. Environmental Protection Agency. Available Online: https://www.epa.ie/pubs/consultation/reviewofdrafteisguidelinesadvicenotes/Draft%20Advice%20Notes%20for%20preparing%20an%20EIS.pdf

Faber Maunsell and Metoc (2007). Scottish Marine Renewables Strategic Environmental Assessment. Environmental Report. Available from: http://www.scotland.gov.uk/Publications/2007/03/seawave

Finstad, B. & Jonsson, N. (2001). Factors influencing the yield of smolt releases in Norway. Nordic Journal of Freshwater Research 75, 37–55.

Haig, J.A., Pantin, J.R., Salomonsen, H., Murray, L.G., Kaiser, M.J. (2015) Temporal and spatial variation in size at maturity of the common whelk (*Buccinum undatum*), ICES Journal of Marine Science, Volume 72, Issue 9, November/December 2015, Pages 2707–2719, https://doi.org/10.1093/icesjms/fsv128

Hancock, D. (1967) Whelks. Laboratory leaflet (new series) No. 15. MAFF. Burnham-on-Crouch.

Hervas, A., Tully, O., Hickey, J., O'Keeffe, E. and Kelly, E. (2008) Assessment, Monitoring and Management of the Dundalk Bay and Waterford Estuary Cockle (*Cerastoderma edule*) Fisheries in 2007.Fisheries Resource Series, No. 7 (2008), 38pp. http://www.bim.ie/media/bim/content/publications/bimNo,7,Assessment,Monitoring,and,Management,of,the,Dundalk,Bay,and,Waterford,Estuary,Cockle,Fisheries,in,2007.pdf

Hoar, W. S. (1988). The physiology of smolting salmonids. In Fish Physiology, Vol. XIB (Hoar, W. S. & Randall, D. J., eds), pp. 275–343. New York, NY: Academic Press.

Høgasen, H. R. (1998). Physiological changes associated with the diadromous migration of salmonids. Canadian Special Publication of Fisheries and Aquatic Sciences 127, 1078–1081

Howson, C.M. & Picton, B.E., (1997). The species directory of the marine fauna and flora of the British Isles and surrounding seas. Belfast: Ulster Museum.

ICES, (2012). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 27 April – 3 May 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACON:13. 1346 p.

ICES (2017). Cod (*Gadus morhua*) in Division 7.a (Irish Sea). ICES Advice on fishing opportunities, catch, and effort Celtic Seas Ecoregion. 8pp. Available Online: http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/cod.27.7a.pdf

ICES (2019) Report of the Working Group on *Nephrops* Surveys (WGNEPS). 6-8 November. Lorient, France. ICES CM 2018/EOSG:18. 226 pp. Available Online: https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/EOSG/2018/WGNEPS/WGNEPS%20report%202018.pdf

ICES (2022). Trawl Survey Details. Available online: https://datras.ices.dk/home/descriptions.aspx#NI. Accessed 23 September 2022.

IFI (2018). Consolidated Fish Counter Summary Report 2017. https://www.fisheriesireland.ie/extranet/fisheries-management-1/salmon/1493-ifi-consolidated-fish-counter-summary-report-2017.html. Inland Fisheries Ireland/

Igoe F., Quigley D.T.G., Marnell F., Meskell E., O'Connor W. and Byrne, C. (2004). The Sea Lamprey *Petromyzon marinus* (L.), River Lamprey *Lampetra fluviatilis* (L.) and Brook Lamprey *Lampetra planeri* (Bloch) In Ireland: General Biology, Ecology, Distribution and Status with Recommendations for Conservation. Biology and Environment: Proceedings Of The Royal Irish Academy,Vol.104b, No.3, 43/56

Ireland's Marine Atlas. (2023). Available online: https://atlas.marine.ie/. Accessed 23 September 2022.

Johnson, M.P., Lordan, C., Power. A.M. (2012) Habitat and Ecology of *Nephrops norvegicus*. Advances in marine biology 64, 27-6

Kelly, F. L., and King, J. J. (2001). A review of the ecology and distribution of three lamprey species, *Lampetra fluviatilis (L.)*, *Lampetra planeri* (Bloch) and *Petromyzon marinus (L.)*: a context for conservation and biodiversity considerations in Ireland. Biology and environment: proceedings of the royal Irish academy (pp. 165-185). Royal Irish Academy.

Kelly, C. J., Codling, E. A., and Rogan E. (2006) The Irish Sea cod recovery plan: some lessons learned. ICES Journal of Marine Science, 63: 600-610.

King, J.L., Marnell, F., Kingston, N., Rosell, R., Boylan, P., Caffrey, J.M., FitzPatrick, Ú., Gargan, P.G., Kelly, F.L., O'Grady, M.F., Poole, R., Roche, W.K. & Cassidy, D. (2011). Ireland Red List No. 5: Amphibians, Reptiles & Freshwater Fish. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Klemetsen, A., Amundsen, P. A., Dempson, J. B., Jonsson, B., Jonsson, N., O'connell, M. F., & Mortensen, E. (2003). Atlantic salmon *Salmo salar (L.*), brown trout *Salmo trutta (L.*) and Arctic charr *Salvelinus alpinus (L.*): a review of aspects of their life histories. Ecology of freshwater fish, 12(1), 1-59.

Le Févre, J., (1986). Aspects of the biology of frontal systems. Advances in Marine Biology, 23: 164-299.

Lockwood (2005). Strategic Environmental Assessment of the fish and shellfish resources with respect to proposed offshore wind farms in the eastern Irish Sea.

Lum-Kong, A., Pierce, G. J., & Yau, C. (1992). Timing of spawning and recruitment in Loligo forbesi (Cephalopoda: Loliginidae) in Scottish waters. Journal of the Marine Biological Association of the United Kingdom, 72(2), 301-311.

Lundy, M., McCorriston, P., McCausland, I., Erskine, K., Lilley, K., Heaney, J., McArdle, J., Buick, A., Graham, J., Reeve, C. and Doyle, J. (2019) Western Irish Sea Nephrops Grounds (FU15) 2019 UWTV Survey Report and Catch options for 2020. Agri-Food and Bioscience Instititute (AFBI), the Marine Institute and Centre for Environment, Fisheries and Aquaculture Science (Cefas). 22pp.

Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

Malcolm, I., Godfrey, J. and Youngson, A. (2010) Review of migratory routes and behaviour of Atlantic salmon, Sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables. Scottish Marine and Freshwater Science Volume 1 No 14, Marine Scotland Science.

Marine Institute (2005) Irish Sea Cod (Division VIIa). Fisheries Science Service. 7pp.

Marine Institute & Bord Iascaigh Mhara (2020). Shellfish Stocks and Fisheries Review 2019: An assessment of selected stocks. Marine Institute.

Marine Institute & Bord Iascaigh Mhara (2019). Shellfish Stocks and Fisheries Review 2018: An assessment of selected stocks. Marine Institute.

Marine Stewardship Council (2020) Irish squid trawl fishery pre-assessment report, Accessed Feb 2023 , Available at: https://www.cephsandchefs.com/wp-content/uploads/2020/04/Irish-squid-fishery-MSC-pre-assessment-FINAL.pdf

Matson, R., Delanty, K., Gordon, P., O'Briain, R., McCarthy, E., Cierpal, D., Connor, L., Corcoran, W., Coyne, J., McLoone, P., Morrisey-McCaffrey, E., Brett, T., Gavin, A and Kelly, F.L., (2019a) Sampling Fish in Rivers 2018 - Fane, Factsheet No. 3. National Research Survey Programme. Inland Fisheries Ireland.

Matson, R., Delanty, K., Gordon, P., O'Briain, R., McCarthy, E., Cierpal, D., Connor, L., Corcoran, W., Coyne, J., McLoone, P., Morrisey-McCaffrey, E., Brett, T., Gavin, A and Kelly, F.L., (2019b) Sampling Fish in Rivers 2018 - Flurry, Factsheet No. 4. National Research Survey Programme. Inland Fisheries Ireland.

MESL (2008) Marine Macrofauna Genus Trait Handbook, Marine Ecological Surveys Limited, Bath.

McIntyre, R., Lawler, A. and Masefield, R. (2015) Size of maturity of the common whelk, *Buccinum undatum*: Is the minimum landing size in England too low? Fisheries Research 162: 53-57 http://doi.org/10.1016/j.fishres.2014.10.003

Mellet, C., *et al*. (2015). Geology of the seabed and shallow subsurface: The Irish Sea. British Geological Survey Commissioned Report, CR/15/057, British Geological Survey (BGS) 52.

NatureScot. (2022). Lamprey. Available online: https://www.nature.scot/plants-animals-and-fungi/fish/freshwater-fish/lamprey. Accessed 10 October 2022.

NPWS (2017a). NATURA 2000 - Standard Data Form. Site: IE0000781. Site Name: Slaney River Valley SAC

NPWS (2017b) Margaritifera sensitive areas map, Version 8, May 2017. https://www.npws.ie/maps-and-data/habitat-and-species-data

Ó Maoiléidigh, N., White, J., Hansen, L. P., Jacobsen, J. A., Potter, T., Russell, I., Reddin, D., *et al*. (2018). Fifty years of marine tag recoveries from Atlantic salmon. ICES Cooperative Research Report No. 343. 121 pp. http://doi.org/10.17895/ices.pub.4542

Oriel Windfarm Limited (2007). Oriel Windfarm Limited Offshore Wind Farm Environmental Impact Statement, Main EIS, Volume 2 of 3. Aqua-Fact International Sevices Ltd. On behalf of Oriel Windfarm Ltd. January 2007.

O'Sullivan, D, O'Keeffe, E, Berry, A, Tully, O and Clarke, M (2013) An Inventory of Irish Herring Spawning Grounds. Irish Fisheries Bulletin No 42. 2013. The Marine Institute.

Parker-Humphreys, M. 2004. Distribution and relative abundance of demersal fishes from beam trawl surveys in the Irish Sea (ICES Division VIIa) 1993–2001. Science Series Technical Report, Cefas, Lowestoft, 120, 68 pp

Picton, B.E. & Morrow, C.C. (2016). *Solea solea* (Linnaeus, 1758). [In] Encyclopedia of Marine Life of Britain and Ireland. http://www.habitas.org.uk/marinelife/species.asp?item=ZG9290 Accessed on 2019-09-18

Pierce, G. J., Boyle, P. R., Hastie, L. C., and Key, L. (1994). The life history of Loligo forbesi (Cephalopoda: Loliginidae) in Scottish waters. Fisheries Research, 21(1-2), 17-41.

Reeve, A. 2008. Lophius piscatorius Angler fish. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 09-12-2019]. Available from: https://www.marlin.ac.uk/species/detail/2123

Roden, C. & R. Ludgate. 2003. A report on fishing in the waters between Carlingford and Clogher Head based on published data. Report prepared for Airtricity. pp. 33

Rogers, S., and Stocks, R. 2001. North Sea Fish and Fisheries. Strategic Environmental Assessment - SEA2 Technical Report 003 - Fish & Fisheries Written by Cefas. Data supplied by FRS.

Ruiz, A. 2007. Pleuronectes platessa Plaice. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 09-12-2019]. Available from: https://www.marlin.ac.uk/species/detail/2172

Sandlund, O. T., Diserud, O. H., Poole, R., Bergesen, K., Dillane, M., Rogan, G. & Vøllestad, L. A. (2017). Timing and pattern of annual silver eel migration in two European watersheds are determined by similar cues. Ecology and evolution, 7(15), 5956-5966.

Scherer, C., Gowen, R. J., & Tett, P. (2016). Assessing the State of the Pelagic Habitat: A Case Study of Plankton and Its Environment in the Western Irish Sea. Frontiers in Marine Science, 3, 236.

SFPA (2019). 2019 List of Classified LBM production Areas in Ireland. Available online: https://www.sfpa.ie/Search/resource/1989. Sea=Fisheries Protection Authority.

Skinner, A., Young, M. and Hastie, L. (2003) Ecology of the Freshwater Pearl Mussel. Conserving Natura 2000 Rivers. Ecology Series No. 2. English Nature, Peterborough.

SNH (2017). Atlantic Salmon. Scottish Natural Heritage. Available online: https://www.nature.scot/plants-animals-and-fungi/fish/freshwater-fish/atlantic-salmon.

Tesch, F. W. (1980). Occurrence of eel *Anguilla anguilla* larvae west of the European continental shelf, 1971–1977. Environmental Biology of Fishes, 5(3): 185-190.

Tesch, F. W. (1989). Changes in swimming depth and direction of silver eels (*Anguilla anguilla L*.) from the continental shelf to the deep sea. Aquatic Living Resources, 2(1): 9-20.

Thorpe, J. E., Mangel, M., Metcalfe, N. B. & Huntingford, F. A. (1998). Modelling the proximate basis of salmonid life-history variation, with application to Atlantic salmon, Salmo salar L. Evolutionary Ecology 12, 581–599.

Thorstad, E. B., Uglem, I., Finstad, B., Chittenden, C. M., Nilsen, R., Økland, F. & Bjørn, P.-A. (2012). Stocking location and predation by marine fishes affect survival of hatchery-reared Atlantic salmon smolts. Fisheries Management and Ecology.

Thorstad, E.B., Uglem, I., Arechavala-Lopez, P., Økland, F. and Finstad, B. (2011). Low survival of hatchery-released Atlantic salmon smolts during initial river and fjord migration. Boreal Environment Research, 16: 115–120

Tully, O. (2017) Atlas of Commercial Fisheries for Shellfish around Ireland, Marine Institute, March 2017. ISBN 9781902895611 58pp. Available online at: http://inshoreforums.ie/wp-content/uploads/2016/06/Shellfish-Atlas-Printed.pdf

Turtle, Z. (2014) Determination of the Abundance and Population Structure of *Buccinum undatum* in North Wales. Thesis in support of MSc Marine Environmental Protection with the Scool of Ocean Sciences, Bangor University. 66pp. Available online at: http://fisheries-conservation.bangor.ac.uk/wales/documents/Turtleredactedthesis.pdf

Van Deurs M, van Hal R, Tomczak MT, Jónasdóttir SH, Dolmer P (2009) Recruitment of lesser sandeel *Ammodytes marinus* in relation to density dependence and zooplankton composition. Mar Ecol Prog Ser 381:249-258. https://doi.org/10.3354/meps07960

Went, A. E. J. and M. Kennedy (1976). List of Irish Sea Fishes. Dublin, Stationary Office.

Wheeler, A. (1992). A list of the common and scientific names of fishes of the British Isles. Journal of Fish Biology, 41 (Suppl. A).

Wheeler, A., Merrett, N.R. and Quigley, D.T.G. (2004). Additional records and notes for Wheeler's (1992) List of the Common and Scientific Names of Fishes of the British Isles. Journal of Fish Biology, 65.