Natura Impact Statement

NISA

North Irish Sea Array

Volume 2: Appendices

Appendix 21

Fish and Shellfish Ecology Baseline Characterisation

North Irish Sea Array Wind Farm Ltd

Fish and Shellfish Ecology Baseline Characterisation

North Irish Sea Array Offshore Wind Farm

Revision	Date	Status	Author:	Checked by:	Approved by:
1.0	Nov2023	Draft 1 Issue to Client	SP/AL	AL	GJ
2.0	Apr2024	Draft 2 Issue to Client	SP	CC	
3.0	May2024	Final	SP	CC	

Contents

Figures

Tables

Acronyms

Term	Definition
AEPM	Annual Egg Production Method
BEIS	Department for Business, Energy and Industrial Strategy
BTS	Beam Trawl Survey
CFP	Common Fisheries Policy
CIEEM	Chartered Institute of Ecology and Environmental Management
CMS	Convention on Migratory Species
CO	Conservation Objective
CPUE	Catch Per Unit Effort
cSPA	Candidate Special Protection Area
CSTP	Celtic Sea Trout Project
DAS	Digital Aerial Survey
dB	Decibel
DCCAE	Department of Communications, Climate Action and Environment
DCENR	Department of Communications, Energy and Natural Resources
DDV	Drop Down Video
ECC	Export Cable Corridor
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMF	Electro-Magnetic Fields
EMODnet	European Marine Observation and Data Network
EPA	Environmental Protection Agency
EU	European Union
F_{MSY}	Fishing mortality consistent with achieving Maximum Sustainable Yield
FU	Functional Unit
GES	Good Environmental Status
GIS	Geographic Information System
HWM	High-water mark
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Sea

IFI	Inland Fisheries Ireland
INFOMAR	Integrated Mapping for the Sustainable Development of Ireland's Marine Resource
ISMA	Irish Sea Marine Assessment
IUCN	International Union for the Conservation of Nature
MAC	Maritime Area Consent
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSY	Maximum Sustainable Yield
NIGFS	Northern Irish Ground Fish Survey
NINEL	Northern Irish Northeastern Larvae Survey
NISA	North Irish Sea Array
OREDP	Offshore Renewable Energy Development Plan
OSP	Offshore Substation Platform
OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
OWF	Offshore Wind Farm
PSA	Particle Size Analysis
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SEL	Sound Exposure Level
SPA	Special Protection Area
SPUE	Sightings Per Unit Effort
SSB	Spawning-stock biomass
SSC	Suspended Sediment Concentration
TTS	Temporary Threshold Shift
VER	Valued Ecological Receptor
WFD	Water Framework Directive
WTG	Wind Turbine Generator
ZoI	Zone of Influence

1 Introduction

1.1 Project Background

1.1.1 This document has been prepared by GoBe Consultants Limited (GoBe) on behalf of North Irish Sea Array Windfarm Limited (the Developer).

1.1.2 The North Irish Sea Array (hereafter 'NISA') Offshore Wind Farm (OWF) is an offshore wind energy project being proposed off the coast of counties Dublin, Meath and Louth, bringing with it an opportunity to significantly contribute to the development of a clean, renewable energy future for the region The proposed development will consist of a combination of offshore infrastructure and onshore infrastructure, and other supporting infrastructure and ancillary works.

1.1.3 The boundary between onshore and offshore infrastructure is the high-water mark (HWM) as defined by Ordnance Survey Ireland mapping. The offshore infrastructure is located within the proposed development boundary below the HWM, from the landfall to the furthest extent of the array area covering an area of approximately 125 km^2 referred to as the 'offshore development area'.

1.1.4 The offshore development area comprises the array area, where the following infrastructure will be located:

- Offshore Wind Turbine Generators (WTGs);
- Offshore Substation Platform (OSP);
- Seabed foundations (for WTGs and OSP); and
- Inter-Array cables.

1.1.5 The offshore development also includes the Offshore Export Cable Corridor (ECC), where the offshore electrical infrastructure, consisting of two export cables, will be routed from the OSP to landfall. In addition, the offshore infrastructure consists of the transition of the two offshore export cables coming ashore to the onshore export cables at the transition joint bays.

1.2 Report Aim

1.2.1 The aim of this document is to characterise the baseline environment for fish (benthic, pelagic and elasmobranch species), shellfish (molluscs and crustaceans), and marine turtle receptors within the proposed offshore development area and potential Zones of Influence (ZoIs) (as defined in **Section 2.2**), for the purposes of informing the Environmental Impact Assessment (EIA). These findings are used to determine those receptors which are of relevance to the assessment of potential impacts from the proposed development within Volume 3, Chapter 13: Fish and Shellfish Ecology. For ease of reference, all receptors considered in this report are collectively referred to as fish and shellfish receptors.

1.2.2 As fish and shellfish receptors rely on and interact with habitats and species, this document should be read alongside the following documents included within the Environmental Impact Assessment Report (EIAR):

- Volume 3, Chapter 10: Marine Geology, Oceanography and Physical Processes (hereafter referred to as the Physical Processes Chapter) for an overview on the surficial sediment properties, suspended sediments and seabed features;
- Volume 3, Chapter 11: Marine Water and Sediment Quality (hereafter referred to as the Marine Water and Sediment Quality Chapter) for a review of the marine water and sediment quality of the receiving environment;
- Volume 3, Chapter 12: Benthic Subtidal and Intertidal Ecology (hereafter referred to as the Marine Water and Sediment Quality Chapter) for an overview of the benthic subtidal and intertidal habitats and communities of the receiving environment;
- Volume 3, Chapter 16: Commercial Fisheries (hereafter referred to as the Commercial Fisheries Chapter) for an overview of the commercial fisheries fleets that operate within and adjacent to the proposed development; and
- Volume 9, Appendix 16.1: Commercial Fisheries Technical Report (hereafter referred to as the Commercial Fisheries Technical Baseline) for a detailed description of the commercial fisheries fleets that operate within and adjacent to the proposed development.

1.3 Report Structure

1.3.1 The report is structured as follows:

- Section 1 (Introduction) introduces the report and outlines its aims;
- Section 2 (Methodology) presents the methodology and data sources applied to characterise the baseline environment;
- Section 3 (Baseline Environment) presents the characterisation of the existing environment for fish, shellfish and marine turtles;
- Section 4 (Future Receiving Environment) presents the characterisation of the future receiving environment;
- Section 5 (Conclusions) provides high-level conclusions from the findings of this report; and
- Section 6 (References) provides the bibliography for the data sources, scientific papers and information reviewed within this report.

2 Methodology

2.1 Approach

2.1.1 This report establishes the baseline of the existing environment as it relates to fish and shellfish ecology. In accordance with requirements of the Environmental Protection Agency (EPA) Guideline (EPA, 2022), the gathering of baseline data has been undertaken by the collection and analysis of information, specifically in relation to the following aspects:

- Fish and elasmobranch spawning and nursery grounds;
- Important fish and shellfish feeding and overwintering grounds;
- Species of conservation importance;
- Species of commercial and recreational importance;
- Diadromous species that may migrate through the study area; and
- Species potentially sensitive to specific impacts of offshore wind farm developments, for example elasmobranch species that are known to be sensitive to Electro-Magnetic Fields (EMF) generated by subsea electricity cables, fish species considered to be hearing specialists that may be affected by noise resulting from the offshore wind farm development process, or species that spawn on the seabed that may be sensitive to habitat disturbance or loss as a result of the proposed development.

2.2 Fish and Shellfish Study Area

2.2.1 The fish and shellfish study area was initially identified at the proposed development scoping stage, in line with Department of Communications, Climate Action and Environment (DCCAE) Guidance (DCCAE, 2017). The extent of the study area for the fish and shellfish ecology assessment has been defined to capture the greatest extent of potential direct and indirect effects on fish and shellfish receptors. The study area incorporates the offshore development area and the surrounding ZoIs (**Figure 2-1**). The actual extent of the ZoI will vary according to the nature of the impact being studied. For the proposed development, the ZoIs to assess effects on fish and shellfish receptors have been defined by the following spatial scales:

- For impacts related to seabed disturbance events that extend beyond the direct footprint of an activity, a sedimentary ZoI of 12 km buffering the offshore development area has been applied. The extent of this ZoI has been determined by reference to the modelled maximum spread of sediment plumes that may locally elevate background levels of turbidity. Site-specific plume dispersal modelling predicts that suspended sediments at concentrations above background levels may be displaced up to about 12 km from the point of release (Physical Processes Chapter). The 12 km buffer zone has been set with reference to these modelled plume dispersal distances, resulting in a ZoI that is likely to cover the maximum extent over which suspended sediment concentrations (SSC) above natural background concentrations might occur.

- An additional ZoI of 70 km buffering the offshore development area was defined for underwater noise effects on fish and shellfish receptors, based on predictions that underwater noise may have a larger effect range than that associated with sedimentary impacts. The extent of this underwater noise ZoI has been set to fully encapsulate site-specific modelled maximum impact ranges for the 186 dB re 1µPa^{2}s Sound Exposure Level (SEL) during pile driving when applied to static receptors. The 186 dB re 1µPa^{2}s SEL represents the recommended threshold for the onset of temporary threshold shifts (TTS) in hearing of sensitive fish receptors (Popper et al., 2014). Fish were previously assumed to flee noise stimuli at a rate of 1.5 ms^{-1}; however, recent UK OWF projects have been advised to also consider stationary receptor modelling for some species groups. For example, the recent Thanet Extension OWF EIA concluded that the 186 dB noise contour could extend up to 3.09 km (Vattenfall, 2018) for the most sensitive fleeing receptors but up to 15.95 km (Vattenfall, 2019) when these species are considered as static receptors. For the proposed development, the modelled maximum impact range for the onset off TTS (186 dB noise contour) for static receptors was 69 km (Volume 3, Chapter 13: Fish and Shellfish Ecology). Therefore, a precautionary ZoI for underwater noise has been set at 70 km around the offshore development area.

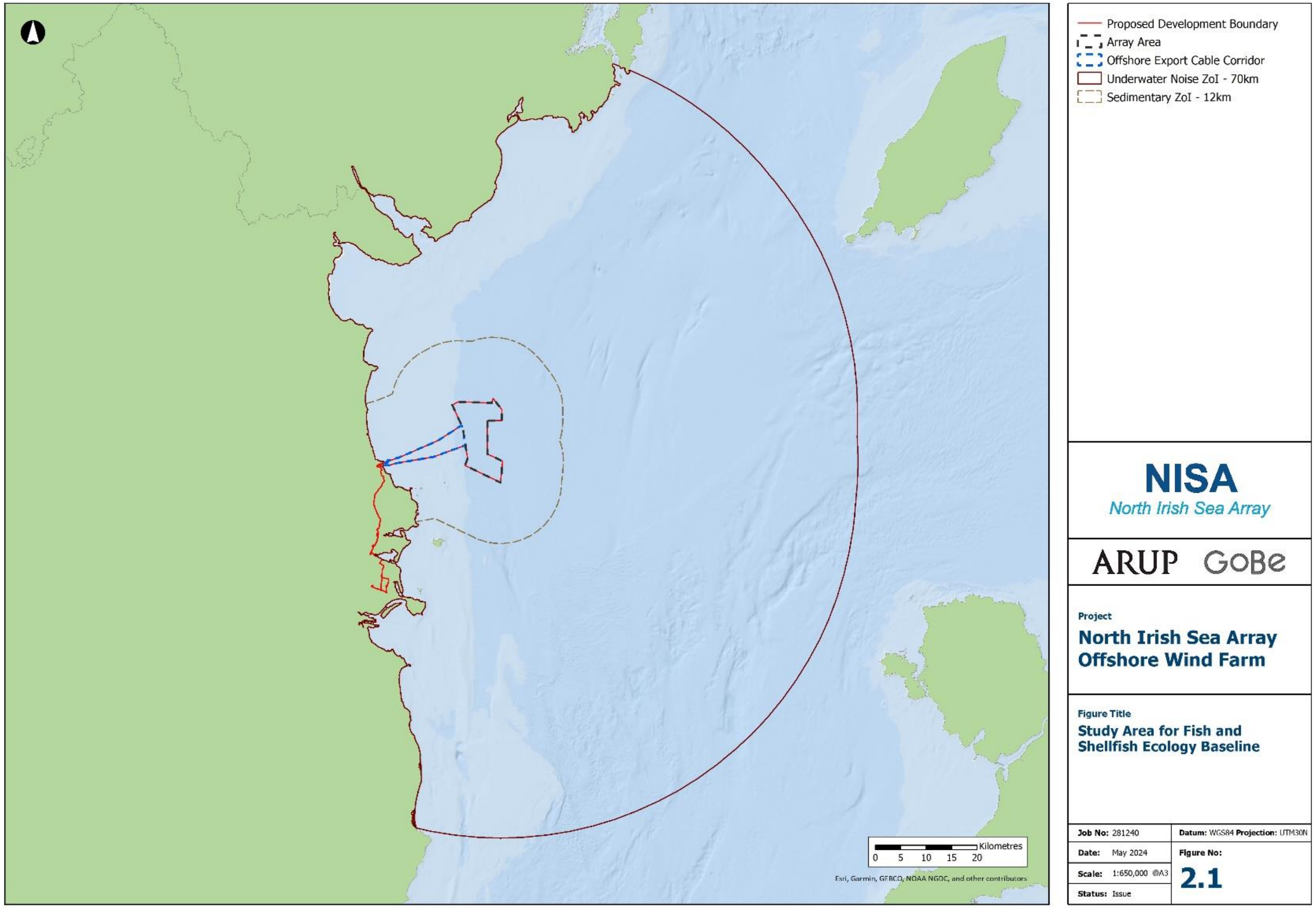

Figure 2-1: Study Area for Fish and Shellfish Ecology Baseline.

2.3 Data Sources

Baseline Data Review

2.3.1 A detailed desktop review has been carried out to inform the baseline characterisation of fish and shellfish resources within the study area. The characterisation draws on regional fisheries datasets, scientific literature, monitoring data, and industry-specific survey data collected for infrastructure projects within the region. In addition, survey data collected during the site-specific benthic ecology baseline surveys were used to complement the characterisation. Information was sought on fish and shellfish ecology in general, and on spawning and nursery behaviour and habitats for key species.

2.3.2 The data and information sources used to establish the fish and shellfish baseline are listed in **Table 2-1** below alongside their temporal and spatial extents in the context of the proposed development. These have provided coverage across large parts of the fish and shellfish study area and the wider region.

Table 2-1: Data sources used to inform the fish and shellfish baseline.

Data Source	Type of Data	Temporal and Spatial Coverage
Site- Specific Surveys		
Natural Power, 2023. NISA Benthic Ecology Baseline: Cable Route Benthic Survey Report.	Grab samples collected 28th September to 1st October 2022 at 30 stations using a 0.1m^2 Day grab. All samples were subject to faunal and Particle Size Analysis (PSA). Drop Down Video (DDV) transects were conducted at 30 stations with samples subject to both still and video analysis.	Coverage of the proposed development ECC.
Natural Power, 2022. NISA Benthic Ecology Baseline: Array Area Survey Report.	Grab samples collected 1st to 4th May 2022 at 40 stations using a 0.1m^2 Day grab. All samples were subject to faunal and PSA. DDV transects were conducted at 20 stations with samples subject to both stills and video analysis.	Coverage of the proposed development array area.
Existing data sources		
Coull et al., 1998. Fisheries Sensitivity Maps in British Waters.	Spawning and nursery ground data of commercially important fish species.	Spawning seasonality presented, 1991-1996. Covers UK and Irish waters.
Ellis et al., 2010. Mapping spawning and nursery areas of species considered in Marine Protected Areas (MPAs).	Spawning and nursery ground data of selected fish and elasmobranch species.	Spawning seasonality presented, 1998-2008. Covers UK and Irish waters.

Data Source	Type of Data	Temporal and Spatial Coverage
Ellis et al., 2012. Spawning and nursery grounds of selected fish species in UK waters.	Spawning and nursery ground data of selected fish and elasmobranch species.	Spawning seasonality presented, 1998-2008. Covers UK and Irish waters.
Marine Institute, 2016. Species spawning and nursery areas - Ireland's Marine Atlas.	Data layers for spawning and nursery grounds of common commercially important fish species in the area.	Covers the entire study area.
Marine Institute, 2009. Irish Sea Marine Assessment (ISMA) (2009) Survey CV0926.	Integrated seabed and sub-seabed mapping of the Irish Sea, with specific focus on the Codling Deep, Lambay Area, Rockabill Area and the Northern Mud Belt.	2009. Covers the Northern Mudbelt, and Rockabill Areas, which overlap with the study area.
Integrated Mapping for the Sustainable Development of Ireland's Marine Resources (INFOMAR), 2023. PSA data.	A joint project between the Marine Institute and Geological Survey of Ireland creating integrated seabed mapping products using multibeam echosounder and seabed survey data. PSA dataset used to determine the presence of suitable spawning substrates for herring and sandeel.	Broadscale habitat data collected across the Irish Sea from 2006 onwards.
EUSeaMap, 2021. European Marine Observation and Data Network (EMODnet) Broad-scale seabed habitat map of Europe.	Predictive seabed habitat map used to describe seabed substratum types and benthic habitats present in the study area.	Latest data from 2021. Coverage of the entire study area.
Cefas, 2000. Irish Sea Annual Egg Production Method (AEPM) Plankton Survey.	Abundance and distribution data of fish eggs, larvae and zooplankton.	Data collected in 2000 during the spawning seasons of target species across the Irish Sea.
ICES, 2023a. Northern Irish Ground Fish Survey (NIGFS) (2012-2022).	Annual otter trawl surveys undertaken from 1992 onwards to monitor the distribution of ground fish in the Irish Sea.	2012-2022. ICES statistical rectangles 36E3, 36E4, 35E3, 35E4, 37E3, and 37E4.
ICES, 2023b. Offshore Beam Trawl Survey (BTS) (2012-2022).	Annual beam trawl surveys to monitor the distribution of commercially important flatfish in the Irish Sea	2012-2022. ICES statistical rectangles 36E3, 36E4, 35E3, 35E4, 37E3, and 37E4.
Marine Institute, 2023. The Stock Book 2023: Annual Review of Fish Stocks in 2023 with Management Advice for 2024.	Distribution data on commercially exploited fish stocks of interest to Ireland.	2023. Irish Waters.
Marine Institute and Bord Iascaigh Mhara, 2024. Shellfish	An assessment of selected shellfish stocks within the Irish Sea.	2023. Irish waters.

Data Source	Type of Data	Temporal and Spatial Coverage
Stocks and Fisheries Review 2023.		
Gerritsen and Kelly, 2019. Atlas of Commercial Fisheries around Ireland.	The atlas reviews the fishing activity of commercial fish stocks of relevance to Ireland.	Published 2019. Irish waters.
Tully, 2017. Atlas of Commercial Fisheries for Shellfish around Ireland.	The atlas reviews the shellfish fishing activity within Irish inshore and territorial waters.	Published 2017. Irish waters.
Celtic Sea Trout Project (CSTP), 2016.	Status, distribution and ecology of sea trout populations in the Irish Sea.	2010-2012. Waters around Ireland and western Britain within Irish Sea.
O'Sullivan et al., 2013. An Inventory of Irish Spawning Herring Grounds.	An inventory of key herring spawning and fishing grounds around the coast of Ireland.	2013. Irish waters.
King et al., 2011. Ireland Red List No. 5: Amphibians, Reptiles and Freshwater Fish.	Details most up-to-date list of amphibians, reptiles and freshwater fish native and non-native to Ireland, listed from least concern to extinct.	2011. Coverage of the entire study area.
Clarke et al., 2016. Ireland Red List No. 11: Cartilaginous fish (sharks, skates, rays and chimaeras).	Details most up-to-date list of cartilaginous fish native and non-native to Ireland, listed from least concern to extinct.	2016. Coverage of the entire study area.
Inland Fisheries Ireland (IFI) publications on the status of migrating fish populations, 2018-2023.	Findings of monitoring programmes designed to assess the status of fish populations in river catchments throughout Ireland. Used to establish the baseline for migrating fish species.	2018-2023. Coverage of Irish rivers, some of which flow into the study area.
Marine Institute, 2013. Article 6 Assessment of Fisheries, including a Fishery Natura Plan for Seed Mussel (2013-2017), in the Irish Sea.	Assessment of the potential ecological impact of fishing activity on Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) in the Irish Sea.	2013-2017. Includes SACs located near to the proposed development study area.
ICES, 2022a. ICES Ecosystem Overviews. Celtic Seas ecoregion - Ecosystem Overview.	Overview of the state of the ecosystem in the Celtic Seas ecoregion.	2022. Irish waters.
ICES, 2022b. ICES Fisheries Overviews. Celtic Seas ecoregion - fisheries overview.	Overview of all common commercially important fish and shellfish in the region.	2022. Irish waters.
Aquatic Services Unit, 2020. Dublin Port Maintenance Dredging 2022 - 2029 Benthic and Fisheries Assessment.	Trawls undertaken in 2020 within Dublin Bay, to build the fish baseline for the Dublin	2020, Dublin Bay

Data Source	Type of Data	Temporal and Spatial Coverage
	Port Maintenance Dredging project.	
Saorgus Energy Limited, 2013. Dublin Array An Offshore Wind Farm on the Kish and Bray Banks. Environmental Impact Statement.	Environmental Impact Statement for the Dublin Array OWF including data on the fish and shellfish species recorded during site-specific trawl and dredge surveys at the Kish and Bray sandbanks.	2004 and 2008. Coverage of Kish and Bray sandbanks.
Department of Communications, Energy and Natural Resources (DCENR), 2010. Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREDP) in the Republic of Ireland: Environmental Report Volume 2: Main Report and Appendix F - Commercial Fisheries in Environmental Report Volume 4: Appendices .	Baseline of fish and shellfish across Irish waters with spawning and nursery grounds of key species.	Published 2010. All Irish waters.
Department of the Environment, Climate and Communications, 2023. Draft OREDP II: Draft SEA Report and Appendix 3 - Updated Baseline Summary Report.	Baseline of fish and shellfish across Irish waters with spawning and nursery grounds of key species.	Draft published 2023. All Irish waters.

Regional and local datasets

2.3.3 The overview of fish and shellfish species present within the study area is largely based on data collected during International Bottom Trawl Surveys (IBTS) and site surveys conducted to inform project specific EIAs. These data are further supplemented by information from monitoring reports and published research. Species of commercial importance were identified through reference to the Commercial Fisheries Technical Baseline.

2.3.4 Regional IBTS datasets used to inform the baseline were:

- **Northern Ireland Groundfish Survey (NIGFS) data:** To identify common fish and elasmobranch species within the wider western Irish Sea region, data collected during the NIGFS were sourced from the DATRAS (Database of Trawl Surveys) data portal (ICES, 2023a). The NIGFS is part of the IBTS programme coordinated by ICES, which aims to collect data on the size, abundance, and distribution of juvenile and adult ground fish. Surveys in the Irish Sea have been carried out bi-annually since 1992 using a Rock Hopper otter trawl (ICES, 2017). Sampling stations are stratified by water depth and seabed type. Data were obtained for the years 2012-2022 covering ICES statistical rectangles 36E3 and 36E4 to characterise assemblages within the array area, ECC and adjacent areas of the ZoIs as well as ICES rectangles 35E3, 35E4, 37E3 and 37E4 to obtain data for fish assemblages for the outer sections of the ZoIs (**Figure 2-2**).
- **Beam Trawl Survey (BTS) data:** Offshore beam trawl surveys are carried out annually in the Irish Sea as part of the IBTS programme to provide time-series data for the monitoring of commercial flatfish species (de Boois et al., 2023). Samples are collected in September of each year using a 4 m commercial beam trawl. Sampling follows a fixed station design with positions primarily chosen in areas fished for European plaice (*Pleuronectes platessa*) and various species of sole (Soleidae) (de Boois et al., 2023). As for the NIGFS data, survey data were downloaded for ICES rectangles 36E3, 36E4, 35E5, 35E4, 37E3 and 37E4 covering the years 2012-2022 (ICES, 2023b; **Figure 2-2**).

2.3.5 In addition to the regional ICES data, the following data from monitoring and characterisation surveys overlapping the study area were reviewed:

- **Dublin Port Maintenance Dredging data:** To inform the application for ongoing maintenance dredging of the Dublin shipping channel biological surveys covering Dublin port and Dublin Bay were conducted in 2020 (Aquatic Services Unit, 2020). The surveys included Drop Down Videos (DDVs) and beam trawls to assess the distribution of epibenthic invertebrates and demersal fish.
- **Dublin Array site-specific survey data:** Data from trawl and dredge surveys conducted over the Bray and Kish sandbanks to inform the first application for the Dublin Array OWF (Saorgus Energy Limited, 2013) were reviewed to complement the baseline characterisation.

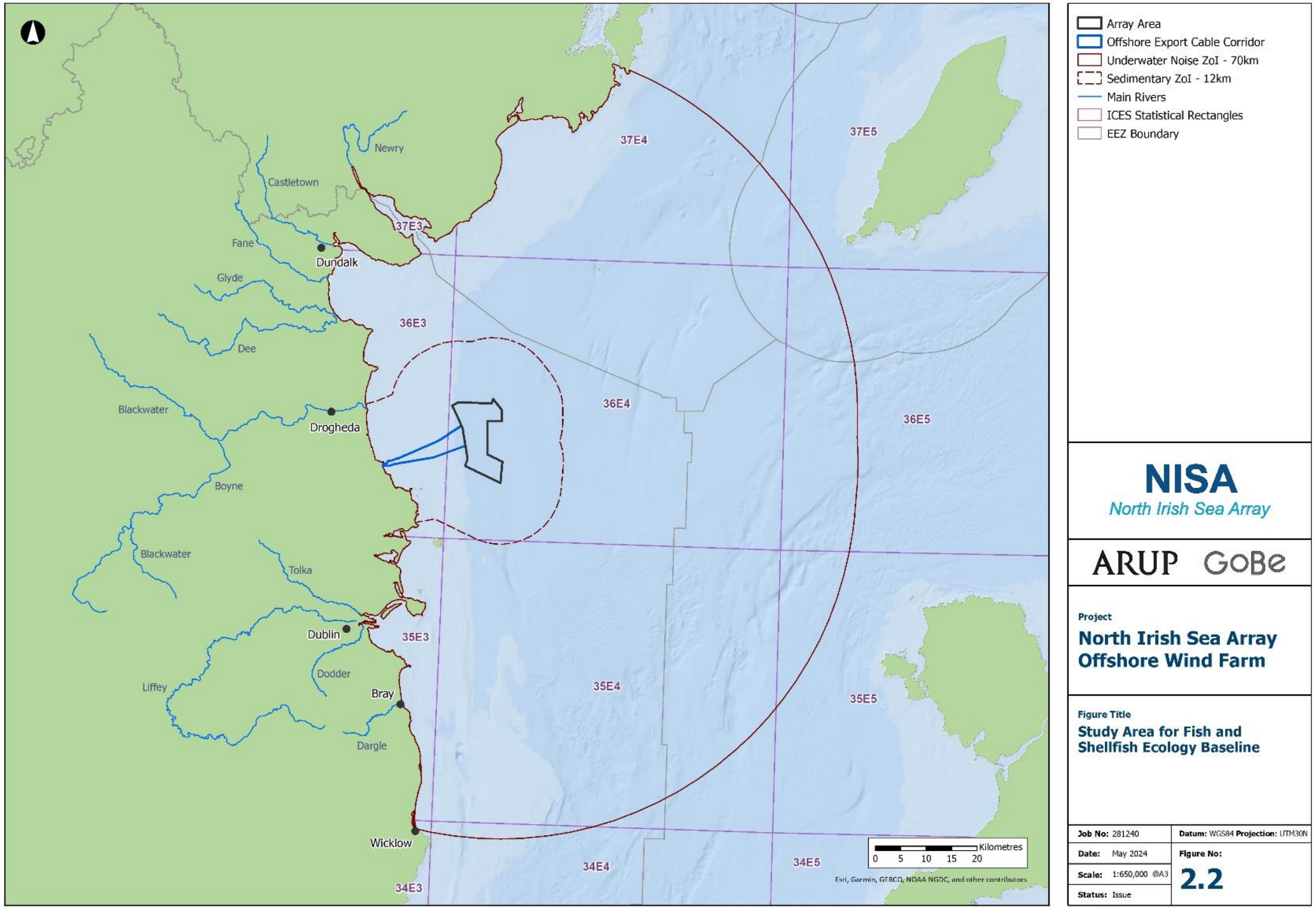

Figure 2-2: Study Area for Fish and Shellfish Ecology Baseline.

Site-specific surveys

2.3.6 Site-specific benthic ecology characterisation surveys were conducted across the array area in May 2022 (Natural Power, 2022) and within the ECC in September and October 2022 (Natural Power, 2023). These surveys were carried out to characterise the benthic subtidal environment within the offshore development area, and to identify the occurrence and distribution of any benthic habitats or species of conservation importance. The surveys included the collection of DDVs to characterise epibenthic assemblages and benthic grabs to describe the infaunal communities and to analyse the physical nature of the seafloor. Records of fish and shellfish obtained during these surveys were used to complement the fish and shellfish baseline characterisation. Particle Size Analysis (PSA) data collected during the grab surveys were used to identify seabed areas with the potential to support sandeel *Ammodytes* spp. and herring *Clupea harengus* spawning.

Spawning and nursery grounds data analysis

2.3.7 An overview of the methodology adopted to identify fish and shellfish spawning and nursery grounds overlapping the study area is provided below. Due to the demersal spawning nature of sandeel and herring, and therefore their increased sensitivity to potential impacts from the proposed development, these species are being addressed separately.

Spawning and nursery ground data analysis

2.3.8 Data to identify spawning and nursery grounds within and adjacent to the fish and shellfish study area were sourced from Coull et al. (1998), Ellis et al. (2010, 2012), and Ireland's Marine Atlas (Marine Institute, 2016). Additional data sourced from the Irish Sea Annual Egg Production Method (AEPM) Plankton Survey (Cefas, 2000) were used to ground-truth the Coull et al. (1998) and Ellis et al. (2010, 2012) datasets.

2.3.9 The Coull et al. (1998) dataset shows spawning and nursery grounds for commercially important fish species in waters surrounding the UK and Ireland. Ellis et al. (2010, 2012) provides an update to these maps and extends the identification of spawning and nursery locations to ecologically important species, including elasmobranchs. Spawning and nursery areas are categorised by Ellis et al. (2010) as either 'high' or 'low' intensity dependent on the level of spawning activity or presence of juveniles recorded in these areas. Coull et al. (1998) does not always provide this level of detail, although they define more refined areas of potential spawning and nursery grounds.

2.3.10 Spawning and nursery ground locations overlapping with the study area as identified in Coull et al. (1998), Ellis et al. (2010, 2012) and Ireland's Marine Atlas (Marine Institute, 2016) are summarised in **Section 3.2** of this report. Information on potential spawning and nursery grounds of fish and shellfish species not considered by these studies is, where available, included within the respective species descriptions provided in **Sections 3.4** to **3.7**.

Larval data analysis

2.3.11 AEPM data were downloaded from the Cefas Data Hub (Cefas, 2000) to provide the most recent available description of larval distribution for Atlantic cod *Gadus morhua*, whiting *Merlangius merlangus* and plaice in the Irish Sea. Point data for larval and egg counts were extracted for each species and used to create heat maps using Geographic Information Systems (GIS), following methodologies as described by Boyle and New (2018). A radius of approximately 10 km was used to amalgamate the point data and to allow sufficient overlap between the points, allowing the extrapolation of the data to provide heat maps covering the full AEPM survey area. The heat maps show spawning 'hot spots' for cod, whiting and plaice across the study area, thereby providing a data set to support the identification of active spawning grounds for these species. The heat map data are presented alongside the Coull et al. (1998) and Ellis et al. (2010, 2012) maps in **Section 3.2**.

Identification of potential sandeel and herring spawning areas

2.3.12 Site-specific PSA data collected within the array area and ECC during the benthic baseline characterisation surveys (Natural Power, 2022, 2023) were analysed to identify seabed substrates suitable to support sandeel and herring spawning. Additional PSA data collected across the ZoIs were sourced from Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR, 2023) to provide a more comprehensive cover of the fish and shellfish study area. The PSA data were processed in accordance with the methodologies described by Reach et al. (2013) and Latto et al. (2013). Both methodologies are widely accepted by the offshore industry sector and are now routinely used as an approved approach to support EIAs for offshore wind developments in UK waters.

2.3.13 The methodologies detailed by Reach et al. (2013) and Latto et al. (2013) divide seabed sediments into sediment preference categories for herring and sandeel, respectively, based on the proportions of silts, fine and coarse sands, and gravels in surficial sediments. The sediment preference categories are then used to define areas of the seabed with the potential to be used as spawning grounds by herring and sandeel, categorising seabed areas as either "preferred", "marginal" or "unsuitable" for spawning.

2.3.14 The substrate categories used to identify potential herring spawning grounds within the study area are shown in **Table 2-2**: Herring spawning habitat sediment classification (adapted from Reach et al., 2013).

Folk Class (Folk, 1954)	Habitat Sediment Preference	Habitat Sediment Classification
Gravel and part sandy Gravel (< 5% muds, > 50% gravel)	Prime	Preferred
Part sandy Gravel and part gravelly Sand (< 5% muds, > 25% gravel)	Sub-prime	Preferred
Part gravelly Sand (< 5% muds, > 10% gravel)	Suitable	Marginal
Everything excluding Gravel, sandy Gravel, and part gravelly Sand (> 5% muds, < 10% gravel)	Unsuitable	Unsuitable

2.3.15 Table 2-3, while the categories used for sandeel are listed in

2.3.16 **Table** 2-3. The results of the habitat suitability assessment are presented in **Section 3.2 (Spawning Grounds)**.

2.3.17 The sediment classification and habitat suitability categories derived from the PSA data are used as a proxy to indicate the location of potential spawning grounds for herring and sandeel within the fish and shellfish study area. However, it is important to note that the sediment composition is not the only parameter that defines potential spawning habitat. Other environmental (physical, chemical and biotic) parameters, such as sediment oxygenation, siltation rates, micro-scale seabed morphology and the distribution of spawning populations will also contribute to the suitability of seabed environments to be used as spawning grounds by herring and sandeel. As such the sediment categories assigned alone will over-represent the extent of seabed areas with the potential to support spawning events, therefore ensuring a precautionary approach to the assessment.

Table 2-2: Herring spawning habitat sediment classification (adapted from Reach et al., 2013).

Folk Class (Folk, 1954)	Habitat Sediment Preference	Habitat Sediment Classification
Gravel and part sandy Gravel (< 5% muds, > 50% gravel)	Prime	Preferred
Part sandy Gravel and part gravelly Sand (< 5% muds, > 25% gravel)	Sub-prime	Preferred
Part gravelly Sand (< 5% muds, > 10% gravel)	Suitable	Marginal
Everything excluding Gravel, sandy Gravel, and part gravelly Sand (> 5% muds, < 10% gravel)	Unsuitable	Unsuitable

Table 2-3: Sandeel spawning habitat sediment classification (adapted from Latto et al., 2013).

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

Data Limitations

2.3.18 Mobile species such as fish and elasmobranchs exhibit varying spatial and temporal patterns, and their distribution and standing stocks may vary considerably both seasonally and annually. Therefore, the data used to inform the baseline characterisation represent snapshots of the fish and shellfish assemblages within the study area at the time of sampling. Should species be absent from the surveys, the outcome is not then to exclude consideration of these species from the baseline characterisation. Rather, the baseline description draws upon wider scientific literature and available information, as this provides a more thorough, robust, and longer time-series evidence base, which therefore ensures a more comprehensive and precautionary baseline, identifying all species that are likely to be present within the study area.

2.3.19 Furthermore, the efficiency at collecting certain species will vary depending on the sampling gear deployed. For example, a semi-pelagic otter trawl would not collect pelagic species (e.g., herring and sprat *Sprattus sprattus*) as efficiently as a pelagic trawl. Likewise, a 2 m scientific beam trawl would not be as efficient at collecting sandeel and shellfish species as other methods used commercially in the study area (e.g., sandeel or shrimp trawls and shellfish traps). This limits the data utility in estimating relative abundances of species within the study area. To minimise this limitation caused by survey methodology, sensitive receptors were identified based on their presence or absence in surveys, rather than whether that species contributes more significantly to the fish or shellfish assemblage in the survey area.

2.3.20 Some uncertainties are also associated with the broad-scale data layers that were used to identify the locations of nursery and spawning grounds and associated spawning and pupping periods (Coull et al., 1998; Ellis et al., 2010, 2012). The maps produced by Coull et al. (1998) are based on historic data and, therefore, may not account for more recent changes in fish distributions and spawning behaviour available since its publication. The maps by Ellis et al. (2010, 2012) also face some limitations due to the often large spacing of sampling sites used for the annual international larval surveys, which is used as a key data source, consequently resulting in broader scale grids of spawning and nursery grounds than those presented by Coull et al. (1998). Nonetheless, the spatial extent of the mapped spawning grounds is considered to represent the widest known distribution within which spawning will occur, while the duration of spawning periods indicated in these studies is considered likely to represent the maximum duration of spawning (Coull et al., 1998). Therefore, these maps provide a precautionary basis for assessing impacts on spawning activity.

2.3.21 Active or particularly important spawning grounds for some species may be smaller in extent and spawning periods may be shorter than are indicated by the Coull et al. (1998) and Ellis et al. (2010) data. Therefore, where available, additional research publications and data were reviewed to provide the best, most contemporary and site-specific information. In addition, when considering demersal spawners that display substrate dependency (e.g., sandeel and herring), site-specific PSA data (Natural Power, 2022, 2023) were analysed to ground truth the Coull et al. (1998) and Ellis et al. (2010, 2012) datasets. In addition, EUSeaMap (EuSeaMap, 2021) broadscale marine habitat maps and PSA data from INFOMAR were used to support the identification of preferred sandeel spawning habitats. It should be acknowledged, however, that these predictive maps are limited by the broadscale nature of their underlying data and do not account for small-scale, localised differences in seabed sediments, unlike the data obtained from site-specific grab sampling. Nevertheless, it is important to review all available datasets to develop a clear overview of potential sandeel habitat. Together, the PSA data and broadscale habitat maps are intended to provide a proxy for the presence of sandeel habitat within the study area.

2.3.22 Despite the data limitations detailed , the data as listed in **Table 2-1** and referenced throughout the report are considered to provide a robust and sufficient evidence base to inform the fish and shellfish baseline characterisation and underpin the impact assessment process.

2.4 Nature Conservation

2.4.1 There are several existing legal instruments for the protection of fish and shellfish ecology in Ireland. The European Union (EU) Habitats (92/43/ECC) and Birds (79/409/EEC) Directives list habitats and species for strict protection and include provisions for the designation of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) to protect various features of interest. The Nature Directives are transposed into Irish law by the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011) and subsequent amendments. Ireland is also bound to the EU Water Framework Directive (WFD; 2000/60/EC), which provides for an evaluation of fish across lakes, rivers and transitional water bodies. The WFD also provides for specific provisions for the protection and improvement of freshwater environments capable of supporting salmonids including Atlantic salmon and trout, with important freshwater habitats designated as Salmonid waters. The EU's Marine Strategy Framework Directive (MSFD; 2008/56/EC) aims to achieve Good Environmental Status (GES) of the EU's marine waters. A key component of the MSFD is the designation of Marine Protected Areas (MPAs), which have a primary focus of nature conservation.

2.4.2 Other international commitments of which Ireland is a signatory include the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention, 1992)[1], which aims to protect marine biodiversity in the north-east Atlantic, and the Convention on the Conservation of Migratory Species of Wild Animals (CMS, also known as the Bonn Convention, 1979)[2], which aims to conserve migratory species throughout their range. The Bonn Convention requires signatories to conserve migratory species and their habitats by providing strict protection for endangered migratory species (Appendix I of the Convention) and also lists migratory species that would benefit from multilateral Agreements for conservation and management (Appendix II of the Convention). Commercial fisheries in the Irish Sea fall under the remit of the EU Commons Fisheries Policy (CFP)[3], which sets out management provisions for the conservation of commercially important fish species, ensuring the protection of fish stocks from fishing pressures.

2.4.3 At the national level, provisions for the protection and conservation of species and habitats are set out in the Wildlife Act (1976), the Wildlife (Amendment) Act (2000) and subsequent amendments. In addition, Red Lists for the Irish Sea have been developed in accordance with recommendations by the International Union for Conservation of Nature (IUCN), showing the risk of extinction of marine species in Irish waters including fish species (King et al., 2011) and elasmobranchs (Clarke et al., 2016).

2.4.4 The current conservation status of individual fish and shellfish species is discussed in the respective species descriptions provided in Sections 3.4 to 3.7 of this report. A summary of any species of conservation importance with the potential to occur within the study area is given in Section 3.8.

[1] https://www.ospar.org/convention
[2] https://www.cms.int/en/legalinstrument/cms
[3] https://oceans-and-fisheries.ec.europa.eu/policy/common-fisheries-policy-cfp_en

3 Baseline Environment

3.1 Fish and Shellfish Assemblages

3.1.1 The following section describes the fish and shellfish communities present within the study area (**Figure 2-1**). The baseline description of the study area draws on site-specific data collected within the array area and ECC, regional datasets as well as industry specific survey accounts and monitoring studies undertaken for existing or proposed infrastructure projects within the north-western Irish Sea.

3.1.2 The datasets provide a snapshot of the species composition across the northern extent of the western Irish Sea and within the study area. Therefore, the data presented are considered both spatially and temporally appropriate for the purposes of undertaking the EIAR.

Regional context

NIGFS and BTS data

3.1.3 Data collected during the NIGFS (ICES, 2023a) and offshore BTS (ICES, 2023b) between 2012 and 2022 suggest that the ground fish assemblages within the study area are dominated by whiting, haddock *Melanogrammus aeglefinus*, common dab *Limanda limanda*, and plaice. Other species caught in higher numbers were Norway pout *Trisopterus esmarkii*, grey gurnard *Eutrigla gurnardus*, common dragonet *Callionymus lyra*, poor cod *Trisopterus minutus*, Witch flounder *Glyptocephalus cynoglossus,* American plaice *Hippoglossoides platessoides*, sand gobies *Pomatoschistus*, and scaldfish *Arnoglossus laterna*. Species that were typically caught during the trawl surveys albeit in lower numbers included Atlantic cod, spotted dragonet *Callionymus maculatus*, the white anglerfish *Lophius piscatorius* and various species of sole.

3.1.4 The distribution of these species within the study area is likely to vary in response to a range of environmental factors such as substratum type, water depth and temperature.

3.1.5 The most abundant pelagic fish species caught during the NIGFS were Atlantic herring and European sprat followed by Atlantic mackerel *Scomber scombrus* and Atlantic horse mackerel *Trachurus trachurus*. These species undertake long migrations between winter feeding and summer spawning grounds.

3.1.6 Among the elasmobranch species recorded within the study area, small-spotted catshark *Scyliorhinus canicula* was typically the most abundant. Other elasmobranch species regularly recorded in these surveys were nursehound *Scyliorhinus stellaris*, spiny dogfish *Squalus acanthias*, starry smooth-hound *Mustelus asterias*, thornback ray *Raja clavata,* spotted ray *Raja montagui* and the cuckoo ray *Leucoraja naevus*. Species caught infrequently included tope *Galeorhinus galeus*, broadnose skate *Bathyraja brachyorops*, and the small-eyed ray *Raja microocellata*. The blonde ray *Raja brachyura* was relatively common within ICES rectangle 35E4 overlapping the ZoI to the south of the offshore development area but was only occasionally recorded within the remaining sections of the study area.

3.1.7 Decapod crustaceans and epibenthic molluscs commonly recorded in ICES rectangles 36E3 and 36E4 during the BTS include common whelk *Buccinum undatum*, king scallop *Pecten maxiumus*, queen scallop *Aequipecten opercularis*, brown crab *Cancer pagurus,* velvet crab *Necora puber*, angular crab *Goneplax rhomboides,* swimming crabs *Liocarcinus* spp., and the Norway lobster *Nephrops norvegicus* (hereafter referred to as *Nephrops*). Less regular recorded species included the long-clawed porcelain crab *Pisidia longicornis,* hermit crabs *Pagurus* spp., spider crabs *Inachus* spp., and shrimp species including the brown shrimp *Crangon crangon*.

Industry-specific surveys

3.1.8 Trawl samples from the Kish and Bray banks (Saorgus Energy Limited, 2013) recorded plaice, dab, lemon sole, whiting, thornback ray, grey gurnard, lesser weaver *Echiichthys vipera* and butterfish *Pholis gunnellus*. In addition, herring, two-spotted clingfish *Diplecogaster bimaculata,* lesser sandeel *Ammodytes tobianus*, greater sandeel *Hyperoplus lanceolatus* and flounder were recorded from dredge samples. Marine invertebrates collected by the sublittoral dredge included crabs, common whelk, and blue mussel *Mytilus edulis*.

3.1.9 Beam trawls undertaken across the Dublin shipping channel and inner Dublin Bay (Aquatic Services Unit, 2020) recorded dab, plaice, flounder *Plathichtys flesus,* cod, whiting as well as butterfish, dragonet, gobies *Pomatoschistus*, short-spined sea scorpion *Myxocephalus scorpius,* pipefish, sandeel, and thornback ray. Epibenthic shellfish present within the trawls included common whelk, brown shrimp and green crab, the latter two species numerically dominating the epibenthic assemblages in the mid to inner sections of the shipping channel. Other invertebrates caught included brown crab, hermit crab, velvet crab, harbour crab *Liocarcinus*, and spider crab *Majidae*.

3.1.10 Surveys undertaken by Inland Fisheries Ireland (IFI) in the outer Liffey estuary in 2008 (Aquatic Services Unit, 2020) recorded assemblages dominated by sprat, sand goby *Pomatoschistus minutus*, sand smelt *Osmerus eperlanus*, and stickleback *Gasterosteidae* spp. in 2008, and grey mullet *Mugilidae* spp. and sand goby in 2010. European eel *Anguilla anguilla* were also recorded during the 2008 and 2010 surveys.

Site-Specific Surveys

3.1.11 Site-specific baseline benthic ecology characterisation surveys were conducted across the array area and the ECC in May 2022 (Natural Power, 2022) and September and October 2022 (Natural Power, 2023), respectively. Both surveys consisted of DDV to capture footage of the seafloor environment and associated epifaunal species as well as grab samples to analyse the sediment composition and help identify seabed areas suitable for sandeel and herring spawning (see **Section 3.2 Spawning Grounds**). Sampling stations were selected randomly from each of the substrate types predicted to occur within the survey areas. In addition, a series of video transects were run across the south-west corner of the array area to sample seabed areas predicted to contain coarser substrate (Natural Power, 2022).

Array Area

3.1.12 The analysis of the DDV footage and grab samples from the site-specific benthic ecology surveys indicate that the seabed across the array area is generally homogenous, being characterised by soft sediments, with finer muddy sediment classified as 'Subtidal Mud' to the north and increasing coarser material classified as 'Subtidal Mixed Sediment' to the south (Natural Power, 2022). Burrows of *Nephrops* were observed in the finer sediments across the northern portion of the array area.

3.1.13 Very low numbers of fish and shellfish were observed within the imagery collected over 'Subtidal Mud', with flatfish (Pleuronectiformes), dragonet (*Callionymidae*) and unidentified fish and decapod crustaceans being recorded. At the southern stations dragonet, cod fishes (*Gadidae*) and unidentified fish species were seen. At the stations sampled at the south-west corner of the array area, fish and shellfish were more abundant, with higher numbers of flatfish and dragonet recorded. Other species frequently seen were cod fishes including haddock, gurnards (*Triglidae*) and other (unidentified) fish species. Less frequently seen species were scallops (*Pectinidae*), hermit crabs (*Paguridae*), crabs (Brachyura) and unidentified elasmobranch species.

ECC

3.1.14 The site-specific benthic ecology survey across the ECC (Natural Power, 2023) indicates a homogenous seabed characterised predominantly by sand with small but increasing proportions of silt and gravel evident further offshore. At the four stations furthest inshore, muddy sand substrates with small burrows were recorded as the broadscale habitat 'Subtidal Sand'. The remaining stations sampled were recorded as the broadscale habitat 'Subtidal Mud'. Here, burrows including complex burrow systems (e.g., *Nephrops*) were observed at most sites.

3.1.15 Fish observed throughout the ECC included flatfish, cod fishes, dragonet, gurnards and unidentified species. Shellfish observed included frequent sightings of decapod crustaceans (Paguridae and Brachyura including brown crab, angular crab and the masked crab *Corystes cassivelaunus*), and some instances of *Nephrops*, scallop, sea snails (*Buccinidae*) and bivalve siphons. Higher numbers of both Brachyura and bivalve siphons were recorded at the stations furthest inshore.

3.2 Spawning and Nursery Grounds

3.2.1 This section summarises the distribution of spawning and nursery grounds of key fish and elasmobranch species within the study area as identified by Coull et al. (1998), Ellis et al. (2010, 2012), and the Irish Marine Atlas (Marine Institute, 2016).

Spawning Grounds

3.2.2 Spawning grounds that are known to be present within or adjacent to the study area are presented in **Figure 3-1** to **Figure 3-7**

3.2.3 'High intensity' spawning grounds for Atlantic cod and plaice overlap the offshore development area and parts of the ZoIs, with 'low intensity' spawning grounds for these species also present across the ZoIs and wider region (Coull et al., 1998; Ellis, et al., 2010, 2012; Marine Institute, 2016). Low intensity spawning grounds for mackerel, horse mackerel, hake, and common ling *Molva molva* overlap the study area (Ellis et al., 2010, 2012). Low intensity spawning grounds for sole (Coull et al., 1998; Ellis et al., 2010, 2012) and whiting (Coull et al., 1998; Ellis et al., 2010, 2012; Marine Institute, 2016) also overlap the study area. Furthermore, spawning grounds of unidentified intensity are present for lemon sole and sprat (Coull et al., 1998) and haddock (Marine Institute, 2016).

3.2.4 Larval densities for cod, plaice and whiting, as recorded within the Irish Sea AEPM plankton surveys (Cefas, 2000) have been presented as heatmaps in **Figure 3-8**. These data indicate areas of high intensity spawning of cod, plaice and whiting within the study area.

3.2.5 A summary of spawning times with peak spawning periods is presented in **Table 3-1**. Detailed information on spawning and nursery behaviour of species is provided in **Sections 3.4** to **3.7**.

Table 3-1: Summary of spawning times in the Irish Sea for fish and shellfish species known to have spawning grounds in the study area. Spawning period sources: 1 - Coull et al. (1998); 2- ICES (2005); 3 - Nichols et al. (1993); 4 - Campanella and van der Kooij (2021); 5 - ICES (1994).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Atlantic cod[2]	Spawning	Spawning	Peak	Peak	Spawning							
Whiting[1,4]		Spawning	Spawning	Peak	Peak	Spawning						
Common ling[3]				Spawning	Spawning	Spawning						
Horse mackerel[4]	Spawning	Spawning	Spawning	Spawning	Peak	Peak	Spawning	Spawning	Spawning			Spawning
Mackerel[1]			Spawning	Spawning	Peak	Peak	Spawning					
Plaice[1,2]	Spawning	Spawning	Peak	Spawning								Spawning
Witch flounder[3]			Spawning	Spawning	Spawning							
Common sole[1,3]			Spawning	Peak	Peak							
Lemon sole[1]				Spawning	Spawning	Spawning	Spawning	Spawning	Spawning			
Sprat[1]					Peak	Peak	Spawning	Spawning				
Haddock[1]		Peak	Peak	Peak	Spawning							
Sandeel[3]	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning	Spawning				Spawning	Spawning
Herring[5]									Peak	Peak	Spawning	

Colour code: Light orange indicates spawning period, dark red indicates approximate peak spawning period.

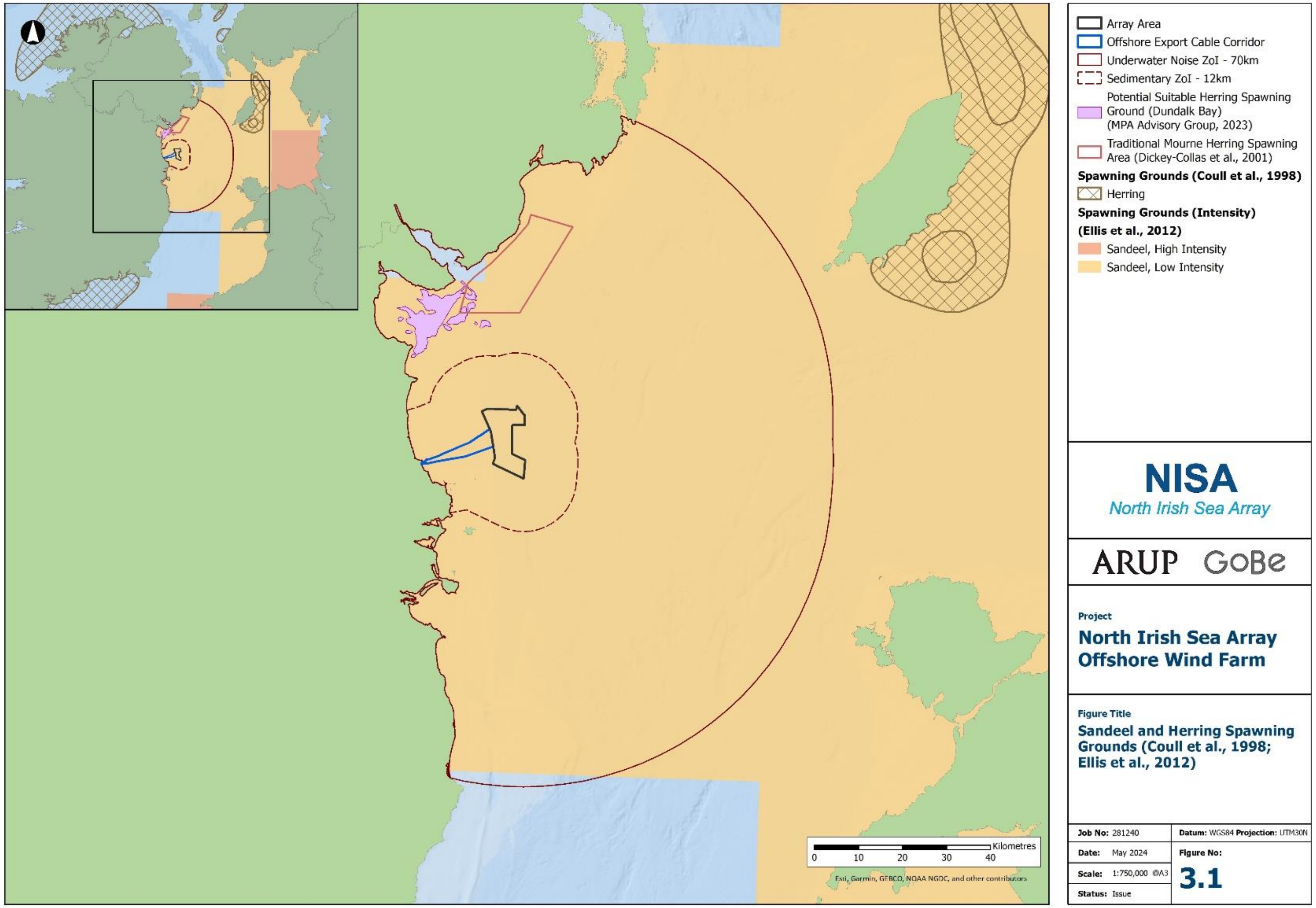

Figure 3-1: Sandeel and Herring Spawning Grounds (Coull et al., 1998; Ellis et al., 2012).

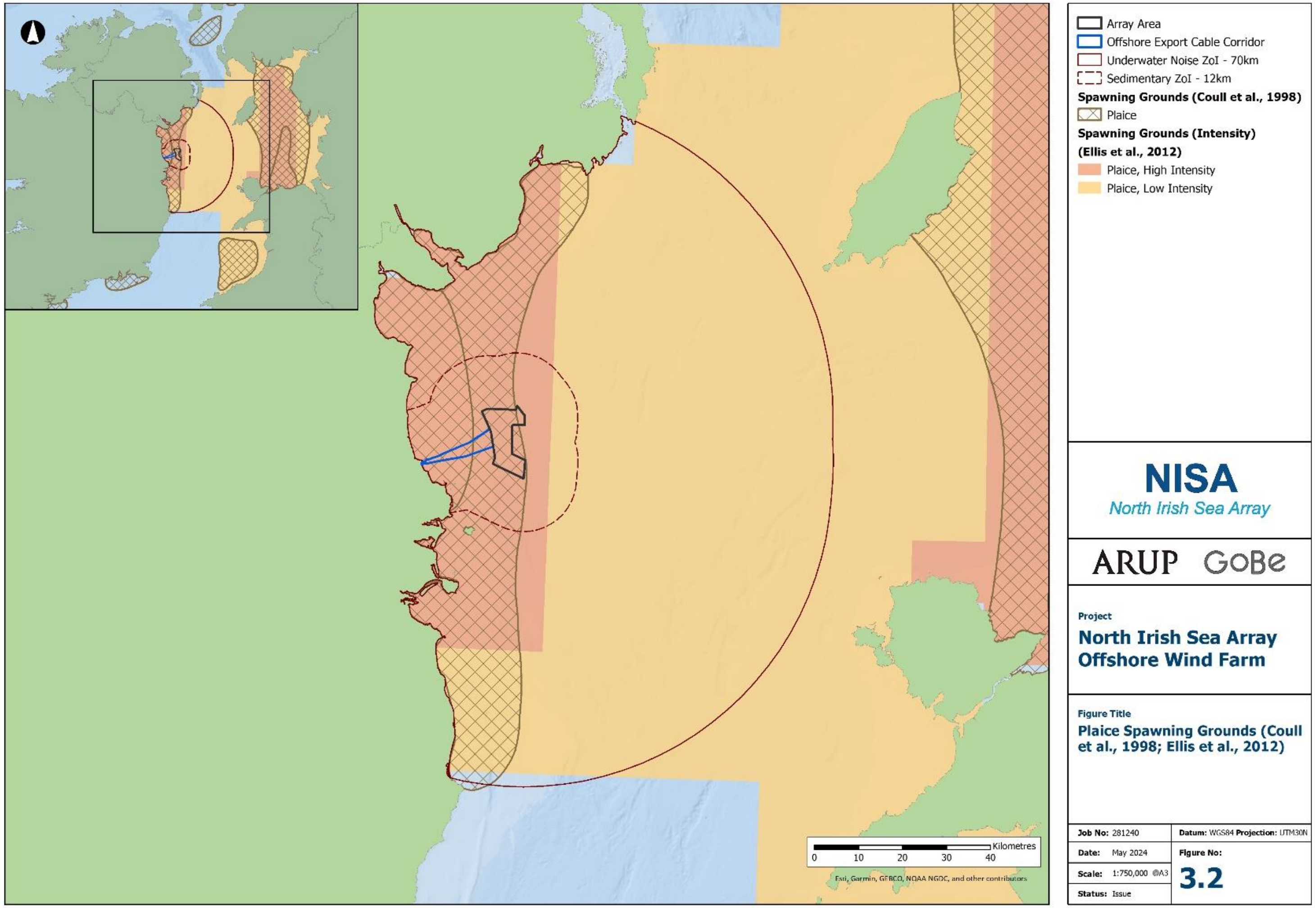

Figure 3-2: Plaice Spawning Grounds (Coull et al., 1998; Ellis et al., 2012).

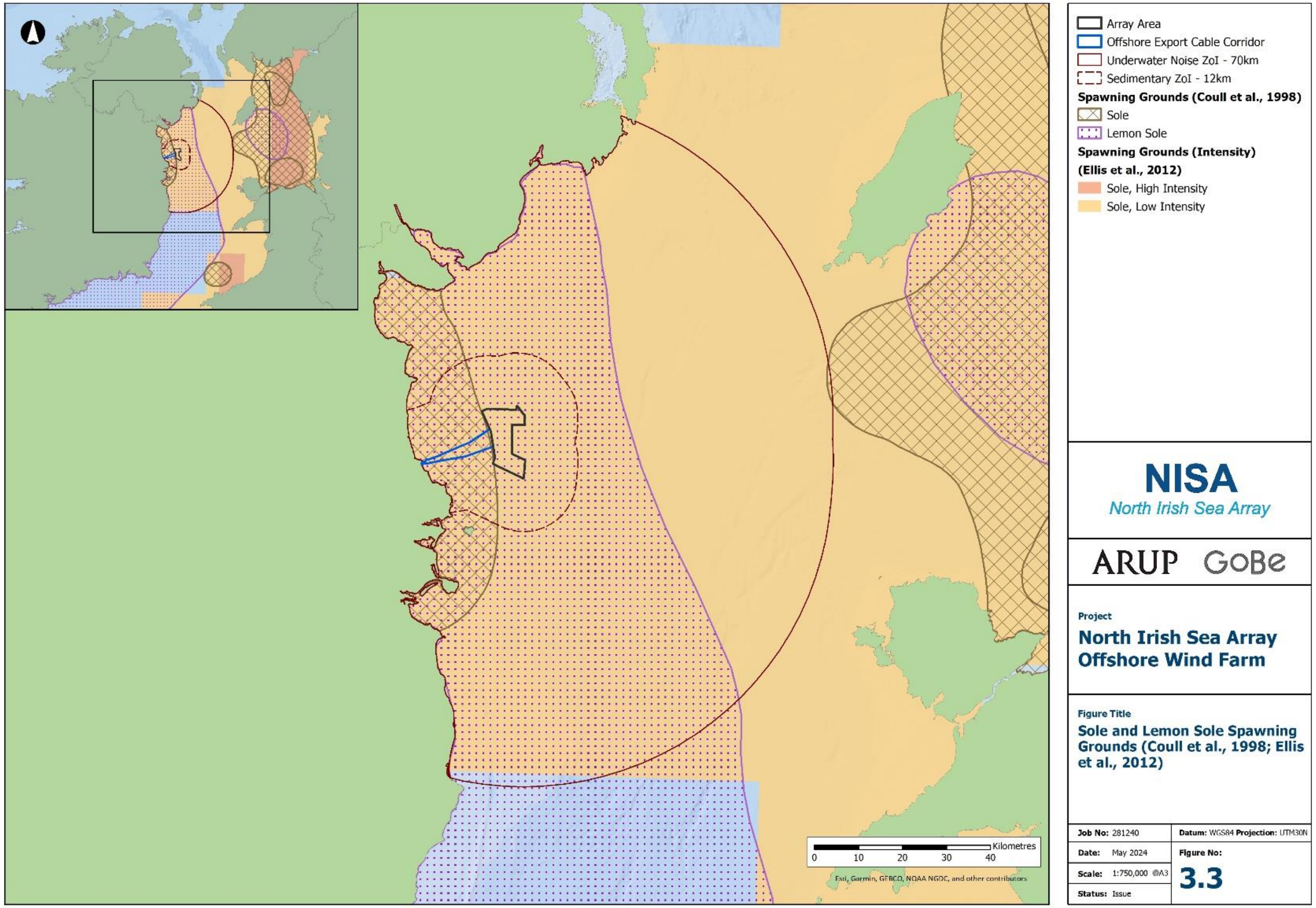

Figure 3-3: Sole and Lemon Sole Spawning Grounds (Coull et al., 1998; Ellis et al., 2012).

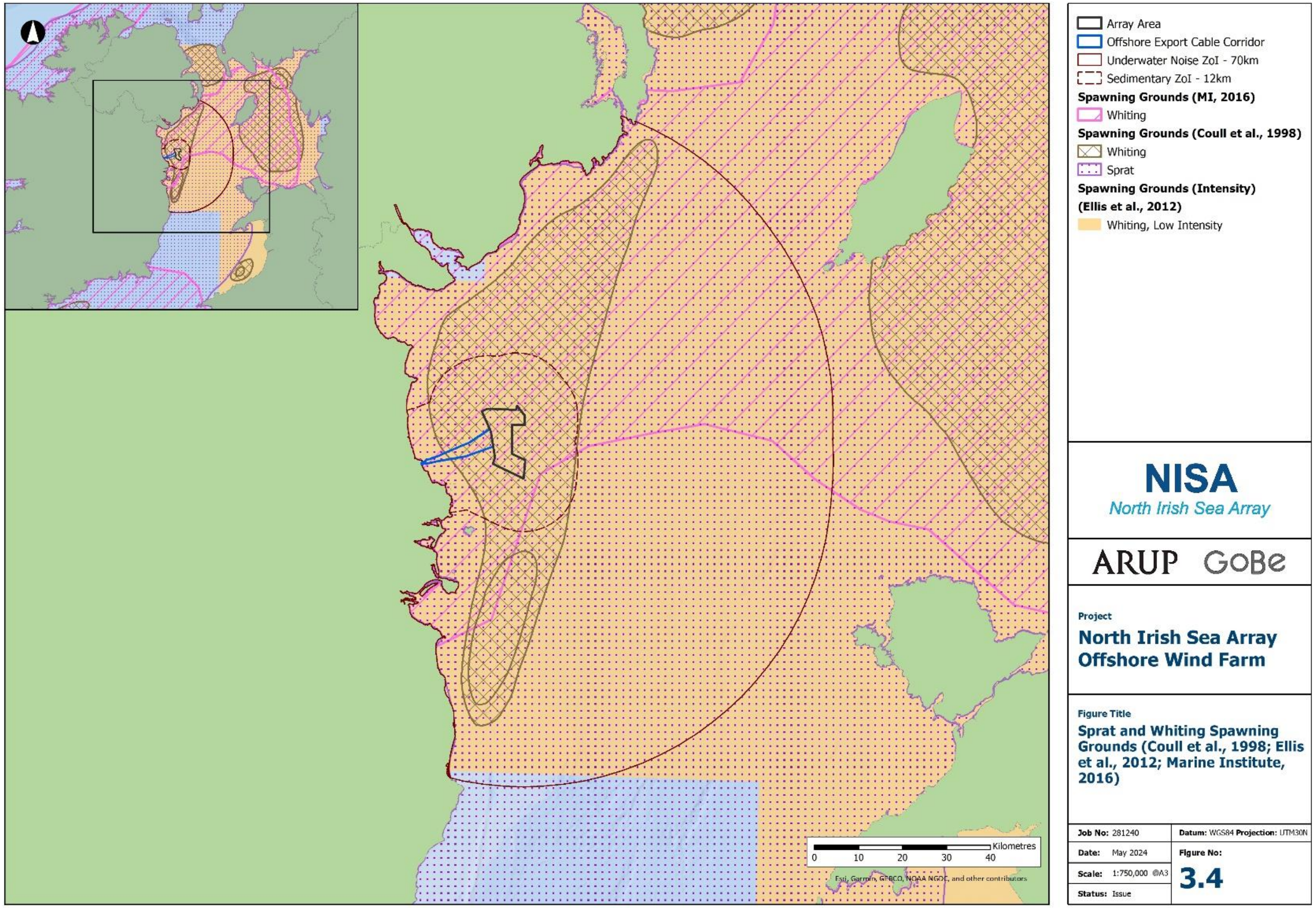

Figure 3-4: Sprat and Whiting Spawning Grounds (Coull et al., 1998; Ellis et al., 2012; Marine Institute, 2016).

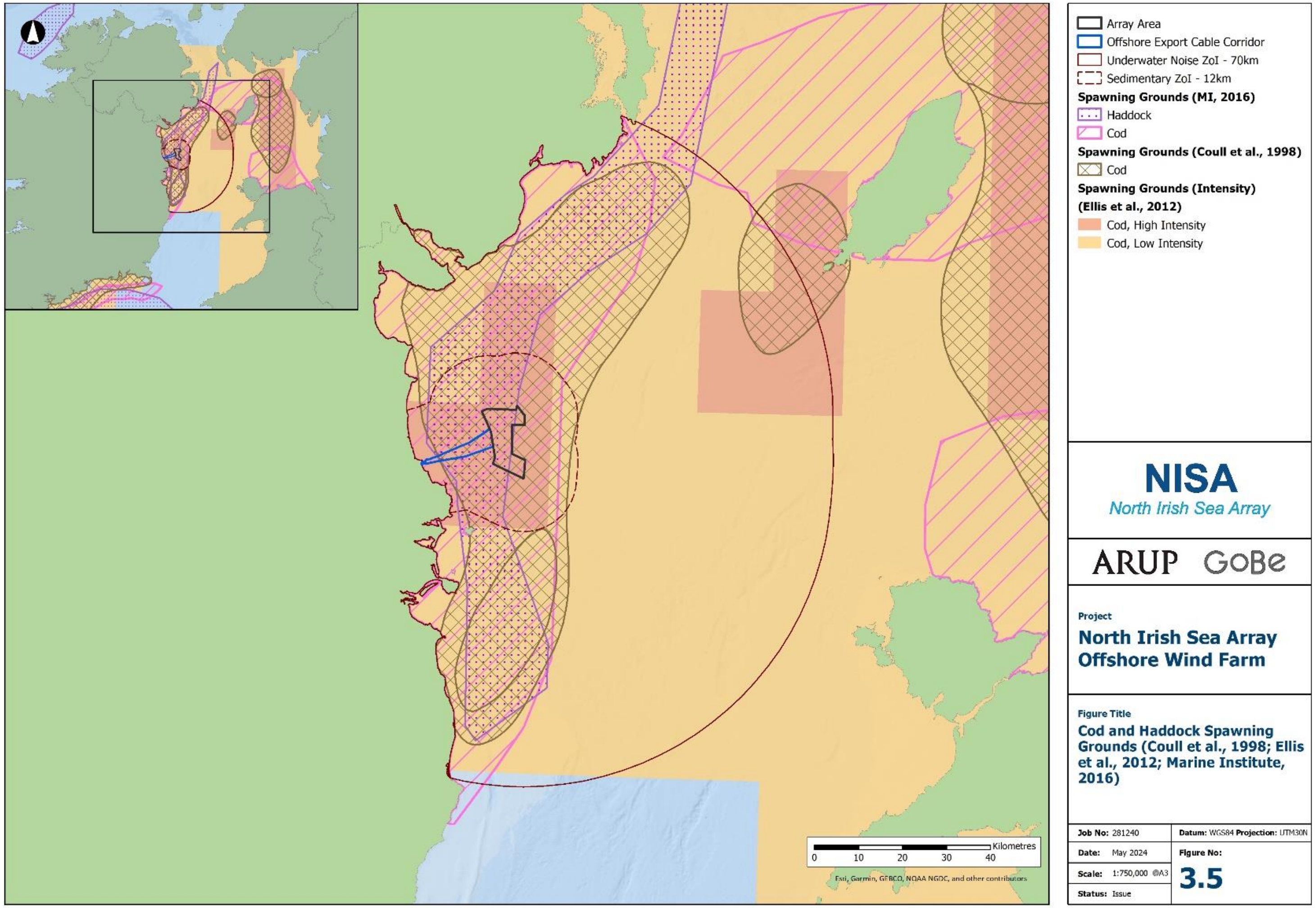

Figure 3-5: Cod and Haddock Spawning Grounds (Coull et al., 1998; Ellis et al., 2012; Marine Institute, 2016).

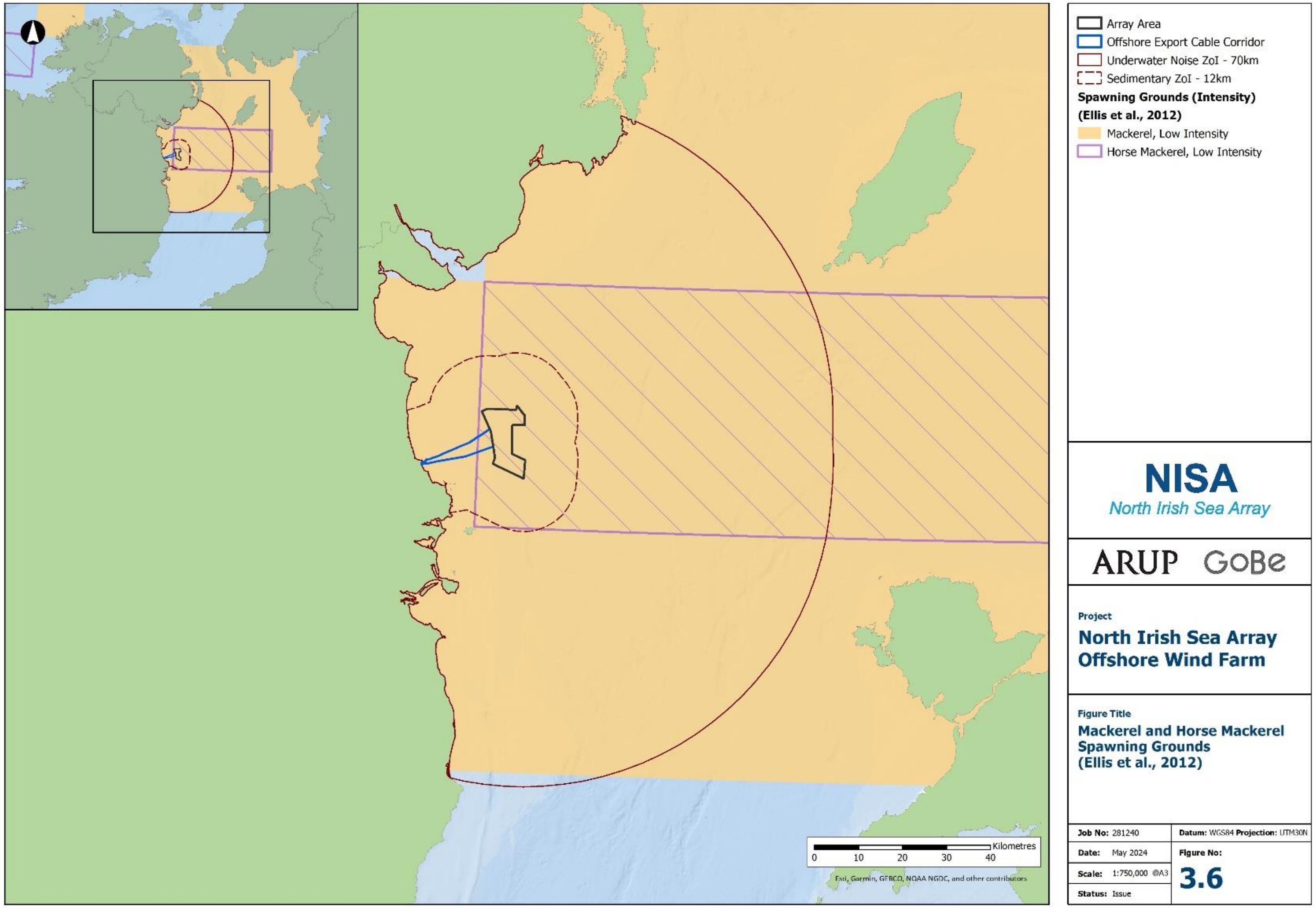

Figure 3-6: Mackerel and Horse Mackerel Spawning Grounds (Ellis et al., 2012).

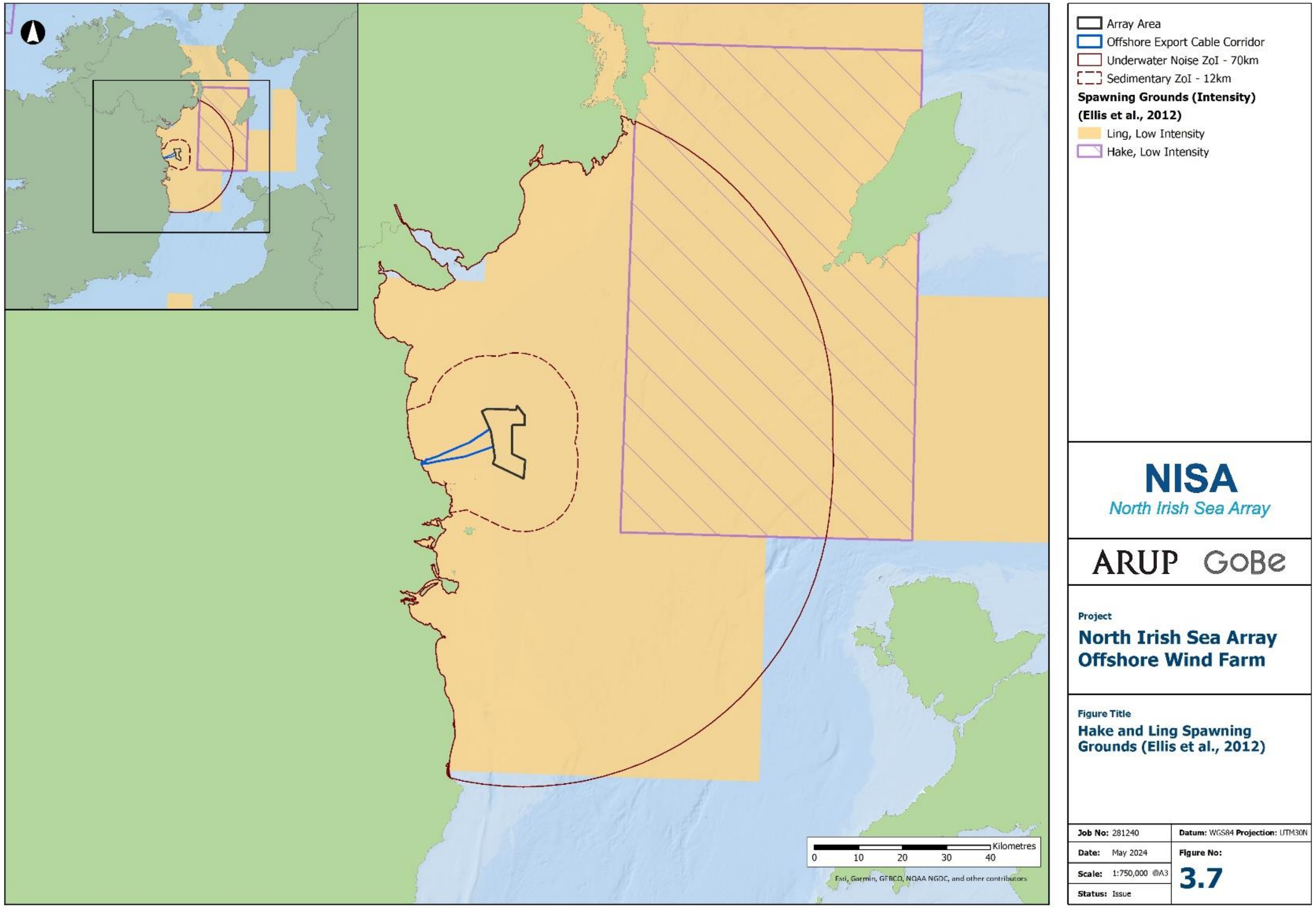

Figure 3-7: Hake and Ling Spawning Grounds (Ellis et al., 2012).

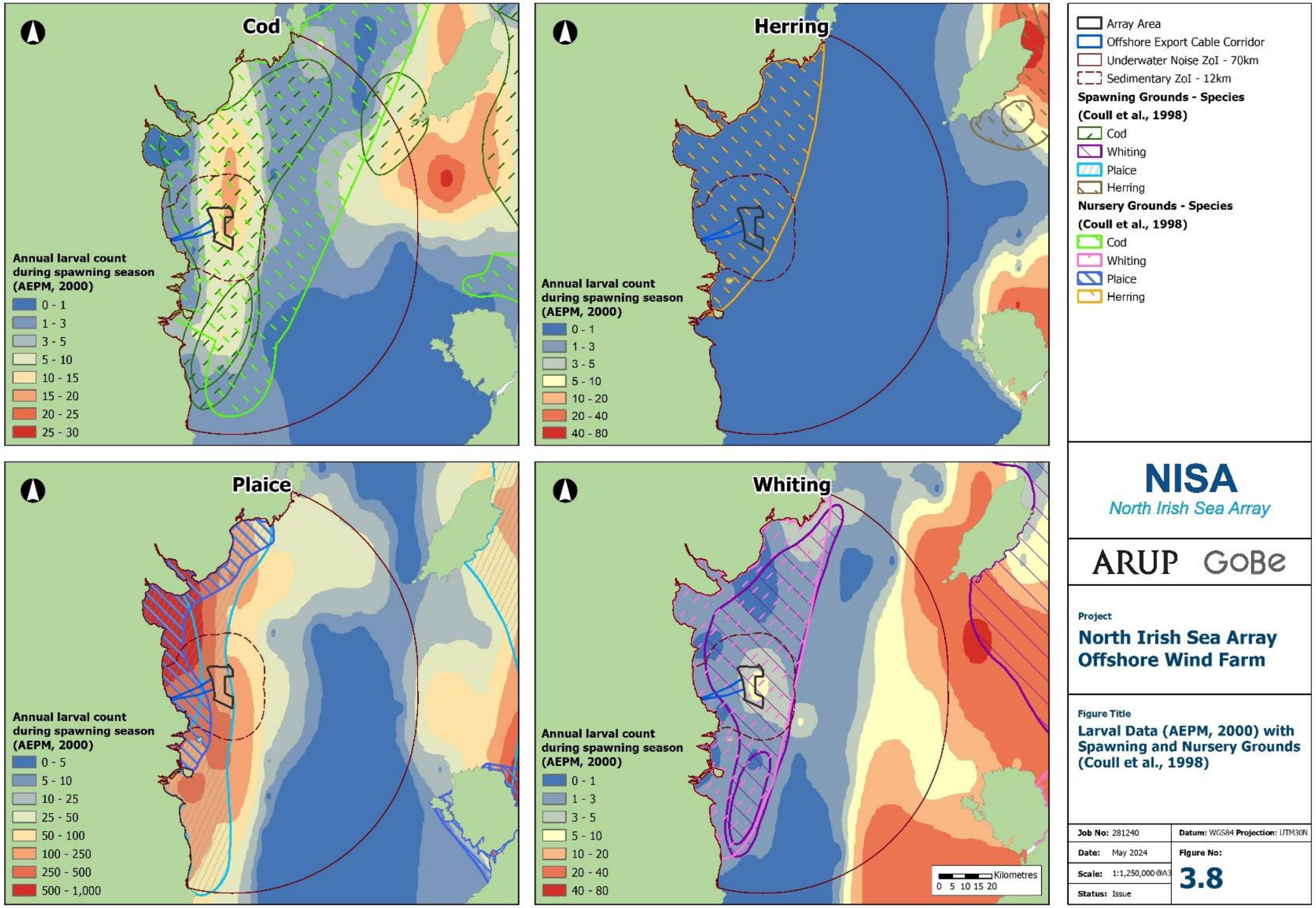

Figure 3-8: Larval Data (AEPM, 2000) with Spawning and Nursery Grounds (Coull et al., 1998).

3.2.6 Sandeel (*Ammodytes* spp.) are small, shoaling fish found on continental shelves in the northern hemisphere. Sandeel species recorded in Irish water include the lesser sandeel *A. tobianus*, Raitt's lesser sandeel *A. marinus*, the greater sandeel *Hyperoplus lanceolatus* and the smooth sandeel *Gymnammodytes semisquamatus* (Nichols et al., 1993). Sandeel are highly substrate dependent, being demersal spawners and spending large amounts of time buried in the sediment. Consequently, they are more susceptible to seabed disturbance impacts and as such are of particular relevance when assessing impacts of offshore wind developments.

3.2.7 In the Irish Sea, sandeel spawn either in autumn and from later winter to spring, depending on species (Nichols et al., 1993). The eggs are demersal and are covered with a glutinous secretion that enables them to attach to the seabed (Proctor et al., 1998). After hatching and an initial larval dispersal period of one to three months sandeel settle, preferably, on well-oxygenated sandy substrate (Green, 2017). In-situ and laboratory studies indicate that lesser sandeel prefer substrates with a high proportion of medium and coarse sand (particle size 0.25-2 mm) (Wright et al., 2000). They rarely occur in sediments where the silt content (particle size less than 0.63 µm) is greater than 4%, and they are absent in substrates with a silt content greater than 10% (Holland et al., 2005; Wright et al., 2000). After settlement, sandeel show a high degree of site fidelity (Jensen et al., 2011) and distinct foraging patterns (van Deurs et al., 2011). Throughout spring and summer, sandeel emerge from the seabed during the day to feed in large schools and at night return to bury in the sediment (van Deurs et al., 2011). Between September and March, they mostly remain within the seabed except to spawn (Green, 2017).

3.2.8 Given their high degree of site fidelity, the settled distribution of adult sandeel is largely reflective of preferred spawning sediments (Jensen et al., 2011). Sandeel spawning habitats are known to occur throughout the Irish Sea, with low intensity spawning (**Figure 3-1**) and nursery (**Figure 3-11**) grounds overlapping the study area (Ellis et al., 2010, 2012). More recent data suggest that although juvenile sandeel are widespread in the Irish Sea, juvenile hotspots are located in the Central Irish Sea (Campanella and van der Kooij, 2021), including the southern parts of the ZoI. Sandeels are an important trophic link in the North Sea food chain, between zooplankton and sandeel predators including piscivorous fish, most seabirds and mammals. As many marine predators rely on sandeels, coupled with their vulnerability to changes in habitat, sandeels are of increasing conservation interest.

3.2.9 To support the identification of suitable sandeel habitat within the study area, PSA data collected during site-specific surveys (Natural Power, 2022, 2023) and INFOMAR surveys (INFOMAR, 2023) were categorised following the methodology described in Latto et al. (2013). The site-specific sediment data showed a seabed characterised by sandy Muds[4] and muddy Sands within the array area, indicating 'Unsuitable' conditions for sandeel spawning (**Figure 3-9**). 'Unsuitable' sediments for sandeel spawning are also located in the north-eastern corner of the ECC, where muddy Sands and Mixed sediments with mud concentrations greater than 10% were recorded. Sediments within the remaining ECC sampling area were categorised as Sands that are either 'Suitable' or 'Sub-Prime' for sandeel spawning (**Figure 3-9**). Within the sedimentary ZoI (12 km), INFOMAR (2023) seabed substrate data indicate 'Suitable' areas for sandeel spawning to the north and south of the ECC between the array area and the coastline. In addition, the data indicate 'Preferred' ('Prime' and 'Sub-Prime') and 'Marginal' ('Suitable') sandeel habitats to be present to the south of the array area within the southern part of the underwater noise ZoI.

3.2.10 Potential suitable substrates for herring spawning were also defined using site-specific and publicly available PSA data, following the methodology described by Reach et al. (2013). The results of this analysis suggest that sediments within the array area and ECC are unsuitable for herring spawning, based on the analysis of substrate type, being dominated by Sands and Muds (**Figure 3-10**). Besides 'Preferred' substrates across Dundalk Bay (**Figure 3-1**), sediments suitable for herring spawning may be present across the coarser sediments along nearshore areas within the southern portion of the study area, including the coastal areas of Howth. Whether such areas are ultimately used by herring for spawning depends on additional factors, including small-scale seabed geomorphology and local wind and flow conditions (Frost and Diele, 2022). Larval data taken across the Irish Sea suggests that these are not used as key spawning sites (Dickey-Collas et al., 2001; ICES, 1994). The nearest known active herring spawning ground (the Mourne ground) is located off County Down and the northern sections of County Louth in the underwater noise ZoI to the north of the array area (Dickey-Collas et al., 2001; ICES, 2023c) (**Figure 3-1**).

[4] The PSA data collected during the site-specific benthic baseline surveys were originally classified using the standard Folk 16 sediment classification system (Folk, 1954). Review of the data indicated that the gravel content was skewed by the proportion of shell fraction in the samples. It was therefore decided to re-classify the sediments according to the Folk 7 system to reduce the importance of the gravel proportion. Consequently, sediment samples that were originally characterised as slightly gravelly Sands became Sands, slightly gravelly muddy Sands became muddy Sands, and gravelly muddy Sands became Mixed sediments. The substrate categories presented in this report are based on the Folk 7 classification system.

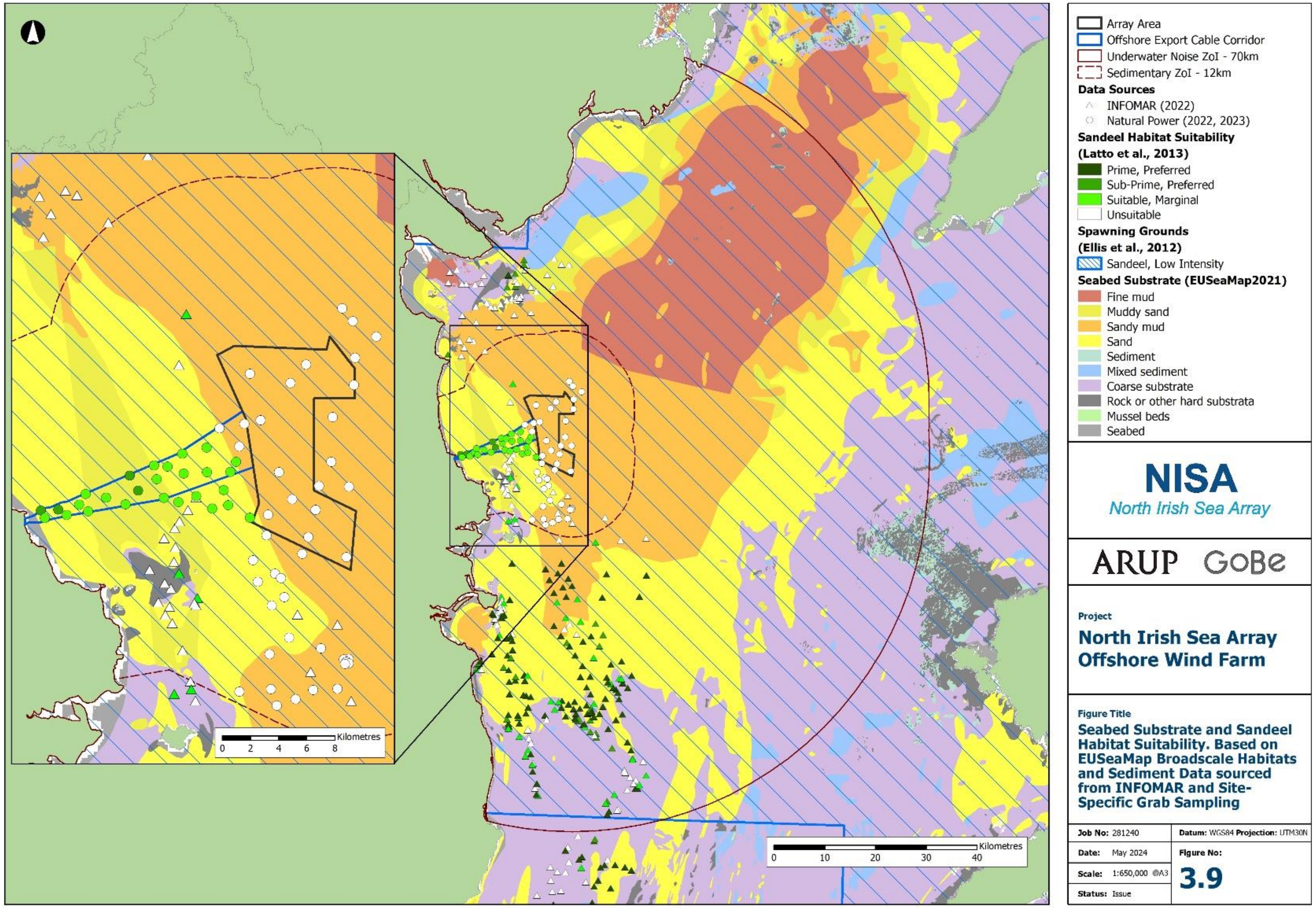

Figure 3-9: Seabed Substrate and Sandeel Habitat Suitability.

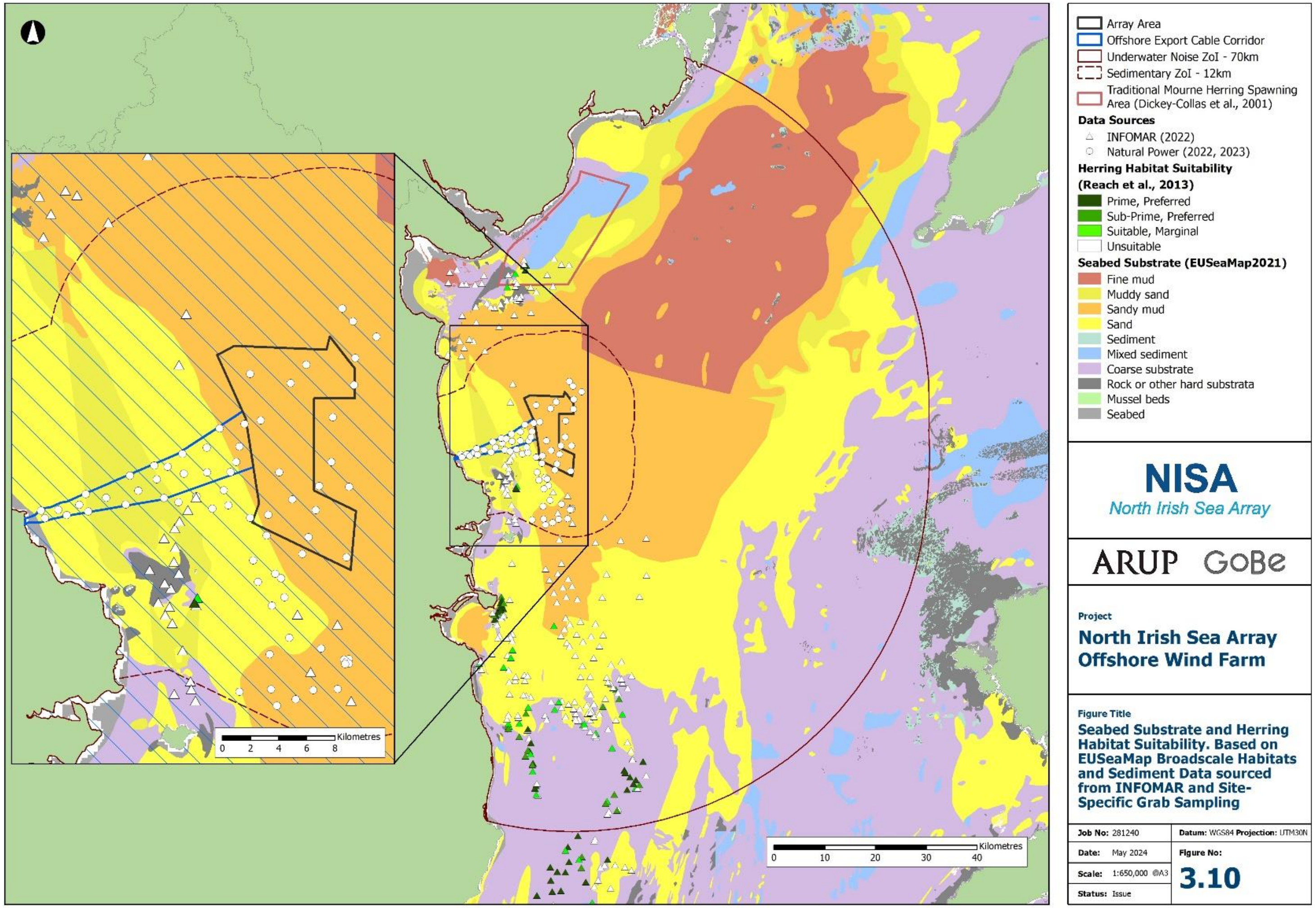

Figure 3-10: Seabed Substrate and Herring Habitat Suitability.

Nursery Grounds

3.2.11 Species of fish including elasmobranchs that are known to have nursery grounds in relatively close proximity to, or potentially overlapping with the study area are presented in **Figure 3-11** to **Figure 3-18**.

3.2.12 The offshore development area and part of the ZoIs coincide with 'high intensity' nursery grounds for herring, Atlantic cod and whiting, which 'low intensity' nursery areas also being present for cod and whiting (Coull et al., 1998; Ellis et al., 2010, 2012; Marine Institute, 2016). 'Low intensity' nursery grounds are present across the study area for plaice (Coull et al., 1998; Ellis et al., 2010, 2012), Atlantic mackerel (Ellis et al., 2010, 2012; Marine Institute, 2016), and sandeel, anglerfish and hake (Ellis et al., 2010, 2012). There are also nursery grounds present across the study area for haddock (Coull et al., 1998; Marine Institute, 2016), lemon sole (Coull et al., 1998), and Atlantic horse mackerel (Marine Institute, 2016). Furthermore, the study area also likely acts as a 'high intensity' nursery ground for spiny dogfish and 'low intensity' nursery grounds for tope, thornback ray and spotted ray (Ellis et al., 2010, 2012).

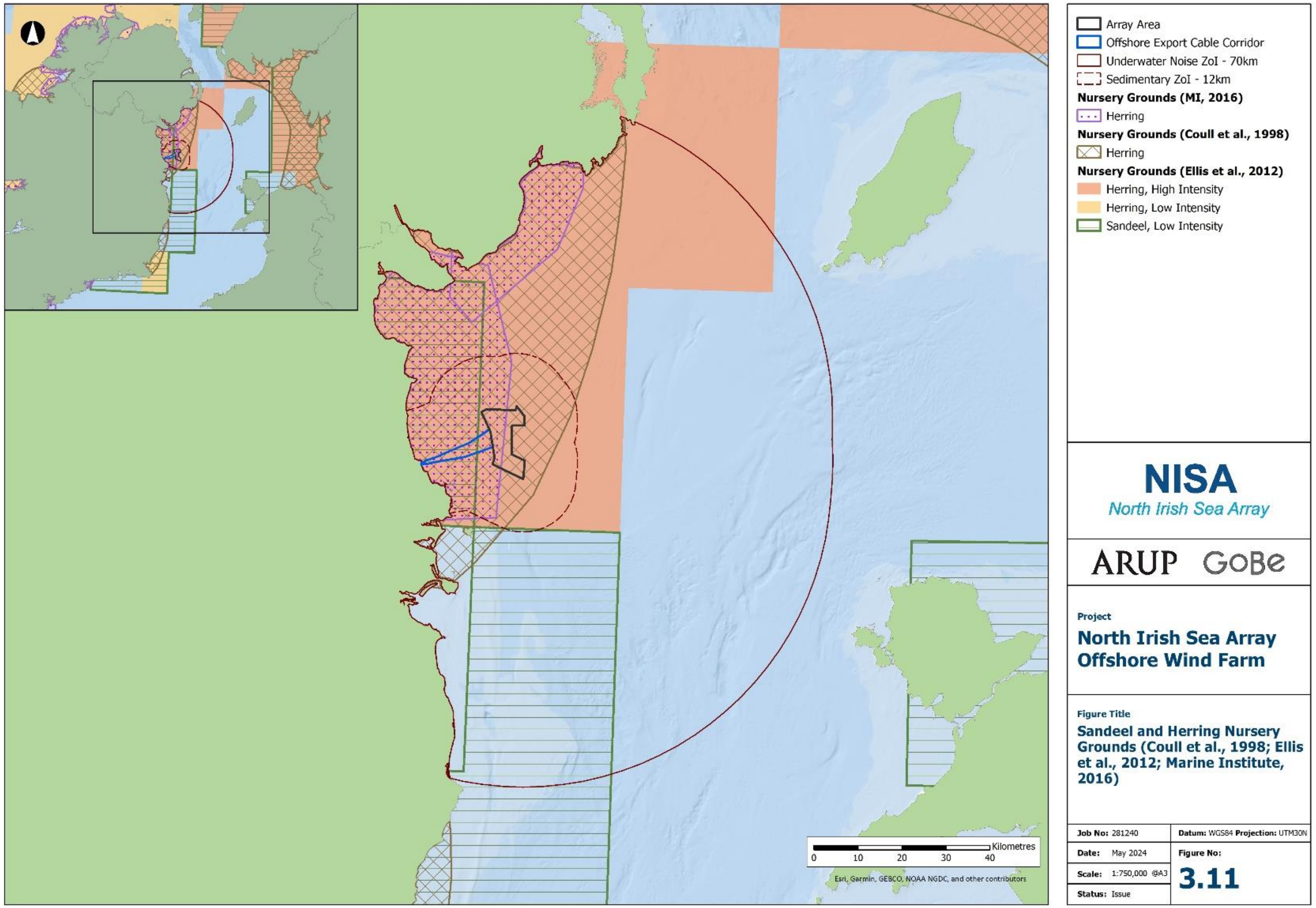

Figure 3-11: Sandeel and Herring Nursery Grounds (Coull et al., 1998; Ellis et al., 2012; Marine Institute, 2016).

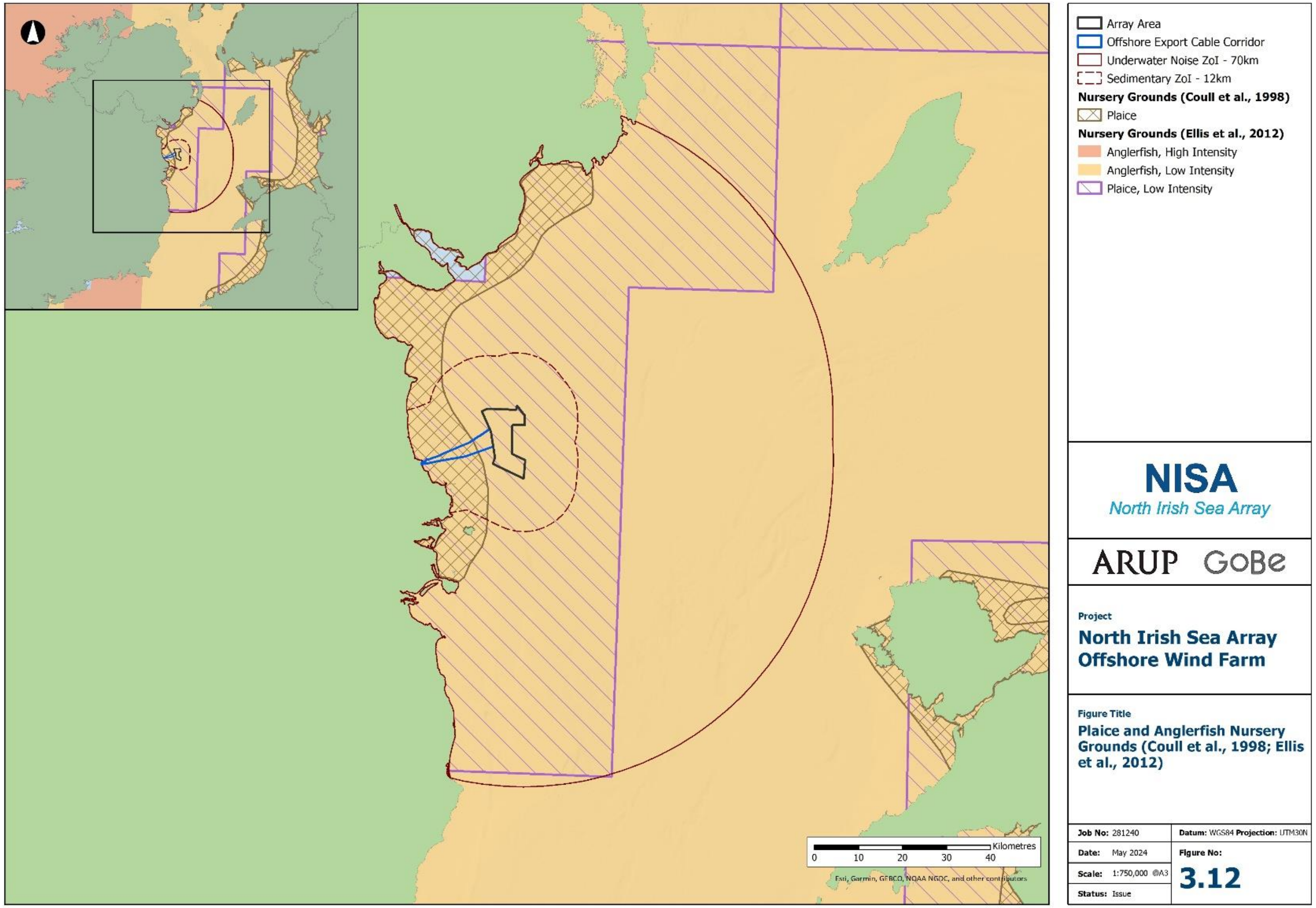

Figure 3-12: Plaice and Anglerfish Nursery Grounds (Coull et al., 1998; Ellis et al., 2012).

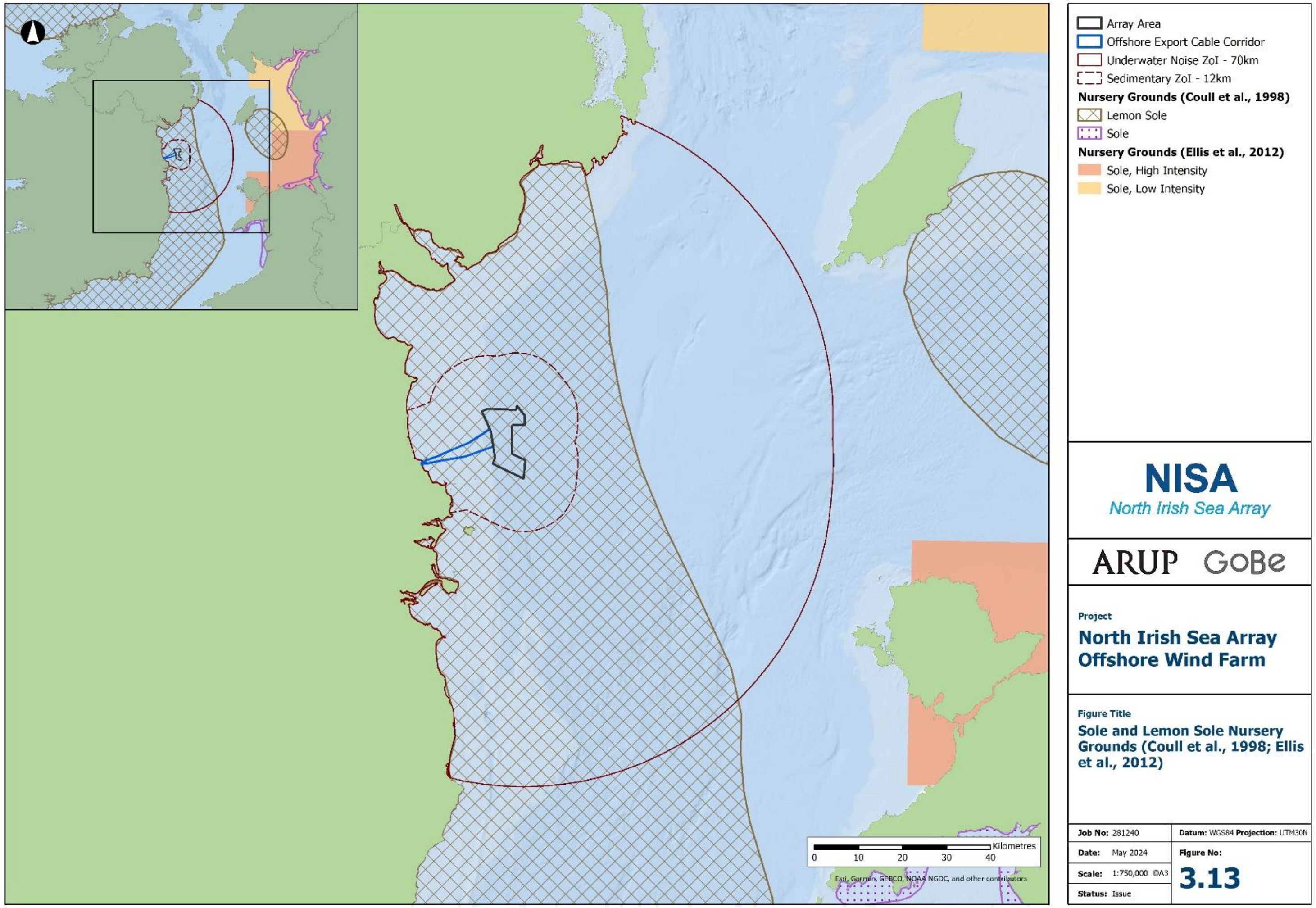

Figure 3-13: Sole and Lemon Sole Nursery Grounds (Coull et al., 1998; Ellis et al., 2012).

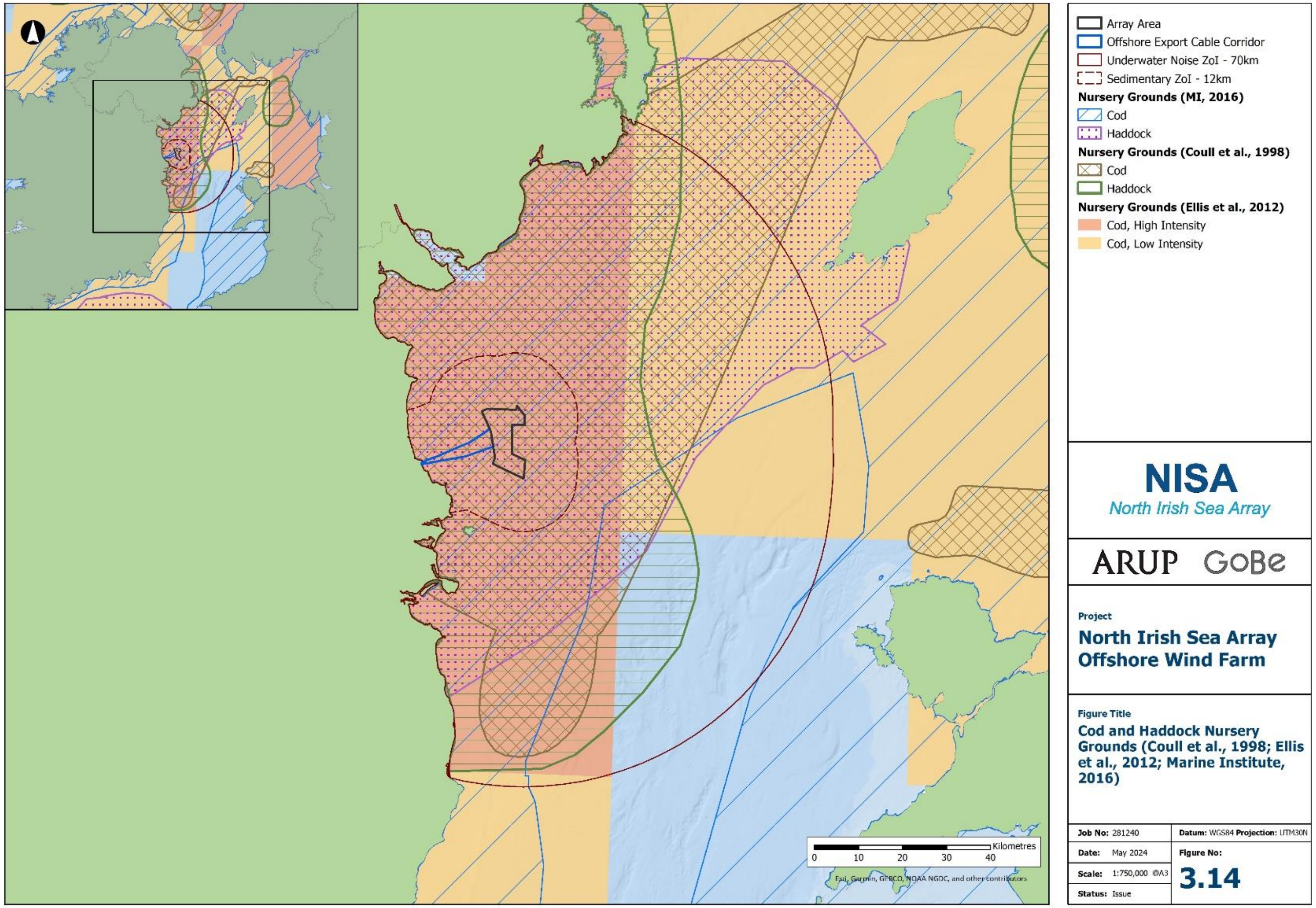

Figure 3-14: Cod and Haddock Nursery Grounds (Coull et al., 1998; Ellis et al., 2012; Marine Institute, 2016).

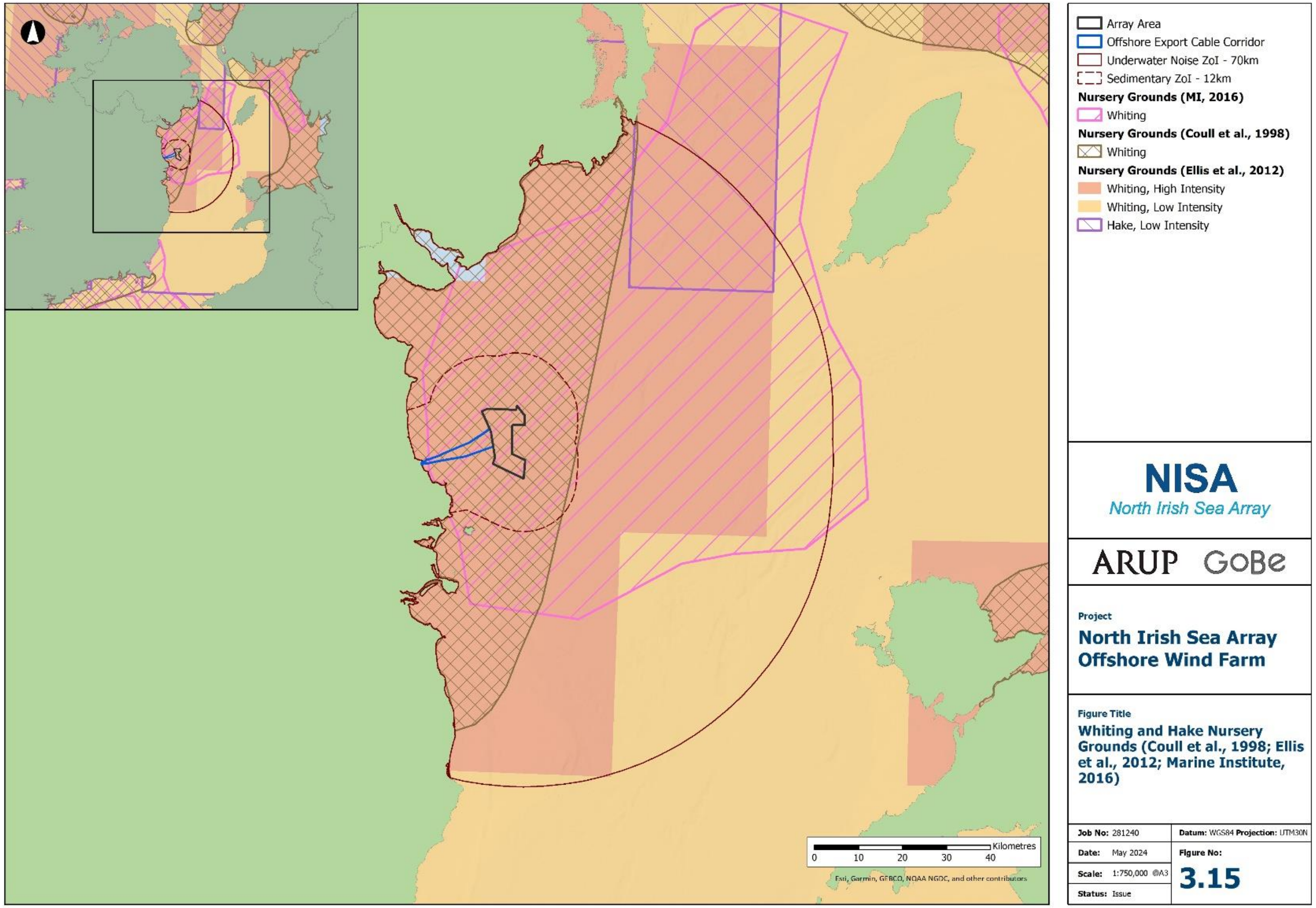

Figure 3-15: Whiting and Hake Nursery Grounds (Coull et al., 1998; Ellis et al., 2012; Marine Institute, 2016).

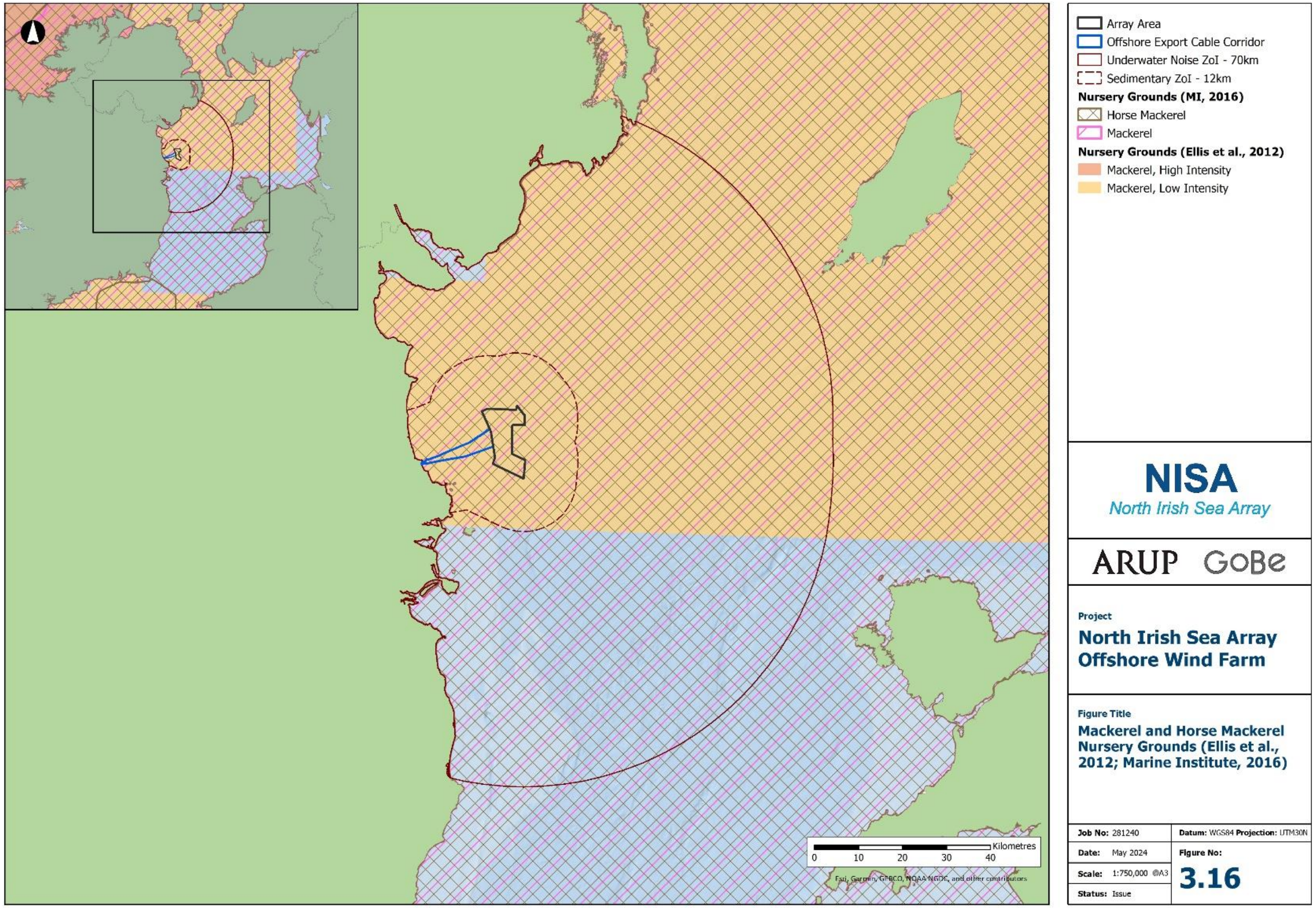

Figure 3-16: Mackerel and Horse Mackerel Nursery Grounds (Ellis et al., 2012; Marine Institute, 2016).

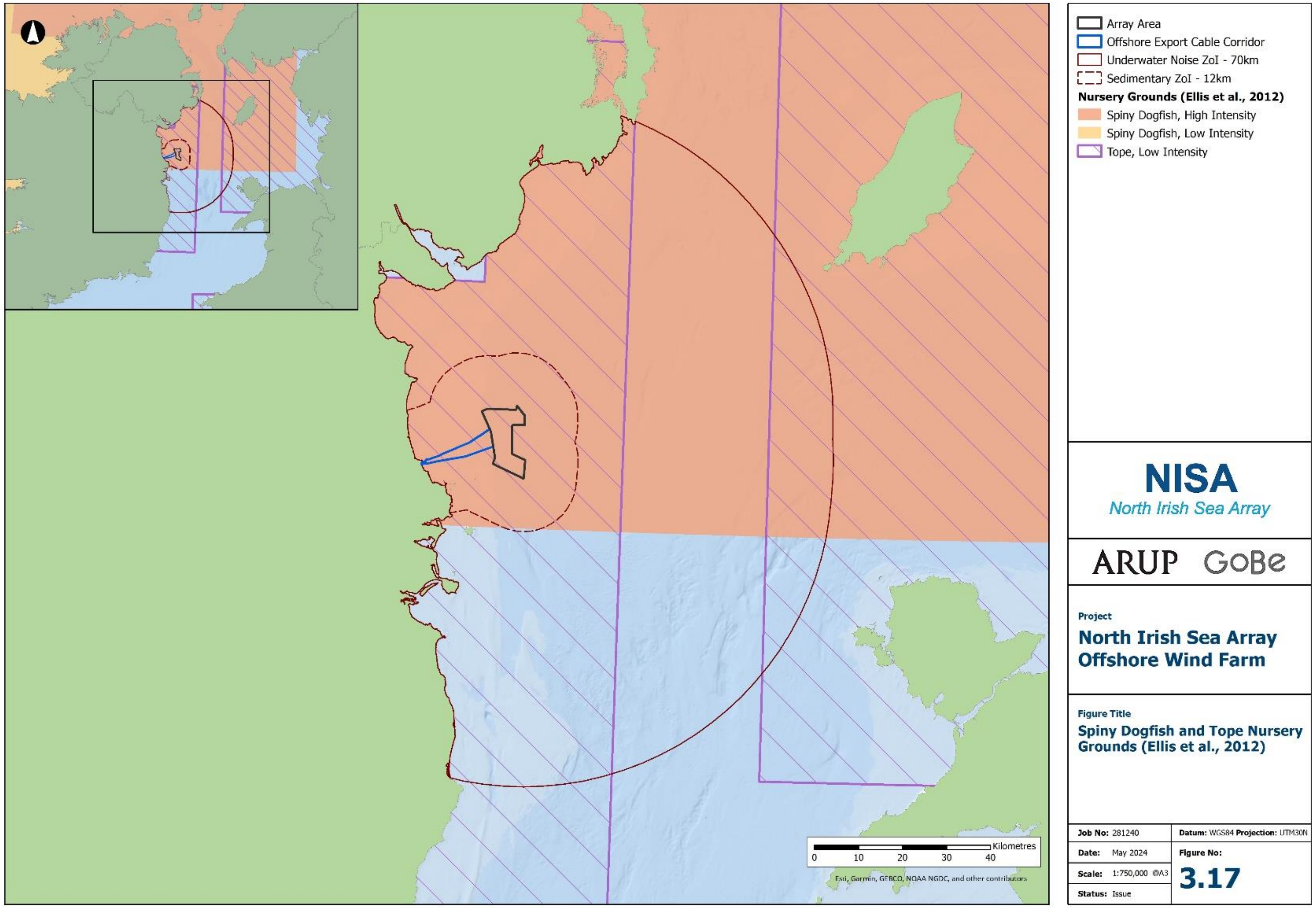

Figure 3-17: Spiny Dogfish and Tope Nursery Grounds (Ellis et al., 2012).

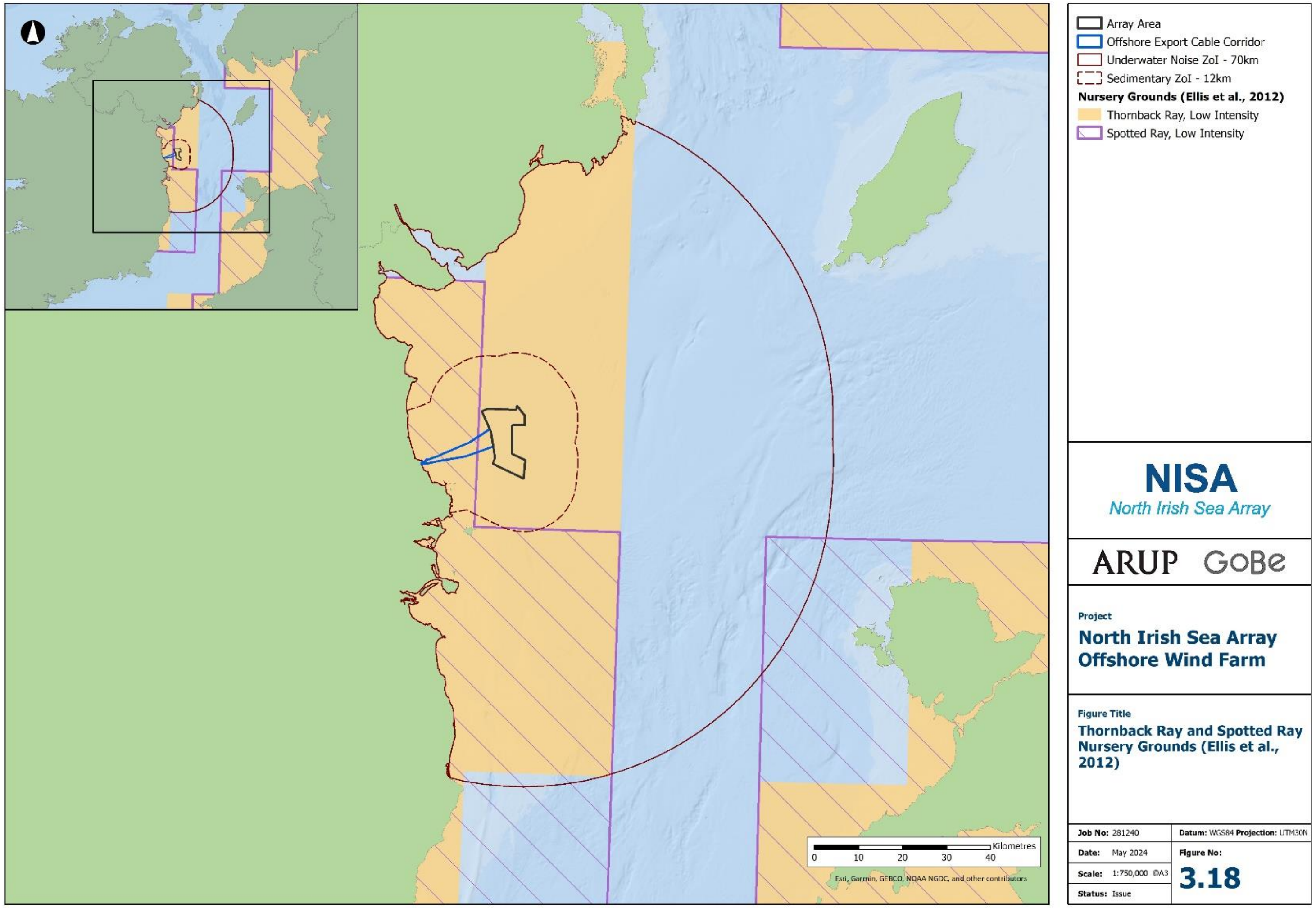

Figure 3-18: Thornback Ray and Spotted Ray Nursery Grounds (Ellis et al., 2012).

3.3 Species of Commercial Importance

3.3.1 The study area supports a variety of commercial fisheries for fish and shellfish. ICES rectangle 36E4, which overlaps the array area and the deeper areas of the ECC, is dominated by landings of *Nephrops* caught with demersal otter trawls (see also **Section 3.5 Nephrops**). Demersal fish and elasmobranch species caught in conjunction with the *Nephrops* fishery include haddock, plaice, anglerfish (monkfish), cod, lesser-spotted dogfish, and thornback ray. A low intensity beam trawl fishery mainly targeting sole, plaice and thornback ray also occurs within the study area, with notable grounds located approximately 50 km south-east of the array area. Pelagic species commercially targeted within the study area are Atlantic herring and European sprat, with fishing grounds mainly located inshore in Dublin Bay and off Howth (Commercial Fisheries Technical Baseline).

3.3.2 Landed weights from ICES rectangle 36E3, which overlaps the EEC (**Figure 2-2**), are dominated by shellfish including sword razorshell *Ensis siliqua*, brown crab, common cockle *Cerastoderma edule*, and common whelk, as well as some catches of *Nephrops*, likely taken to the north of the ECC. Other shellfish commercially fished within the study area are king scallop, queen scallop and European lobster (Commercial Fisheries Technical Baseline).

3.3.3 Cockles, razor clams, and scallops are fished using commercial dredges. Fishing grounds for razor clams are located close to the coast from Portmarnock to north Dundalk Bay in water depths of about 4-14 m (**Figure 3-19**; Commercial Fisheries Technical Baseline), while cockles are currently commercially harvested across the inshore areas in Dundalk Bay (Marine Institute and Bord Iascaigh Mhara, 2024). Scallops is commercially fished further offshore from several scallop beds, with King scallop fished primarily during winter (November to February) and the Queen scallop fishery peaking during spring and summer (Commercial Fisheries Technical Baseline).

3.3.4 Whelks, brown crabs, and lobster are targeted using baited traps. Whelks are fished year-round with landings from the study area peaking during the spring and summer months. Fishing activity for brown crab typically increases throughout summer, peaking in autumn and winter in the study area. Potting activity for brown crab and whelk is understood to have changed since publication of the most recent activity maps (**Figure 3-20**), with brown crab currently targeted across the ECC right up to the boundary of the array area, and whelk is targeted further north towards the array area (Commercial Fisheries Technical Baseline). Lobster fishery is located inshore along the coast from Howth to Dundalk Bay (**Figure 3-20**) with landings peaking during the summer and in December (Tully, 2017).

3.3.5 In addition to the species commercially fished, juvenile (seed) blue mussel are dredged from licensed beds for use by the aquaculture industry. Current seed mussel beds overlapping the study area are located inshore between Rush and Howth to the south of the sedimentary ZoI (**Figure 3-19**).

3.3.6 Further detail on the commercial fisheries interests in the fish and shellfish study area and the wider western Irish Sea is included in the Commercial Fisheries Technical Baseline. Information about the ecology of key commercial species is presented in the following sections.

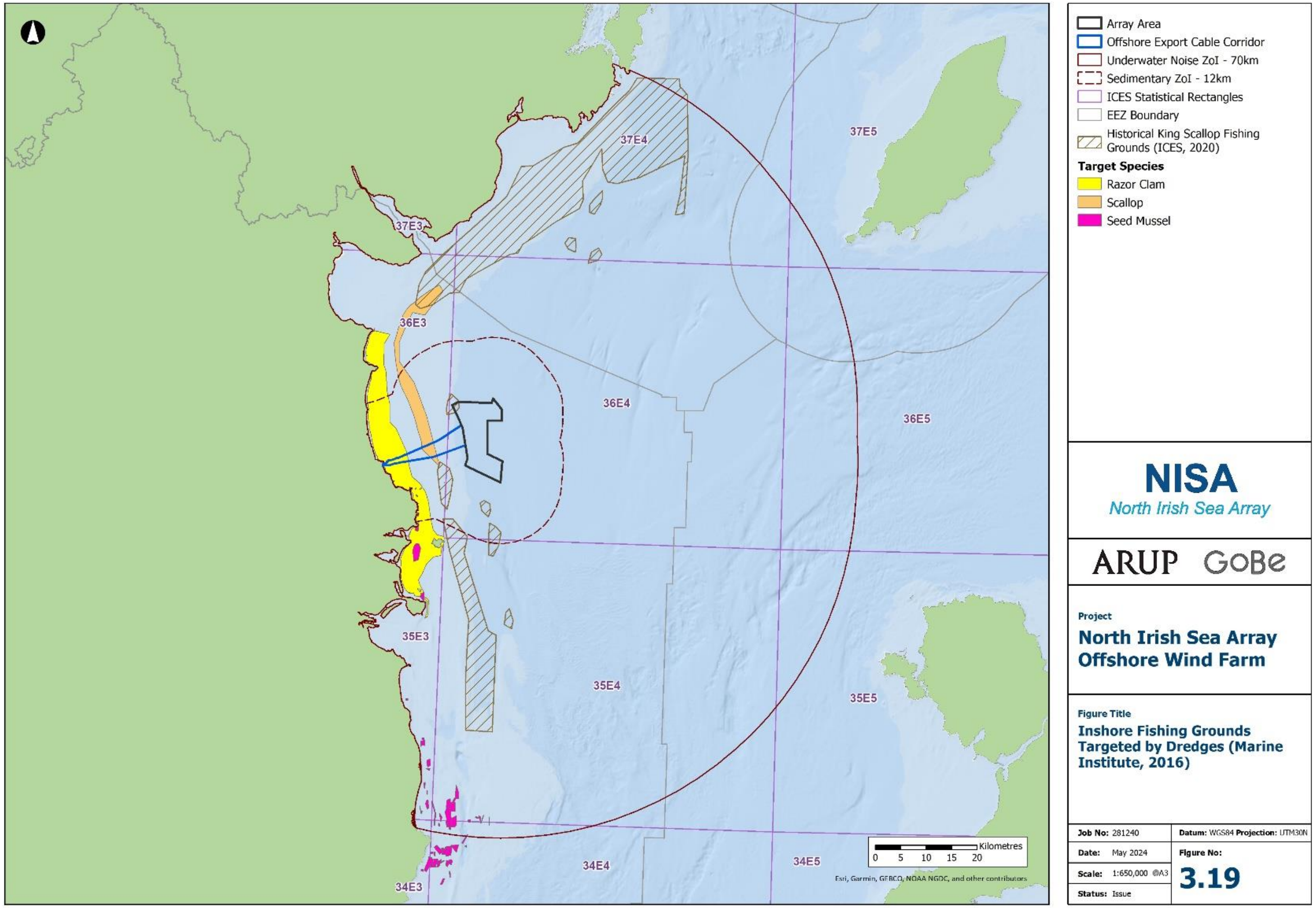

Figure 3-19: Inshore Fishing Grounds Targeted by Dredges (Marine Institute, 2016).

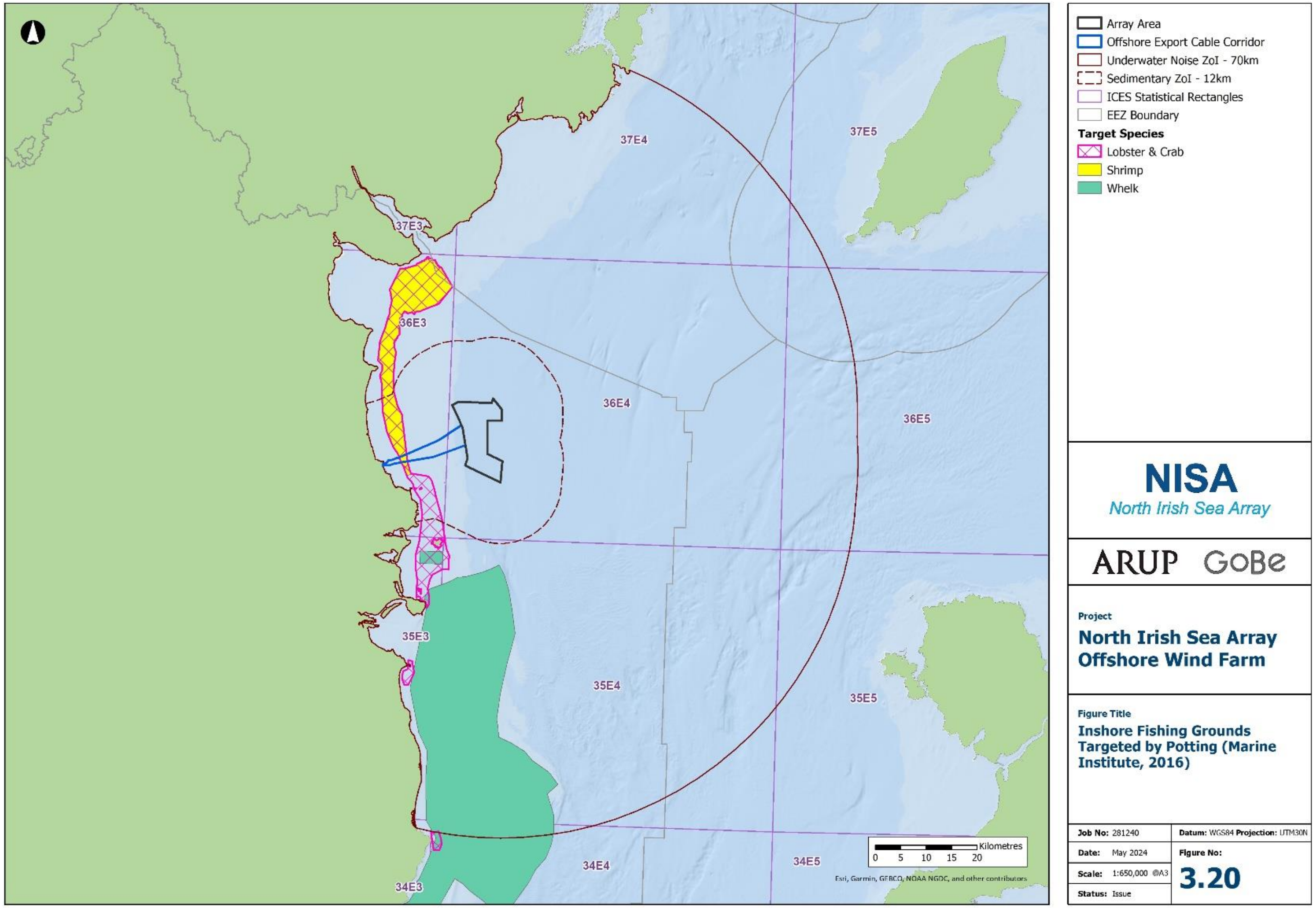

Figure 3-20: Inshore Fishing Grounds Targeted by Potting (Marine Institute, 2016).

3.4 Fish ecology

Atlantic cod

3.4.1 Atlantic cod are widely distributed on both sides of the North Atlantic Ocean, typically occurring at depths of 150-200 m (Cohen et al., 1990). It is a gregarious species that moves in large, size-structured schools between 30-80 m above the seabed during the day (Cohen et al., 1990). Juveniles are more commonly found in shallower waters over more complex bottoms such as gravel, rocky or vegetated habitats (e.g., Froese et al., 2023; Lilley and Unsworth, 2014). Adult cod are opportunistic predators and feed primarily on epibenthic and burrowing crustacea and various species of fish (ICES, 2005).

3.4.2 Atlantic cod are broadcast spawners that release buoyant gametes into the open water. In the Irish Sea, spawning takes place between January and May, with peak spawning occurring from late March to early April (ICES, 2005). Fertilised eggs are pelagic and typically hatch over a period of two to three weeks, depending on water temperature (Wright et al., 2003). Male cod are known to produce a drumming sound during the spawning season (Fudge and Rose, 2009; Nordeide and Kjellsby, 1999), and it has been suggested that the sounds are used to defend territories and attract females during spawning (Brawn, 1961).

3.4.3 There is strong evidence that cod exhibit spawning site fidelity behaviour, whereby mature fish migrate in dense shoals to discrete inshore spawning grounds (e.g., ICES, 2005; van Hoeck et al., 2023; Zemeckis et al., 2014). In the western Irish Sea, cod spawning is concentrated in the coastal regions between County Down in the north and Wicklow to the south (Coull et al., 1998; ICES, 2005; Marine Atlas, 2016), with areas of 'high intensity' spawning overlapping with the offshore development area and large parts of the sedimentary ZoI (**Figure 3-5**; Ellis et al., 2010, 2012). The distribution of cod larvae as interpolated from ichthyoplankton data (Cefas, 2000) further indicate high intensity cod spawning and larval development within the study area, particularly across the north-eastern section of the array area and sedimentary ZoI **(Figure 3-8**). High intensity nursery grounds are likely to overlap with the entire offshore development area and sedimentary ZoI, and the coastal regions of the underwater noise ZoI (Ellis et al., 2010, 2012; **Figure 3-14**).

3.4.4 Cod are currently classed as Vulnerable on the IUCN Red List (IUCN, 2023). They are also assessed as being threatened and/or declining across the OSPAR region III, on account of significant declines in stocks over the last decades and very low rates of recovery. The most recent stock assessment for cod populations in the Irish Sea suggests that stock biomass in 2023 remains low, with the spawning-stock biomass (SSB) below the estimated maximum sustainable SSB threshold (Marine Institute, 2023). No direct cod fishery is currently permitted within the Irish Sea and catch quota are exclusively set for landings from bycatch. In 2021, landings of cod were mainly associated with vessels targeting demersal fish (37%) and *Nephrops* (33%) (Marine Institute, 2022).

Haddock

3.4.5 Haddock is a demersal, bottom feeding codfish, which is distributed widely throughout Irish waters, with relatively high densities found consistently within the fish and shellfish study area. The species typically occupies areas near the bottom over rock, gravel, mud or smooth, hard sand at depths of about 10-450 m, with highest densities typically observed in continental shelf waters from 80-200 m (Albert, 1994; Cohen et al., 1990). The diet of haddock consists largely of benthic organisms, including molluscs, crustaceans, worms and small fish (Albert, 1994).

3.4.6 Information on the spawning dynamics of haddock in the Irish Sea is relatively sparse. Data from the Marine Institute (2016) show spawning grounds along the western Irish Sea coast from Bangor south to Wicklow Head (**Figure 3-5)**. Nursery grounds are found at a similar geographic range but extend further offshore (Coull et al., 1998; Marine Institute 2016; **Figure 3-14**). Spawning is likely to take place at some point between February and May, with peak spawning from February to April (Coull et al., 1998). Similar to other bentho-pelagic fish species, haddock have a demersal courting period followed by pelagic egg release and planktonic larval phases (Casaretto and Hawkins, 2002). Like male cod, male haddock produce a variety of sounds during the spawning season, which are thought to play an important role in synchronising the reproductive behaviour of mature male and female haddock (Hawkins and Amorim, 2000)

3.4.7 Haddock are currently classed as Vulnerable on the global IUCN Red List and as of Least Concern on the European Red List (IUCN, 2023). The stock size of haddock in the Irish Sea remains high and fishing mortality is low, indicating that the haddock population is in a good state and harvested sustainably (Marine Institute, 2023).

Whiting

3.4.8 Whiting is a bentho-pelagic codfish, which is widely distributed throughout Irish and other European waters on the continental shelf at depths from 10 to 200 m, with highest densities typically occurring from 30 to 100 m (Cohen et al., 1990). Juveniles prefer shallower coastal waters from about 5 to 30 m (Cohen et al., 1990; Kerby et al., 2013), while adults are found in deeper areas, most commonly over sandy and muddy substrates (Marine Institute, 2023). Both high and low intensity spawning grounds for whiting are located within the study area (**Figure 3-4**), with high intensity nursery grounds also being present (**Figure 3-15**, Ellis et al., 2010, 2012).

3.4.9 Whiting move in large shoals and hunt mobile prey such as crustaceans and small fish. They can grow up to 70 cm in length and are fast growing; at age 2 almost 100% of females and about 85% of males are fully mature (Marine Institute, 2023).

3.4.10 Catches of whiting in the waters around Ireland usually form part of a mixed bottom trawl fishery, with the majority of whiting caught as discards in the *Nephrops* fishery (Marine Institute, 2023). Stock levels in the Irish Sea are considered to be in poor condition; stock size is extremely low and has been since the early 1990s and shows no sign of recovery (Marine Institute, 2023).

Plaice

3.4.11 Plaice are widely distributed throughout European waters, including the Irish Sea. The species is typically found in waters of less than 100 m depth and most commonly on sandy, muddy or gravel bottom. Juveniles inhabit mostly shallow waters including intertidal areas, while older fish are found in deeper, more exposed waters (Loots et al., 2010; Marine Institute, 2023).

3.4.12 Spawning takes place between January and April (Coull et al., 1998; ICES, 2005) and is controlled by water temperature (Marine Institute, 2023). Tagging studies in the North Sea suggest that plaice exhibit strong site fidelity, returning to the same locations to spawn and feed (Hunter et al., 2003). Both high and low intensity spawning grounds for plaice are present within the offshore development area and ZoIs (**Figure 3-2**, Ellis et al., 2010, 2012), with spawning concentrated across the coastal regions (**Figure 3-8**; Fox et al., 2000). Similarly, **Figure 3-12** demonstrates the presence of nursery grounds across the study area (Ellis et al., 2010, 2012).

3.4.13 Irish vessels typically catch plaice as minor bycatch in mixed fisheries targeting *Nephrops* and haddock. Landings in plaice from Irish fleets have decreased in recent years, and fishing mortality of the Irish Sea stock remains below the Maximum Sustainable Yield (F_{MSY}) threshold, indicating that the stock is harvested sustainably (Marine Institute, 2023).

American plaice

3.4.14 The American plaice, also known as long rough dab, is a right-eye flatfish that is widely distributed throughout the eastern and western North Atlantic and adjacent Arctic oceans from the shallows down to depth of up to 3000 m (Cadrin et al., 2022a). It is most abundant in shallow waters between 10 and 400 m water depth (Cadrin et al., 2022a) and mainly occurs on soft substratum (Froese et al., 2023). Batch spawning of pelagic gametes takes place near the seabed (Froese et al., 2023).

3.4.15 The American plaice is currently classed as Endangered on the global IUCN Red List (Cadrin et al., 2022a), but listed as of Least Concern on the European Red List (Monroe et al., 2015a). It is not commercially targeted by the fishing industry in European waters, but may be retained as bycatch (Cadrin et al., 2022a).

Common sole

3.4.16 Common sole, also known as black sole or Dover sole, is a demersal flatfish, which lives buried in sandy or muddy sediments (Marine Institute, 2023). Juveniles (< 3 years) remain in shallow coastal and estuarine nurseries a few meters deep, while older individuals move into deeper waters (Cuveliers et al., 2011; Savina et al., 2010). Spawning takes place in spring and early summer (Coull et al., 1998; Nichols et al., 1993). The planktonic eggs and larvae spend between 4-5 weeks in the water column before they metamorphose into demersal juveniles (Savina et al., 2010). Sole spawning grounds are denoted as being present within the majority of the inshore areas of the study area (Coull et al., 1998; **Figure 3-3**). Data on the distribution of sole nursery grounds within the western Irish Sea are limited; groundfish surveys have recorded juveniles across mapped spawning areas (Ellis et al., 2012), indicating the presence of nursery grounds within the shallower inshore waters of the study area.

3.4.17 In the Irish Sea, common sole are mainly fished as a minor bycatch in mixed fisheries targeting rays and plaice in the St. George's Channel and, to a lesser extent, in the *Nephrops* fishery. Most landings are from beam trawlers; however, an increasing proportion of landings are from otter trawl fleets (Marine Institute, 2023). Recent biomass estimates suggest that the Irish Sea stock is currently below levels required to support the maximum sustainable yield, following low recruitment and increasing fishing mortality (Marine Institute, 2023).

Lemon sole

3.4.18 Lemon sole are found throughout the shelf waters from the Barents Sea to the Bay of Biscay, typically at depth of 50-200 m, though the species has been recorded down to about 1,100 m water depth (Geffen et al., 2021). Data from groundfish surveys in the English Channel suggest that, unlike plaice and sole, lemon sole prefer sandy and gravelly sand substrata in deeper waters (Hinz et al., 2006).

3.4.19 Spawning takes primarily place between April and September (Coull et al., 1998) although evidence exists of spawning through the winter months (Geffen et al., 2021). The locations of spawning and nursery grounds for lemon sole in the western Irish Sea are not well defined, but they are likely to overlap with the offshore development area and parts of the ZoIs (Coull et al., 1998; **Figure 3-3** and **Figure 3-13**).

Witch flounder

3.4.20 The Witch flounder, also known as grey sole, is a long-lived, late-maturing, right-eye flatfish, which is widely distributed throughout the eastern and western North Atlantic and adjacent Arctic Ocean from the shallows down to depth of up to 1600 m. Adults are most abundant on the continental shelves and upper continental slopes at depths between about 45-500 m, where they occur on fine substratum including muds and muddy sands. Juveniles are reported to inhabit different depths bands than adult flounders, generally preferring deeper waters (Cadrin et al., 2022b; Cargnelli et al., 1999).

3.4.21 Witch flounder in the western North Atlantic are known to form dense spawning aggregations in colder offshore waters (Cargnelli et al., 1999). Spawning takes place at or near the seabed from March to November, with the exact spawning period depending on geographic location (Cargnelli et al., 1999). The pelagic larval stage can last up to one year (Cadrin et al., 2022b).

3.4.22 Witch flounder is currently classed as Vulnerable on the global IUCN Red List (Cadrin et al., 2022b), but listed as of Least Concern on the European Red List (Monroe et al., 2015b). It is not commercially targeted by the fishing industry operating in Irish waters, but it may be retained as bycatch in *Nephrops* and other demersal trawl fisheries (MPA Advisory Group, 2023).

Anglerfish

3.4.23 Two closely-related species of anglerfish are known to occur in Irish waters, the white anglerfish *Lophius piscatorius* and the black anglerfish *L. budegassa*. Fisheries catch data indicate that anglerfish in the Irish Seas are mainly white anglerfish (Marine Institute, 2023). Anglerfish are demersal species, with white anglerfish being most abundant at depths of 200-800 m, though they have also been recorded in shallow coastal waters (Marine Institute, 2023; Whitehead et al., 1986), including the study area (ICES, 2023a,b). Anglerfish are known to migrate hundreds of kilometres. Their planktonic eggs and larvae spent up to 4 months in the water column, allowing them to be dispersed over large areas (Marine Institute, 2023).

3.4.24 ICES stock assessments for white anglerfish indicate that the stock is currently fished sustainably, with fishing mortality currently below the F_{MSY} threshold for achieving the Maximum Sustainable Yield; the stock size increased since 2004, peaked in 2020, and has been fluctuating around the 2020 stock size since (Marine Institute, 2023). Much of the Irish anglerfish landings come from highly mixed fisheries, where they are caught together with megrim, *Nephrops*, haddock, hake and other species (Marine Institute, 2023).

Atlantic herring

3.4.25 Herring are pelagic shoaling fish, which are distributed widely throughout the North Atlantic, typically occurring in continental shelf waters at depth of 0-200 m (Froese and Pauly, 2023). Juveniles are typically found closer inshore, while adults prefer deeper offshore waters (ICES, 1994). Herring mainly feed on copepods (Blaxter and Hunter, 1982), while they in turn are important prey for larger fish like cod and whiting and marine mammals including seals and dolphins (e.g., Patterson, 1985; Sveegaard et al., 2012). Consequently, herring play a key role in marine food webs, transporting energy from lower to higher trophic levels (Blaxter and Hunter, 1982).

3.4.26 Herring are benthic spawners, which deposit adhesive eggs to hard surfaces. Spawning typically occurs in high energy and/or structurally complex environments with good circulation and oxygenation and sufficient surfaces to attach large volumes of eggs (Frost and Diele, 2022). Preferred locations include inshore areas with submerged vegetation and areas with coarse substrates, such as gravel, small rocks, maerl beds, or coarse sand (e.g., Frost and Diele, 2022; Maravelias et al., 2000). Whether such areas are ultimately used by herring for spawning depends on additional factors, including small-scale seabed geomorphology and local wind and flow conditions (Frost and Diele, 2022). As a result, herring spawning beds are typically spatially discrete patches distributed throughout wider areas (spawning grounds) of suitable spawning substrate (O'Sullivan et al., 2013).

3.4.27 Herring are known to display spawning site fidelity, returning to distinct spawning grounds (Frost and Diele, 2022). The Irish Sea herring has historically been divided into two adult spawning populations: (1) the Manx component with spawning grounds located to the east and north of the Isle of Man, and (2) the Mourne component with spawning grounds along coastal areas off County Louth and County Down (ICES, 1994; **Figure 3-1**). A decline in spawning activity of the Mourne herring population was reported by Dickey-Collas et al. (2001), who, based on larvae data, estimated that the Mourne spawning stock accounted for about 3% of the total production of Irish Sea herring larvae in the 1990s. More recent larval data collected as part of the annual Northern Irish Northeastern Larvae Survey (NINEL) suggests ongoing spawning activity along the Irish and North Irish coasts over the traditional Mourne herring ground (e.g., ICES, 2022c, 2023c), with the overall contributions of the Mourne herring to the Irish Sea spawning stock remaining low (e.g., ICES 2022d). The continued operation of a small local (traditional) gillnet fishery on the Mourne herring, aimed at adult fish that spawn off the Northern Irish eastern coast, further confirm the presence of active spawning beds over the traditional Mourne herring ground (ICES, 2022d).

3.4.28 Both Irish Sea herring populations spawn in autumn between September to November (peak spawning in late September or early October), with a small proportion of the spawning stock likely to continue spawning during the winter months until January/February (Dickey-Collas et al., 2001; ICES, 1994). Following spawning, adult herring disperse to offshore feeding grounds across the northern Irish Sea from October/November until the following April/May (ICES, 1994). Tagging studies suggest that some adults migrate northwards and join the feeding aggregations on the Scottish west coast (Geffen et al., 2011; ICES, 1994). Juvenile herring concentrate in coastal nursery areas in the northern Irish Sea (Campenella and van der Kooij, 2021), which overlap with the offshore development area, the sedimentary ZoI and some parts of the underwater noise ZoI (**Figure 3-11**). Herring were recorded in relatively high abundances across the study area and western Irish Sea in the NIGFS (ICES, 2023a).

Sprat

3.4.29 Sprat are widely distributed across the Irish Sea and are an important prey resource for a number of piscivorous fish, marine mammals and sea birds. Sprat have been recorded across the Irish Sea. Spawning grounds for sprat are extensive, covering the majority of the Irish Sea (Coull et al., 1998) (**Figure 3-4)** and UK waters, with spawning occurring over a period from May to August (Coull et al., 1998).

Atlantic mackerel

3.4.30 Atlantic Mackerel is a migratory, epi-pelagic and meso-demersal species, which is widely distributed across much of the north-eastern and north-western Atlantic shelf. Atlantic mackerel form dense shoals near the surface, feeding primarily on zooplankton and small fish (Froese and Pauly, 2023). Atlantic mackerel is a species of commercial importance and is also an important prey species for marine mammals, seabirds and other fish.

3.4.31 Spawning takes place in warmer inshore areas during spring and summer, with peak spawning likely to occur in May and June (Coull et al., 1998). The importance of the Irish Sea for Mackerel spawning is not established well, although data analysed by Ellis et al. (2010, 2012) indicate the presence of 'low intensity' spawning grounds across the northern Irish Sea, overlapping the study area (**Figure 3-6**). After spawning, adults disperse and migrate to overwintering areas in cooler, deeper waters (Collette and Nauen, 1983). Juvenile mackerel are known to grow rapidly, reaching 30 cm in length after 2 years, at which point more than half are mature (Marine Institute, 2023). Nursery areas of Atlantic mackerel are extensive, covering large parts of the study area and wider Irish Sea (**Figure 3-16**).

3.4.32 Atlantic mackerel in the Irish Sea are part of the north-east Atlantic stock, which is considered to form a single spawning population (Marine Institute, 2023). The biomass of the stock has been decreasing since 2015, although it remains above the biomass threshold that would trigger amendments to management measures (Marine Institute, 2023)

Atlantic horse mackerel

3.4.33 Horse mackerel is a pelagic schooling species with a wide distribution across the eastern Atlantic continental shelf. Horse mackerel are commonly caught in both pelagic and bottom trawl surveys, suggesting they spend some time near the seabed (Marine Institute, 2023). Horse mackerel in the Irish Sea belong to the western stock, which spawns from December until September, with peak spawning occurring in May/June (Campanella and van der Kooij, 2021).

3.4.34 Stock levels of Atlantic horse mackerel in Irish aters and the wider north-east Atlantic have been low since the early 2000s, with the current SSB remaining below levels required to support a sustainable fishery (Marine Institute, 2023). Therefore, no direct fishery for Atlantic horse mackerel is currently permitted.

Prey species and food webs

3.4.35 Several of the fish and shellfish species present in the study area are important prey items for top marine predators including elasmobranchs, piscivorous fish, seabirds, and marine mammals (e.g., Cummins et al., 2019; Hernandez-Milian et al., 2015). Small planktivorous species such as sandeel, sprat and herring act as important link between zooplankton and top predators (Frederiksen et al., 2006). Sandeels, for example, constitute an important food source for sea birds, such as tern, puffins, kittiwakes and razorbills. They are also preyed upon by marine mammals, such as seals and harbour porpoise, piscivorous fish, such as herring, cod, whiting, and sea trout. Other fish species important in the diet of marine mammals include whiting, mackerel and various clupeoids (e.g., Hernandez-Milian et al., 2015).

3.5 Shellfish ecology

Nephrops

Ecology

3.5.1 The Norway lobster *Nephrops norvegicus,* also known as the Dublin Bay prawn, is a small burrowing decapod crustacean, which is widely distributed throughout the north-east Atlantic and Mediterranean Sea at depths of between 20-800 m (Hill and Sabatini, 2008). They are mainly found on fine cohesive muddy substrates that are stable enough to support the construction of complex burrow systems (Chapman, 1980). The burrows are typically up to 20-30 cm deep and can be up to 10 cm in diameter and over a metre long (Hill and Sabatini, 2008).

3.5.2 *Nephrops* in shallow waters (< 50 m) usually stay within their burrows during the day (Chiesa et al., 2010), probably to avoid predation (Chapman, 1980). At night they emerge to forage, feeding primarily on other crustaceans as well as sediment-dwelling molluscs, echinoderms, and polychaetes (Hill and Sabatini, 2008). In deeper water, a reversed diel feeding pattern has been observed with individuals being more active by day.

3.5.3 *Nephrops* in the Irish Sea spawn annually with the fertilisation of eggs typically occurring throughout August and September (Farmer, 1974). Fertilised eggs are incubated by the females under their abdomen for about 8-9 months. During this time, female *Nephrops* tend to remain within their burrows, re-emerging in late March to July for the larvae to hatch (Dickey-Collas et al., 2000; Farmer, 1974; Hill et al., 1996). The planktonic larvae then spend several weeks in the water column before settling out, with suitable settlement areas being confined to muddy substrates (Dickey-Collas et al., 2000; White et al., 1988).

3.5.4 Juvenile and adult *Nephrops* exhibit a high degree of site fidelity and show no evidence of migration (Hill and Sabatini, 2008). Tagging studies, for instance, have demonstrated that individuals stay close to their burrows during their adult life, while laboratory studies have shown territorial behaviour, particularly among adult males (Hill and Sabatini, 2008).

Distribution in the study area

3.5.5 The site-specific DDV surveys indicated the presence of *Nephrops* burrows along most of the ECC (Natural Power, 2023) and within the northern section of the array area where sandy muds predominated (Natural Power, 2022). Faunal communities here were assigned the biotopes 'Burrowing megafauna *Maxmuelleria lankesteri* in circalittoral fine mud' (SS.SMu.CfiMu.MegMax) or 'Seapens and burrowing megafauna in circalittoral fine mud' (SS.Smu.CfiMu.SpnMeg) (**Figure 3-21**). In stable muds, these biotopes contain distinctive megafauna including *Nephrops*.

3.5.6 *Nephrops* populations are highly discontinuous with at least 30 populations occurring in European waters (Bell et al., 2006, cited in O'Sullivan et al., 2014). Norway lobster within the study area are part of the western Irish Sea *Nephrops* population, which inhabits the fine sediments of the Western Irish Sea Mud Belt from about 54.5°N in the north to 53.5°N in the south (**Figure 3-21**). Sediment deposition across the mud belt is high, driven by a low energy tidal regime and resulting in a substrate favourable for both juvenile and adult *Nephrops* (Hill et al., 1996). Burrow densities across the western Irish Sea *Nephrops* ground are amongst the highest recorded for north-east Atlantic stocks, reaching an average density of up to one burrow per square metre (Lundy et al., 2019). By contrast, the average size of adult individuals is comparatively small, which has been linked to high recruitment rates and/or suppressed growth due to competition (Johnson et al., 2013).

3.5.7 The western Irish Sea *Nephrops* population is believed to be stable, though isolated from surrounding populations with limited imports of larvae from outside the Irish Sea (McGeady et al., 2022; O'Sullivan et al., 2014). Across the western Irish Sea, larval dispersal is thought to be influenced by the Irish Sea gyre, a seasonal water circulation feature that forms above the western Irish Sea mud belt in spring and summer, partly coinciding with the *Nephrops* larval dispersal period (Hill et al., 1996). It has been suggested that the gyre promotes the retention of resident larvae and thus may provide an important mechanism to maintain the western Irish Sea *Nephrops* population (Hill et al., 1996).

Fishing grounds

3.5.8 *Nephrops* is commercially exploited throughout its geographic range. The western Irish Sea stock (assessed and managed as Functional Unit (FU) 15) supports one of the most productive *Nephrops* fisheries in Irish waters, yielding landings of 5,000-10,000 tonnes annually over the last two decades. The current stock of FU15 is estimated to contain about 4,500 million individuals (ICES, 2022e), which is more than ten times larger than the abundance estimate for the neighbouring stock in FU14 (Irish Sea East) (ICES, 2022f).

3.5.9 *Nephrops* within FU15 are mainly fished by otter trawlers from the Irish and Northern Ireland demersal fleets (ICES, 2022a). Most landings are taken from ICES rectangle 36E4, which overlaps the array area and the offshore section of the ECC (**Figure 3-22**). Current stock abundance estimates for FU15 are well above the Maximum Sustainable Yield (MSY) reference trigger point of 3 million burrows, indicating that the western Irish Sea *Nephrops* population is in a good state and harvested sustainably (ICES, 2022g; McGeady et al., 2022).

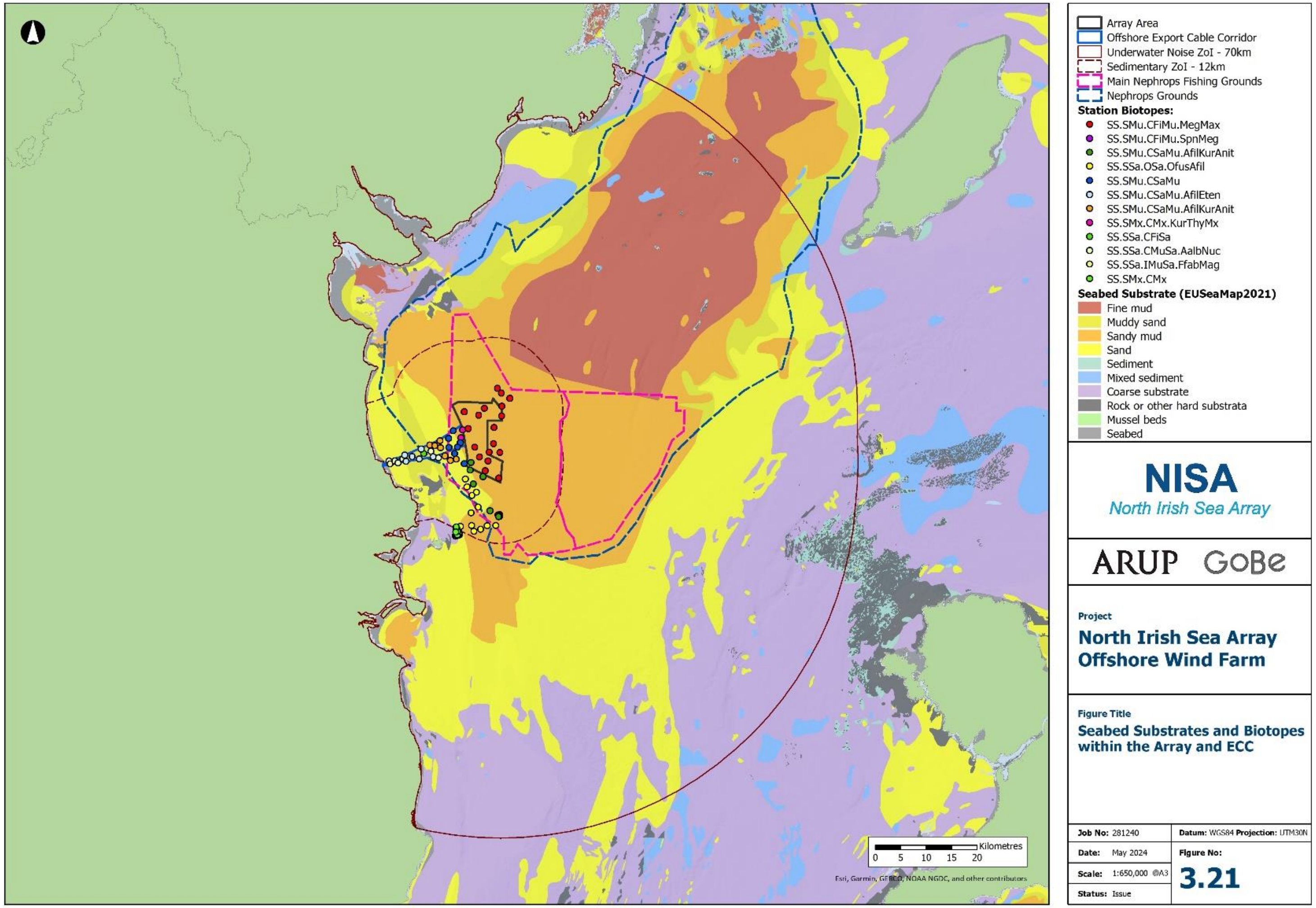

Figure 3-21: Seabed Substrates and Biotopes within the Array and ECC (Natural Power, 2022, 2023).

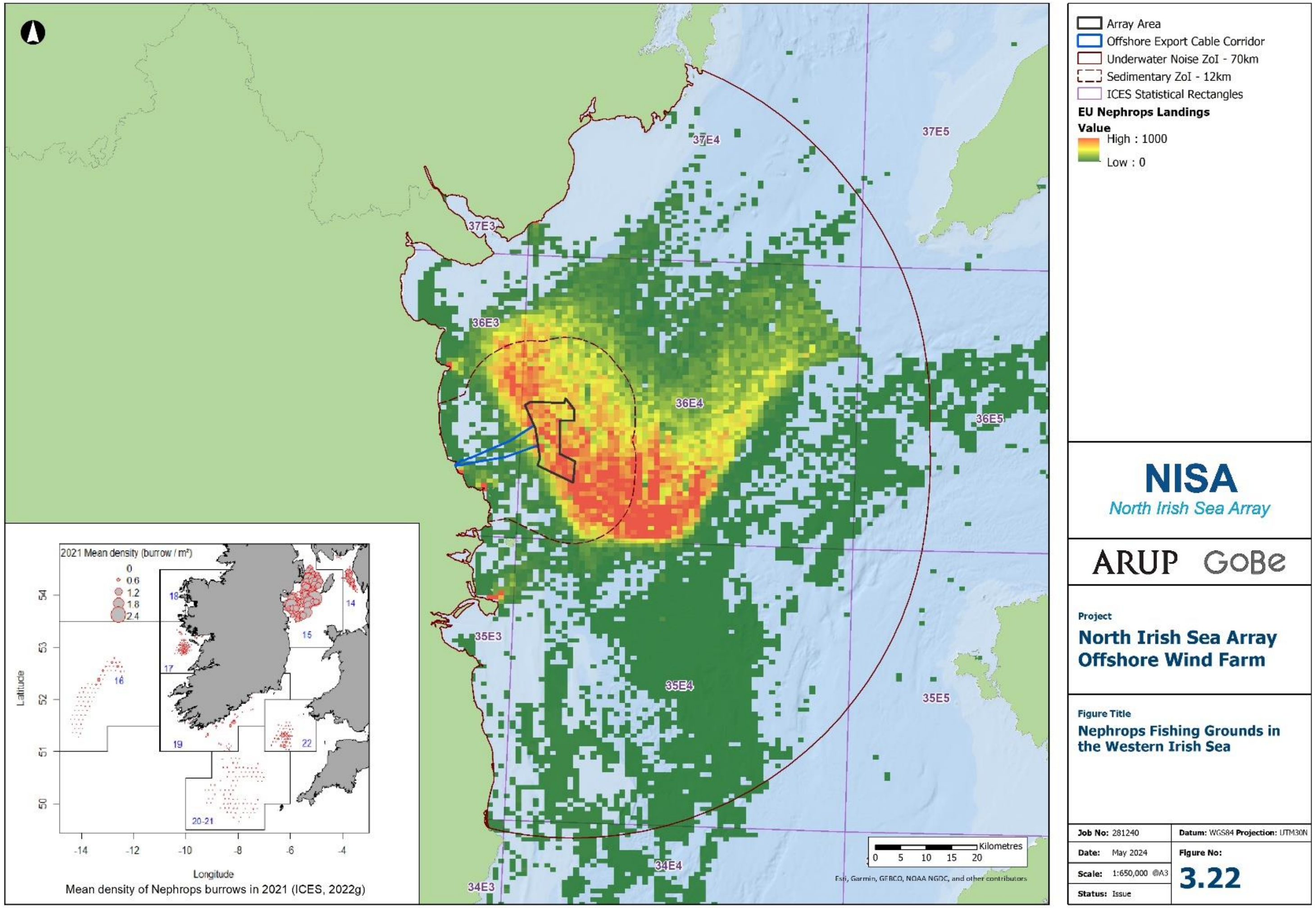

Figure 3-22: *Nephrops* Fishing Grounds in the Western Irish Sea (Marine Institute, 2016).

European lobster

3.5.10 European lobster are widely distributed in the Eastern Atlantic from Norway south to the Azores and the Atlantic coast of Morocco (Holthuis, 1991). They are typically found on coarser ground and rocky reefs from the sublittoral fringe to depths up to 150 m, although most commonly they prefer waters less than 30 m (Holthuis, 1991; Pawson, 1995).

3.5.11 Lobster are predominantly nocturnal and rely on suitable shelter throughout their life cycle (e.g., Paille et al., 2002; Smith et al., 1998). Juvenile lobsters are particularly sedentary and known to remain within their burrows to feed, while older individuals forage outside their burrows and generally prefer less complex habitats (Prodöhl et al., 2007; Smith et al., 1998). Unlike edible crabs, lobsters are not thought to undertake extensive migrations and will move only a few kilometres away from shelter to find suitable foraging grounds (Pawson, 1995; Skerrit et al., 2015; Smith et al., 2001).

3.5.12 Female lobster spawn annually or bi-annually during summer (Pawson, 1995; Prodöhl et al., 2007). Fertilised eggs are carried by the females for 10 to 12 months (Holthuis, 1991), and hatching takes place in spring and early summer (Pawson, 1995). Berried females do not typically exhibit a sedentary overwintering behaviour (Pawson, 1995) and are therefore considered less sensitive to potential impacts from the proposed development compared to other species that are known to be sedentary during overwintering periods.

3.5.13 A key European lobster fishery lies within the study area and overlaps the ECC (**Figure 3-20**; Marine Institute, 2016). The status of European lobster is considered generally stable in the Irish Sea, with minimum and maximum landing sizes and v-notching safeguarding against stock decline (Marine Institute and Bord Iascaigh Mhara, 2024).

Brown crab

3.5.14 Brown crab, also known as edible crab, are large crab that occur from the lower shore down to the subtidal at depths of up to 200 m (Brown and Bennett, 1980; Tully, 2017). Juvenile brown crabs prefer shallow inshore waters, while adults typically inhabit deeper areas (Mesquita et al., 2021). Brown crabs are often associated with rocky reefs but also inhabit mixed coarse grounds and soft sediments particularly offshore (Neal and Wilson, 2008).

3.5.15 Mature female crabs are known to undertake long-distance seasonal migrations to offshore overwintering grounds following the mating season in spring and summer (e.g., Bennett, 1995; Fahy and Carroll, 2008; Ungfors et al., 2007). Sperms are temporarily stored by female crabs before fertilisation takes place in late autumn or early winter (Bennett, 1995). The fertilised eggs are then carried by the females for 6-9 months before the pelagic larvae are released in spring to early summer (Brown and Bennett, 1980; Thompson et al., 1995).

3.5.16 Berried females are thought to exhibit a largely sedentary lifestyle during the overwintering period whilst brooding their eggs. During this time, they do not feed and are thought to remain buried in sand and gravel substrates (Neal and Wilson, 2008; Thompson et al., 1995). However, larval distribution data suggest that hatching of eggs may not be confined to the overwintering sites but instead may occur over a wider area and range of substrates (Thompson et al., 1995). The movements of male brown crabs are typically less directed and cover shorter distances (Bennett, 1995; Ungfors et al., 2007).

3.5.17 The status of brown crab in the Irish Sea has long been considered stable (based on catch rates and recruitment), with their spawning potential considered to be largely protected by a minimum landing size of 140 mm carapace width (Tully, 2017). However, recent stock assessments (Marine Institute and Bord Iascaigh Mhara, 2024) indicate overall declines in crab biomass and landings for stocks off the north-western and south-western Irish Coast since 2014/2015. Data on the current state of the Irish Sea stock were not available.

Razor clam

3.5.18 Razor clams (*Ensis* spp.) are elongated, suspension-feeding bivalves that inhabit vertical burrows in sand and muddy sediments from the intertidal to depths of up to 40-60 m (Cross et al., 2014; Fraser et al., 2018). In the waters surrounding Ireland, three species of *Ensis* are of particular interest due to their commercial importance, namely the common razor shell *Ensis ensis*, the curved razor shell *E. magnus*, and the sword razor shell *E. siliqua* (Fahy et al., 2001; Fraser et al., 2018). Of these, *E. siliqua* makes up the majority of landings from the fish and shellfish study area (Marine Institute and Bord Iascaigh Mhara, 2023), which are obtained by hydraulic dredges from clam beds located in shallow inshore waters (Figure 3-19).

3.5.19 Razor clams breed annually, with the development of the gonads taking place throughout winter (Fraser et al., 2018). Spawning typically occurs during spring and summer, and larvae settle on to the seabed after spending approximately one month in the water column (da Costa et al., 2010; Fraser et al., 2018). However, successful recruitment of razor clams has been shown to be irregular and sporadic (Fraser et al., 2018). The size distribution of razor clams across intertidal beds has been found to vary spatially, with the largest clams typically found at greater depths (Fraser et al., 2018). This indicates the possibility of post settlement movement of juvenile and possibly adult clams into deeper areas following their initial settlement in shallower areas (Marine Institute and Bord Iascaigh Mhara, 2023).

3.5.20 *E. siliqua* prefers clean fine sand (Fraser et al., 2018) and is most commonly found in shallow subtidal waters at 3-7 m water depth (Cross et al., 2014). The current fishery for *E. siliqua* in the western Irish Sea operates in about 4-14 m water depth (**Figure 3-19**), and it is thought that no large beds occur outside of those areas commercially fished (Marine Institute and Bord Iascaigh Mhara, 2023). The stocks of *E. siliqua* in the northern Irish Sea are currently managed by a minimum landing size (125 mm shell length) and weekly quotas with the fishery closed on Sundays and in June during peak spawning (Marine Institute and Bord Iascaigh Mhara, 2022). Monitoring data indicate that large size classes were reduced between 2017-2018 but were stable or increasing between 2018 and 2021 (Marine Institute and Bord Iascaigh Mhara, 2023). Data on stock structure are limited, but larval dispersal and the movement of juveniles suggest relatively strong connectivity between beds along the east coast of the north Irish Sea, with the likelihood of self-recruiting beds assessed as being low (Marine Institute and Bord Iascaigh Mhara, 2024).

Common cockle

3.5.21 The common cockle is a widely distributed, gregarious bivalve molluscs that inhabits intertidal sands, muds, and muddy gravels preferably within sheltered bays, estuaries, or sea lochs (Tyler-Walters, 2007). It lives buried in surface sediments, typically within the top 2 to 5 cm of the substratum (Richardson et al., 1993). In Irish waters, cockles often occur in isolated and discrete areas around the coast, and consequently they are thought to form local self-recruiting populations (Marine Institute and Bord Iascaigh Mhara, 2023).

3.5.22 Cockle gametes are pelagic. Populations in UK waters generally spawn between March and August, and larvae settle between May and September. Onset of spawning varies geographically and is likely driven by seasonal changes in water temperature. Settlement success and subsequent survival also varies with geographic location and can be highly variable in response to abiotic (e.g., post-settlement erosion by currents and storms) and biotic (competition, predation) stressors. In addition, overwinter mortality of both juvenile and adult cockles can be high as they are easily disturbed and washed away. Resident cockle populations may therefore undergo distinct cycles in growth, production, and mortality (Tyler-Walters, 2007).

3.5.23 Although there are many cockle beds around the Irish coast only Dundalk Bay has supported commercial cockle dredge fisheries in recent years. The fishery is managed under a Fisheries Natura Plan that links fisheries management measures with protection measures for the Dundalk Bay SAC. Cockle landings are managed through fishing permits and annual quotas (Marine Institute and Bord Iascaigh Mhara, 2024).

King scallop

3.5.24 King scallops, also known as great scallops, are found in water depths of between about 10-110 m, commonly in areas of clean, firm sand and fine or sandy gravel exposed to water currents, which provide good feeding conditions (Marshall and Wilson, 2008). Adults are largely sedentary and usually found recessed in shallow depressions in the sediment. King scallop can live up to 20 years and reach reproductive maturity at 3-5 years at a size of 6 cm; the average maximum size is 16 cm (Marshall and Wilson, 2008).

3.5.25 The timing of spawning varies between stocks, with spawning typically occurring in spring (April to May) or early autumn (end of August to September (ICES, 2016; Marshall and Wilson, 2008). A bi-modal spawning pattern has been recorded for some stocks, such as in Manx waters, where 'spring spawning' and 'autumns spawning' has been observed (Marshall and Wilson, 2008). The duration of the planktonic larval phase is strongly dependent on water temperature, lasting typically 21 days in warm waters and more than 50 days under colder conditions (Hold et al., 2021). Recruitment can be highly variable as it depends not only on successful spawning and larval production but also on larval retention and the transport of larvae to areas suitable for settlement. As a consequence, scallop beds frequently show a patchy distribution with spatial differences in age structure and recruitment mechanisms (Marshall and Wilson, 2008).

3.5.26 Scallop in the Irish Sea represent spatially discrete stocks, though some can be interconnected through larval dispersal. Larval dispersal simulations indicate no connectivity between stocks in the northern Irish Sea and around the Isle of Man and stocks in the southern Irish Sea and further south. By contrast, stocks in Cardigan Bay and off the Irish coast show limited connectivity, while strong connectivity is predicted between stocks in the south Irish Sea and northeast Celtic Sea (Marine Institute and Bord Iascaigh Mhara, 2024).

Common whelk

3.5.27 Common whelk is a large, epibenthic gastropod that is found from the shallow subtidal down to the continental slope at depth up to 1200 m, being most common at depths above 50 m (Ager, 2008; Tully, 2017). The species has been recorded from a wide variety of hard and soft substrates including rock, cobbles, and gravel as well as coarse and muddy sands.

3.5.28 Whelks do not release pelagic eggs; instead, eggs are fertilised internally and then laid as large clumps onto hard substrates (Hancock, 1967). In the Irish Sea, breeding and egg deposition is thought to occur during the autumn and winter months, and hatching of fully formed juveniles takes place between April and early May, three to five months after breeding (Kideys et al., 1993; Smith and Thatje, 2013). The distribution of juvenile whelks tends to be restricted to areas close to the adult stock (Lockwood, 2005) due to the absence of a pelagic dispersal stage, and therefore populations are likely to be locally discrete with limited connectivity (Tully, 2017; Valentinsson, 2002).

3.5.29 Tagging experiments have shown little movement of adult whelk suggesting that they exhibit strong site fidelity (Hancock, 1963). Wider movements may be excepted during the breeding season when female whelk search for suitable egg-deposition sites on hard surfaces (Valentinsson, 2002).

3.5.30 In the western Irish Sea, potting activity for whelk has historically been concentrated to the south of the proposed development (**Figure 3-20**). However, recent consultation with the fishing industry suggests that whelk is currently targeted further north towards the array area. Whelk stocks in Irish waters are managed by a minimum landing size, but no catch limits or quotas are currently in place (Marine Institute and Bord Iascaigh Mhara, 2023). The long-term sustainability of the Irish whelk fishery remains unclear; several populations are subject to high fishing mortality and the current minimum landing size is well below the size at which whelk mature, suggesting that the reproductive potential of the stock may not be sufficiently protected (Marine Institute and Bord Iascaigh Mhara, 2024).

Mussel

3.5.31 Blue mussels are gregarious, suspension-feeding bivalves, which are common around European coasts from the high intertidal to the shallow subtidal down to about 30 m water depth (Knights, 2012; Seed and Suchanek, 1992). They can be found in a variety of settings, ranging from littoral estuarine sand and mudflats and sublittoral sediments to gravel, pebble and rocky shores and artificial structures such as piers and offshore oil platforms (Tyler-Walters, 2008).

3.5.32 Blue mussels can form dense beds on both hard and soft substrate, creating a multi-layered framework of mussels where individuals remain connected through their byssus threads. Such beds can completely cover the substratum, or they consist of a mosaic of smaller mussel patches of various size and shape separated by open spaces (Seed and Suchanek, 1992). Spawning occurs in early summer, with a pelagic larval dispersal phase (Tully, 2017).

3.5.33 Stocks of mussel in the western Irish Sea consist mainly of seed mussel which settle in spring on coarse substrates. Wild mussel seed is dredged from the Irish Sea and other areas for growing in aquaculture sites licenced for the culture of bottom grown mussels. Most of the beds are thought to be ephemeral features, which are washed out or predated on prior to the mussels maturing. Some sub-tidal mussel beds in the Irish Sea may, however, contribute significantly to larval production in some years. The stock status changes seasonally and is driven by recruitment and growth in spring and summer and mortality during winter. Given the ubiquitous distribution of mussel and the larval dispersal phase the population structure may be open at a regional scale.

3.5.34 Historically hand raking of seed has taken place along the Louth and North Dublin Coasts (Marine Institute, 2018). Dredgers target mussel seed off the Irish Coast with up to 20 vessels operating, including in Dublin Bay, located to the south of the offshore development area (**Figure 3-19**).

3.6 Diadromous species

3.6.1 Diadromous fish are species that spend part of their lives in freshwater and part in saltwater, migrating between freshwater and marine environments at points in their life cycle. Such species are not generally present in the study area for much of their life cycle. Nonetheless, they can be present at times when migrating to and from rivers and transitional water bodies in the area, and they may therefore be affected by impacts arising from the development process as they transit the site.

3.6.2 Diadromous fish species that have the potential to occur in the fish and shellfish study area are Atlantic salmon *Salmo salar*, brown trout *Salmo trutta*, European eel, twaite shad *Alosa fallax*, and lamprey species.

Atlantic salmon

3.6.3 Atlantic salmon are of great biological, conservation and economic importance. Most populations have an anadromous life history, beginning their life in freshwater and then migrating to sea to feed and grow, before periodically returning to their home rivers to spawn. The strong homing behaviour of salmon has resulted in a vast amount of genetically distinct salmon stocks across their distributional range (Gilbey et al., 2021).

3.6.4 Atlantic salmon is a species of conservation importance listed on Annex II of the Habitats Directive as species whose conservation requires the designation of SACs. The nearest SAC designated for Atlantic salmon to the study area is the River Boyne and River Blackwater SAC (**Figure 3-23**). Along the south-east coast of Ireland, salmon is also afforded protection in the Slaney River Valley SAC, which is located approximately 149 km from the array area (**Figure 3-23**). The SAC is also a designated site for the freshwater pearl mussel *Margaritifera margaritifera*, which is closely linked with salmon populations, with pearl mussel larvae depending on juvenile Atlantic salmon as hosts (Skinner et al., 2003; Taeubert and Geist, 2017).

3.6.5 Atlantic salmon are also classed as being under threat and/or in decline by OSPAR, and the IUCN has recently assessed Atlantic salmon as Near Threatened at global scale (Darwall, 2023) on account of global declines in population densities. The nearest rivers designated as Salmonid waters under the Salmonid River Regulations are the River Boyne and the River Dargle, the latter entering the Irish Sea at Bray to the south of the offshore development area (**Figure 2-2**).

3.6.6 In addition to the River Boyne and its tributaries, Atlantic salmon are known to be present within several rivers entering the Irish Sea close to the offshore development area, including the Rivers Varty, Dargle, Liffey, Dodder, Tolka, Fane, Glyde, Dee and Castletown (IFI, 2018, 2022; Millane et al., 2023; O'Connor, 2006; **Figure 2-2**).

3.6.7 The marine phase of Atlantic salmon begins between spring and early summer when large numbers of young salmon (smolts) leave Irish rivers to migrate into the rich feeding grounds of the Norwegian Sea and the greater expanse of the north-east Atlantic Ocean (e.g., Gilbey et al., 2021; Holm et al., 2000). On leaving natal rivers, it has been reported that salmon undertake a rapid and active migration away from their river of origin (Holm et al., 2000; Jonsson et al., 1993), as reported by Martin and Mitchell (1985) who caught post-smolts tagged in Scottish rivers in the Faroese fishery within 6 months of leaving freshwater. The return migration of salmon into their native rivers mainly takes place during spring and summer, and spawning occurs during the following autumn and winter (Finstad et al., 2005).

3.6.8 Salmon smolts are known to descend the river Liffey between March and May but are not counted (Holmes et al., 2018; Millane et al., 2023). A review of monthly fish counter returns on the Liffey for several years, shows that while salmon can run into the Liffey in every month of the year, the main months are June to September, with years when October can also contribute significantly (Aquatic Services Unit, 2020; IFI, 2018). However, since the 1980's the number of wild salmon returning to Irish rivers has decreased from 15-20% to only 5%, indicating a decrease in salmon survival in the marine environment (Millane et al., 2023). Analysis of data from fish counters indicate that salmon stocks within the Rivers Boyne and Slaney are currently below river-specific conservation limits (Millane et al., 2023).

3.6.9 The migratory routes of Atlantic Salmon away from coastal waters to their oceanic feeding grounds are generally poorly understood. Experimental post-smolt trawls in the Norwegian sea and Western Scotland have provided evidence for a northerly migration route for Irish salmon stocks in the early months of their long migration. Recent acoustic telemetry data suggest that young salmon (smolts) from the River Boyne and other rivers along the east coast of Ireland move north upon leaving their home rivers (Barry et al., 2020). The tracking data further suggest that on leaving their natal rivers, smolts move rapidly away from the coast towards the deep waters of the Irish Sea, possibly to take advantage of the northwards flowing surface currents, which can assist their journey to the oceanic feeding grounds in the north-east Atlantic (Barry et al., 2020). There is therefore high potential that migratory smolts from the River Boyne and its tributaries pass through the study area. No information is available on the movement patterns of returning salmon; however, a similar pathway to that of outward moving smolts may be assumed.

3.6.10 Tracking data further suggest that salmon smolts within the south-east coast of Ireland (where the river Slaney is located) head in a south-westerly direction upon leaving the estuary (Rikardsen, et al., 2021), suggesting that they do not migrate through the study area to reach their oceanic feeding grounds.

3.6.11 During the site-specific DDV survey, no Atlantic salmon were observed (Natural Power, 2022, 2023). However, the evidence indicates that there is potential for salmon smolt and adult salmon to occur within the offshore development area during outward and return migrations.

Brown/sea trout

3.6.12 Brown trout are widespread in all major river and lake systems of Ireland, justifying a conservation assessment of Least concern (Freyhof, 2011a; King et al., 2011). Rivers flowing into the study area that support sea trout include the Boyne, Nanny, Liffey, Dargle, Varty, Avoca, Castletown, Fane, Glyde and Dee (IFI, 2022; **Figure 2-2**).

3.6.13 Trout spawn in late autumn to early spring in channels of suitable gradient and over cobbly and gravelly substratum (King et al., 2011). Juveniles may spend their entire life in natal streams or may descend to lower reaches and the sea. Individuals with a marine stage are commonly referred to as sea trout. Netting and tracking data for post-smolt sea trout provide evidence supporting relatively local movements to the coast for the first couple of months in the sea (Finstad et al., 2005 as cited in Malcolm et al., 2010). This is supported by more recent data (CSTP, 2016), which indicate that a significant proportion of sea trout remain relatively close to their river of origin, with those fish undertaking longer distance migrations being strongly influenced by the prevailing currents of the area.

3.6.14 In contrast to Atlantic salmon, sea trout often return to fresh water to over-winter as well as to spawn. During the site-specific DDV survey, sea trout was not recorded (Natural Power, 2022), but it is assumed that sea trout may at some point transit through the study area.

European eel

3.6.15 The European eel is a demersal fish that is widely distributed across most inland waters of Europe from Norway to the Mediterranean Sea and the North African coastline (Pike et al., 2020). It is a species of high conservation importance, being classed as Critically Endangered on the Irish, European and Global IUCN Red Lists (Clarke et al., 2016; IUCN, 2023; Pike et al., 2020). European eel is also listed as threatened and/or declining in the OSPAR region.

3.6.16 European eels have a complex life cycle. Adult eel spawn in the Sargasso Sea in the West Central Atlantic throughout late winter and early spring. The larvae then drift back towards Europe and North Africa within the North Atlantic Current and metamorphose into young (glass) eels. Many juvenile eels re-enter their home rivers and migrate upstream as elvers, though some individuals remain in estuaries or coastal waters. After several years in fresh or coastal waters (yellow eel stage), eels metamorphose into silver eels and then return to the Sargasso Sea to spawn after which they die (Arai et al., 2006; Pike et al., 2020).

3.6.17 Tagging studies suggests that European eels begin their oceanic migration from their home rivers to the spawning grounds in the Sargasso Sea between August and December (Righton et al., 2016). Data collected from the Marine Institute using elver traps within the river Liffey, captured upstream migrating glass eels and elvers. These data were indicative of peak upstream movements of glass eel in the months of April and May, while elver migration mainly occur from May to July with an occasional year migration extending into August (Aquatic Services Unit, 2020).

3.6.18 European eel were not recorded within the array area and ECC during the site-specific benthic baseline surveys (Natural Power, 2022, 2023). However, it is assumed that they may be present within or in the vicinity of the study area during their migration.

Lamprey species

3.6.19 There are three species of lamprey native to Ireland, the sea lamprey *Petromyzon marinus*, the river lamprey *Lampetra fluviatilis* and the brook lamprey *Lampetra planeri* (Kelly and King, 2001). Both river and sea lamprey species are mainly anadromous, migrating from their marine feeding grounds to freshwater to reproduce. The young larvae, known as ammocoetes, spend several years buried in freshwater sediments before undergoing metamorphosis into free-swimming adults. The young post-larval lampreys travel downstream to the sea, where they live several years before returning to their riverine spawning grounds (Kurz and Costello, 1999). Brook lamprey reside permanently in freshwater, inhabiting rivers and occasionally lakes (Maitland, 2003).

3.6.20 In northwest Europe, the upstream migration of mature river lampreys from the sea to freshwater spawning streams typically begins in late summer and autumn (Kelly and King, 2001), and spawning takes place the following spring throughout March and April (Maitland, 2003). Newly metamorphosed young adults migrate downstream into estuaries between summer and late autumn/early winter (Kelly and King, 2001; Maitland, 2003). The upstream spawning migration of mature sea lamprey into rivers occurs throughout spring and early summer, one or two months before the onset of spawning (Kelly and King, 2001; Maitland, 2003), while the seaward movement of newly metamorphosed young adults takes place during autumn and early winter (Kelly and King, 2001).

3.6.21 On the east coast of Ireland, river lamprey have been reported from the Rivers Boyne, Liffey, Dodder, Aughrim, and Avoca (Kelly and King, 2001; King and Linnane, 2004; O'Connor, 2006). There are no recent records of sea lampreys in rivers along Ireland's east coast, though historic records exist for sea lampreys in the Liffey (Igoe et al., 2004). In the south-eastern coastal regions, important spawning populations of river and sea lamprey are present within the Rivers Slaney, Barrow, Nore, Suir, and Munster Blackwater (Kelly and King, 2001; King and Linnane, 2004; King, 2006; Kurz and Costello, 1999).

3.6.22 Most research on lamprey species to date has focussed on the freshwater portion of their life cycle, while the distribution and habitat requirements of adult lamprey at sea is poorly documented. River lamprey are reported to typically remain in estuarine areas during their marine stage, where they spend about one to two years feeding on a variety of fishes including herring, sprat, smelt and flounder (Kelly and King, 2001; Maitland, 2003).

3.6.23 Adult sea lamprey have been recorded in both shallow coastal and deep offshore waters, with sightings as deep as 4,000 m (Kelly and King, 2001). The parasitic feeding phase at sea is estimated to last between 18-30 months (King et al., 2016; Silva et al., 2013), and targeted hosts include basking sharks, cetaceans, and a variety of pelagic and demersal fishes such as herring, mackerel, cod, haddock and salmon (Kelly and King, 2001; Waldmann et al., 2008).

3.6.24 All species of lamprey are protected as Annex II species under the EU Habitats Directive on account of dramatic population declines observed across Europe over the last decades (Kelly and King, 2001). The nearest SAC designated for river lamprey to the study area is the River Boyne and River Blackwater SAC (**Figure 3-23**).

3.6.25 There are no designated Natura 2000 sites for sea lamprey in the vicinity of the study area, although records for the species exist within several nearby river catchments draining into the western Irish Sea (European Environment Agency, 2023). The nearest SAC protected for sea lamprey is the Slaney River Valley SAC, which is located approximately 149 km from the array area (Figure 3-23). Sea lamprey is also on the OSPAR threatened or declining species list and classed as Near Threatened on the Ireland Red List (King et al., 2011) and as of Least Concern on a global scale (NatureServe, 2013). River lamprey has a classification of Least Concern on both the Irish and global IUCN Red List (Freyhof, 2011b; King et al., 2011).

Twaite shad

3.6.26 The twaite shad is an anadromous species found in the north-east Atlantic Ocean, including the Irish Sea. The freshwater habitat requirements of twaite shad are not fully understood, but they are known to spawn at night in shallow areas near deeper pools, with their eggs sinking into the spaces between coarse gravel and cobble substrates (JNCC, 2021). Mature individuals start to migrate from the sea into suitable spawning rivers in early summer (April and May) and spawning takes place from May to July (King et al., 2011; Maitland and Hatton-Ellis, 2003).

3.6.27 The distribution and habitat requirements of twaite shad while at sea are also poorly documented. The species is reported to prefer shallow waters at depths of 10-20 m, although it has also been recorded in deeper waters of up to 300 m (Maitland and Hatton-Ellis, 2003).

Marine turtles

3.6.28 Five species of marine turtles have been recorded in Irish waters including leatherback turtle *Dermochelys coriacea*, loggerhead turtle *Caretta caretta* and Kemp's Ridley turtle *Lepidochelys kempii*. Of these, leatherback turtle is the most regularly reported around the coast of Ireland, accounting for just over 80% of all records. Rare vagrant species to southern Irish waters include hawksbill turtle *Eretmochelys imbricata* and green turtle *Chelonia mydas* (King and Berrow, 2009).

3.6.29 The majority of turtle sightings or stranding records are along the south and west coasts of Ireland; however, there are also records of leatherback turtles along the east coast of Ireland (King and Berrow, 2009). Leatherback sea turtles are a migratory species that can occur anywhere in Irish coastal waters between June and October. They are more likely to occur in higher numbers off the south and west coasts of Ireland because of their facing aspects. There is a greater probability of leatherback turtle occurrence in areas where jellyfish regularly occur in high concentrations. Irish oceanic waters may also support appreciable densities of foraging leatherbacks due to the presence of gelatinous zooplankton located there. Aerial survey estimates of leatherback numbers suggests that the density of leatherbacks in Irish waters is low when compared to similar high latitude foraging areas (e.g., Nova Scotia, Canada) (Doyle, 2007). Sightings of leatherback turtles in the wider region are concentrated off the south and west of Ireland, the southwest of England and the west coast of Wales. Most sightings occur in the summer, peaking in August (Botterell et al., 2020; Penrose et al., 2021; Penrose and Gander 2016). Loggerhead sea turtles have also been identified as a migratory species that are occasionally sighted in Irish waters; however, most sightings, strandings and captures tend to occur on the western facing aspects of Ireland, with records significantly decreased with increasing latitude (Botterell et al., 2020).

3.6.30 All five species of sea turtle found in Irish waters are included on the IUCN Red List of Threatened Species. The sub-population of leatherback that visits Irish coastal waters may well be what is termed the north-west Atlantic sub-population in the IUCN Red List (IUCN, 2023).

3.7 Elasmobranchs

3.7.1 Elasmobranchs are cartilaginous fish and include sharks, skates, and rays. Elasmobranchs are of interest when considering the effects of OWF development since some species are of conservation interest. In addition, several species are considered to be sensitive to EMF effects that might result from the operation of subsea cables since their sensory systems detect and use EMF for navigation and hunting (Gill and Desender, 2020).

Small-spotted catshark

3.7.2 Small-spotted catshark, also known as lesser-spotted dogfish, are small, slender, bottom-dwelling shark found in the Mediterranean Sea and the north-east and eastern central Atlantic Ocean to a depth of about 800 m (Finucci et al., 2021a). They are one of the most abundant elasmobranch species in the north-east Atlantic, including the Irish Sea, and are found over a variety of substrates including sandy, gravelly and muddy bottoms and coralline algal grounds (Clarke et al., 2016; Ellis et al., 2005; Finucci et al., 2021a). There is growing evidence for philopatry and sex-based differences in behaviour and habitat selection (Sims et al., 2001).

3.7.3 Small-spotted catshark are oviparous, producing eggs that are deposited in thick-walled cases on macroalgae or sessile erect invertebrates such as sponges, soft corals, and bryozoans (Clarke et al., 2016; Ellis et al., 2005). The eggs-laying period is thought to last most of the year with peaks observed in summer for small-spotted catsharks studied in the Bristol Channel (ICES, 2022h). Data on egg-laying sites and nursery areas in the western Irish Sea are sparse; previous groundfish surveys recorded small numbers of egg cases and juveniles in ICES rectangle 37E4 (Ellis et al., 2005), which overlap with the ZoIs. Consequently, it is deemed likely that small-spotted catshark breed within the study area.

3.7.4 Populations of small-spotted catshark in the north-east Atlantic are stable or increasing (Finucci et al., 2021a). Recent stock assessments by ICES using groundfish survey data have shown an increasing trend in the size of the north-east Atlantic stock from 2004 to 2010 and annual fluctuations around higher stock levels since then (Marine Institute, 2023). The species is currently listed as of Least Concern on both the IUCN Red List (Finucci et al., 2021a) and the Ireland Red List (Clarke et al., 2016).

Nursehound

3.7.5 Nursehound, also known as greater-spotted dogfish or bull huss, are a medium-sized, demersal catshark found throughout the north-east Atlantic Ocean and the Mediterranean Sea (Finucci et al., 2021b). The species occurs mostly on continental shelves down to about 60 - 65 m water depth and favours structurally complex grounds such as rocky substrates and seagrass beds (Clarke et al., 2016; Ellis et al., 2005; Finucci et al., 2021b).

3.7.6 Like small-spotted catshark, nursehound are oviparous. Data on egg-deposition grounds and nursery areas within the Irish Sea are not available for this species, although Ellis et al. (2005) suggested that egg-cases may be primarily laid in shallower waters attached to macroalgae. Like small-spotted catshark, nursehound have been shown to exhibit refuging behaviour (Sims et al., 2005).

3.7.7 Data from groundfish surveys conducted in the Irish Sea and Bristol Channel show an overall increase in nursehound numbers since the early 1990s (Clarke et al., 2016). This is also evident in ICES stock assessments, which have shown an increasing trend from 2000 to 2020 (Marine Institute, 2023). Nursehound is a species of conservation importance (IUCN Red List Status: Vulnerable), although it is currently listed as of Least Concern on the Ireland Red List (Clarke et al., 2016).

3.7.8 Due consideration has also been given to its importance to the angling community in the region.

Tope

3.7.9 Tope, also known as tope shark or school shark, is a medium-sized, bottom-dwelling shark species that is found in shallow waters (< 10 m) down to depths of up to 500 m (Ebert and Stehmann, 2013). Tope feed on a variety of prey, including small fish, crustaceans, and cephalopods (Barnes, 2008; Ebert and Stehmann, 2013). It is a species of conservation importance (IUCN Red List Status, Critically Endangered; Walker et al., 2020). Tope is also listed as Vulnerable on the Ireland Red List (Clarke et al., 2016). It is widespread in the eastern Atlantic, ranging from Iceland and Norway to South Africa. Tope occurs more frequently along the east coast on Ireland and off the coast of Donegal (Clarke et al., 2016), although an exploratory assessment of catch per unit effort (CPUE) data trends from over 20 years of trawl survey data from the Northeast Atlantic suggests a decline in the number of tope present (Dureuil, 2013, cited in Clarke et al., 2016).

3.7.10 The study area overlaps with low intensity nursery grounds of tope (**Figure 3-17**; Ellis et al., 2010, 2012), although the area of interaction with the proposed development is considered small in the context of the wider nursery grounds across the Irish Sea. Data on spawning locations are not well established for this species (Ellis et al., 2012).

Spiny dogfish

3.7.11 The spiny dogfish, also known as spurdog, is a small shark species, which is found on or near the bottom in continental shelf waters and near the surface in oceanic waters (Ebert and Stehmann, 2013). The species primarily feeds on bony fish but is also known to target invertebrates including squid, octopuses and crabs. Spiny dogfish were historically widespread in the north-east Atlantic; however, its population has declined significantly due to overfishing and bycatch (Marine Institute, 2022).

3.7.12 Spiny dogfish in the Irish Sea belong to the north-east Atlantic population, which stretches from Portugal to Norway, including the Irish Sea (ICES, 2014a). ICES stock assessments have shown an increasing trend of the north-east Atlantic stock since 2004 (Marine Institute, 2022).

3.7.13 Spiny dogfish are listed as Vulnerable on the IUCN Red List (Finucci et al., 2020), and as Endangered on the Ireland Red List (Clarke et al., 2016). The study area overlaps with high intensity nursery grounds of spiny dogfish (**Figure 3-17**; Ellis et al., 2010, 2012).

Basking shark

3.7.14 The basking shark *Cetorhinus maximus* is a species of conservation importance, being on the OSPAR list of threatened and/or declining species and currently classed as Endangered by the IUCN in Ireland, Europe and on a global scale (Clarke et al., 2016; Rigby et al., 2021). On a national level, basking sharks are protected under the Wildlife Act 1976 (as amended).

3.7.15 Basking sharks are a large migratory pelagic species with circumpolar distribution, which can reach up to 12 m in length. They are known to migrate through the Irish Sea (Compagno, 2001; Gore et al., 2008; Southall et al. 2005), with known basking shark hotspots located across the central Irish Sea, particularly around the Isle of Man; however, there are also records of basking sharks across the western Irish Sea, including the study area (e.g., Dolton et al., 2020; Irish Whale and Dolphin Group, 2023). Monthly site-specific digital aerial surveys (DAS) conducted across the array area (plus a 4km buffer area)[5] between May 2020 and October 2022 recorded one basking shark each in September and November 2020. Five sightings were recorded in October 2022, though it is unclear if these records captured different individuals or constitute repeat sightings.

3.7.16 Basking sharks are obligate ram feeders, meaning that they use their gill rakers to filter zooplankton from the water as they swim along (Wilson et al., 2020). They are a long-lived species, with some individuals reaching up to 100 years old. Defining characteristics of basking shark include slow growth, delayed maturation, long gestation periods, production of few young. Males are believed to reach sexual maturity between 12-16 years and females in the region of 16-20 years (Wilson et al., 2020). They are thought to breed at the start of summer and offspring gestation takes between one to three and a half years (Wilson et al., 2020).

3.7.17 Basking sharks have the potential to pass through the fish and shellfish study area, but this will likely occur infrequently and in low numbers. Basking sharks concentrate along ocean fronts wherever there is an aggregation of the zooplankton they feed on and can occur anywhere around the Irish coastline during the spring and summer months. In Irish waters sightings occur in April through to late July and early August, typically peaking from mid-May to mid-June (Gray et al., 2022). Most individuals are sighted in shallow, coastal waters; however, when relying on sightings from offshore cetacean surveys, it is difficult to estimate the number of basking sharks present in the Irish Sea. Sightings are often a function of observer effort and sighting rate, usually expressed as sightings per unit effort (SPUE) which is often used as a proxy for comparison (Austin et al., 2019).

Skate species

Thornback ray

3.7.18 Thornback rays, or roker, belong to the Rajidae family of skates and rays. They are known to exhibit philopatric behaviour, whereby individuals return to a specific location in order to breed or feed. Females can grow up to 118 cm in length and 18 kg in weight, while males can reach 98 cm in length. Thornback rays are found over a wide variety of grounds from mud, sand, shingle to gravel. They are most common at depths of between 10 to 60 m, but have also been recorded in deeper waters, at depths of up to 300 m. They move offshore to deeper waters in the autumn and winter, and back to shallower inshore waters in spring.

[5] Further information about the DAS programme including transect lines and data collection methods is provided in Volume 9, Appendix 15.1: Offshore Ornithology Baseline Characterisation.

3.7.19 Thornback ray is a species of conservation importance (IUCN Red List Status, Near Threatened), although it is listed as Least Concern on the Ireland Red List (Clarke et al., 2016). ICES considers two main populations around Ireland, one in the Irish and Celtic Seas, the other off north-west Ireland (ICES, 2014a,b; 2022h). In the Irish and Celtic Sea stock, the population size indicator has increased markedly since the early 2000s (ICES, 2014b).

3.7.20 Low intensity nursery grounds occur across the study area (**Figure 3-18**; Ellis et al., 2010, 2012). There are insufficient data to delineate spawning grounds, although they should broadly overlap with nursery grounds (Ellis et al., 2012).

Blonde ray

3.7.21 Blonde ray is a species of conservation importance (IUCN Red List Status, Near Threatened). It is also listed as Near Threatened on the Ireland Red List (Clarke et al., 2016). Blonde ray has a wide geographic distribution in the north-east Atlantic and Mediterranean Sea and is relatively common in the Irish Sea and Bristol Channel. The only trend information available is for juveniles and shows an increase over time. However, available evidence suggests that the population is over-exploited (Clarke et al., 2016).

3.7.22 Blonde ray in the north-east Atlantic favour shallow coastal waters of less than 150 m in depth and live mainly on soft substrata such as sandy grounds (Ebert and Stehmann, 2013; Gibson-Hall, 2018a). Juveniles feed upon crustaceans, including shrimps and crabs, whilst the main diet for adults consists of fish such as sandeels (Ebert and Stehmann, 2013).

3.7.23 Data on spawning and nursery grounds is not available for this species in the published literature, but it has been suggested that blonde ray prefer shallower, coastal waters as nursery grounds (Martin et al., 2010). The species has been included due to it being vulnerable to depletion.

Spotted ray

3.7.24 The spotted ray is a small, bottom-dwelling ray species that feeds on a variety of prey, including small fish, crustaceans, polychaetes, and molluscs (Gibson-Hall, 2018b). It has been recorded at depths of 8-530 m but is most commonly observed between 100 to 500 m water depth, mainly over soft, sandy substratum (Gibson-Hall, 2018b).

3.7.25 Spotted ray is on the OSPAR threatened or declining species list and considered to be of Least Concern on both the IUCN Red List and the Ireland Red List (Clarke et al., 2016). It has a wide geographic distribution in the north-east Atlantic and Mediterranean Sea, with two separate Irish stocks located in the Irish and Celtic Seas, and in the north-west and west of Ireland (ICES, 2014a,b). The Irish and Celtic Seas population has increased over time; however, it is being fished at above sustainable levels (ICES, 2014a; ICES, 2022h).

3.7.26 Low intensity nursery grounds occur across the study area (**Figure 3-18**; Ellis et al., 2010, 2012). There are insufficient data to delineate spawning grounds, although it is suggested that these broadly overlap with nursery grounds (Ellis et al., 2012).

Cuckoo ray

3.7.27 Cuckoo ray is listed as Least Concern on the Global and European IUCN Red Lists and classed as Vulnerable on the Ireland Red List (Clarke et al., 2016). ICES considers that a single population is found in Irish waters and includes the Irish and Celtic Seas (ICES 2014a; ICES, 2022h). The population around Ireland and the Celtic Sea shows an overall decline over time.

3.7.28 Data on spawning and nursery grounds is not available for this species in the published literature, but due consideration has been given due to its importance to the angling community.

Small-eyed ray

3.7.29 Small-eyed ray is a species of conservation importance (IUCN Red List Status, Near Threatened), although it is listed as Least Concern on the Ireland Red List (Clarke et al., 2016). It is restricted primarily to the Atlantic coasts of north-west Europe. Although occasionally caught in the southern Irish Sea, the main concentration is in the Bristol Channel. Survey based indicators showed a stable trend from the mid-1990s to the late 2000s with a more recent decline of 27% (ICES, 2014a).

3.7.30 Data on spawning and nursery grounds is not available for this species in the published literature, but due consideration has been given due to the species being vulnerable to depletion.

3.8 Species of Conservation Importance and Designated Sites

3.8.1 Elasmobranchs and fish and shellfish species of conservation importance that have the potential to be present within the study area are listed in **Table 3-2** below. Among the listed species, four are listed as Annex II species under the EU Habitats Directive: river and sea lamprey, twaite shad and Atlantic salmon. European eel, listed on the Ireland Red List as Critically Endangered, also have the potential to occur within the study area. These species are all diadromous.

3.8.2 The nearest Natura 2000 site to the offshore development area with qualifying fish interests is the River Boyne and River Blackwater SAC, which is located inland approximately 21 km to the west of the array area (**Figure 3-23**). The River Boyne estuary lies approximately 17 km to the west of the array area and about 11 km to the north of the ECC. The SAC is designated for river lamprey and Atlantic salmon (NPWS, 2021). Along the south-east coast of Ireland, migrating fish species are afforded protection in the Slaney River Valley SAC (**Figure 3-23**). The site is designated for sea lamprey, brook lamprey, river lamprey, twaite shad and Atlantic salmon (NPWS, 2011). The Slaney River estuary is located approximately 149 km from the array area and 153 km from the ECC. Whilst this designated site lies outside of the fish and shellfish study area, it has been given due consideration due to the migratory nature of the protected features, and therefore the potential for the features to transit the study area.

3.8.3 Another SAC relevant to the protection of fish species is the Rockabill to Dalkey Island SAC, whose northern boundary is located about 2.4 km south of the array. The Conservation Objectives (COs) for this site include to provision to maintain the favourable conservation condition of harbour porpoise *Phocoena phocoena*, and any human activities should occur at levels that do not adversely affect the harbour porpoise community at the site (NPWS, 2013a). This target also includes any activities or operations that may result in the deterioration of key resources (e.g. water quality, feeding, etc.) upon which harbour porpoises depend, such as key prey stocks for feeding. Similarly, the Rockabill SPA (NPWS, 2013b) and the North-west Irish Sea candidate SPA (cSPA) (NPWS, 2023), which are designated for ornithology features, include COs that provide for the protection of key bird foraging grounds and prey species, including fish and crustaceans.

3.8.4 Cartilaginous species listed under the Ireland Red List No. 11 (Clarke et al., 2016) with the potential to occur within the study area include basking shark, tope, spiny dogfish, cuckoo ray, blonde ray, nursehound, small-eyed ray, spotted ray, thornback ray, starry smooth-hound, and small-spotted catshark. These species will be considered further in the EIAR due to their potential sensitivity to changes in EMFs, which could result from cable installation. Since 2021, basking sharks are also protected under Irish law by the Wildlife Act (1976) (as amended). Eel populations in European waters are strictly managed under the European Eel Regulations, with an Irish Eel Management Plans in place since 2009 (Technical Expert Group on Eel, 2021).

Table 3-2: Species of conservation importance with the potential to occur within the study area.

Species	European Habitats Directive	Ireland Red List (King et al., 2011; Clarke et al., 2016)	IUCN Red List of Threatened Species (2023)	Bonn Convention (1979)	OSPAR list of threatened and/or declining species and habitats[6]
River lamprey	II, V	Least Concern	Least Concern	N/A	N/A
Sea lamprey	II	Near Threatened	Least Concern	N/A	✓
Atlantic salmon	II, V	Vulnerable	Near Threatened	N/A	✓
European eel	N/A	Critically Endangered	Critically Endangered	II	✓
Twaite shad	II	Vulnerable	Least Concern	N/A	N/A
Atlantic cod	N/A	N/A	Vulnerable	N/A	✓
Common haddock	N/A	N/A	Vulnerable	N/A	N/A
American plaice	N/A	N/A	Endangered	N/A	N/A
Witch flounder	N/A	N/A	Vulnerable	N/A	N/A
Basking shark	N/A	Endangered	Endangered	I, II	✓
Tope	N/A	Vulnerable	Critically Endangered	II	N/A
Spiny dogfish	N/A	Endangered	Vulnerable	II	✓
Cuckoo ray	N/A	Vulnerable	Least Concern	N/A	N/A
Blonde ray	N/A	Near Threatened	Near Threatened	N/A	N/A
Nursehound	N/A	Least Concern	Vulnerable	N/A	N/A
Small-eyed ray	N/A	Least Concern	Near Threatened	N/A	N/A
Spotted ray	N/A	Least Concern	Least Concern	N/A	✓
Thornback ray	N/A	Least Concern	Near Threatened	N/A	N/A
Starry smooth-hound	N/A	Least Concern	Near Threatened	N/A	N/A
Small-spotted catshark	N/A	Least Concern	Least Concern	N/A	N/A

[6] Listed as threatened and/or declining in OSPAR Region III, the Celtic Seas, which includes the Irish Sea.

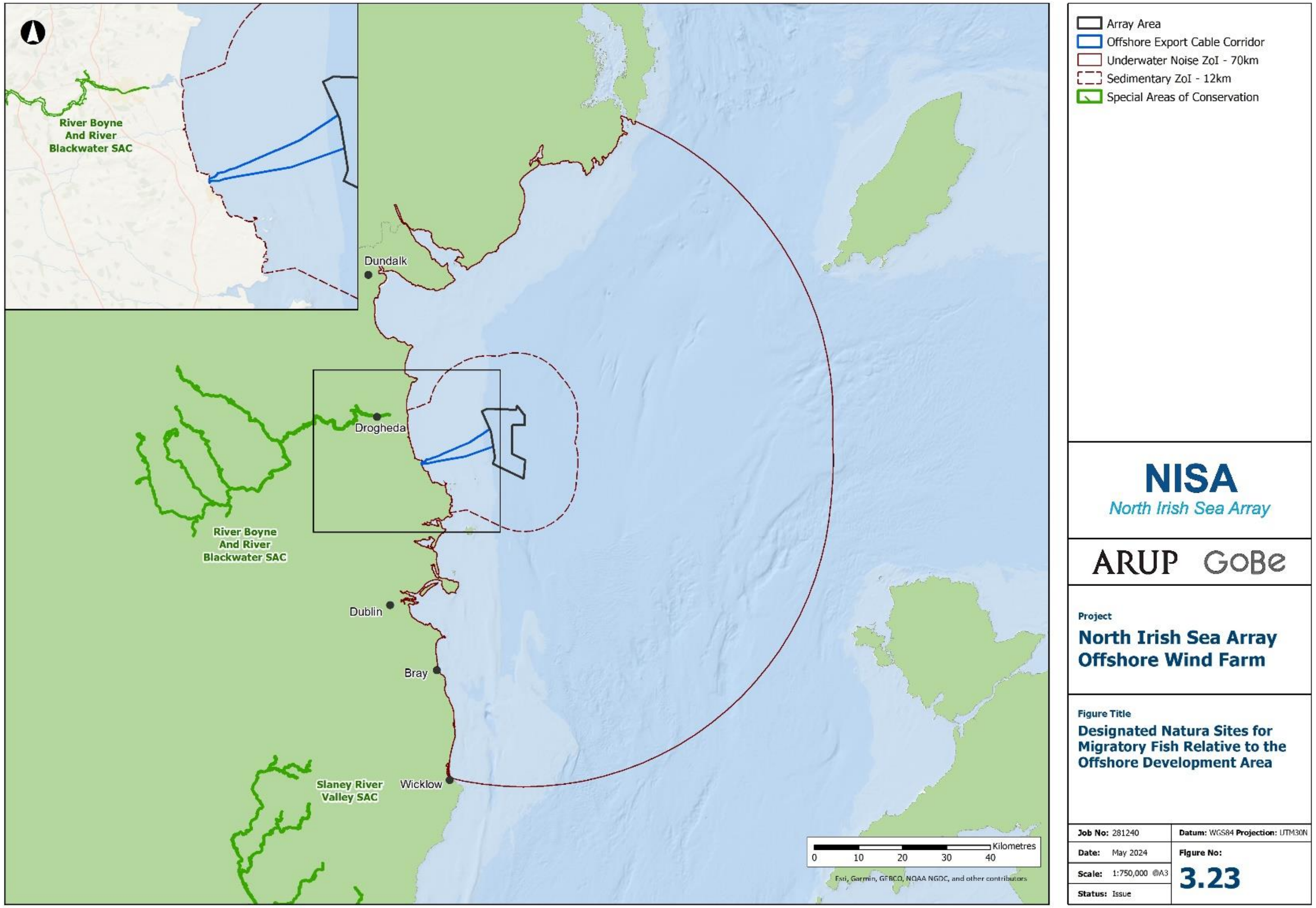

Figure 3-23: Designated Natura Sites for Migratory Fish Relative to the Offshore Development Area.

3.9 Valued Ecological Receptors

3.9.1 The impact assessment for fish and shellfish species has taken a Valued Ecological Receptor (VER) approach to determine which species to take forward to the impact assessment stage. This allows the assessment to focus on important ecological features that might be affected by the proposed development (Chartered Institute of Ecology and Environmental Management (CIEEM), 2018). The value of ecological features is dependent upon a range of factors, including their ecological, conservation, 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., species listed on the IUCN Red List of Threatened Species, on Ireland's Red List and those species protected under the European Habitats Directive). The evaluation of value has also assessed the potential for migratory species to transit the study area and the importance of the study area to support key life stages, such as spawning and nursery periods. The criteria used to inform this assessment are listed in **Table 3-3** below.

Table 3-3: Criteria used to inform the valuation of ecological receptors in the fish and shellfish study area (derived from guidance published by CIEEM (2018)).

VER Value	VER criteria used to define value
International	Species protected under international law (i.e., Bonn Convention Appendix II species, species listed as threatened and/or declining in OSPAR Region III).
National	Species protected under national law (i.e., Annex II species listed as features of SACs) within the National Site Network. Annex II species which are not listed as features of SACs in the fish and shellfish study area. Species that have spawning or nursery areas within the fish and shellfish study area that are important nationally (e.g., may be primary spawning/nursery area for that species).
Regional	Species that have regionally important populations within the fish and shellfish study area (are locally widespread and/or abundant). Species of commercial importance to fisheries in the study area and wider eastern Irish Sea region. Species of ecological importance, i.e., are an important prey for other species of conservation or commercial value and that are key components of the assemblages in the fish and shellfish study area. Species that have spawning or nursery area within the study area that are regionally important.
Local	Species of commercial importance, but which do not form a key component of the assemblages within the fish and shellfish study area. The spawning/nursery areas for the species are located outside of the study area. The species is common throughout Ireland but forms a component of the assemblages in the study area.

3.9.2 With consideration of each receptor's distribution and presence, spawning and nursery activity, as well as their commercial, conservation and ecological importance, an assessment of the value of each of these receptors within the defined fish and shellfish study area, and therefore those species considered VERs has been provided in **Table 3-4**.

Table 3-4: Summary of fish and shellfish VERs and their value/importance within the fish and shellfish study area.

VER	Valuation	Justification
Demersal VERs		
Atlantic cod	International	Study area overlaps high intensity spawning and nursery grounds. Cod was also recorded in regional surveys. A species of commercial importance in the study area and of conservation importance listed on the OSPAR list of threatened and/or declining species and as vulnerable on the IUCN Red List.
Plaice	Regional	Study area overlaps high intensity spawning and low intensity nursery grounds. Plaice was also abundant in regional surveys. A species of commercial importance in the study area.
Lemon sole	Regional	Study area overlaps spawning and nursery grounds. Lemon sole was also recorded in regional surveys.
Common sole	Regional	Study area overlaps low intensity spawning grounds. Sole was also recorded in regional surveys. A species of commercial importance in the study area.
Whiting	Regional	Study area overlaps low intensity spawning and high intensity nursery grounds. Whiting was also abundant in regional surveys. A species of commercial importance in the study area.
Common haddock	Regional	Study area overlaps spawning and nursery grounds. Haddock was also abundant in regional surveys. A species of commercial importance in the study area. A species of conservation importance listed as vulnerable on the global IUCN Red Lists.
Anglerfish	Regional	Study area overlaps with low intensity nursery grounds. Anglerfish was also recorded in regional surveys. A species of commercial importance in the study area
Common dab	Regional	Dab was abundant in regional surveys.
American plaice	Regional	American plaice was frequently recorded in regional surveys. A species of conservation importance listed as endangered on the global IUCN Red Lists.
Witch flounder	Regional	Witch flounder was frequently recorded in regional surveys. A species of conservation importance listed as vulnerable on the global IUCN Red Lists.
Pelagic VERs		
Atlantic mackerel	Regional	Study area overlaps low intensity spawning and low intensity nursery grounds. Mackerel was also recorded in regional surveys.
Sprat	Regional	Study area overlaps spawning grounds. Sprat was also abundant in regional surveys.
Atlantic horse mackerel	Regional	Study area overlaps low intensity spawning and nursery grounds. Atlantic horse mackerel was also recorded in regional surveys. A species of commercial importance.
Substrate-spawning VERs		

VER	Valuation	Justification
Atlantic herring	Regional	Study area overlaps high intensity nursery grounds. Herring was also abundant in regional surveys. Prey species for birds and marine mammals.
Sandeel	Regional	Study area overlaps spawning and low intensity nursery grounds. Sandeel was also recorded in regional surveys. Important prey species for fish, birds, and marine mammals.
Diadromous VERs		
Sea trout	Regional	Potential for this species to transit the study area.
European eel	International	A species of conservation importance listed on the OSPAR list of threatened and/or declining species, as critically endangered on the Ireland and IUCN Red Lists and in Appendix II of the Bonn Convention. Potential for this species to transit the study area.
Atlantic salmon	National and International	A species of conservation importance listed as EU Habitats Directive Annex II and V species, on the OSPAR list of threatened and/or declining species and as vulnerable on the Ireland Red List and as near threatened on the IUCN Red Lists. Potential for this species to migrate through the study area.
Sea lamprey	National and International	A species of conservation importance listed as EU Habitats Directive Annex II species, on the OSPAR list of threatened and/or declining species and as near threatened on the Ireland Red List. Potential for this species to transit the study area.
River lamprey	National	A species of conservation importance listed as EU Habitats Directive Annex II and V species. Potential for this species to transit the study area.
Twaite shad	National	A species of conservation importance listed as EU Habitats Directive Annex II species. Potential for this species to transit the study area.
Shellfish VERs		
Nephrops	Regional	Study area overlaps spawning and nursery grounds. Nephrops burrows were also observed in site-specific and regional surveys. A species of high commercial importance in the study area.
European lobster	Regional	A species of commercial importance in the study area.
Brown crab	Regional	A species of commercial importance in the study area.
Razor clam	Regional	A species of commercial importance in the study area.
Common cockle	Regional	A species of commercial importance in the study area.
King scallop	Regional	A species of commercial importance in the study area.
Common whelk	Regional	A species of commercial importance in the study area.
Mussel	Regional	A species of commercial importance in the study area.
Elasmobranch VERs		
Thornback ray	Regional	Study area overlaps nursery grounds. Thornback ray was also recorded in regional surveys. A species of commercial importance. A species of conservation importance listed as near threatened on the IUCN Red List.

VER	Valuation	Justification
Blonde ray	Regional	Blonde ray was recorded in regional surveys. A species of conservation importance listed as near threatened on the Ireland and IUCN Red Lists.
Spotted ray	International	Study area overlaps nursery grounds. Spotted ray was also observed in regional surveys. A species of conservation importance listed on the OSPAR list of threatened and/or declining species.
Cuckoo ray	Regional	Cuckoo ray was observed in regional surveys. A species of conservation importance listed as vulnerable on the Ireland Red List.
Small-eyed ray	Regional	Small-eyed ray was recorded in regional surveys. A species of conservation importance listed as near threatened on the IUCN Red List.
Tope	International	Study area overlaps nursery grounds. Tope was also recorded in regional surveys. A species of conservation importance listed in Appendix II of the Bonn Convention and as vulnerable on the Ireland Red List and as critically endangered on the IUCN Red List.
Nursehound	Regional	Nursehound was recorded in regional surveys. A species of conservation importance listed as vulnerable on the IUCN Red List.
Spiny dogfish	International	Study area overlaps high intensity nursery grounds. Spiny dogfish was also recorded in regional surveys. A species of conservation importance listed on the OSPAR list of threatened and/or declining species, in Appendix II of the Bonn Convention, and as endangered on the Ireland and European IUCN Red Lists and as vulnerable on the global IUCN Red List.
Starry smooth-hound	Regional	Starry smooth-hound was recorded in regional surveys. A species of conservation importance listed as near threatened on the IUCN Red List.
Small-spotted catshark	Regional	Study area may overlap with breeding and nursery grounds. Small-spotted catshark was abundant in regional surveys. A species of commercial importance.
Basking shark	National and International	A species of conservation importance listed on the OSPAR list of threatened and/or declining species, as endangered on the Ireland and IUCN Red Lists and in Appendices I and II of the Bonn Convention. Protected by the Wildlife Act (1976) as amended.
Marine turtle VERs		
Leatherback turtle, loggerhead turtle, Kemp's Ridley turtle, hawksbill turtle, green turtle	International	All five species are of conservation importance listed on the IUCN Red List. Potential for these species to transit the study area.

4 Future Receiving Environment

4.1.1 Rising sea temperatures, ocean acidification, ocean deoxygenation and rising sea levels have been identified as four of the key stressors impacting the state of the world's oceans and coastal environments (EPA, 2020). Recent and projected future changes in the temperature and chemistry of marine waters around Ireland are having, and will in the future have, effects on the phenology, productivity and distribution of marine fish and shellfish (Heath et al., 2012). However, the overall consequences are still hard to predict because fish behaviour, genetic adaptation, habitat dependency and the impacts of fishing on species, result in complex species' responses that may be only partially explained by simple climate envelope predictions.

4.1.2 There is a broad body of evidence to suggest climatic fluctuations and associated changes in ocean chemistry are playing an important role in changing fish distributions, abundances, and community composition in the north-east Atlantic region (e.g., Heath et al., 2012; Townhill et al., 2023). Fish and shellfish play a pivotal role in the transfer of energy from some of the lowest to the highest trophic levels within the ecosystem and serve to recycle nutrients from higher levels through the consumption of detritus. Consequently, their populations will be determined by both top-down factors, such as ocean climate and plankton abundance, and bottom-up factors, such as predation.

4.1.3 Climate effects may influence fish and shellfish species in a variety of ways, from changes in species distributions and community composition, growth rates, recruitment, behaviour, survival to alterations in food web structures. For example, ocean warming has caused many species to move northward or into deeper, colder waters (Simpson et al., 2013), a trend that is predicted to continue in the future (e.g. Townhill et al., 2023). The Celtic Seas ecoregion (which incorporates the Irish Sea) is at the edge of the geographical range of several species, potentially making these species more susceptible to environmental variation (ICES, 2022a).

4.1.4 Sandeel are one species identified of concern as they are less likely to be able to adapt to increasing temperatures as a result of its specific habitat requirements for coarse sandy sediment; declining recruitment in sandeel in parts of the UK has been correlated with increasing temperature (Heath et al., 2012).

4.1.5 Climate change may also affect key life history stages of fish and shellfish species, including the timing of spawning migrations (Department for Business, Energy and Industrial Strategy (BEIS), 2016). Fish may also be affected by climate indirectly, in particular through changes in the availability of prey species. However, climate change effects on marine fish populations are difficult to predict and the evidence is not easy to interpret, and therefore it is difficult to make accurate estimations of the future baseline scenario for the entire lifetime of the proposed development.

4.1.6 In addition to climate change, overfishing subjects the populations of many fish species to considerable pressure, reducing the biomass of commercially valuable species, and non-target species. Overfishing can reduce the resilience of fish and shellfish populations to other pressures, including climate change and other anthropogenic impacts. For example, a study on cod in an area where trawl fishing has been banned in the North Sea indicated that this population was significantly more resilient to environmental change (including climate change) than populations in neighbouring fished areas (Lindegren et al., 2010).

4.1.7 The 2023 Stock Book (Marine Institute, 2023) reports that of the commercial stocks fished around the Irish coast 51% are considered to be sustainably fished (i.e., 38 out of 74 fish stocks assessed), while 24% of stocks are currently considered to be overfished). Overall, the stock assessment data show a long-term increase in the number of stocks sustainably harvested.

4.1.8 ICES recently published an ecosystem overview of the Celtic Sea, which includes a large part of the Irish Exclusive Economic Zone (EEZ) (ICES, 2022a). It found that overall fishing pressure on the commercial fish and shellfish stocks in the Celtic Sea ecoregion has decreased since its peak in 1998. Overall biomass of commercial fish and shellfish stocks in the Celtic Sea has increased since the late 1990s. The fishing footprint and the average number of times the seabed is trawled per year have reduced. However, there are still a number of species with very low spawning stocks in some areas, particularly cod and sole in the Irish Sea (ICES, 2022a).

4.1.9 The fish and shellfish baseline characterisation described in the preceding sections represents a 'snapshot' of the fish and shellfish assemblages of the Irish Sea, within a gradual and continuously changing environment. Any changes that may occur during the lifetime of the proposed development (i.e., construction, operation, and decommissioning) should be considered in the context of the natural variability and other existing anthropogenic effects, including climate change, overfishing and other environmental impacts.

5 Conclusions

5.1.1 After consideration of site-specific and regional information, it is concluded that the level of information available is adequate for the purposes of characterising the existing environment in terms of fish and shellfish ecology. With the addition of site-specific PSA analysis, grab sampling and DDV, the information presented within this report provides a robust evidence base which is reinforced by historical data.

5.1.2 The analysis also describes appropriately the fish community with regards to diadromous species, commercial species, and species of conservation importance, such that it is considered that a further survey will not identify any additional receptors that may constitute VERs for the purposes of undertaking the EIA for the proposed development.

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

6 References

Ager, O.E.D., 2008. *Buccinum undatum* Common whelk. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1560 Accessed: August 2023.

Albert, O.T., 1994. Ecology of haddock (*Melanogrammus aeglefinus L.)* in the Norwegian Deep. ICES Journal of Marine Ecology 51: 31-44.

Arai, T., Kotake A. and McCarthy, T.K., 2006. Habitat use by the European eel *Anguilla anguilla* in Irish waters. Estuarine, Coastal and Shelf Science 67: 569-578.

Aquatic Services Unit, 2020. Dublin Port Maintenance Dredging 2022 - 2029 Benthic and Fisheries Assessment. Available at: https://www.gov.ie/en/foreshore-notice/60147-dublin-port-maintenance-dredging/ Accessed: November 2023.

Austin, R.A., Hawkes, L.A., Doherty, P.D., Henderson, S.M., Inger, R., Johnson, L., Pikesley, S.K., Solandt, J.L., Speedie, C. and Witt, M.J., 2019. Predicting habitat suitability for basking sharks (*Cetorhinus maximus*) in UK waters using ensemble ecological niche modelling. Journal of Sea Research 153: 101767.

Barnes, M.K.S., 2008. *Galeorhinus galeus* Tope shark. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/66 Accessed: April 2024.

Barry, J., Kennedy, R.J., Rosell, R. and Roche, W.K., 2020. Atlantic salmon smolts in the Irish Sea: first evidence of a northerly migration trajectory. Fisheries Management and Ecology 27(5): 517-522.

BEIS, 2016. UK Offshore Energy Strategic Environmental Assessment 3 (OESEA 3) Appendix 1a.4 - Fish and Shellfish. March 2016.

Bell, M.C., Redant, F. and Tuck, I., 2006. *Nephrops* Species. In: Lobsters: Biology, Management, Aquaculture and Fisheries. Ed. Philips, B., Blackwell Publishing.

Bennett, D., 1995. Factors in the life history of the edible crab (*Cancer pagurus* L.) that influence modelling and management. ICES Marine Science Symposia. Copenhagen, Denmark: International Council for the Exploration of the Sea, 199, pp. 1991-1995.

Blaxter, J.H.S. and Hunter, J.R., 1982. The Biology of the Clupeoid Fishes. Advances in Marine Biology 20: 1-223.

Botterell, Z.L.R., Penrose, R., Witt, M.J. and Godley B.J., 2020. Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910-2018). Journal of the Marine Biological Association of the United Kingdom 100: 869-877.

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

Brawn, V.M., 1961. Reproductive behaviour of the cod (*Gadus callarias* L.). Behaviour 18: 177-198.

Brown, C.G. and Bennett, D.B., 1980. Population and catch structure of the edible crab (*Cancer pagurus*) in the English Channel. Journal du Conseil 39: 88-100.

Cadrin, S., González Troncoso, D., Wheeland, L. and Munroe, T.A., 2022a. *Hippoglossoides platessoides*. The IUCN Red List of Threatened Species 2022: e.T18214783A162705101.

Cadrin, S., González Troncoso, D., Nimmegeers, S., Vansteenbrugge, L., Wheeland, L. and Munroe, T.A., 2022b. *Glyptocephalus cynoglossus*. The IUCN Red List of Threatened Species 2022: e.T18214757A162704857.

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

Cargnelli, L.M., Griesbach, S.J., Packer, D.B., Berrien, P.L., Morse, W.W. and Johnson, D.L., 1999. Essential Fish Habitat Source Document: Witch Flounder, *Glyptocephalus cynoglossus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-139.

Casaretto, L. and Hawkins, A.D., 2002. Spawning behaviour and the acoustic repertoire of haddock. Bioacoustics 12(2-3): 250-252.

Cefas, 2000. Irish Sea Annual Egg Production Method (AEPM) Plankton Survey. Available online: https://data.cefas.co.uk/view/2641

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

Chapman, C.J., 1980. Ecology of juvenile and adult *Nephrops*. In: Cobb, J.S. and Phillips, B.F. ed. The biology and management of lobsters, Vol. 1. New York, Academic Press, pp. 143-148.

Chartered Institute of Ecology and Environment Management (CIEEM), 2018. Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater and Coastal. Chartered Institute of Ecology and Environmental Management, Winchester.

Chiesa, J.J., Aguzzi, J., García, J.A., Sardà, F. and de la Iglesia, H.O., 2010. Light Intensity Determines Temporal Niche Switching of Behavioral Activity in Deep-Water *Nephrops norvegicus* (Crustacea: Decapoda). Journal of Biological Rhythms 24(4): 277-287.

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.

CMS, 1979. Convention on the Conservation of Migratory Species of Wild Animals. Available at: https://www.cms.int/en/legalinstrument/cms Accessed: April 2024.

Cohen, D.M., Inada, T., Iwamoto, T. and Scialabba, N., 1990. FAO Species Catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fisheries Synopsis, No 125, Vol 10. Rome, FAO, 1990, 442 pp. Available at: https://openknowledge.fao.org/browse/jobnumber?value=T0243E Accessed: July 2023.

Compagno, L.J., 2001. Sharks of the world: an annotated and illustrated catalogue of shark species known to date (Vol. 2). Food and Agriculture Organisation.

Coull, K.A., Johnstone, R., and Rogers, S.I., 1998. Fisheries Sensitivity Maps in British Waters. UKOOA Ltd. Available at: https://www.cefas.co.uk/media/52612/sensi_maps.pdf Accessed: 23 January 2023.

Cross, M.E., O'Riordan, R.M. and Culloty, S.C., 2014. The reproductive biology of the exploited razor clam, *Ensis siliqua*, in the Irish Sea. Fisheries Research 150: 11-17.

Cummins, S., Lauder, C., Lauder, A. and Tierney, T. D., 2019. The Status of Ireland's Breeding Seabirds: Birds Directive Article 12 Reporting 2013-2018., Irish Wildlife Manuals, No. 114, National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht.

Cuveliers, E.L., Volckaert, F.A.M., Rijnsdorp, A.D., Larmuseau, M.H.D. and Maes, G.E., 2011. Temporal genetic stability and high effective population size despite fisheries-induced life-history trait evolution in the North Sea sole. Molecular Ecology 20(17): 3555-3568.

da Costa, F. Martínez-Patiňo, D., Ojea, J. and Nóvoa, S., 2010. Larval rearing and spat production of the razor clam *Ensis siliqua* (Bivalvia: Pharidae). Journal of Shellfish Research 29(2): 347-351.

Darwall, W.R.T., 2023. *Salmo salar*. The IUCN Red List of Threatened Species 2023: e.T19855A67373433.

DCCAE, 2017. Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects. Prepared for the Environmental Working Group of the Offshore Renewable Energy Steering Group and the Department of Communications, Climate Action and Environment. Available at: https://www.gov.ie/en/publication/3d6efb-guidance-documents-for-offshore-renewable-energy-developers/ Accessed: November 2023.

de Boois, I.J., Burt, G., Lecomte, J.-B., Masnadi, F., Panten, K., Raat, H., Sigurdsson, G.M. and Thorlacius, M., 2023. ICES Survey Protocols - Offshore beam trawl surveys, coordinated by Working group on Beam Trawl Surveys (WGBEAM). Version 04. ICES Techniques in Marine Environmental Sciences Vol. 69. 70 pp. Available at: https://doi.org/10.17895/ices.pub.21603336

Department of Communications, Energy and Natural Resources (DCENR), 2010. Strategic Environmental Assessment (SEA) of Offshore Renewable Energy Development Plan (OREDP) in the Republic of Ireland. Environmental Report Volume 2: Main Report. Available at: https://www.gov.ie/en/publication/e13f49-offshore-renewable-energy-development-plan/ Accessed: November 2023.

Department of Housing, Local Government and Heritage, 2022. General Scheme of Marine Protected Areas Bill 2022. Available at: https://www.gov.ie/en/publication/2fd71-general-scheme-of-marine-protected-areas-bill-2022/ Accessed: June 2023.

Department of the Environment, Climate and Communications, 2023. OREDP II SEA Appendices. Appendix 3 - Summary of Baseline. Available at: https://www.gov.ie/en/consultation/7ad6f-the-second-offshore-renewable-energy-development-plan-oredp-ii-public-consultation/?referrer=https://www.gov.ie/OREDP2/#oredp-ii-sea-appendices Accessed: November 2023.

Department of the Taoiseach, 2021. Programme for Government: Our Shared Future. Available at: https://www.gov.ie/en/publication/7e05d-programme-for-government-our-shared-future/ Accessed: June 2023.

Dickey-Collas, M., Briggs, R.P., Armstrong, M.J. and Milligan, S.P., 2000. Production of *Nephrops norvegicus* larvae in the Irish Sea. Marine Biology 137: 973-981.

Dickey-Collas, M., Nash, R.D.M. and Brown, J., 2001. The location of spawning of Irish Sea herring (*Clupea harengus*). Journal of the Marine Biological Association of the United Kingdom 81(4): 713-714.

Dolton, H.R., Gell, F.R., Hall, J., Hall, G., Hawkes, L.A. and Witt, M.J., 2020. Assessing the importance of Isle of Man waters for the basking shark *Cetorhinus maximus*. Endangered Species Research 41: 209-223.

Doyle, T.K., 2007. Leatherback Sea Turtles (*Dermochelys coriacea*) in Irish waters. Irish Wildlife Manuals, No. 32. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Dureuil, M., 2013. Status and conservation of sharks in the Northeast Atlantic. Submitted in fulfilment of a Master of Science in Biological Oceanography. University of Kiel, Kiel, Germany.

Ellis, J.R., Cruz-Martínez, A., Rackham, B.D. and Rogers, S.I., 2005. The Distribution of Chondrichthyan Fishes Around the British Isles and Implications for Conservation. Journal of Northwest Atlantic Fishery Science 35: 195-213.

Ellis, J.R., Milligan, S.P., Readdy, L., South, A., Taylor, N. and Brown, M., 2010. MB5301 Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones). Report No. 1: Final Report on development of derived data layers for 40 mobile species considered to be of conservation importance.

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. Cefas Scientific Series Technical Report, 147, 56 pages.

Environmental Protection Agency (EPA), 2020. Ireland's Environment - An Integrated Assessment 2020. Available at: https://www.epa.ie/publications/monitoring--assessment/assessment/state-of-the-environment/irelands-environment-2020---an-assessment.php Accessed: November 2023.

Environmental Protection Agency (EPA), 2022. Guidelines on the information to be contained in Environmental Impact Assessment Reports.

EuSeaMap, 2021. EMODnet broad scale seabed habitat map for Europe (EUSeaMap) (2021). Available at: https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/ Accessed: March 2023.

Fahy, E. and Gaffney, J., 2001. Growth statistics of an exploited razor clam (*Ensis siliqua*) bed at Gormanstown, Co Meath, Ireland. Hydrobiologia 465: 139-151.

Fahy, E. and Carroll, J., 2008. Two records of long migrations by Brown or Edible Crab (*Cancer pagurus* L.) from the Irish inshore of the Celtic Sea. The Irish Naturalists Journal 29(2): 119-121.

Farmer, A.S.D., 1974. Reproduction in *Nephrops norvegicus* (Decapoda: Nephropidae). Journal of Zoology 174: 161-183.

Finucci, B., Cheok, J., Chiaramonte, G.E., Cotton, C.F., Dulvy, N.K., Kulka, D.W., Neat, F.C., Pacoureau, N., Rigby, C.L., Tanaka, S. and Walker, T.I., 2020. *Squalus acanthias*. The IUCN Red List of Threatened Species 2020: e.T91209505A124551959.

Finucci, B., Derrick, D., Neat, F.C., Pacoureau, N., Serena, F. and van der Wright, W.J., 2021a. *Scyliorhinus canicula*. The IUCN Red List of Threatened Species 2021: e.T161307554A124478351.

Finucci, B., Derrick, D. and Pacoureau, N., 2021b. *Scyliorhinus stellaris*. The IUCN Red List of Threatened Species 2021: e.T161484A124493465.

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

Folk, R.L., 1954. The distinction between grain size and mineral composition in sedimentary rock nomenclature. Journal of Geology 62: 344-359.

Fox, C., Brien, C.M.O., Dickey-Collas, M. and Nash, R.D.M., 2000. Patterns in the spawning of cod (*Gadus morhua* L.), sole (*Solea solea* L.) and plaice (*Pleuronectes platessa* L.) in the Irish Sea as determined by generalized additive modelling. Fisheries Oceanography 9(1): 33-49.

Fraser, S., Shelmerdine, R.L., and Mouat, B., 2018. Razor clam biology, ecology, stock assessment, and exploitation: a review of *Ensis* spp. in Wales. NAFC Marine Centre report for the Welsh Government. Contract number C243/2012/2013. pp 52.

Frederiksen, M., Edwards, M., Richardson, A.J., Halliday, N.C. and Wanless, S., 2006. From plankton to top predators: bottom-up control of a marine food web across four trophic levels. Journal of Animal Ecology 75: 1259-1268.

Freyhof, J., 2011b. *Lampetra fluviatilis*. The IUCN Red List of Threatened Species 2011: e.T11206A97805807.

Froese, R. and Pauly, D. (Eds), 2023. FishBase. World Wide Web electronic publication. Available at: www.fishbase.org Accessed: August 2023

Frost, M. and Diele, K., 2022. Essential spawning grounds of Scottish herring: current knowledge and future challenges. Reviews in Fish Biology and Fisheries 32(3): 721-744.

Fudge, S.B., and Rose, G.A., 2009. Passive- and active-acoustic properties of a spawning Atlantic cod (*Gadus morhua*) aggregation. ICES Journal of Marine Science 66: 1259-1263.

Geffen, A.J., Nash, R.D.M. and Dickey-Collas, M., 2011. Characterization of herring populations west of the British Isles: an investigation of mixing based on otolith microchemistry. ICES Journal of Marine Science 68(7): 1447-1458.

Geffen, A.J., Albretsen, J., Huwer, B. and Nash, R.D., 2021. Lemon sole *Microstomus kitt* in the northern North Sea: a multidisciplinary approach to the early life-history dynamics. Journal of Fish Biology 99(2): 569-580.

Gerritsen, H.D. and Kelly, E., 2019. Atlas of Commercial Fisheries around Ireland, third edition. Marine Institute, Ireland. ISBN 978-1-902895-64-2. 72 pp.

Gibson-Hall, E., 2018a. *Raja brachyura* Blonde ray. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/2320 Accessed: April 2024.

Gibson-Hall, E., 2018b. *Raja montagui* Spotted Ray. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/2321 Accessed: April 2024.

Gilbey, J., Utne, K.R., Wennevik, V., Beck, A.C., Kausrud, K., Hindar, K., Garcia de Leaniz, C., Cherbonnel, C., Coughlan, J., Cross, T.F. and Dillane, E., 2021. The early marine distribution of Atlantic salmon in the North-east Atlantic: A genetically informed stock-specific synthesis. Fish and Fisheries 22(6): 1274-1306.

Gill, A.B. and Desender, M., 2020. State of the Science Report, Chapter 5: Risk to Animals from Electromagnetic Fields Emitted by Electric Cables and Marine Renewable Energy Devices. In: Copping, A.E. and Hemery, L.G. (Eds), OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES). United States.

Gore, M.A., Rowat, D., Hall, J., Gell, F.R. and Ormond, R.F., 2008. Transatlantic migration and deep mid-ocean diving by basking shark. Biology letters 4(4): 395-398.

Gray, C., Peters-Burton, E., Smith, C. and Parsons, E.C.M., 2022. Basking shark tourism in Donegal, Ireland. A case study of public interest and support for shark conservation. Aquatic Conservation: Marine and Freshwater Ecosystems 32(3): 537-550.

Green, E., 2017. A literature review of the lesser (Raitt's) sandeel *Ammodytes marinus* in European waters. Technical Report by RSPB funded through LIFE14 NAT/UK/00394 Roseate Tern.

Hancock, D.A., 1963. Marking experiments with the commercial whelk (*Buccinum undatum*). ICNAF Special Publication 4: 176-187.

Hancock, D.A., 1967. Whelks. Fisheries Laboratory, Burnham on Crouch, Essex, MAFF Laboratory Leaflet No. 15: 14 pp.

Hawkins, A.D. and Amorim, C.P., 2000. Spawning sounds of the male haddock, *Melangogrammus aeglefinus*. Environmental Biology of Fishes 59: 29-41.

Heath, M.R., Neat, F.C., Pinnegar, J.K., Reid, D.G., Sims, D.W. and Wright, P.J., 2012. Review of climate change impacts on marine fish and shellfish around the UK and Ireland. Aquatic Conservation 22: 337-367.

Hernandez-Milian, G., Berrow, S., Santos, M.B., Reid, D. and Rogan, E., 2015. Insights into the Trophic Ecology of Bottlenose Dolphins (*Tursiops truncatus*) in Irish Waters. Aquatic Mammals 41(2): 226-239.

Hill, A.E., Brown J. and Fernand L., 1996. The western Irish Sea gyre: a retention system for Norway lobster (*Nephrops norvegicus*)? Oceanologica Acta 19(3-4): 357-368.

Hill, J.M. and Sabatini, M., 2008. *Nephrops norvegicus* Norway lobster. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1672. Accessed: August 2023.

Hinz, H., Bergmann, M., Shucksmith, R., Kaiser, M.J. and Rogers, S.I., 2006. Habitat association of plaice, sole, and lemon sole in the English Channel. ICES Journal of Marine Science 63(5): 912-927.

Hold, N., Robins, P., Szostek, C.L., Lambert, G., Lincoln, H., Le Vay, L., Bell, E. and Kaiser, M.J., 2021. Using biophysical modelling and population genetics for conservation and management of an exploited species, *Pecten maximus* L. Fisheries Oceanography 30(6): 740-756.

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

Holm, M., Holst, J.C. and Hansen, L.P., 2000. Spatial and temporal distribution of post-smolts of Atlantic salmon (*Salmo salar* L.) in the Norwegian Sea and adjacent areas. ICES Journal of Marine Science, 57(4): 955-964.

Holmes, T., Roche, W. and Gargan, P., 2018. Report on Salmon Monitoring Programmes (June 2015 - June 2016) funded under the Salmon Conservation Fund. Available at: https://www.fisheriesireland.ie/sites/default/files/migrated/docman/Report%20on%20Salmon%20monitoring%20Programmes%20%28June%202016-June%202017%29%20funded%20under%20the%20Salmon%20Conservation%20Fund.pdf

Holthuis, L.B., 1991. FAO species catalogue. Vol. 13. Marine lobsters of the world. An annotated and illustrated catalogue of species of interest to fisheries known to date. FAO Fisheries Synopsis No. 125, Vol. 13. Rome, FAO, 292 pp.

Hunter, E., Metcalfe, J.D. and Reynolds, J.D., 2003. Migration route and spawning area fidelity by North Sea plaice. Proceedings of the Royal Society of London. Series B: Biological Sciences 270(1529): 2097-2103.

ICES, 1994. Report of the study group of herring assessment and biology in the Irish Sea and adjacent waters. C.M.1994/H:5.

ICES, 2005. Spawning and life history information for North Atlantic cod stocks. ICES Cooperative Research Report, No. 274. 152 pp.

ICES, 2014a. Advice on stocks in the Celtic Seas Ecoregion. In Report of the ICES Advisory Committee, 2014. ICES Advice 2014, Book 1, Section 5.

ICES, 2014b. Report of the Working Group on Elasmobranch Fishes (WGEF), 17-26 June 2014, Lisbon, Portugal. ICES CM 2014/ACOM:19. 671 pp.

ICES, 2016. Report of the ICES Scallop Assessment Working Group (WGScallop), 3-7 October 2016, Aberdeen, UK. ICES CM 2016/ACOM: 24. 39 pp.

ICES, 2017. Manual of the IBTS North Eastern Atlantic Surveys. Series of ICES Survey Protocols SISP 15. 92 pp. Available at: http://doi.org/10.17895/ices.pub.3519 Accessed: August 2023.

ICES, 2020. Scallop Assessment Working Group (WGSCALLOP). ICES Scientific Reports 2: 111. 57 pp. Available at: http://doi.org/10.17895/ices.pub.7626 Accessed: November 2023.

ICES, 2022a. ICES Ecosystem Overviews. Celtic Seas ecoregion - Ecosystem Overview. https://doi.org/10.17895/ices.advice.21731615

ICES, 2022b. ICES Fisheries Overviews. Celtic Seas ecoregion – fisheries overview. https://ices-library.figshare.com/articles/report/Celtic_Seas_ecoregion_fisheries_overview/21641312

ICES, 2022c. Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS; outputs from 2021 meeting). ICES Scientific Reports 4: 27. 47pp. Available at http://doi.org/10.17895/ices.pub.19420232 Accessed: February 2024.

ICES, 2022d. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports 4: 16. 745 pp. Available at: http://doi.org/10.17895/ices.pub.10072 Accessed: February 2024.

ICES, 2022e. Norway lobster (*Nephrops norvegicus*) in Division 7.a, Functional Unit 15 (Irish Sea, West). In Report of the ICES Advisory Committee, 2022. ICES Advice 2022, nep.fu.15. Available at: https://ices-library.figshare.com/articles/report/Norway_lobster_Nephrops_norvegicus_in_Division_7_a_Functional_Unit_15_Irish_Sea_West_/19772407 Accessed: August 2023.

ICES, 2022f. Norway lobster (*Nephrops norvegicus*) in Division 7.a, Functional Unit 14 (Irish Sea, East). In Report of the ICES Advisory Committee, 2022. ICES Advice 2022, nep.fu.14. Available at https://ices-library.figshare.com/articles/report/Norway_lobster_Nephrops_norvegicus_in_Division_7_a_Functional_Unit_14_Irish_Sea_East_/19772404 Accessed: August 2023.

ICES, 2022g. Working Group on *Nephrops* Surveys (WGNEPS). ICES Scientific Reports 4: 29, 183 pp. Available at: http://doi.org/10.17895/ices.pub.19438472 Accessed: September 2023.

ICES, 2022h. Working Group on Elasmobranch Fishes (WGEF). ICES Scientific Reports 4: 74. 848 pp. http://doi.org/10.17895/ices.pub.21089833 Accessed: November 2023.

ICES, 2023a. Fish trawl survey: Northern Irish Ground Fish Trawl Survey. ICES Database on Trawl Surveys (DATRAS). The International Council for the Exploration of the Sea, Copenhagen. Available at: https://datras.ices.dk Accessed: August 2023.

ICES, 2023b. Fish trawl survey: Beam Trawl Survey. ICES Database on Trawl Surveys (DATRAS). The International Council for the Exploration of the Sea, Copenhagen. Available at: https://datras.ices.dk Accessed: August 2023.

ICES, 2023c. Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS; outputs from 2022 meeting). ICES Scientific Reports 5: 22. 57 pp. Available at: https://doi.org/10.17895/ices.pub.22146905 Accessed: February 2024.

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 104(3): 43-56.

INFOMAR, 2023. Seabed sediment particle size analysis data. Available at: https://www.marine.ie Accessed: 2023.

IFI, 2018. The Status of Irish Salmon Stocks in 2017 with Catch Advice for 2018. A Report of the Technical Expert Group on Salmon to the Inland Fisheries Ireland.

IFI, 2022. Report on Salmon Monitoring Programmes 2021. Funded under the Salmon Conservation Fund. IFI/2022/1-4590.

Irish Whale and Dolphin Group, 2023. https://iwdg.ie Accessed: February 2024.

IUCN, 2023. The IUCN Red List of Threatened Species. Version 2023-1. https://www.iucnredlist.org

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

JNCC, 2021. Twaite shad *Alosa fallax* Species Information. Available at: https://sac.jncc.gov.uk/species/S1103/ Accessed: April 2024.

Johnson, M.P., Lordan, C. and Power, A.M., 2013. Habitat and Ecology of *Nephrops norvegicus*. In: Advances in Marine Biology, Vol. 64. Eds. Johnson, M.L. and Johnson, M.P., Burlington: Academic Press, 2013, pp. 27-63.

Jonsson, N., Hansen, L.P. and Jonsson, B., 1993. Migratory behaviour and growth of hatchery-reared post-smolt Atlantic salmon *Salmo salar*. Journal of Fish Biology 42(3): 435-443.

Kelly, F.L. and King, J.J., 2001. A review of the ecology and distribution of three lamprey species, *L. fluviatilis, L. planeri* and *P. marinus*. Biology and Environment Proceedings of the Royal Society B 101: 165-185.

Kerby, T.K., Cheung, W.W., Van Oosterhout, C. and Engelhard, G.H., 2013. Wondering about wandering whiting: Distribution of North Sea whiting between the 1920s and 2000s. Fisheries Research 145: 54-65.

Kideys, A.E., Nash, R.D.M. and Hartnoll, R.G., 1993. Reproductive cycle and energetic cost of reproduction of the neogastropod *Buccinum undatum* in the Irish Sea. Journal of the Marine Biology Association of the United Kingdom 73: 391-403.

King, G.L. and Berrow, S.D., 2009. Marine turtles in Irish waters. Irish Naturalists' Journal - Special Zoological Supplement 2009.

King J.J. and Linnane, S. M., 2004. The status and distribution of lamprey and shad in the Slaney and Munster Blackwater SACs. Irish Wildlife Manuals, No. 14. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

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. and 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.

Knights, A.M., 2012. Spatial variation in body size and reproductive condition of subtidal mussels: Considerations for sustainable management. Fisheries Research 113: 45-54.

Kurz, I. and Costello, M.J., 1999. An Outline of the Biology, Distribution and Conservation of Lampreys in Ireland. Irish Wildlife Manuals, No. 5.

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

Lilley, R.L. and Unsworth, R.K.F., 2014. Atlantic Cod (*Gadus morhua*) benefits from the availability of seagrass (*Zostera marina*) nursery habitat. Global Ecology and Conservation 2: 367-377.

Lindegren, M., Diekmann, R. and Möllmann, C., 2010. Regime shifts, resilience and recovery of a cod stock. Marine Ecology Progress Series 402: 239-253.

Lockwood, S.J., 2005. A strategic Environmental Assessment of the Fish and Shellfish Resources with respect to Proposed Offshore Wind Farms in the Eastern Irish Sea. Coastal Fisheries Conservation and Management Colwyn Bay.

Loots, C., Vaz, S., Planque, B. and Koubbi, P., 2010. What controls the spatial distribution of the North Sea plaice spawning population? Confronting ecological hypotheses through a model selection framework. ICES Journal of Marine Science 67(2): 244-257.

Lundy, M., McCorriston, P., McCausland, I., Erskine, K., Lilley, K., Heaney, G., McArdle, J., Buick, A., Graham, J., Reeve, C., & Doyle, J., 2019. Western Irish Sea Nephrops grounds (FU15) 2019 UWTV survey report and catch options for 2020. In AFBI and Marine Institute UWTV Survey Report.

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

Maitland, P.S. and Hatton-Ellis, T.W., 2003. Ecology of the Allis and Twaite Shad. Conserving Natura 2000 Rivers Ecology Series No. 3. 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. Marine Scotland Science, 1.

Maravelias, C.D., Reid, D.G. and Swartzman, G., 2000. Seabed substrate, water depth and zooplankton as determinants of the prespawning spatial aggregation of North Atlantic herring. Marine Ecology Progress Series 195: 249-259.

Marine Institute, 2009. Cruise Report, Irish Sea Marine Assessment ISMA. Available at: https://www.ucc.ie/en/media/research/marinegeo/mgpdfs/CruiseReport_Final_ISMA.pdf

Marine Institute, 2013. Article 6 Assessment of Fisheries, including a Fishery Natura Plan for Seed Mussel (2013-2017), in the Irish Sea.

Marine Institute, 2016. Ireland's Marine Atlas. Available at: https://atlas.marine.ie/ Accessed: July 2023 to April 2024.
Marine Institute, 2018. Report in support of Appropriate Assessment for a Fishery Natura Plan for Seed Mussel (2018-2023) in the Irish Sea.

Marine Institute, 2022. The Stock Book 2022: Annual Review of Fish Stocks in 2022 with Management Advice for 2023. Available at: https://oar.marine.ie/handle/10793/1805 Accessed: July 2023.

Marine Institute, 2023. The Stock Book 2023: Annual Review of Fish Stocks in 2023 with Management Advice for 2024. Available at: https://www.marine.ie/stock-book-2023 Accessed: April 2024.

Marine Institute and Bord Iascaigh Mhara, 2023. Shellfish Stocks and Fisheries Review 2022: An assessment of selected stocks. Marine Institute, Galway, Ireland. Available at: https://oar.marine.ie/handle/10793/1814 Accessed: July 2023.

Marine Institute and Bord Iascaigh Mhara, 2024. Shellfish Stocks and Fisheries Review 2023: An assessment of selected stocks. Marine Institute, Galway, Ireland. Available at: https://oar.marine.ie/handle/10793/1894 Accessed: April 2024.

Marine Protected Area Advisory Group, 2023. Ecological sensitivity analysis of the western Irish Sea to inform future designation of Marine Protected Areas (MPAs). Report for the Department of Housing, Local Government and Heritage, Ireland. Available at: https://www.gov.ie/en/publication/e00ec-marine-protected-areas/#ecological-sensitivity-analysis-of-the-western-irish-sea Accessed: July 2023

Marshall, C.E. and Wilson, E., 2008. *Pecten maximus* Great scallop. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1398 Accessed: October 2023.

Martin, J.H.A. and Mitchell, K.A., 1985. Influence of sea temperature upon the numbers of grilse and multi-sea-winter Atlantic salmon (*Salmo salar*) caught in the vicinity of the River Dee (Aberdeenshire). Canadian Journal of Fisheries and Aquatic Sciences 42(9): 1513-1521.

McGeady, R., Lordan, C. and Power, A.M., 2022. Long-term interannual variability in larval dispersal and connectivity of the Norway lobster (*Nephrops norvegicus*) around Ireland: When supply-side matters. Fisheries Oceanography 31: 255-270.

Mesquita, C., Dobby, H., Pierce, G.J., Jones, C.S. and Fernandes, P.G., 2021. Abundance and spatial distribution of brown crab (*Cancer pagurus*) from fishery-independent dredge and trawl surveys in the North Sea. ICES Journal of Marine Science 78(2): 597-610.

Millane, M., Fitzgerald, C., Kennedy, R., Maxwell, H., McLean, S., Barry J. & Gargan, P., 2023. The Status of Irish Salmon Stocks in 2022 with Catch Advice for 2023. Report of the Technical Expert Group on Salmon (TEGOS) to the North-South Standing Scientific Committee for Inland Fisheries. 55 pp.

Monroe, T., Costa, M., Nielsen, J., Herrera, J. and de Sola, L., 2015a. *Hippoglossoides platessoides* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T18214783A45790114.

Monroe, T., Costa, M., Nielsen, J., Herrera, J. an de Sola, L., 2015b. *Glyptocephalus cynoglossus* (Europe assessment). The IUCN Red List of Threatened Species 2015: e.T18214757A45790104.

Natural Power, 2022. NISA Benthic Ecology Baseline: Array Area Benthic Survey Report. Statkraft. Volume 9, Appendix 12.1: Array Area Benthic Survey Report.

Natural Power, 2023. NISA Benthic Ecology Baseline: Cable Route Benthic Survey Report. Statkraft. Volume 9, Appendix 12.2: Cable Route Benthic Survey Report.

NatureServe, 2013. *Petromyzon marinus*. The IUCN Red List of Threatened Species 2013: e.T16781A18229984.

Neal, K.J. and Wilson, E., 2008. *Cancer pagurus* Edible crab. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1179 Accessed: August 2023.

Nichols, J.H., Haynes, G.M., Fox, C.J., Milligan, S.P., Brander, K.M. and Chapman, R.J., 1993. Spring plankton surveys of the Irish Sea in 1982, 1985, 1987, 1988 and 1989: hydrography and the distribution of fish eggs and larvae. Fisheries Research Technical Report No 95, Directorate of Fisheries Research, Lowestoft, 111 pp.

Nordeide, J.T. and Kjellsby, E., 1999. Sound from spawning cod at their spawning grounds. ICES Journal of Marine Science 56: 326-332.

NMPF, 2019. National Marine Planning Framework SEA Environmental Report. Available at: https://assets.gov.ie/109184/f1b35f41-3cf9-44e1-931a-481f22641821.pdf. Accessed: 2023.

NPWS, 2011. Conservation Objectives: Slaney River Valley SAC 000781. Version 1.0. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/protected-sites/sac/000781 Accessed: November 2023.

NPWS, 2013a. Rockabill to Dalkey Island SAC (site code: 3000). Conservation objectives supporting document - Marine Habitats and Species. Available at: https://www.npws.ie/protected-sites/sac/003000 Accessed: November 2023.

NPWS, 2013b. Conservation Objectives: Rockabill SPA 004014. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Available at: https://www.npws.ie/protected-sites/spa/004014 Accessed: April 2024.

NPWS, 2021. Conservation Objectives: River Boyne and River Blackwater SAC 002299. Version 1. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage. Available at: https://www.npws.ie/protected-sites/sac/002299 Accessed: November 2023.

NPWS, 2023. Conservation Objectives: North-west Irish Sea SPA 004236. Version 1. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage. Available at: https://www.npws.ie/protected-sites/spa/004236 Accessed: April 2024.

O'Connor W., 2006. A survey of juvenile lamprey populations in the Boyne Catchment. Irish Wildlife Manuals, No. 24. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

OSPAR, 1992. Convention for the Protection of the Marine Environment of the North-East Atlantic. Available at: https://www.ospar.org/convention/text Accessed: April 2024.

O'Sullivan, D., O'Keefe, E., Berry, A., Tully, O. and Clarke, M., 2013. An Inventory of Irish Herring Spawning Grounds. Irish Fisheries Bulletin No. 42. Marine Institute, ISSN: 1649 5055.

O'Sullivan, D., Lordan, C., Doyle, J., Berry, A. and Lyons, K., 2014. Sediment characteristics and local hydrodynamics and their influence on the population of *Nephrops* around Ireland. Irish Fisheries Investigations, No. 26. ISSN: 1649-5055.

Paille, N., Sainte-Marie, B. and Bréthes, J.C., 2002. Behavior, growth and survival of stage V lobsters (*Homarus americanus*) in relation to shelter availability and lobster density. Marine and Freshwater Behaviour and Physiology 35(4): 203-219.

Patterson, K.R., 1985. The trophic ecology of whiting (*Merlangius merlangus*) in the Irish Sea and its significance to the Manx herring stock. ICES Journal of Marine Science 42(2): 152-161.

Pawson, M.G., 1995 Biogeographical identification of English Channel fish and shellfish stocks. Fisheries Research technical report No 99.

Penrose, R.S. and Gander, L.R., 2016. British Isles & Republic of Ireland Marine Turtle Strandings & Sightings Annual Report 2015, 27pp.

Penrose, R.S., Westfield, M.J.B. and Gander L.R., 2021. British and Irish Marine Turtle Strandings & Sightings Annual Report 2020. Marine Environmental Monitoring, Cardigan, Wales, UK.

Pike, C., Crook, V. and Gollock, M., 2020. *Anguilla anguilla*. The IUCN Red List of Threatened Species 2020: e.T60344A152845.

Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D.A., Bartol, S., Carlson, T.J., Coombs, S., Ellison, W.T., Gentry, R.L., Halvorsen, M.B., Løkkeborg, S., Rogers, P.H., Southall, B.L., Zeddies, D.G. and Tavolga, W.N., 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI - Accredited Standards Committee S3/SC1 and registered with ANSI. New York: Springer.

Proctor, R., Wright, P.J. and Everitt, A., 1998. Modelling the transport of larval sandeels on the north-west European shelf. Fisheries Oceanography 7(3-4): 347-354.

Prodöhl, P.A., Jørstad, K.E., Triantafyllidis, A., Katsares, V. and Triantaphyllidis, C., 2007. European lobster - *Homarus gammarus*. Genimpact final scientific report. Norway.

Reach, I.S., Latto, P., Alexander D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R. and Seiderer, L.J., 2013. Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas. A Method Statement produced for the British Marine Aggregates Producers Association.

Richardson, C.A., Ibarrola, I. and Ingham, R.J., 1993. Emergence pattern and spatial distribution of the common cockle *Cerastoderma edule*. Marine Ecology Progress Series 99: 71-81.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Herman, K., Jabado, R.W., Lui, K.M., Marshall, A., Romanov, E. and Kyne, P.M., 2021. *Cetorhinus maximus* (amended version of 2019 assessment). The IUCN Red List of Threatened Species 2021: e.T4292A194720078.

Righton, D., Westerberg, H., Feunteun, E., Økland, F., Gargan, P., Amilhat, E., Metcalfe, J., Lobon-Cervia, J., Sjöberg, N., Simon, J., Acou, A., Vedor, M., Walker, A., Trancart, T., Brämick, U. and Aarestrup, K. 2016. Empirical observations of the spawning migration of European eels: The long and dangerous road to the Sargasso Sea. Science Advances 2(10): e1501694.

Rikardsen, A.H., Righton, D., Strøm, J.F., Thorstad, E.B., Gargan, P., Sheehan, T., Økland, F., Chittenden, C.M., Hedger, R.D., Næsje, T.F., Renkawitz, M., Sturlaugsson, J., Caballero, P., Baktoft, H., Davidsen, J.G., Halttunen, E., Wright, S., Finstad, B. and Aarestrup, K., 2021. Redefining the oceanic distribution of Atlantic salmon. Scientific Reports 11(1): 12266.

Saorgus Energy Limited, 2013. Dublin Array An Offshore Wind Farm on the Kish and Bray Banks. Environmental Impact Statement. Volume 2. Available at: https://www.bing.com/ck/a?!&&p=992d2ac42556e415JmltdHM9MTcxMzkxNjgwMCZpZ3VpZD0yMmMzNzgyNy1iOTI0LTZjMzgtMzRjMS02YjE1YjhlZjZkMTcmaW5zaWQ9NTAwNw&ptn=3&ver=2&hsh=3&fclid=22c37827-b924-6c38-34c1-6b15b8ef6d17&u=a1aHR0cHM6Ly9hc3NldHMuZ292LmllLzExMDUxMS9hYTJiNmQ5Zi1hNDY0LTQ2ZmEtYTUyYy04NzAwMjlkODk4MjIucGRm&ntb=1 Accessed: January 2024.

Savina, M., Lacroix, G., and Ruddick, K., 2010. Modelling the transport of common sole larvae in the southern North Sea: Influence of hydrodynamics and larval vertical movements. Journal of Marine Systems 81(1-2): 86-98.

Seed, R. and Suchanek, T.H., 1992. Population and community ecology of *Mytilus*. In Gosling, E. (ed.), The mussel *Mytilus:* ecology, physiology, genetics and culture, pp. 87-169. Elsevier Press, Amsterdam.

Silva, S., Servia, M.J., Vieira-Lanero, R., Barca, S. and Cobo, F., 2013. Life cycle of the sea lamprey Petromyzon marinus: duration of and growth in the marine life stage. Aquatic Biology 18(1): 59-62.

Simpson, S., Blanchard, J. and Genner, M., 2013. Impacts of climate change on fish. Marine Climate Change Impacts Partnership (MCCIP): Science Review: 113-124.

Sims, D.W., Nash, J.P. and Morritt, D., 2001. Movements and activity of male and female dogfish in a tidal sea lough: alternative behavioural strategies. Marine Biology 139: 1165-1175.

Sims, D.W., Southall, E.J., Wearmouth, V.J., Hutchinson, N., Budd, G.C. and Morritt D., 2005. Refuging behaviour in the nursehound *Scyliorhinus stellaris* (Chondrichthyes: Elasmobranchii): preliminary evidence from acoustic telemetry. Journal of the Marine Biological Association of the United Kingdom 85: 1137-1140.

Skerrit, D.J., Robertson, P.A., Mill, A.C., Polunin, N.V.C. and Fitzsimmons, C., 2015. Fine-scale movement, activity patterns and home-ranges of European lobster *Homarus gammarus*. Marine Ecology Progress Series 536: 203-219.

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.

Smith, I.P., Collins, K.J., Jensen, A.C., 1998. Movement and activity patterns of the European lobster, *Homarus gammarus*, revealed by electromagnetic telemetry. Marine Biology 132(4): 611-623.

Smith, I.P., Jensen, A.C., Collins, K.J. and Mattey, E.L., 2001. Movement of wild European lobster *Homarus gammarus* in natural habitat. Marine Ecology Progress Series 222: 177-186.

Smith, K.E. and Thatje, S., 2013. Nurse egg consumption and intracapsular development in the common whelk *Buccinum undatum* (Linnaeus 1758). Helgoland Marine Research 67: 109-120.

Southall, E.J., Sims, D.W., Metcalfe, J.D., Doyle, J.I., Fanshawe, S., Lacey, C., Shrimpton, J., Solandt, J.L. and Speedie, C.D., 2005. Spatial distribution patterns of basking sharks on the European shelf: preliminary comparison of satellite-tag geolocation, survey and public sightings data. Marine Biological Association of the United Kingdom. Journal of the Marine Biological Association of the United Kingdom 85(5): 1083-1088.

Sveegaard, S., Nabe-Nielsen, J., Stæhr, K.J., Jensen, T.F., Mouritsen, K.N. and Teilmann, J., 2012. Spatial interactions between marine predators and their prey: herring abundance as a driver for the distributions of mackerel and harbour porpoise. Marine Ecology Progress Series 468: 245-253.

Taeubert, J.E. and Geist, J., 2017. The relationship between the freshwater pearl mussel (*Margaritifera margaritifera*) and its hosts. Biology Bulletin 44: 67-73.

Technical Expert Group on Eel, 2021. Report of the Technical Expert Group on Eel to the North-South Standing Scientific Committee on Inland Fisheries (NSSSCIF).

Thompson, B.M., Lawler, A.R. and Bennett, D.B., 1995. Estimation of the spatial distribution of spawning crabs (*Cancer pagurus* L.) using larval surveys of the English Channel. ICES Marine Science Symposia 199: 139-150.

Townhill, B.L., Couce, E., Tinker, J., Kay, S. and Pinnegar, J.K., 2023. Climate change projections of commercial fish distribution and suitable habitat around north western Europe. Fish and Fisheries 24(5): 848-862.

Triturus, 2020. Fisheries assessment of the River Liffey, Co. Kildare. Unpublished report prepared by Triturus Environmental Ltd. North Kildare Trout & Salmon Anglers Association. December 2020. Available at: https://www.nktsaa.com/fisheries_report_2020.pdf Accessed: November 2023.

Tully, O., 2017. Atlas of Commercial Fisheries for Shellfish around Ireland. Marine Institute, March 2017. ISBN 9781902895611 58 pp.

Tyler-Walters, H., 2007. *Cerastoderma edule* Common cockle. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1384 Accessed: August 2023.

Tyler-Walters, H., 2008. *Mytilus edulis* Common mussel. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1421 Accessed: April 2024.

Ungfors, A., Hallbäck, H. and Nilsson, P.G., 2007. Movement of adult edible crab (*Cancer pagurus* L.) at the Swedish West Coast by mark-recapture and acoustic tracking. Fisheries Research 84(3): 345-357.

Valentinsson, D. 2002. Fisheries biology of the whelk (*Buccinum undatum*): population biology, estimation uncertainty and consequences of management alternatives. Doctoral thesis, Göteborg University, Sweden.

Van Deurs, M., Behrens, J.W., Warnar, T. and Steffensen, J.F., 2011. Primary versus secondary drivers of foraging activity in sandeel schools (*Ammodytes tobianus*). Marine Biology 158: 1781-1789.

van Hoeck, R.V., Rowell, T.J., Dean, M.J., Rice, A.N. and van Parijs, S.M., 2023. Comparing Atlantic Cod Temporal Spawning Dynamics across a Biogeographic Boundary: Insights from Passive Acoustic Monitoring. Marine and Coastal Fisheries Dynamics, Management, and Ecosystem Science 15: e10226.

Vattenfall Wind Power Limited, 2018. Thanet Extension Offshore Wind Farm Environmental Statement Volume 2, Chapter 6: Fish and Shellfish Ecology [online]. Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010084/EN010084-000602-6.2.6_TEOW_Fish&SF.pdf Accessed: October 2020.

Vattenfall Wind Power Limited, 2019. Thanet Extension Offshore Wind Farm Appendix 7 to Deadline 4C Submission: Fish Clarification Note [online]. Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010084/EN010084-001758-D4C_Appendix7_TEOW_Herring_Clarification_Note_RevA.pdf Accessed: October 2020.

Waldman, J., Grunwald, C. and Wirgin, I., 2008. Sea lamprey *Petromyzon marinus*: an exception to the rule of homing in anadromous fishes. Biology letters 4(6): 659-662.

Walker, T.I., Rigby, C.L., Pacoureau, N., Ellis, J., Kulka, D.W., Chiaramonte, G.E. and Herman, K., 2020. Galeorhinus galeus. The IUCN Red List of Threatened Species 2020: e.T39352A2907336.

White, R.G., Hill, A.E. and Jones, D.A., 1988. Distribution of *Nephrops norvegicus* (L.) larvae in the western Irish Sea, an example of advective control in recruitment. Journal of Plankton Research 10: 735-747.

Whitehead, P.J., Bauchot, M.L., Hureau, J.C., Nielsen, J., Tortonesse, E., 1986. Fishes of 749 the Northeastern Atlantic and the Mediterranean. UNESCO, Parıs, 1362 pp.

Wilson, C.M., Tyler-Walters, H. and Wilding, C.M., 2020. *Cetorhinus maximus* Basking shark, In H. Tyler-Walters, H. (Ed.), Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1438 Accessed: November 2023.

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

Wright, P.J., Gibb, F.M., Gibb, I.M., Heath, M.R. and McLay, H.A., 2003. North Sea Cod Spawning Grounds. Fisheries Research Services Internal Report No 17/03.

Zemeckis, D.R., Hoffman, W.S., Dean, M.J., Armstrong, M.P. and Cadrin, S.X., 2014. Spawning site fidelity by Atlantic Cod (*Gadus morhua*) in the Gulf of Maine: implications for population structure and rebuilding. ICES Journal of Marine Science 71(6): 1356-1365.

GoBe Consultants Ltd
Suites B2 & C2, Higher Mill
Higher Mill Lane
Buckfastleigh
Devon
TQ11 0EN

GoBe Consultants Ltd
5/2 Merchant's House
7 West George Street
Glasgow
Scotland
G2 1BA

www.gobeconsultants.com