Dublin Array
Generation for generations

EIAR Volume 3: Offshore Infrastructure Assessment Chapters
Chapter 4: Fish and Shellfish Ecology

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Dublin Array Offshore Wind Farm

Environmental Impact Assessment Report

Volume 3, Chapter 4: Fish and Shellfish Ecology

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Glossary

Term	Definition
Benthic	Relating to or occurring on the seabed.
Berried	Bearing eggs. Term often used to describe egg bearing shellfish.
Bony fish	Any species with skeletons primarily composed of bone tissue; comprises fishes of the superclass Osteichthyes.
Cartilaginous fish	Any species with skeletons primarily composed of cartilage; comprises chimaeras and all elasmobranchs.
Clupeids	Fishes belonging to the family Clupeidae; includes Atlantic herring.
Decapod crustacean	Crustaceans of the order Decapoda, which includes crabs, lobsters, shrimp and prawns.
Demersal	Living and feeding on or near the seabed.
Diadromous	Migrating between fresh and saltwater habitats.
Electro-sensitive	Ability to sense electric fields.
Elasmobranch	Cartilaginous fish of the subclass Elasmobranchii; comprises sharks, rays and skates.
Epibenthic	Living on the seafloor.
Far-field	Area encompassing the array area, Offshore ECC and Zones of Influence.
Flatfish	Bony fish of the order Pleuronectiformes; includes plaice, soles, flounders, turbot and their relatives.
Gadoid	Bony fish of the order Gadiformes; includes cod, haddock, hake and their relatives.
Magneto-sensitive	Ability to sense magnetic fields.
Near-field	Area encompassing the array area and Offshore ECC boundary.
Nursery grounds	Areas important for the development of juvenile fish and shellfish.
Ovigerous	Carrying or bearing eggs.
Oviparous	Animals that produce eggs and embryos develop outside the mother's body.
Ovoviviparous	Animals that produce eggs that remain within the mother's body until hatching.
Pelagic	Living and feeding in the water column.
Piscivorous	Animals feeding on fish.
Recruitment	Process by which new individuals join an adult population; in fishes, it includes the transitioning from early life stages (e.g. eggs, larvae, younger juveniles) to later life stages at which natural mortality stabilises near adult levels.
Shellfish	Shell-bearing aquatic invertebrates used as food; includes various species of crustaceans, bivalves and gastropods.
Spawning grounds	Areas where fish and shellfish aggregate to release their gametes for fertilisation or locations where egg cases are deposited.
Swim bladder	Gas-filled organ of many bony fish; used to control buoyancy.

Term	Definition
Viviparous	Elasmobranch species that give birth to their young.
Zone of Influence	The area over which the proposed development could affect the receiving environment such that it could potentially have significant effects.

Acronyms

Acronym	Definition
ABR	Alexandra Basin Redevelopment
AC	Alternating Current
ADO	Alternative Design Option
AEPM	Annual Egg Production Method
ANSI	American National Standards Institute
AyM	Awel Y Mor Offshore Wind Farm
BOWL	Beatrice Offshore Windfarm Limited
BTS	Beam Trawl Survey
CEA	Cumulative Effect Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture
CFP	Common Fisheries Policy
CIEEM	Chartered Institute of Ecology and Environmental Management
CMACS	Centre for Marine and Coastal Studies
CO	Conservation Objective
cSPA	Candidate Special Protection Area
CSTP	Celtic Trust Sea Trout Project
DAS	Dumping at Sea
DC	Direct Current
DCCAE	Department of Communications, Climate Action and Environment (now Department of Environment, Climate and Communications – DECC)
DDV	Drop-Down Video
DBT	Dibutyl Tin
Dublin Array	Dublin Array Offshore Wind Farm
Offshore ECC	Offshore Export Cable Corridor
eDNA	Environmental DNA
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EIS	Environmental Impact Statement
EMF	Electro-Magnetic Fields
EMODnet	European Marine Observation and Data Network

Acronym	Definition
EPA	Environmental Protection Agency
EU	European Union
EVMP	Environmental Vessel Management Plan
GES	Good Environmental Status
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
IAC	Inter-array Cable
IAS	Invasive Alien Species
ICES	International Council for the Exploration of the Seas
IFI	Inland Fisheries Ireland
IMO	International Maritime Organisation
INFOMAR	Integrated Mapping for the Sustainable Development of Ireland's Marine Resources
IUCN	International Union for Conservation of Nature
JUV	Jack Up Vessel
MAC	Maritime Area Consent
MarESA	Marine Evidence based Sensitivity Assessment
MarLIN	The Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	Multibeam Echosounder
MDO	Maximum Design Option
MFE	Mass Flow Excavator
MHWS	Mean High Water Springs
MMMP	Marine Megafauna Mitigation Protocol
MMO	Marine Management Organisation
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MSFD	Marine Strategy Framework Directive
NAS	Noise Abatement System
NIGFS	Northern Irish Groundfish Survey
NIS	Natura Impact Statement
NISA	North Irish Sea Array Offshore Wind Farm
NNS	Non-Native Species

Acronym	Definition
NOAA	National Oceanic and Atmospheric Administration
NPWS	National Parks and Wildlife Service
O&M	Operations and Maintenance
OSP	Offshore Substation Platform
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic (Oslo/Paris convention)
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyls
PEMP	Project Environmental Management Plan
PLGR	Pre-Lay Grapnel Run
PSA	Particle Size Analysis
ROV	Remotely Operated Vehicle
SAC	Special Ares of Conservation
SBP	Sub-bottom Profiler
SEL_{cum}	Cumulative Sound Exposure Level
SFPA	Sea Fisheries Protection Authority
SISAA	Supporting Information for Screening for Appropriate Assessment
SPA	Special Protection Area
SPL_{peak}	Peak Sound Pressure Level
SPL_{rms}	Root-mean square Sound Pressure Level
SPM	Suspended Particulate Matter
SPMP	Scour Protection Management Plan
SSC	Suspended Sediment Concentration
SSS	Side-scan Sonar
TBT	Tributyl Tin
THC	Total Hydrocarbon
TSHD	Trailer Suction Hopper Dredger
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
UHRS	Ultra-high Resolution Seismic Reflection Profiling
UK	United Kingdom
USBL	Ultra-short Baseline

Acronym	Definition
VER	Valuable Ecological Receptor
WFD	Water Framework Directive
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Units

Unit	Expanded Name
A	Ampere
dB	Decibel
Hz	Hertz
kg	Kilogram
kJ	Kilojoule
km	Kilometre
km^2	Kilometre squared
kV	Kilovolt
m	Metre
m^2	Metre squared
m^3	Metre cubed
mg/l	Milligram per litre
mm	Millimetre
m/s	Metre per second
m/s^2	Metre per second squared
MW	Megawatt
nm/s	Nanometre per second
µPa	Micropascal
µT	Microtesla
µV	Microvolt
µV/m	Volt per metre
%	Percentage

4 Fish and Shellfish Ecology

4.1 Introduction

4.1.1 This chapter presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of the construction, operation and maintenance (O&M), and decommissioning phases within the array area and offshore Export Cable Corridor (the latter referred to as the Offshore ECC) on fish and shellfish receptors/resources. In this chapter, "fish and shellfish resources/receptors" captures fish (demersal and pelagic bony fish and elasmobranchs), shellfish (molluscs and crustaceans), and marine turtles.

4.1.2 This chapter should be read in conjunction with the following documents included within the Environmental Impact Assessment Report (EIAR), due to interactions between the technical aspects:

- Volume 3, Chapter 1: Marine Geology, Oceanography and Physical Processes (hereafter referred to as the Physical Processes chapter): *to be referenced for an overview on the surficial sediment properties, suspended sediments and seabed features. This chapter also provides an assessment of the potential impacts of the project upon the marine geology, oceanography and physical processes;*
- Volume 4, Appendix 4.3.1-1: Technical Baseline Report - Physical Processes (hereafter referred to as the Physical Processes technical baseline): *to be referenced for a detailed description of the surficial sediment properties, suspended sediments and seabed features;*
- Volume 4, Appendix 4.3.1-2: Physical Process Modelling for Dublin Array Offshore Wind Farm (hereafter referred to as the Physical Processes Modelling Report): *to be referenced for a detailed description of the hydrodynamic modelling results;*
- Volume 3, Chapter 2: Marine Water and Sediment Quality (hereafter referred to as the Marine Water and Sediment Quality chapter): *to be referenced for a review of the marine water and sediment quality receiving environment. This chapter also provides an assessment of the potential impacts of the project upon marine water and sediment quality;*
- Volume 3, Chapter 3: Benthic Subtidal and Intertidal Ecology (hereafter referred to as the Benthic Ecology chapter): *to be referenced for an overview on the benthic subtidal and intertidal features and ecology. This chapter also provides an assessment of the potential impacts of the project upon the benthic subtidal and intertidal ecology*;
- Volume 4, Appendix 4.3.3-3: Subtidal Survey Report Main Array & ECR - Benthic Ecology Monitoring Report (hereafter referred to as the Subtidal Survey Report): *to be referred to for supporting information regarding the subtidal benthic ecology survey, in addition to sediment sampling analysis and interpretation*;

- Volume 4, Annex 4.3.9-1: Technical Report – Commercial Fisheries (hereafter referred to as the Commercial Fisheries technical baseline): *to be referenced for a detailed description of commercially important fish and shellfish species and the commercial fisheries fleets that operate within and adjacent to Dublin Array;*
- Volume 4, Appendix 4.3.5-7: Dublin Array: Underwater noise assessment (hereafter referred to as the Underwater noise assessment): *to be referenced for a detailed description of the site-specific underwater noise modelling undertaken;* and
- Volume 6: Environmental Impact Assessment Report Chapter 6.5.2.1: Biodiversity Technical Baseline Report (hereafter referred to as the Biodiversity technical baseline): *to be referenced for a description of diadromous fish species in rivers and streams along the onshore export cable route.*

4.1.3 A technical report providing a detailed characterisation of the receiving fish and shellfish baseline is provided in Volume 4, Appendix 4.3.4-1: Technical Baseline Report - Fish and Shellfish Ecology (*hereafter referred to as the Fish and Shellfish technical baseline*). Information from the baseline report has been summarised within this chapter.

4.2 Regulatory background

4.2.1 The legislation, policy and guidance relevant to the whole Planning Application is set out in Consents, Legislation, Policy & Guidance (Volume 2, Chapter 2). The principal legislation, policy and guidance relevant to this chapter is set out in Annex A.

4.2.2 The assessment of potential impacts upon fish and shellfish has been made with specific reference to the relevant regulations, guidelines and guidance, which include: The Common Fisheries Policy Regulation (EU) No 1380/2013 (CFP Regulation) was adopted to ensure that fishing and aquaculture activities within the EU are environmentally sustainable in the long-term and are managed in a way that is consistent with the objectives of achieving economic, social and employment benefits, and of contributing to the availability of food supplies. Compliance with the CFP Regulation across the EU is through the EU Fisheries Control Regulation 2023/2842. As noted in Article 2 of the CFP Regulation, the precautionary approach is to be applied to fisheries management, with the aim of ensuring that the exploitation of living marine biological resources restore and maintain populations of harvested species above levels which can produce the maximum sustainable yield. To that end, the CFP Regulation provides for an ecosystem-based approach to fisheries management, with the aim of ensuring that the impacts of fishing activities on the marine ecosystems are minimised, and that aquaculture and fishing activities avoid the degradation of the marine environment. Notably, the CFP Regulation expressly acknowledges that the Birds Directive 2009/147/EC, the Habitats Directive 92/43/EEC, and the Marine Strategy Framework Directive (MSFD) 2008/56/EC, impose certain obligations on Member States as regards Natura 2000 sites (Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) that are 'European sites' under Irish legislation) and marine protected areas (MPAs), and that the necessary measures to give effect to obligations under those Directives might require the adoption of measures falling under the CFP Regulation. To that end, the CFP Regulation expressly authorises Member States to adopt, in the waters under their sovereignty or jurisdiction, such conservation measures as are necessary to comply with their obligations under those Directives where such measures do not affect the fisheries interests of other Member States. Measures with transboundary fisheries effects are to be managed centrally via the European Commission.

4.2.3 In 2023, the European Commission adopted a Communication on the 'EU Action Plan: Protecting and restoring marine ecosystems for sustainable and resilient fisheries' (COM/2023/102 final). This Action Plan is part of the EU Biodiversity Strategy for 2030, and the aim to protect 30% of the EU's marine waters, through the adoption of measures including fisheries conservation measures to protect and manage MPAs, and to protect fish spawning and nursery areas, to reduce fish mortality rates, and to restore core areas for sensitive species and habitats.

4.2.4 The Marine Strategy Framework Directive 2008/56/EC, as amended, sets out in Annex I a list of eleven descriptors of 'good environmental status' (GES), including:

- Descriptor 1: Biodiversity is maintained;
- Descriptor 3: Populations of commercial fish and shellfish species are healthy;
- Descriptor 6: Sea floor integrity ensures the proper functioning of ecosystems; and
- Descriptor 11: Introduction of energy (including underwater noise) does not adversely affect the ecosystem.

4.2.5 Directive 2017/845 amends the MSFD with a new Annex III setting out an indicative list of ecosystem elements, anthropogenic pressures and human activities relevant to the marine waters. Table 2 of the Directive, which lists anthropogenic pressures, uses and human activities in or affecting the marine environment, lists pressures including commercial and recreational fishing and other activities which may cause physical disturbance to the seabed, physical loss of the seabed, and changes to hydrological conditions, and uses and human activities including aquaculture, fishing, and renewable energy generation (wind, wave and tidal power), all of which have the potential to affect the marine environment. The MSFD is implemented in Ireland through S.I. No. 249 of 2011 – European Communities (Marine Strategy Framework) Regulations 2011, as amended.

4.2.6 The Convention for the Protection of the Marine Environment of the North-East Atlantic ("OSPAR Convention") is an international cooperative agreement between fifteen countries in the North Atlantic. Annex V includes a List of Threatened and/or Declining Species and Habitats, which has been developed and is updated on the basis of species and habitats nominated by Parties and other Observers to the Convention as needing priority protection. This list includes, for example, the European Eel (*Anguilla anguilla*), which is not listed under the Habitats Directive but which is the subject of the European Eel Regulation (EC Regulation 1100/2007).

4.2.7 The International Union for Conservation of Nature (IUCN) is a network or union of organisations that work collaboratively to advance sustainable development across a range of areas including marine. The IUCN recognised as a global authority for the classification, monitoring and conservation of endangered species worldwide. Established in 1964, IUCN's 'Red List of Threatened Species' is the leading source of information on the global conservation status of animal, fungi and plant species.

4.2.8 The Habitats Directive and Birds Directive provide for the creation of a network of SACs and SPAs which form the Natura 2000 network (which under Irish legislation are referred to as European sites), for the protection and conservation of species and their natural habitats. The European Communities (Birds and Natural Habitats Regulations 2011 (S.I. No. 477 of 2011)), as amended (Habitats Regulations), provides for the designation of 'European sites', including sites in the maritime jurisdiction. As noted below, of the fish species listed in Annex II of the Habitats Directive for which European sites are to be designated, four occur in Ireland: river lamprey, sea lamprey, twaite shad, and Atlantic salmon. An assessment of the impact of the Dublin Array offshore infrastructure on European sites and their supporting species and habitat qualifying interests is presented in the Natura Impact Statement (NIS) (Part 4: Habitats Directive Assessments, Volume 4: NIS, included in the Planning Application documentation). For the purposes of a Planning Application, the relevant transposition provisions are found in Part XAB of the Planning and Development Act, 2000, as amended.

4.2.9 Under Regulation 27 of the Habitats Regulations, primary responsibility for the conservation of species of finfish listed in Annex II and V of the Habitats Directive and listed in the Fourth Schedule of the Habitats Regulations, is vested in the Minister with responsibility for Fisheries (currently the Minister for Agriculture, Food and the Marine), and that Minister and their Department and any agencies or bodies under the aegis of that Minister shall exercise their powers and functions so as to comply with and meet the requirements of the Habitats and Birds Directives and of the Habitats Regulations. Certain species, that are listed in Annex IV of the Habitats Directive, are given strict protection under Article 12 of the Habitats Directive, which strict protection is enforced by Regulation 51 of the Habitats Regulations. Annex IV species which occur in Ireland include dolphins, whales and porpoises, and marine turtles.

4.2.10 The Wildlife Act 1976, Wildlife Amendment Act 2000, and Wildlife Amendment Act 2023, all provide for the protection of animals in the wild from a national law perspective. As noted below, this includes the basking shark which is granted protection under S.I. No. 485/2022 - Wildlife Act 1976 (Protection of Wild Animals) Regulations 2022, and all species of marine turtle which were granted protection under S.I. No. 112/1990 - Wildlife Act 1976 (Protection of Wild Animals) Regulations 1990. For further detail on relevant legislation (International, European and Irish), see the Consents, Legislation, Policy & Guidance Chapter (Volume 2, Chapter 2).

4.2.11 Where specific Irish guidance regarding the assessment of impacts of offshore wind on fish and shellfish receptors is not available given the infancy of offshore wind in Ireland, a number of other guidance documents are considered, specific to the consideration of fish and shellfish ecology. Such guidance documents are available from jurisdictions/countries with established offshore renewable energy sectors where comprehensive guidance has been developed. The assessment of potential impacts upon fish and shellfish ecology has been made with specific reference to the relevant regulations, guidelines and guidance, which include:

- Irish, UK and International Guidance
  - Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (Chartered Institute of Ecology and Environmental Management (CIEEM, 2018));
  - Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by American National Standards Institute (ANSI) Accredited Standards Committee S3/SC1 and registered with ANSI (Popper *et al.*, 2014); and
  - Guidelines for The Assessment of Dredge Material for Disposal in Irish Waters (Marine Institute, 2006, 2019).

4.2.12 The relevance of the above (and other relevant legislation and policy identified within the Policy Chapter) with regards to fish and shellfish and how these have been addressed within this assessment are presented in Annex A of this chapter.

4.3 Consultation

4.3.1 As part of the EIA for Dublin Array, non-statutory consultation has been undertaken with various statutory and non-statutory bodies. A Scoping report (RWE, 2020) was made publicly available and issued to statutory consultees on 9th October 2020. Table 1 provides a summary of the consultation undertaken for fish and shellfish ecology to date for Dublin Array.

4.3.2 In accordance with recommendations outlined in the DCCAE guidance[1], the Applicant sought to consult during the scoping stage with the Sea Fisheries Protection Authority (SFPA), the National Parks and Wildlife Service (NPWS), the Inland Fisheries Ireland (IFI), the Marine Institute, representatives from the local fishing fleet, and other relevant statutory and non-statutory authorities. The Dublin Array EIA Scoping Report[2] (Dublin Array, 2020) was made publicly available and issued to statutory consultees on 9th October 2020. Responses to the consultation were used to refine the scope of this assessment.

[1] Guidance on Environmental Impact Statement (EIS) and Natura Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects (Environmental Working Group of the Offshore Renewable Energy Steering Group and the DCCAE, 2017)

[2] https://dublinarray.com/wp-content/uploads/2020/10/Dublin-Array-EIAR-Scoping-Report-Part-1-of-2.pdf

Table 1 Summary of consultation relating to fish and shellfish ecology

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
12th September 2018	Meeting with SFPA	Consultation to discuss the scope and objectives for site specific surveys. An objective to provide further data regarding species diversity and abundance of juvenile fishes and elasmobranchs on the Kish and Bray sandbanks was considered appropriate. It was also noted that sufficient shellfish data was available and that additional shellfish surveys were not required to inform the fish and shellfish baseline characterisation.	A technical report providing a detailed characterisation of the receiving fish and shellfish ecological baseline is provided in the Fish and Shellfish technical baseline. A review of the key findings from that study has been used to describe the receiving environment in Section 4.6.
10th November 2020	Meeting with NPWS	NPWS advised the project to ensure the assessment was very explicit about the extent of plumes associated with different sediment fractions. This meeting was held in lieu of a written response from NPWS to the Scoping phase of the project.	As detailed within Section 4.16 *et seq.*, increases in suspended sediments and sediment deposition because of individual construction activities within the array area and Offshore ECC have been assessed, based on specific modelling presented within the Physical Processes technical baseline. Coarse and fine sediment fractions are discussed as these fundamentally settle out of the water column differently and therefore present a different impact for assessment.
10th November 2020	Meeting with NPWS	NPWS asked whether a Non-Native Species (NNS) Protocol was proposed to be developed.	As part of the Project Environmental Management Plan (PEMP) a marine biosecurity plan is included, which details how the risk of introduction and spread of Invasive Alien Species (IAS) will be minimised (Table 11).

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
23rd November 2020	Scoping response, IFI	IFI recommend that all fish species that live in or transition through the study area should be included in the impact assessment for underwater noise.	The impact assessment for fish and shellfish species has focused on ecologically and economically important species that might be affected by the proposed development. For the underwater noise impact assessment (Impact 4), fish were grouped into functional hearing groups based on their sound detection system. While not all fish species that live in or transition through the study area have been included in the impact assessment, the functional hearing groups applied incorporate the range of hearing mechanisms in fish species and the respective sensitivities to underwater noise. The approach of selecting species to be taken forward to the impact assessments is detailed in paragraph 4.5.1 and the Fish and Shellfish technical baseline report.
23rd November 2020	Scoping response, IFI	IFI noted that some of the data sources used to delineate spawning and nursery grounds are old and their resolution is very coarse compared to other layers of information the project will prepare such as hydrodynamic modelling.	The baseline characterisation of spawning and nursery grounds has been based on all spawning and nursery data available, including existing maps prepared by Coull *et al.*, 1998, Ellis *et al.* (2010, 2012) and the Marine Institute. In addition, research publications and fisheries and ICES data were reviewed to provide site-specific and contemporary information on fish spawning and nursery behaviour within the study area. For species that are demersal spawners, such as herring and sandeel, the assessment of spawning grounds was further underpinned by sediment data. The spatial extent of the spawning grounds and the duration of spawning periods indicated by these studies are therefore considered likely to represent the maximum theoretical extent of the areas and periods within which spawning will occur. The approach of delineating spawning and nursery grounds is summarised in paragraph 4.6.12 *et seq*. Full details are provided in the Fish and Shellfish technical baseline.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
23rd November 2020	Scoping response, IFI	IFI recommend that the inclusion of a robust assessment of the cumulative effects to biota, plankton and fish, of this development with other significant projects including the proposed Arklow, North Irish Sea Array (NISA) and Codling wind farms together with Ringsend and Shanganagh Wastewater Treatment plants.	A comprehensive Cumulative Effects Assessment has been provided within Section 4.19, in relation to fish and shellfish ecology receptors. Other EIAR chapters also include a detailed Cumulative Effects Assessment for the receptors relevant to those topics.
30th November 2020	Scoping response, Marine Institute	The Marine Institute advises that the scale of effects be considered beyond the footprint of the turbines and the licensed area.	The potential extent of impacts extending beyond the footprint of the turbines and the licensed area has been identified through project-specific sediment plume and underwater noise propagation modelling, and the effects on fish and shellfish receptors have been thoroughly assessed within the EIAR (paragraph 4.16 *et seq*.).
30th November 2020	Scoping response, Marine Institute	The Marine Institute advise that consideration of effects at larger scale using ecosystem services as potential metrics may result in modification of the proposed receptors identified in the EIAR.	Any significant impacts from changes to fish and shellfish ecology have been assessed by other technical disciplines (i.e., ornithology and marine mammals) to ensure that there are no negative impacts to ecosystem services. A holistic approach to assessment has been undertaken with technical disciplines cross-referencing the findings of individual chapters.
5th April 2024	Scoping response, Loughs Agency	Loughs Agency are in agreement with the key issues that are likely to impact fish and shellfish from the development but noted that there is a significant knowledge gap on how offshore developments such as wind farms impact fish and shellfish.	The Applicant welcomes Loughs Agency's agreement that the key issues that may impact fish and shellfish have been considered. The EIAR has been prepared based on available information including peer-reviewed literature.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
5th April 2024	Scoping response, Loughs Agency	Loughs Agency suggest that consideration is given to carrying out a thorough baseline survey to monitor migration movements of salmonids and other highly mobile species in this area through an acoustic telemetry programme and hydrodynamic modelling to aid understanding of potential impacts on mobile species protected under the EU Habitats Directive.	The potential spatial extent of impacts has been identified through project-specific sediment plume and underwater noise propagation modelling, as described in the Physical Processes Modelling Report and the Underwater noise assessment, respectively. The potential migration movements of salmonids and other highly mobile species including species protected under the EU Habitats Directive have been detailed in Section 3 of the Fish and Shellfish technical baseline. In relation to the migration movement of salmonids, recent acoustic telemetry data presented in Barry *et al.* (2020) and Rikardsen *et al.* (2021) were used, among other desk-based sources, to inform the baseline characterisation and the impact assessment. In relation to the movements of Atlantic salmon, it has been concluded that there is the potential for salmon smolt and adult salmon to pass through the study area during outward and return migrations. The Applicant notes the suggestion of monitoring migration movements of salmonids and other highly mobile species. A range of reports and peer-reviewed literature, including recent tracking data and IFI publications on the status of salmon populations in river catchments throughout Ireland (2018-2023) were used to provide baseline data. Whilst monitoring of migration movements might add to the overall evidence base for specific species, this would not alter the assessment as salmonids and other migratory species are considered to be present at, or transiting through the study area.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
5th April 2024	Scoping response, Loughs Agency	Loughs Agency suggest that in addition to baseline surveys before works begin, monitoring should continue throughout the construction, operational and decommissioning phases of the wind farm.	The impact assessment presented in this chapter has not identified the need for additional monitoring for fish and shellfish. The assessments conclude that activities associated with the construction, maintenance and decommissioning of the proposed development would at most result in slight (adverse) effects, for both the proposed development alone and for the cumulative effects, which is not significant in EIA terms. Therefore, no additional measures, including monitoring, to that already identified in Table 11 are considered necessary.
5th April 2024	Scoping response, Loughs Agency	Loughs Agency note that the consequences of climate change are already impacting mobile species behaviours. Coupling climate change with the expected changes to other offshore elements considered within the Scoping Report could have a significant negative impact on aquatic species.	The potential impacts of climate change on mobile species have been considered in Section 4.9 of this chapter. The assessment has considered likely naturally occurring variability in fish and shellfish receptors within the lifetime of the proposed development due to natural cycles as well as those that are reasonably foreseeable due to climate change. This is important as it enables a reference baseline level to be established against which the potentially modified fish and shellfish baseline can be compared throughout the lifecycle of the proposed development. As such the effects of a changing baseline as a result of climate change have been considered within the assessment.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
5th April 2024	Scoping response, Loughs Agency	Potential changes in marine processes, benthic and intertidal ecology, marine mammals, offshore ornithology, commercial fisheries and shipping and navigation routes are all likely to impact upon highly mobile and migratory species and shellfish beds. The cumulative effect of all of these potential changes along with climate change impacts needs to be modelled.	The Applicant would like to clarify what is thought to be intended by this question. The response provided below is regarding the project related in-combination effects (when a single receptor or resource is impacted by several environmental impacts that are considered in separate EAIR Chapters), as opposed to the cumulative effects assessment (where the proposed development is assessed cumulatively with other plans and projects). The EIAR considers the potential for project related in-combination effects. For example, where there is the potential for impacts in marine processes to affect benthic ecology, this is considered within the benthic ecology chapter. Where there is the potential for impacts to benthic ecology to affect fish and shellfish ecology, this is considered within the fish and shellfish ecology chapter. Impacts on prey species for bird and marine mammal species are considered within the fish and shellfish chapter. Subsequently, if impacts to fish and shellfish ecology are likely to affect commercial fisheries, sea birds or marine mammals, this is considered within the relevant chapter. Within each of the technical chapters, consideration is given to a future baseline, which includes both likely natural change and reasonably foreseeable alterations due to climate change. As such the Applicant considers that in-combination effects, including the potential impact of climate change has been considered within the assessments.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
5th April 2024	Scoping response, Loughs Agency	There is potential for partnership working with projects such as CETUS to help fill in knowledge gaps	The Applicant welcomes Loughs Agency's suggestion of potential partnerships. However, the assessment has been conducted based on the assumption that salmonids and other migratory species are present at, or passing through the fish and shellfish study area, and therefore additional data gathering is not required for the purposed of the impact assessment (please see full response above). In addition, the impact assessment has not identified the need for additional monitoring during any of the project phases. As such, whilst additional monitoring may add to the overall scientific base for specific species, it would not alter the conclusion of the assessment presented within the EAIR.
5th April 2024	Scoping response, Loughs Agency	Loughs Agency advise that impacts from the development should be broken out to pre-construction phase, construction phase, operational phase and decommissioning phase.	Impacts from the proposed development have been assessed for each development phase. Impacts during the construction phase (including pre-construction activities) have been assessed in Section 4.16, and impacts during the operational and decommissioning phases have been assessed in Section 4.17 and Section 4.18, respectively.
5th April 2024	Scoping response, Loughs Agency	Loughs Agency advise that fish species which are not of 'commercial value' should be given equal weighting to commercial species in the context of their intrinsic value and provision of ecosystem services.	The Applicant notes Lough's Agency's concern that fish species not of 'commercial value' are given equal weighting to commercial species in terms of their ecological value and is able to confirm that such species have been considered in the impact assessment. A detailed characterisation of the fish and shellfish species present in the study area is provided in the Fish and Shellfish technical baseline. For the impact assessment, a Valued Ecological Receptor (VER) approach has been applied to identify the set of fish and shellfish species taken forward to the impact assessment stage.

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
			A range of factors have been considered to identify VERs including the conservation, social, and economic value of a species, 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 selection process of VERs is detailed in Section 3.8 of the Fish and Shellfish technical baseline and summarised in Section 4.8 of this chapter.

4.4 Methodology

4.4.1 For a full description of the methodology as to how this EIAR was prepared, see Volume 2 Chapter 3: EIA Methodology Chapter. The methodology that follows below is specific to this chapter.

Study area

4.4.2 The extent of the Dublin Array Fish and Shellfish Ecology study area has been set to capture the greatest extent of direct and indirect impacts[3] on fish and shellfish receptors that may arise from the construction, O&M and decommissioning of the offshore infrastructure. For the purposes of this chapter, the study area incorporates the wind farm array area, the intertidal and subtidal areas of the Offshore ECC, temporary occupation area and the surrounding Zone of Influence (ZoI) (Figure 1). The actual extent of the ZoI will vary according to the nature of the impact being studied; to assess the effects on fish and shellfish receptors, the ZoI has been defined by the following spatial scales:

- For impacts related to seabed disturbance events that extend beyond the direct footprint of offshore infrastructure, a sedimentary ZoI of 17[4] km buffering the array area and Offshore ECC[5] has been applied. The extent of this ZoI has been determined by reference to the project-specific hydrodynamic modelling (see Physical Processes Modelling Report), which indicates a maximum tidal excursion of approximately 16 km from the point of release during spring tides. The results of the modelling also indicate that construction activities would create sediment plumes that would disperse over a maximum distance of 10 km from the point of release. Therefore, a sedimentary ZoI of 17 km is considered to be precautionary and to encapsulate the area within which all of the potential significant indirect effects of increases in Suspended Sediment Concentrations (SSC) and associated sediment deposition on fish and shellfish receptors and their environment might occur; and

[3] For the purpose of this assessment, impacts that occur within the footprint of an activity are termed direct impacts (e.g., physical disturbance to the seabed), while those impacts occurring away from an activity are termed indirect impacts (e.g., dispersal of sediment plumes and associated sediment deposition following the disturbance of the seabed).

[4] All distances are taken from the outer boundary of all offshore works incorporating the offshore infrastructure, the buffer also incorporates the temporary occupation area and as such are inherently precautionary

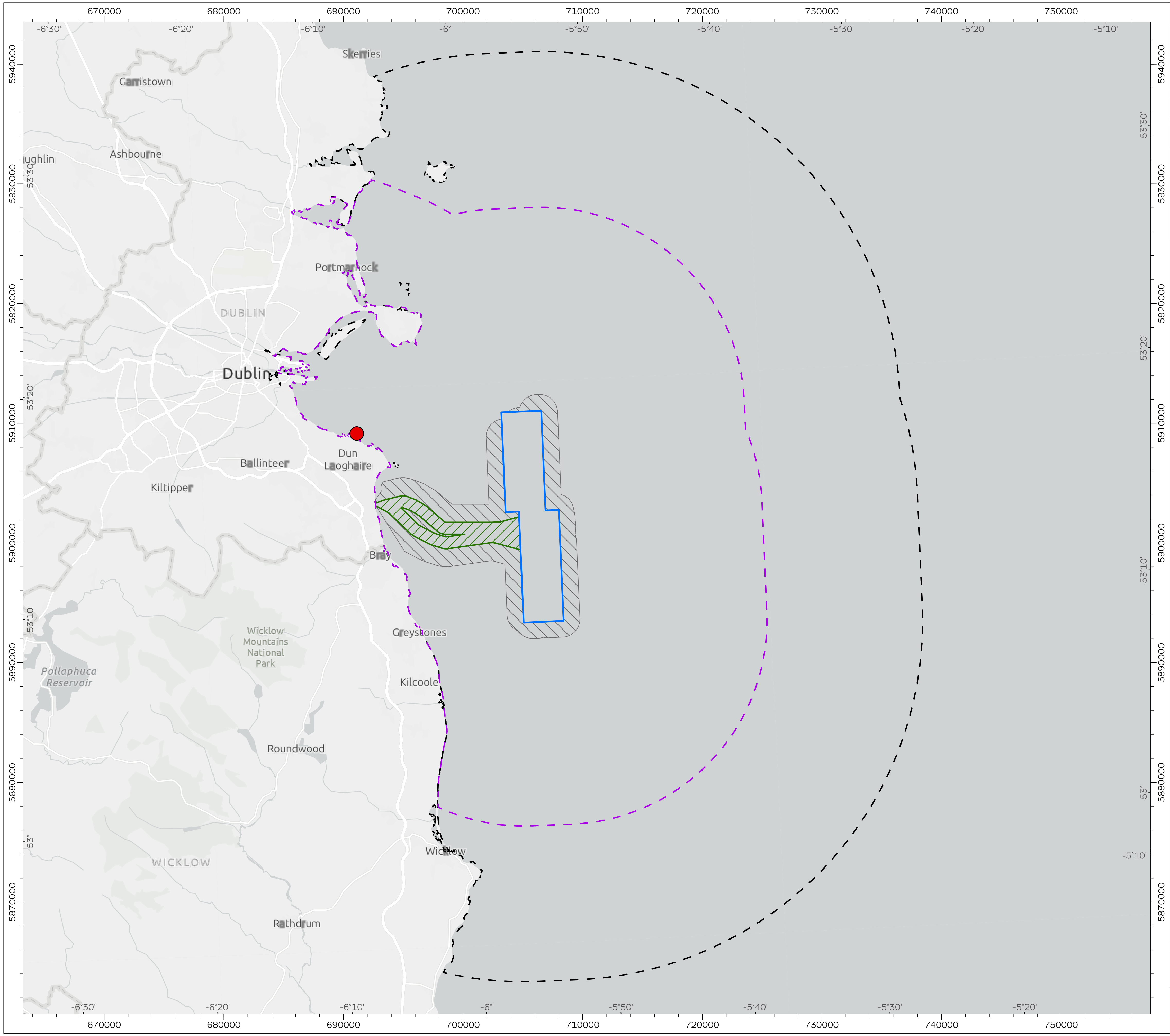
[5] Activities undertaken within the temporary occupation area, namely the use of jack-up vessels and anchors during the construction, O&M, and decommissioning phases have been screened out within the physical processes chapter for suspended sediment and deposition with their use not resulting in notable changes in SSC and associated sediment deposition, however the use of a buffer ensures a precautionary approach is taken.

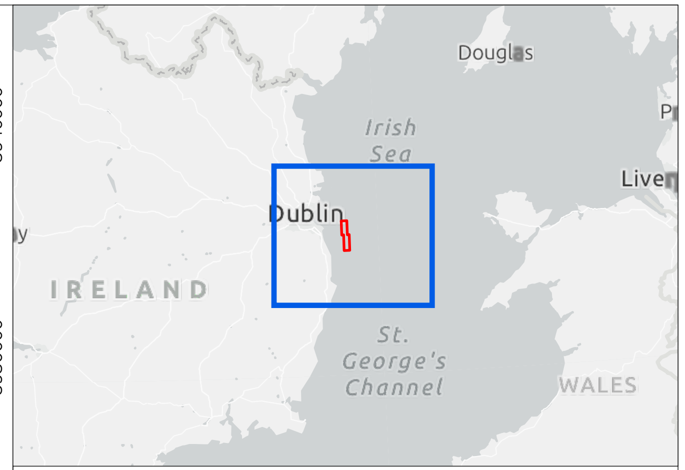
- An additional underwater noise ZoI of 30 km buffering the array area and Offshore ECC was defined for potential underwater noise effects on sensitive fish and shellfish receptors, acknowledging that underwater noise may have a larger impact range than that associated with sedimentary impacts. The largest impact ranges of underwater noise are anticipated from piling of foundations in the array area during the construction phase. The extent over which effects from underwater noise may arise has been determined through project-specific underwater noise modelling (Underwater Noise Modelling Report), based on the maximum design option and the noise effect thresholds for fish recommended by Popper *et al.* (2014). The results of the modelling indicate that the maximum effect range[6] from underwater noise will extend up to 29 km from the array area. Therefore, a precautionary ZoI for underwater noise has been set at 30 km around the array area and Offshore ECC (Figure 1).

4.4.3 Collectively, the area covered by the array area, Offshore ECC and the sedimentary and underwater noise ZoIs defined for fish and shellfish receptors is referred to throughout this report as the fish and shellfish study area (hereafter referred to in this Chapter as the study area). The study area encompasses the two Offshore ECC route options within the Offshore ECC up to and including the intertidal zone at the Shanganagh landfall area below Mean High Water Springs (MHWS)[7].

[6] For fish the extent of the underwater noise ZoI has been set to fully encapsulate the modelled maximum impact ranges for the 186 dB re 1µPa2s cumulative Sound Exposure Level (SELcum) during pile driving when applied to static receptors. The 186 dB re 1µPa2s SELcum represents the recommended exposure threshold for the onset of temporary hearing loss in the most sensitive fish receptors (Popper et al., 2014). Fish were previously assumed to flee noise stimuli at a rate of 1.5 m/s; however more recent UK Offshore Wind Farm (OWF) projects have been advised to also consider stationary receptor modelling for some species groups, such as sandeel and eggs and larvae to explore the effects of underwater noise on less mobile life stages and benthic spawning species (e.g. ScottishPower Renewables, 2019).

[7] Mean high water springs is the highest level that spring tides reach on the average over a period of time.





Operations and Maintenance Base
Array Area
Temporary Occupation Area
Export Cable Corridor
Sedimentary ZoI (17km)
Underwater Noise ZoI (30km)

DRAWING STATUS

FINAL

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MAP NOTES / DATA SOURCES:

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Offshore Windfarm Fish And Shellfish Ecology Study Area

DRAWING NUMBER: 1

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 3 6 9 12 km
0 1.5 3 4.5 6 nm

N GRID NORTH

SCALE	1:325,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

Baseline data

4.4.4 A detailed desktop review has been carried out to inform the baseline characterisation of fish and shellfish resources within the study area. Information was obtained on fish and shellfish ecology in general, on spawning and nursery behaviour and habitats of key species.

4.4.5 In addition, site-specific characterisation surveys were conducted across the Dublin Array fish and shellfish ecology study area in 2002 (results summarised in Ecoserve, 2008) and 2019 (Aquafact, 2019). These were designed to provide an understanding of the function of the Kish and Bray Banks in relation to the local fisheries resource. The fish and shellfish ecology assessment is also informed by data collected during site-specific grab, Drop-Down Video (DDV) and dredge surveys (Aquafact, 2018; Ecoserve, 2008[8] and Fugro, 2021 (Volume 4, Appendix 4.3.3-4 Array Area & ECR – Environmental Features Report (Habitat Analysis Only)), which were used to complement the description of fish and shellfish resources in the study area and to identify potential suitable spawning grounds for sandeels (*Ammodytes* spp.) and Atlantic herring (*Clupea harengus*).

4.4.6 The data and information sources used to inform the fish and shellfish ecology baseline are described in the Fish and Shellfish technical baseline; key data sources are listed in Table 2.

[8] https://www.gov.ie/en/foreshore-notice/60c81-bray-offshore-wind-ltd/

Table 2 Key data sources used to inform the fish and shellfish ecology baseline characterisation and assessment

Data source	Type of data and temporal and spatial coverage
Site-specific surveys	
Aquafact (2019). A Fisheries survey of the Kish and Bray Banks (included in Volume 4, Appendix 4.3.4-2).	Fishing resource data collected from 10 otter trawls within and adjacent to the array area in 2019. Species records, size data and abundance data were used to inform the fish and shellfish baseline.
Subtidal Survey Report Main Array & ECR - Benthic Ecology Monitoring Report (included in Volume 4, Appendix 4.3.3.3).	Biological grab and DDV survey undertaken between February and March across array area and Offshore ECC in 2021. Grab samples collected from 28 stations for faunal analysis and sediment Particle Size Analysis (PSA). DDV collected from 29 sites. DDV data used to inform the fish and shellfish baseline; PSA data used to determine potential for herring and sandeel spawning grounds.
Aquafact (2018). Marine Ecological Assessment of Dublin Array Wind Farm.	Site-specific biological dredge samples collected within the array area and Export Cable Search Area in 2017; data used to inform the fish and shellfish baseline and to determine the potential for herring and sandeel spawning grounds.
EcoServe (2008). A marine ecological study of the Kish and Bray Banks for a proposed offshore wind farm development: Re-characterization survey[9].	Site-specific re-characterisation survey of the Kish and Bray Banks in 2008. Biological dredge samples used to inform the fish and shellfish baseline.
Saorgus Energy Limited (2013). Dublin Array: An Offshore Wind Farm on the Kish and Bray Banks. Environmental Impact Statement[10]	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 in 2002. During the 2002 survey, site-specific data were collected through four Agassi trawls. Fish and shellfish species were also recorded from benthic dredge survey samples.
Pre-existing data sources	
Coull *et al*. (1998). Fisheries Sensitivity Maps in British Waters.	Maps of spawning and nursery grounds for commercially important fish species. Spawning seasonality presented, 1991-1996. Covers UK and Irish waters, including the fish and shellfish study area.
Ellis *et al.* (2010, 2012). Spawning and nursery grounds of selected fish species in UK waters. Scientific Series Technical Report.	Spawning and nursery ground data for commercially important fishes and species of conservation importance. Spawning and nursery seasonality presented, 1990-2008. Covers UK and Irish waters, including the fish and shellfish study area.

[9] https://www.gov.ie/en/foreshore-notice/60c81-bray-offshore-wind-ltd/
[10] https://www.gov.ie/en/foreshore-notice/60c81-bray-offshore-wind-ltd/

Data source	Type of data and temporal and spatial coverage
Marine Institute data sourced from Ireland's Marine Atlas (Marine Institute, 2016).	Online maps for spawning and nursery grounds for commercially important species in Irish waters; developed as part of the reporting for the Marine Strategy Framework Directive. Covers all Irish waters. Data downloaded in 2023 and 2024.
Integrated Mapping for the Sustainable Development of Ireland's Marine Resources (INFOMAR) (2023).	A joint project between the Marine Institute and Geological Survey of Ireland creating integrated seabed mapping products using multibeam echosounder and seabed survey data. Sediment data used as a proxy to identify seabed areas suitable for herring and sandeel spawning. Data collected across Irish Sea from 2006 onwards, including the study area.
European Marine Observation and Data Network (EMODnet) broadscale seabed habitat map of Europe (EUSeaMap, 2021).	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 for zooplankton and fish eggs and larvae. Data collected in 2000 during the spawning seasons of target species. Data collected across Irish Sea, including the study area.
ICES (2023a). Northern Irish Groundfish Survey (NIGFS) (2018-2022).	Annual otter trawl surveys undertaken from 1992 onwards to monitor the distribution of ground fish in the Irish Sea. Data collected in ICES statistical rectangles 34E3, 34E4, 35E3, 35E4, 36E3 and 36E4 from 2018-2022 used to inform the fish and shellfish baseline.
ICES (2023b). Offshore Beam Trawl Survey (BTS) (2018-2022).	Annual beam trawl surveys undertaken to monitor the distribution of commercially important flatfish. Data collected in ICES statistical rectangles 34E3, 34E4, 35E3, 35E4, 36E3 and 36E4 from 2018-2022 used to inform the fish and shellfish baseline.
EIA undertaken to inform the Alexandra Basin Redevelopment (ABR) Capital Dredging project (RPS, 2014[11])	Beam trawls and fyke nets deployed in Dublin Bay in 2013 to inform the fish and shellfish baseline for the ABR impact assessment. Environmental data submitted as part of Foreshore Licence application FS005699. Data has been used to inform the fish and shellfish baseline for inshore areas across Dublin Bay.
Aquatic Services Unit (2019, 2020). Dublin Port Company Maintenance Dredging 2020-2029[12].	Beam trawls and DDV were undertaken within Dublin Bay and the Dublin port shipping channel between 2016 and 2020 to inform the fish and shellfish baseline for the Dublin Port Maintenance Dredging project. Environmental data submitted as part of Foreshore Licence applications FS006980 and FS007132. Data has been used to inform the fish and shellfish baseline for inshore areas.

[11] https://dublinportabr.ie/wp-content/uploads/2014/03/ABR-Project-March-2014-EIS-Volume-1.pdf
[12] https://dublinportdredgingforeshoreconsent.ie/environmental-impact-assessment-report/

Data source	Type of data and temporal and spatial coverage
Marine Institute (2023). The Stock Book 2023: Annual Review of Fish Stocks in 2023 with Management Advice for 2023.	Distribution data on commercially exploited fish stocks of interest to Ireland. Annual publication covering all Irish waters.
Marine Institute and Bord Iascaigh Mhara (2023) Shellfish Stocks and Fisheries Review 2023.	An assessment of selected shellfish stocks in Irish waters. 2022. Covering all Irish waters.
Gerritsen and Kelly (2019). Atlas of Commercial Fisheries around Ireland.	The atlas reviews the fishing activity of fish stocks of relevance to Ireland that come under the EU Common Fisheries Policy. Published 2019. Covering all 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. Covering all Irish waters.
Celtic Sea Trout Project (CSTP) (2016).	Information on the status, distribution and ecology of sea trout populations in the Irish Sea. Report covers waters around Ireland and western Britain including the Irish Sea.
King *et al.* (2011). Ireland Red List No. 5: Amphibians, Reptiles and Freshwater Fish.	Details most up-to-date list of freshwater fish native and non-native to Ireland, listed from least concern to extinct. 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. Coverage of the entire study area.
National Parks and Wildlife Service (NPWS).	Information and published resources on protected areas around Ireland (NPWS 2013a, 2013b, 2013c, 2015, 2023).
Inland Fisheries Ireland (IFI) publications on the status of migrating fish populations (2018-2023).	Findings of monitoring programs designed to assess the status of fish populations in river catchments throughout Ireland. Used to establish the baseline for migrating fish species.
Data sourced from Transitional Water monitoring results for the Water Framework Directive (IFI, 2008-2012)	A combination of beach seines, fyke nets and beam trawls. This data has been used to characterise the fish species present in transitional water bodies. Coverage of the Liffey and Tolka estuaries.
Marine Protected Area Advisory Group (2023). Ecological sensitivity analysis of the western Irish Sea to inform future designation of Marine Protected Areas (MPAs).	Report to the Irish Government by the MPA Advisory Group to inform the selection of future MPAs in the western Irish Sea. Information used to inform the fish and shellfish baseline characterisation.

Assessment methodology

4.4.7 The impact assessment for fish and shellfish receptors identifies, describes and assesses the significance of effects during the offshore construction, O&M and decommissioning phases of Dublin Array (Section 4.16 to Section 4.18). The potential for significant cumulative effects to arise are assessed in Section 4.19.

4.4.8 The assessment also considers likely naturally occurring variability in, or long-term changes to, fish, shellfish and marine turtle receptors within the lifetime of Dublin Array, considering both natural variations and cycles and predicted changes due to climate change. This is important as it enables a reference baseline level to be established against which the potentially modified fish and shellfish baseline can be compared throughout the Dublin Array lifecycle. The baseline conditions of the receiving environment are described in Section 4.6, and the future receiving environment is detailed in Section 4.9.

4.5 Assessment Criteria

4.5.1 The assessment of fish and shellfish receptors is consistent with the EIA Methodology Chapter but includes an additional step: 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 (CIEEM, 2018). The importance of a fish or shellfish species is dependent upon a range of factors, including their conservation, social, and economic value. Other factors used to identify VERs for the proposed development include 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 factors considered during the selection of VERs are detailed within the Fish and Shellfish technical baseline report.

4.5.2 The criteria for determining the sensitivity of the receiving environment and the magnitude of impacts for the fish and shellfish receptors assessment are defined in Table 4 and Table 5 respectively. A matrix was used for the determination of significance in EIA terms (see Table 6). The combination of the magnitude of the impact with the sensitivity of the receptor determines the assessment of significance of effect. The project design options on which the assessments are based are defined in accordance with the Maximum Design Option (MDO) and alternative design options (ADO) as described in the EIA Methodology Chapter and provided in Table 10.

Sensitivity of receptor criteria

4.5.3 The determination of a receptor's sensitivity to an impact has been based on the receptor's adaptability, tolerance, and recoverability together with its assigned value. Adaptability relates to a receptor's capacity to avoid or adapt to an impact, while tolerance refers to a receptor's ability to absorb environmental changes arising from an impact. For example, when regarding fish and shellfish receptors, consideration is given to several factors, including the mobility of the receptor: Receptors that can move away from an impact are considered more adaptable than those that are sedentary or less mobile. When applying this consideration to a fish and shellfish assessment, less adaptable receptors typically include shellfish of limited mobility, fish that will potentially be engaging in spawning behaviours, substrate dependent receptors, and eggs and larvae.

4.5.4 The determination of tolerance takes account of a receptor's ability to absorb temporary or permanent changes without altering its character (Holling, 1973). This may relate to a receptor's ability to resist damage or death or the likelihood of behavioural and physiological changes or changes in reproductive success. When applying this consideration to a fish and shellfish assessment, less tolerant receptors may include shellfish species with less mobility that are susceptible to damage from physical disturbances, fish and shellfish unable to tolerate changes in substratum type, and fish that will be affected by underwater noise, for example, by sustaining physical injuries. The determination of tolerance will also consider the likelihood of damage to, or loss of early life stages.

4.5.5 The recoverability of a receptor relates to the degree to which the receptor can recover after an impact has stopped. It takes account of the rate of recovery, which for the purpose of this assessment is evaluated against the time periods recommended in the EPA Guidelines (EPA, 2022). For fish and shellfish receptors, recoverability can relate to the ability of a receptor to recolonise an area after an impact has occurred, for normal behaviour to resume, or the time needed for recovery from a reduction in population levels or recruitment success due to injury or mortality.

4.5.6 The determination of receptor adaptability, tolerance and recoverability for fish and shellfish receptors has been informed by reference to available peer-reviewed scientific literature, relevant Marine Evidence-Based Sensitivity Assessments (MarESA) from the Marine Life Information Network (MarLIN) database[13], and expert judgement. The different categories used to describe adaptability, tolerance and recoverability of fish and shellfish receptors and their respective definitions are presented in Table 3.

4.5.7 The value of the receptor refers to the receptor's relative ecological, social or economic importance or worth. Regarding fish and shellfish receptors, the determination of value is primarily informed by the conservation status of the receptor and the receptor's role in the ecosystem. In addition, for fish and shellfish stocks that support significant fisheries, commercial value is also taken into consideration. Full details about the determination of value of fish and shellfish receptors are given in the Fish and Shellfish technical baseline. The commercial importance of individual receptors is fully described in the Commercial Fisheries technical baseline report.

4.5.8 The overall sensitivity of a receptor is derived by considering the receptor's ability to adapt, tolerate and recover from an impact in relation to its value. Adaptability, tolerance, recoverability and value are considered in-combination on a receptor-by-receptor basis, as outlined in Table 4. For example, if a receptor is considered of high value, or has rapid recovery rates, these criteria may be given greater weighting in defining the sensitivity of the receptor. Where a receptor could reasonably be assigned more than one level of sensitivity, professional judgement has been used to determine which level is applicable, in line with the CIEEM Guidance (CIEEM, 2018).

Table 3 Definitions of adaptability, tolerance and recoverability applied to determine receptor sensitivity

[13] The MarLIN database (https://www.marlin.ac.uk) holds the largest review of potential sensitivities of North-East Atlantic marine and coastal habitats to human activities (Tyler-Walters et al., 2023). This includes historic (MarLIN approach) and more recent (MarESA approach) sensitivity assessments for some fish and shellfish receptors, which have been used to inform the impact assessment.

Criteria	Definition
Adaptability	
High	Receptor has high capacity to avoid or adapt to impact.
Medium	Receptor has a reasonable capacity to avoid or adapt to impact.
Low	Receptor has a limited capacity to avoid or adapt to impact.
None	Receptor cannot avoid or adapt to impact.
Tolerance	
High	Receptor is considered tolerant to impact (i.e., receptor has a high capacity to accommodate change).
Medium	Receptor has some tolerance to impact (i.e., receptor has a moderate capacity to accommodate change).
Low	Receptor has limited tolerance to impact (i.e., receptor has a low capacity to accommodate change).
Very low to none	Receptor has very limited tolerance to impact (i.e., receptor has no or very low capacity to accommodate change).
Recoverability	
High	Effects are anticipated to be temporary (i.e., lasting less than one year).[14]
Medium	The receptor is anticipated to recover fully within the short-term (i.e., 1-7 years).
Low	The receptor is anticipated to recover fully within the medium-term (i.e., 7-15 years).
Very low	The receptor is anticipated to recover fully within the long-term (i.e., 15-60 years).
No recoverability	The effect on the receptor is anticipated to be permanent (i.e., over 60 years).

Table 4 Sensitivity criteria used to assess impacts on fish and shellfish receptors

Receptor sensitivity	Definition
High	Nationally and internationally important receptors with no adaptability, no or very low tolerance and no ability for recovery.
Medium	Nationally and internationally important receptors with low adaptability, medium to low tolerance and medium to low recoverability; Regionally important receptors with low to no adaptability, no or very low tolerance and no or very low ability for recovery; or Regionally important receptors with low tolerance and medium to low recoverability.
Low	Nationally and internationally important receptors with medium adaptability, medium tolerance and high recoverability;

[14] The potential time for recovery and the duration of impacts are assessed against the definitions proposed within the EPA EIA guidelines (EPA, 2022). The criteria have been reviewed and considered appropriate for fish and shellfish receptors. The impact assessments have been informed by available peer-reviewed scientific literature, grey literature and professional judgement.

Receptor sensitivity	Definition
	Regionally important receptors with medium to low adaptability, medium tolerance and medium to low recoverability; Regionally important receptor with low tolerance and high recoverability; or Locally important receptors with low adaptability, low to very low tolerance and low recoverability.
Negligible	Receptors are considered tolerant (i.e., high adaptability, tolerance, and recoverability) to the impact regardless of value/importance; or Locally important receptors with medium adaptability, medium tolerance and medium to high recoverability.

Magnitude of impact criteria

4.5.9 The magnitude of impacts, as defined in Table 5, has been evaluated based on the potential consequences of impacts on fish and shellfish receptors. The determination of consequences has considered the scale of the impact including its spatial extent, duration and frequency. The probability (i.e. likelihood) of the impact has not been considered in defining the magnitude of impact as all impacts included in the EIAR are considered reasonably likely to occur.

4.5.10 Four levels of impact magnitude were used: High, Medium, Low, and Negligible. Where an effect could reasonably be assigned to more than one level of magnitude, professional judgement has been used to determine which level is the most appropriate for the impact. The level has been assigned based on the most appropriate potential consequences of the impact as defined for each level of magnitude (see Table 5). For example, an impact may occur constantly throughout the O&M period but is not discernible or measurable in practice, therefore it would be concluded to be of a negligible magnitude despite the frequency of the impact.

4.5.11 For the purposes of the definitions in Table 5, near-field has been defined as within the array area and Offshore ECC boundary (Figure 1). Far-field has been defined as extending beyond these boundaries, within the sedimentary and underwater noise ZoIs as defined in Section 4.1 (study area).

Table 5 Magnitude criteria used to assess impacts on fish and shellfish receptors

Magnitude	Definition
High	**Extent:** The impact occurs across the near-field and far-field areas (i.e., across the whole fish and shellfish study area). **Duration:** The impact is anticipated to be permanent (i.e., over 60 years). **Frequency:** The impact will occur constantly throughout the relevant project phase. **Consequences (Adverse):** Permanent and fundamental adverse changes to key characteristics or features of the receptor's character or distinctiveness.

Magnitude	Definition
	Consequence (Beneficial): Large scale or major improvement to key characteristics or features of the receptor's character or distinctiveness.
Medium	**Extent:** The maximum extent of the impact is restricted to the near-field and adjacent far-field (i.e., covering parts of the ZoI). **Duration:** The impact is anticipated to be medium-term (i.e., seven to 15 years) to long-term (15-60 years). **Frequency:** The impact will occur constantly throughout a relevant project phase. **Consequences (Adverse):** Noticeable change to key characteristics or features of the receptor's character or distinctiveness. **Consequences (Beneficial):** Benefit to, or addition of, key characteristics or features of the receptor's character or distinctiveness.
Low	**Extent:** The maximum extent of the impact is restricted to the near-field (i.e., within the boundaries of the array area and Offshore ECC). **Duration:** The impact is anticipated to be temporary (i.e., lasting less than one year) to short-term (i.e., one to seven years). **Frequency:** The impact will occur frequently and intermittently throughout a relevant project phase. **Consequences (Adverse):** Barely discernible to noticeable change to key characteristics or features of the receptor's character or distinctiveness. **Consequences (Beneficial)** Minor benefit to, or addition of, some key characteristics or features of the receptor's character or distinctiveness.
Negligible	**Extent:** The maximum extent of the impact is restricted to immediate vicinity of offshore infrastructure (i.e., within about 0-10m). **Duration:** The impact is anticipated to be momentary (seconds to minutes) to brief (lasting less than one day). **Frequency:** The impact will occur once or infrequently throughout a relevant project phase. **Consequences:** No discernible to barely discernible change to key characteristics or features of the receptor's character or distinctiveness.

Defining the significance of effect

4.5.12 The significance of effects on fish and shellfish receptors is determined by correlating the magnitude of the impact with the overall sensitivity of the receptor, using the matrix presented in Table 6.

4.5.13 For the purpose of this assessment, any effects with a significance level of Slight or less have been concluded to be not significant in EIA terms. Any effects assessed as Significant or Very Significant are concluded to be significant in EIA terms. For effects assessed as being of Moderate significance expert judgment has been applied to determine whether the effect is considered significant in EIA terms. Where more than one receptor has been considered for a given impact (e.g., multiple fish species) that vary in their sensitivity to a given impact due to different life histories for example, the worst-case level of significance has been assigned to the impact.

Table 6 Significance of potential effects upon fish and shellfish ecology.

			Existing Environment - Sensitivity			
			High	**Medium**	**Low**	**Negligible**
Description of Impact – Magnitude	Adverse impact	**High**	Profound or Very Significant (significant)	Significant	Moderate*	Imperceptible
		Medium	Significant	Moderate	Slight	Imperceptible
		Low	Moderate	Slight	Slight	Imperceptible
	Neutral impact	**Negligible**	Not significant	Not significant	Not significant	Imperceptible
	Positive impact	**Low**	Moderate	Slight	Slight	Imperceptible
		Medium	Significant	Moderate	Slight	Imperceptible
		High	Profound or Very Significant (significant)	Significant	Moderate	Imperceptible

* Effects deemed to be of Moderate significance have the potential to be significant in EIA terms, subject to the assessor's professional judgement. Moderate effects are determined to be significant or not significant in EIA terms, depending on the sensitivity and potential magnitude of change. These evaluations are explained as part of the assessment, where they occur.

4.6 Receiving environment

4.6.1 A technical report has been prepared to provide a detailed characterisation of the receiving environment for fish and shellfish receptors (Fish and Shellfish technical baseline). This characterisation draws on regional datasets, published literature, site-specific data collected within the array area and Offshore ECC, and data collections undertaken for nearby infrastructure projects (for key data sources see Table 2). A summary of the key findings from the baseline study is provided in the following sections below. This summary is not intended to repeat or to carry out any additional reviews or analysis of ecological data and should therefore be read alongside the Fish and Shellfish technical baseline report.

Marine fishes and elasmobranchs

4.6.2 The array area is located on the Kish and Bray Banks, two submarine sandbanks located within the outer Dublin Bay area, which consist mainly of sand and gravel. The northern 10-12 km of the bank system is called the Kish Bank. South of this point the bank system extends a further 10 km and is known as the Bray Bank. The banks are approximately 2.2 km wide at their widest point.

4.6.3 The site-specific data collected across the Kish and Bray Banks showed that the banks support a variety of demersal fish and elasmobranch species. The ground fish assemblages sampled in 2019 (Aquafact, 2019) were dominated by haddock (*Melanogrammus aeglefinus*) and grey gurnard (*Eutrigla gurnardus*), with common dab (*Limanda limanda*), plaice (*Pleuronectes platessa*) and tub gurnard (*Cheliodonichthys lucerna*) also regularly being present albeit in lower numbers. Other species recorded across the banks during site-specific trawl and dredge surveys were whiting (*Merlangius merlangus*), Atlantic cod (*Gadus morhua*), poor cod (*Trisopterus minutus*), lemon sole (*Microstomus kitt*), witch flounder (*Glyptocephalus cynoglossus*), John Dory (*Zeus faber*), lesser weever fish (*Echiichthys vipera*), butterfish (*Pholis gunnellus*), lesser sandeel (*Ammodytes tobianus*), and greater sandeel (*Hyperoplus lanceolatus*). The demersal assemblages recorded on the sandbanks and those sampled in deeper waters outside the array boundary were generally similar in terms of species composition but showed some differences in species densities. For example, whiting and poor cod were locally abundant in deeper areas surveyed outside the array boundary but less common in the shallower areas sampled across Kish and Bray banks.

4.6.4 Pelagic species commonly caught during the site-specific survey were Atlantic horse mackerel (*Trachurus trachurus*) and Atlantic mackerel (*Scomber scombrus*) with few records of European sprat (*Sprattus sprattus*).

4.6.5 The elasmobranch assemblages sampled over the Kish and Bray Banks as part of the 2019 site-specific otter trawl survey (Aquafact, 2019) were dominated by small-spotted catshark (*Scyliorhinus canicula*), with starry smooth-hound (*Mustelus asterias*), thornback ray (*Raja clavata*) and spotted ray (*Raja montagui*) also regularly recorded. Less regularly recorded elasmobranchs were tope (*Galeorhinus galeus*), nursehound (*Scyliorhinus stellaris*), blonde ray (*Raja brachyura*), and cuckoo ray (*Leucoraja naevus*). Site-specific trawls undertaken across the array area during the 2002 baseline survey (EcoServe, 2004) recorded relatively high abundances of thornback ray. Thornback rays were also regularly recorded within outer Dublin Bay west of Burford Bank and at the outer end of the Dublin Bay shipping channel during trawl and gill net surveys in 2016, 2018 and 2019 (Aquatic Services Unit, 2019, 2020; RPS, 2014). The sites sampled within the study area as part of the annual Northern Irish Groundfish Survey (NIGFS) and offshore Beam Trawl Surveys (BTS) (ICES, 2023a, 2023b) supported a similar suite of elasmobranch species to the species recorded during the site-specific surveys, with small-spotted catshark typically being the most abundant. In addition to the species observed during the site-specific survey, these surveys also recorded spiny dogfish (*Squalus acanthias*) at several sites within the study area.

4.6.6 Moreover, basking shark (*Cetorhinus maximus*) are known to migrate through the Irish Sea (e.g., Compagno, 2001; Gore *et al.*, 2008). Opportunistic public sightings and satellite tracking indicate that basking shark hotspots are located across the central Irish Sea, 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).

4.6.7 Length frequencies of the specimens caught during the site-specific 2019 otter trawl survey suggest that the Kish and Bray Banks are an important nursery ground for juvenile fish such as haddock, cod, plaice and common dab (Aquafact, 2019). A similar conclusion was drawn by Atalah *et al.* (2013), who reported high numbers of small juvenile dab, plaice and spotted ray in beam trawl samples taken on Kish Bank.

4.6.8 Demersal fish assemblages sampled within the fish and shellfish study area between 2018 and 2022 as part of the NIGFS (ICES, 2023a) and offshore BTS (ICES, 2023b) programmes were generally dominated by whiting, haddock and common dab. Other species regularly caught within the study area, often in higher numbers, were Norway pout (*Trisopterus esmarkii*), poor cod, grey gurnard, common dragonet and plaice. Species often present within the trawl samples but typically in lower numbers included Atlantic cod, tub gurnard, sandeels, lemon sole, common sole (*Solea solea*), and thickback sole (*Microchirus variegatus*). Among the many species that were only occasionally recorded between 2018 and 2022 were the white anglerfish (*Lophius piscatorius*) and American plaice (*Hippoglossoides platessoides*). Common pelagic species recorded within the study area during the NIGFS surveys were herring, sprat, Atlantic mackerel and Atlantic horse mackerel.

4.6.9 Findings from site specific surveys undertaken for other projects that overlap with the study area have also been reviewed to provide additional context. Beam trawls and fyke nets deployed within the middle and outer Dublin shipping channel to inform the Alexandra Basin Redevelopment (ABR) Project EIA (RPS, 2014) were dominated by juvenile flatfish (dab and plaice). Sand goby and pipefish were also recorded in higher numbers. Beam trawls undertaken across Dublin Bay and the Dublin shipping channel between 2016 and 2020 (Aquatic Services Unit, 2019, 2020) recorded a similar suite of species including dab, plaice, flounder (*Plathichtys flesus*), cod, whiting, butterfish, dragonet, gobies (*Pomatoschistus* spp.), short-spined sea scorpion (*Myxocephalus scorpius*), pipefish, and sandeels.

4.6.10 Fish stock surveys in the lower river Liffey in 2008 and 2010 as part of the Water Framework Directive (WFD) transitional water monitoring recorded high numbers of sprat, sand goby and juvenile thick-lipped grey mullet (*Chelon labrosus*). Other species encountered included sand smelt (*Osmerus eperlanus*), sticklebacks (*Gasterosteidae* spp.), flounder, dab, plaice, long-spined sea scorpion (*Taurulus bubalis*), cod, whiting, pollack and European eel (*Anguilla anguilla*) (IFI, 2008a; IFI, 2010a). Inshore, transitional water monitoring data for the Tolka river estuary (IFI, 2008b; IFI, 2010b) recorded very similar fish assemblages, which were dominated by sand goby, sprat, grey mullet and cod, with sand smelt, flounder, lesser sandeel, pollack, stickleback, whiting and short-spined sea scorpion also recorded, albeit in lower numbers.

4.6.11 Species records from ICES rectangles 34E3, 34E4, 35E3, 35E4, 36E3 and 36E4 (ICES, 2023a, 2023b) show that the pelagic and demersal fish species recorded across the study area are also present throughout the wider western Irish Sea.

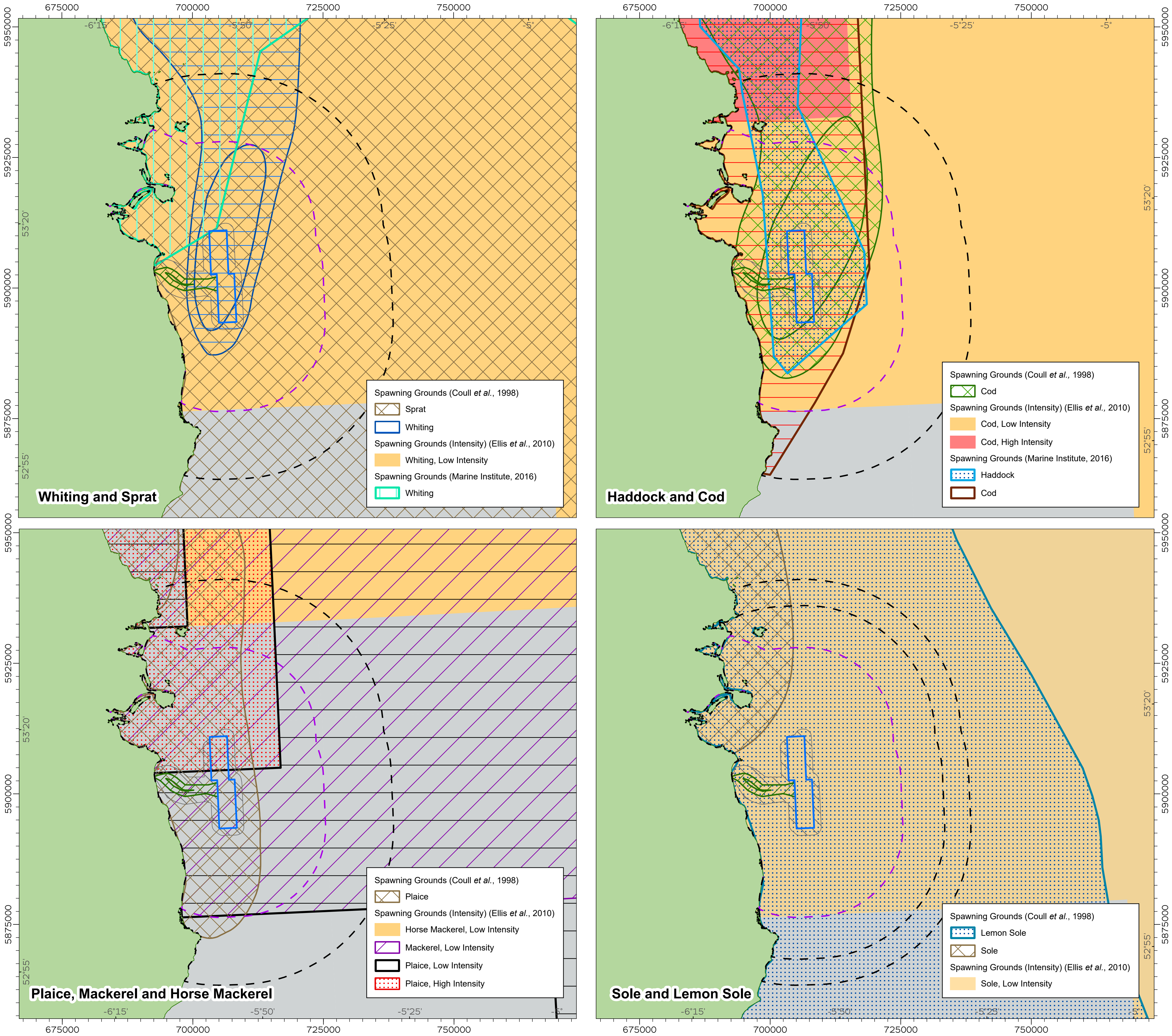
Spawning and nursery grounds

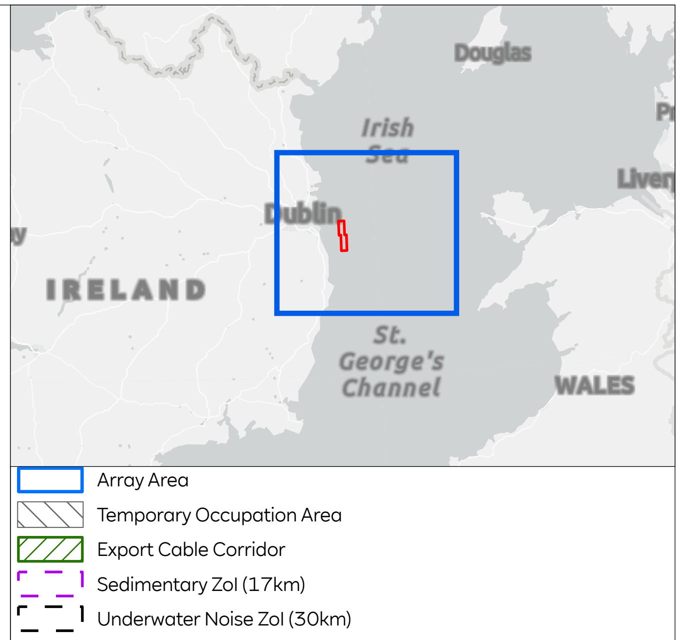
4.6.12 Potential fish and elasmobranch spawning and nursery grounds within the fish and shellfish study area were identified using data from Coull *et al.* (1998), Ellis *et al.* (2010; 2012) and Ireland's Marine Atlas (Marine Institute, 2016). Additional data sourced from the Irish Sea Annual Egg Production Method (AEPM) Plankton Survey (Cefas, 2000) have been used to ground-truth the Coull *et al.* (1998), Ellis *et al.* (2010, 2012) and Marine Institute datasets. 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) provide an update to these maps and extend 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) and the data from the Marine Atlas do not always provide this level of detail, although they delineate more spatially refined areas of potential spawning and nursery grounds. 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. Therefore, these maps provide a precautionary basis for assessing impacts on spawning activity.

4.6.13 Spawning and nursery ground locations for key fish and elasmobranch species are illustrated in Figure 2 to Figure 5. Due to the demersal spawning nature of sandeel and herring, and therefore their increased sensitivity to potential impacts from the proposed development, the suitability of the study area to support sandeel or herring spawning is discussed separately in paragraphs 4.6.16 *et seq.* and 4.6.20 *et seq.*, respectively. The spawning and nursery grounds (Coull *et al.*, 1998; Ellis *et al.*, 2010; Marine Institute, 2016) discussed and illustrated below are considered robust sources of information, as the physical drivers such as sediment type remain the same and are supplemented by project specific PSA data.

4.6.14 'High intensity' spawning grounds for Atlantic cod and plaice overlap part of the study area (Figure 2), with 'low intensity' spawning grounds for these species evident across the wider region (Coull *et al.*, 1998; Ellis *et al.*, 2010, 2012; Marine Institute, 2016). The study area is also likely to contain 'low intensity' spawning grounds for sole (Coull *et al.*, 1998; Ellis *et al.*, 2010, 2012), whiting (Coull *et al.*, 1998; Ellis *et al.*, 2010, 2012; Marine Institute, 2016), and mackerel and horse mackerel (Ellis *et al.*, 2010, 2012) (Figure 2). Furthermore, spawning grounds of unidentified intensity are present within the study area for lemon sole, sprat (Coull *et al.*, 1998) and haddock (Marine Institute, 2016) (Figure 2). Larval densities recorded during the Irish Sea AEPM plankton surveys (Cefas, 2000) support the Ellis *et al.* (2010, 2012) data of low intensity spawning of whiting within the study area (Figure 3). For cod and plaice, the larval data indicate intermediate levels of spawning within the array area and Offshore ECC, with peak spawning likely to be located along the coast of the north Irish Sea, partly overlapping with the underwater noise ZoI (Figure 2).

4.6.15 The fish and shellfish study area coincides with 'high intensity' nursery grounds for Atlantic cod and whiting (Coull *et al.*, 1998; Ellis *et al.*, 2010, 2012; Marine Institute, 2016) and 'low intensity' nursery grounds for plaice (Coull *et al.*, 1998; Ellis *et al.*, 2010, 2012) and anglerfish (Ellis *et al.,* 2010, 2012) (Figure 4). There are also nursery grounds present across the study area for haddock (Coull *et al.*, 1998; Marine Institute, 2016) and lemon sole (Coull *et al.*, 1998) (Figure 4) and for Atlantic mackerel (Ellis *et al.*, 2010, 2012; Marine Institute, 2016) and Atlantic horse mackerel (Marine Institute, 2016) (Figure 5). Information on the location of elasmobranch nursery grounds remains scarce. The data analysed by Ellis *et al.* (2010, 2012) suggest that the study area overlaps with 'low intensity' nursery grounds for tope, thornback ray and spotted ray (Figure 5). Potential 'high intensity' nursery grounds for spiny dogfish are located at the northern border of the study area (Ellis *et al.*, 2010, 2012) (Figure 5).





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PROJECT TITLE

Dublin Array

DRAWING TITLE

Spawning Grounds Relative to the Study Area (Coull *et al.*, 1998; Ellis *et al.*, 2010; Marine Institute, 2016)

DRAWING NUMBER: **2**

PAGE NUMBER: **1 of 1**

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

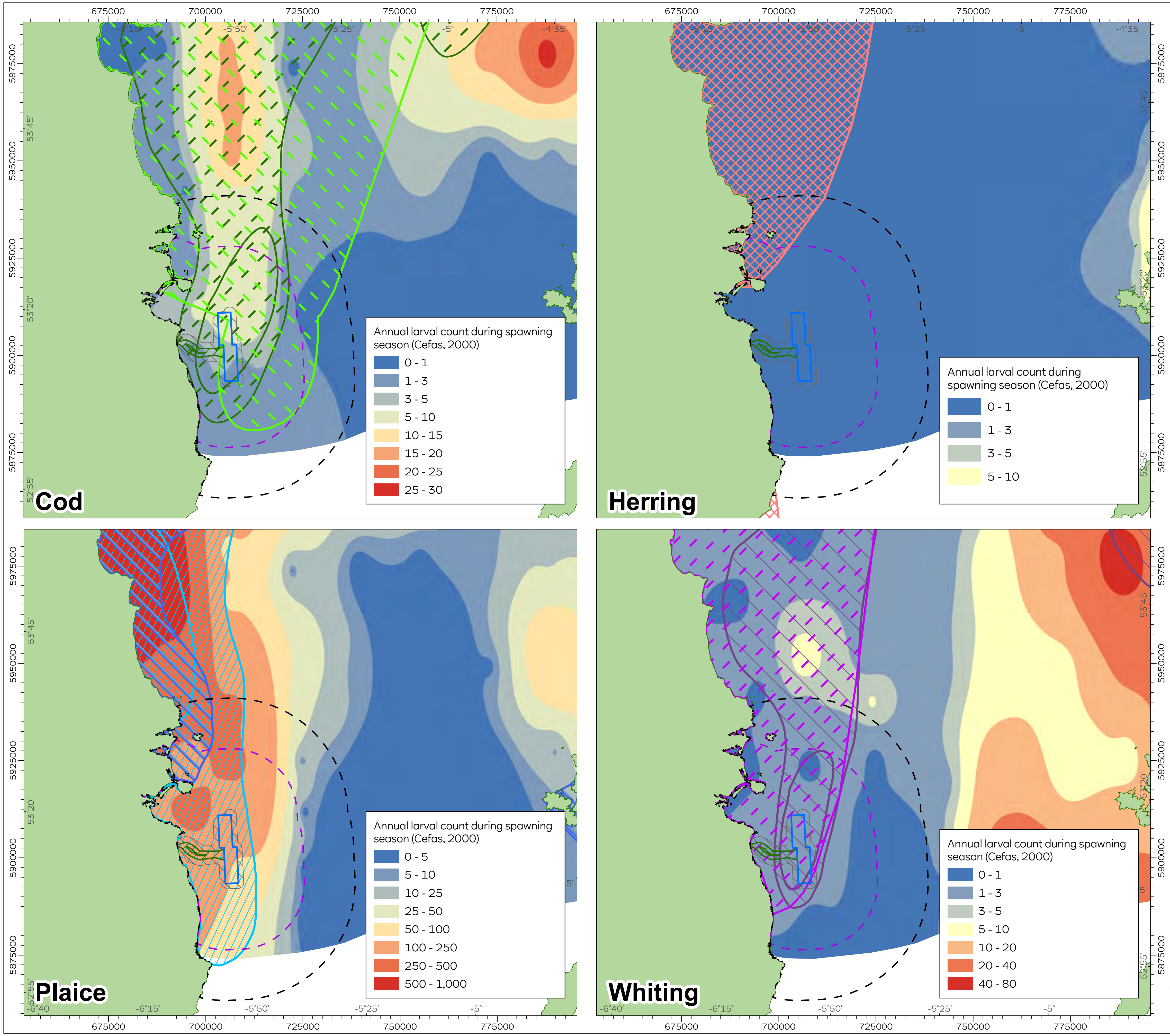
0 7 14 21 28 km
0 4 7 11 14 nm

N GRID NORTH

SCALE	1:750,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited



- Array Area
- Temporary Occupation Area
- Export Cable Corridor
- Sedimentary ZoI (17km)
- Underwater Noise ZoI (30km)

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

- Cod
- Plaice
- Whiting
- Herring

Nursery Grounds (Species) from Coull *et al.*, (1998)

- Cod
- Herring
- Plaice
- Whiting

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Data Source: Cefas; DOI: http://doi.org/10.14466/CefasDataHub.31

PROJECT TITLE

Dublin Array

DRAWING TITLE

Larval Data (Cefas, 2000) with Spawning and Nursery Grounds (Coull *et al.*, 1998)

DRAWING NUMBER: 3

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

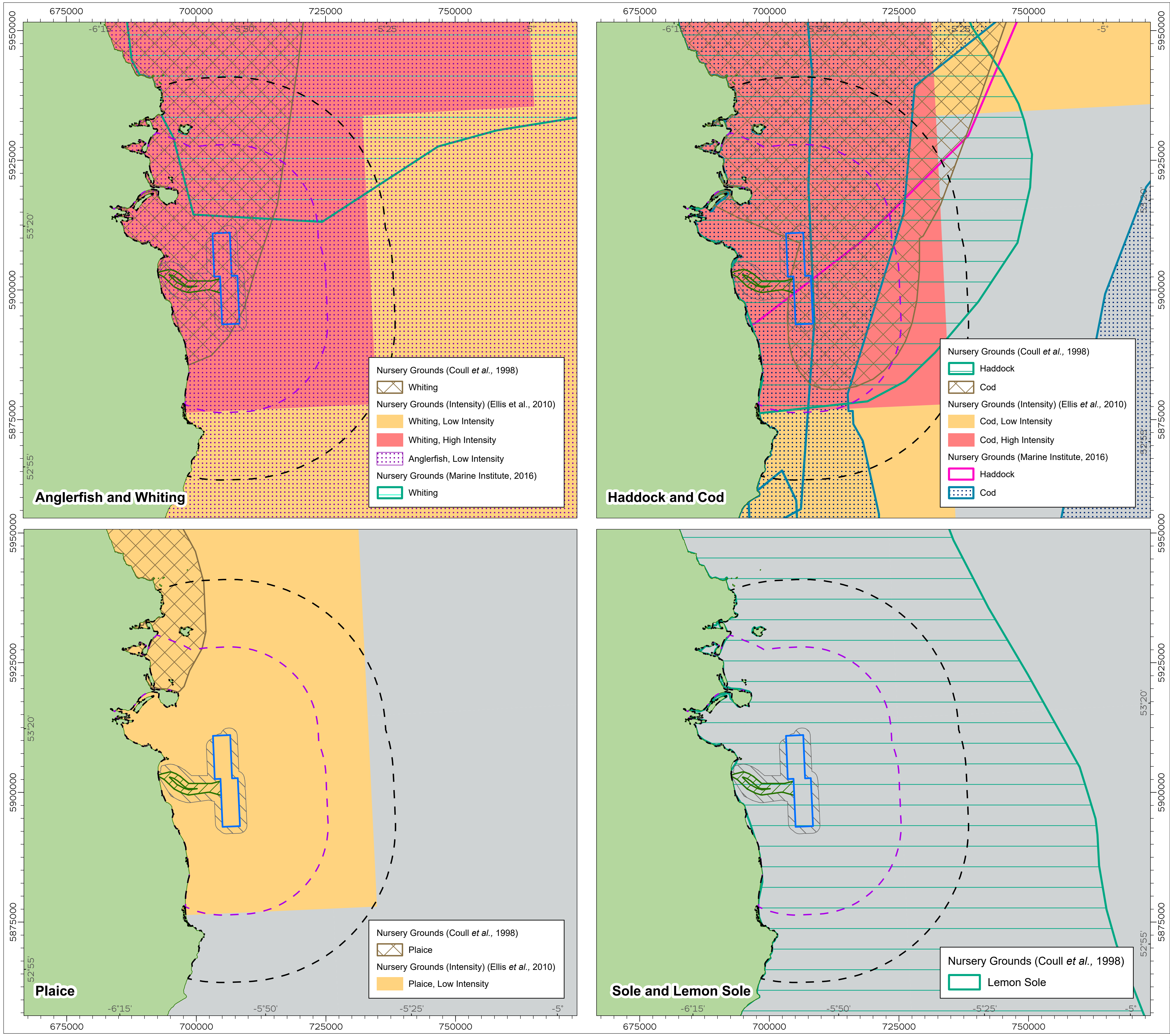
0 9 18 27 36 km
0 5 10 15 20 nm

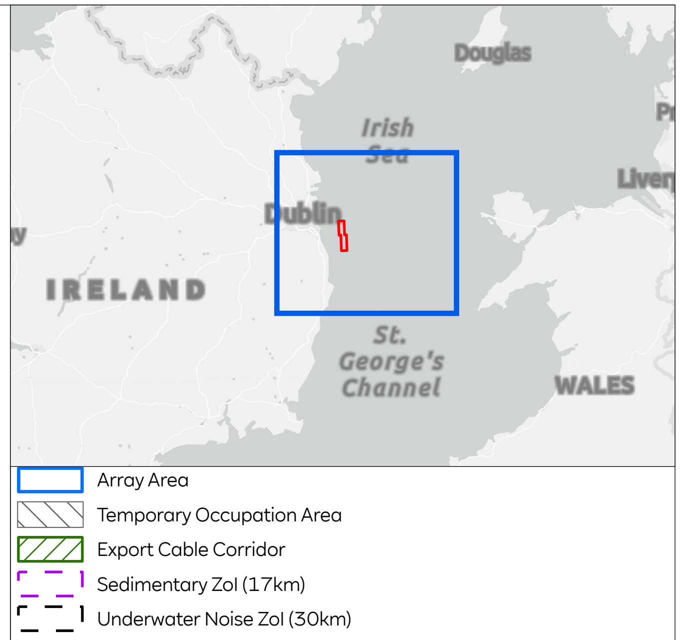
N GRID NORTH

SCALE	1:1,000,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited





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Data Source: Cefas; DOI: http://doi.org/10.14466/CefasDataHub.31

PROJECT TITLE

Dublin Array

DRAWING TITLE

Nursery Grounds Relative to the Study Area (Coull *et al.*, 1998; Ellis *et al.*, 2010; Marine Institute, 2016)

DRAWING NUMBER: **4**

PAGE NUMBER: **1 of 1**

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

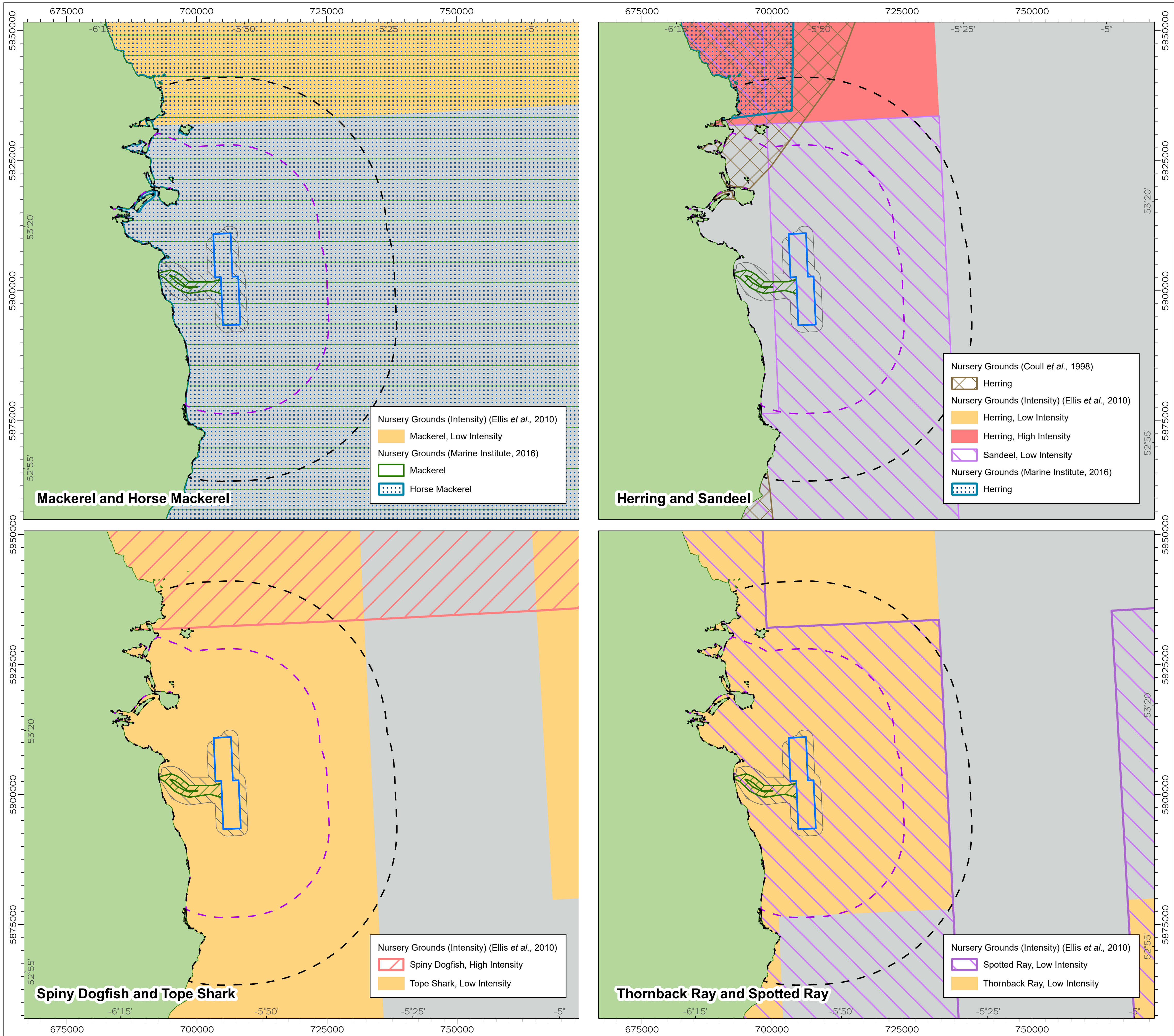
0 7 14 21 28 km
0 4 7 11 14 nm

N
GRID NORTH

SCALE	1:750,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited



- Array Area
- Temporary Occupation Area
- Export Cable Corridor
- Sedimentary ZoI (17km)
- Underwater Noise ZoI (30km)

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Nursery Grounds Relative to the Study Area (Coull *et al.*, 1998; Ellis *et al.*, 2010; Marine Institute, 2016)

DRAWING NUMBER: 5

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 7 14 21 28 km
0 4 7 11 14 nm

N GRID NORTH

SCALE	1:750,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array Generation for generations

Kish Offshore Wind Limited - Bray Offshore Wind Limited

Sandeel spawning and nursery grounds

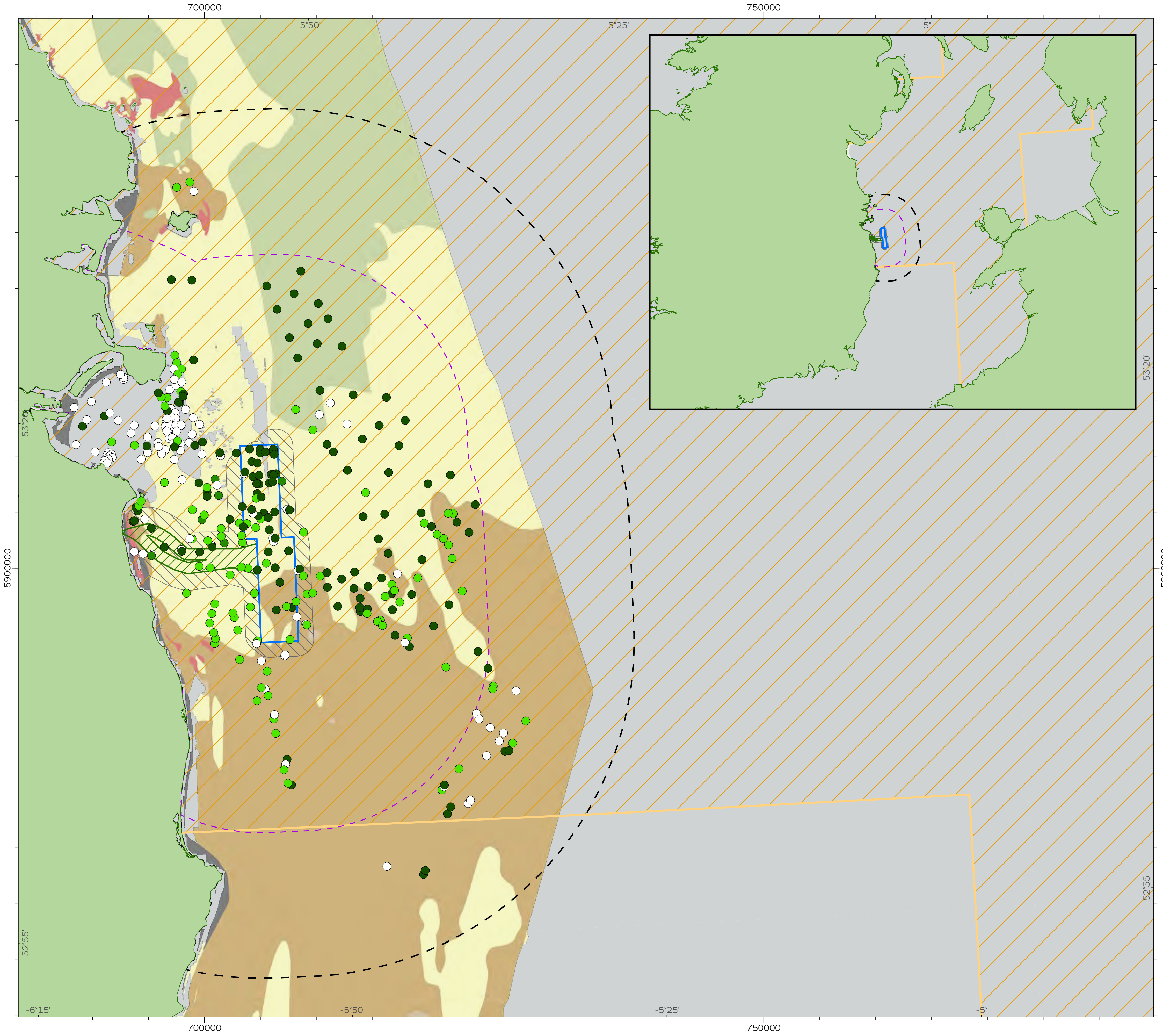
4.6.16 Sandeel (which include five species in Irish waters) are considered important prey for piscivorous fish, seabirds and marine mammals. They are more susceptible to seabed disturbance impacts as they are highly substrate dependent, being demersal spawners and spending large amounts of time buried in the sediment (Green, 2017). Consequently, sandeel are of particular relevance when assessing impacts of offshore wind developments.

4.6.17 Sandeel including lesser sandeel and greater sandeel were recorded during site-specific (Aquafact, 2018, 2019; Fugro, 2021) and ICES (2023a, 2023b) trawl surveys. Although only recorded in low numbers due to the survey methods employed, these species are likely to be widely distributed in the sandy substrates within the study area.

4.6.18 Sandeel spawn throughout the Irish Sea, with mapped low intensity spawning grounds (Figure 6) and nursery grounds (Figure 5) overlapping the study area (Ellis *et al.*, 2010, 2012). To further refine understanding of the distribution of potential sandeel habitats including spawning grounds within the study area, site-specific (Fugro, 2021) and publicly available (INFOMAR, 2023) PSA data collected across the study area were classified according to the methodology described in Latto *et al.* (2013). The substrate classification derived from these data are used as a proxy to indicate the location of potential suitable sandeel habitat, based on known habitat preferences for sandeel.

4.6.19 The substrate classification indicates that 'Prime'[15] sandeel spawning habitats are present within the array area, particularly across the Kish Bank, coinciding with the sandy areas of the bank (Figure 6). Sediments sampled within the northern cable corridor and the inshore sections of the temporary occupation area at Shanganagh are also mainly classed as 'Prime' sandeel habitats, while sediments sampled within the southern cable route are classified as 'Sub-Prime', 'Suitable' and 'Unsuitable' substrate for sandeel. The PSA data sourced from INFOMAR (2023) indicate 'Prime' and 'Sub-Prime' sandeel habitats, and therefore potential spawning grounds, mainly to the north-east and west of the array area. The seabed to the south of the Offshore ECC is dominated by sands that are classified as 'Suitable' substrate for sandeel, while the PSA data collected to the north of the Offshore ECC indicate 'Suitable' to 'Prime' sandeel substrates (Figure 6). Sediments within Dublin Bay are mainly 'Unsuitable' for sandeel.

[15] The classification approach used to identify potential suitable spawning substrates for sandeel and herring categorises seabed areas as either 'Prime', 'Sub-Prime', 'Suitable' or 'Unsuitable' for spawning, based on the proportions of silts, fine and coarse sands, and gravels in surficial sediments. The sediment categories used are presented in the Fish and Shellfish technical baseline report.



Array Area
Temporary Occupation Area
Export Cable Corridor
Sedimentary ZoI (17km)
Underwater Noise ZoI (30km)

Spawning Grounds (Intensity) (Ellis *et al.*, 2010)

Sandeel, Low Intensity

INFOMAR Seabed Substrate

Rock
Coarse Sediment
Mixed Sediment
Sand
Mud to Muddy Sand
Unclassifed Substrate

Sandeel Habitat Suitability (Latto *et al.*, 2013)

Preferred (Prime)
Preferred (Sub-Prime)
Suitable
Unsuitable

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Seabed Substrates and Sandeel Habitat Suitability

DRAWING NUMBER: 6

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 3 6 9 12 km

0 1.5 3 4.5 6 nm

N GRID NORTH

SCALE	1:350,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array Generation for generations

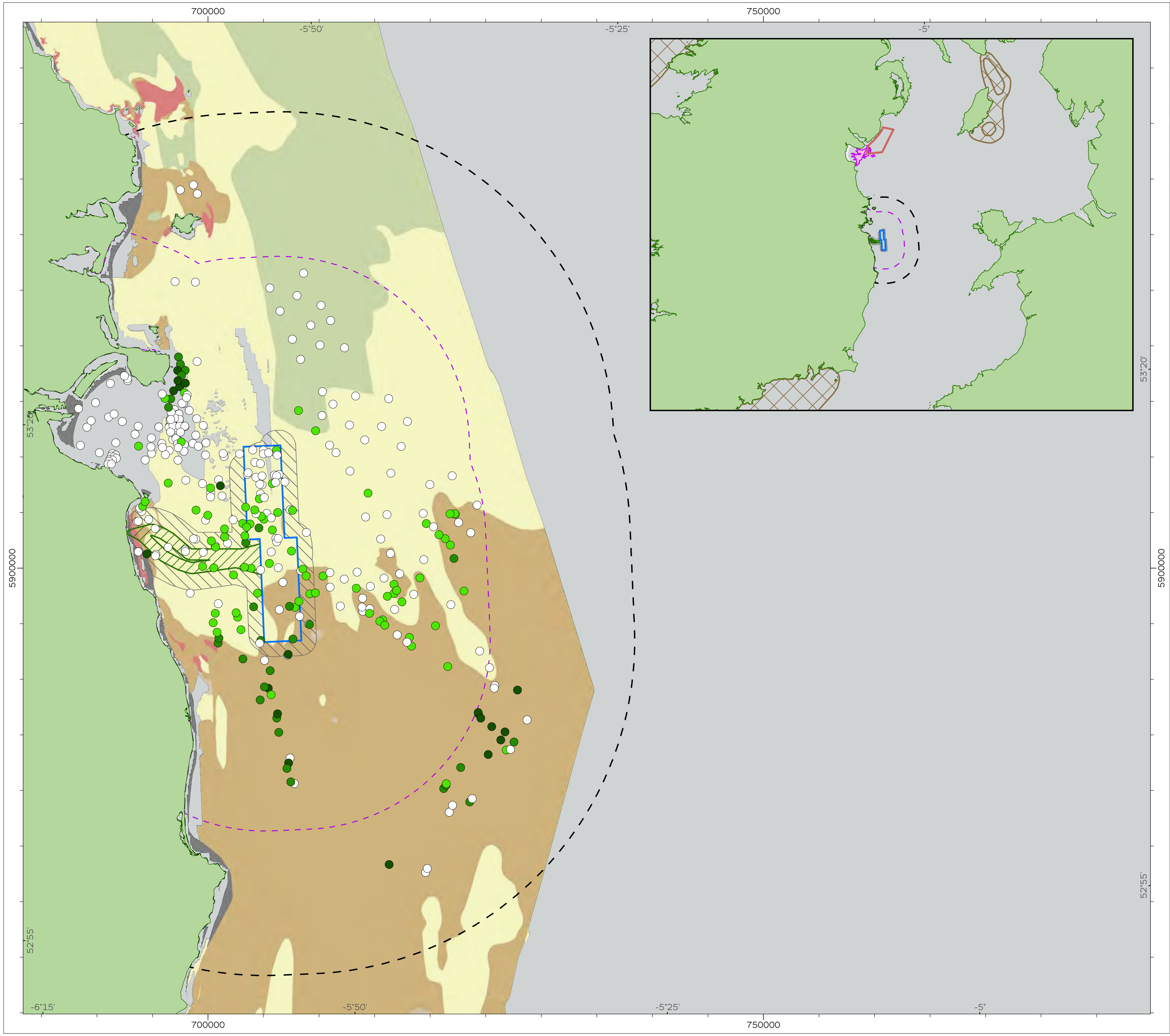
Kish Offshore Wind Limited - Bray Offshore Wind Limited

Herring spawning and nursery grounds

4.6.20 Current evidence suggests that herring nursery grounds are concentrated in the coastal waters of the northern Irish Sea, overlapping with the north-western sections of the sedimentary and underwater noise ZoIs (Coull *et al.*, 1998; Ellis *et al.*, 2010, 2012; Marine Institute, 2016) (Figure 7). The nearest known active herring spawning ground to the study area is the Mourne herring ground, which is located off County Down and the northern sections of County Louth more than 75 km to the north of the array area (ICES, 1994). Suitable spawning substrate is also known to be present across the outer sections of Dundalk Bay at approximately 70 km from the northern boundary of the array area (MPA Advisory Group, 2023) (Figure 7).

4.6.21 Potential suitable substrate 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 large parts of the array area and Offshore ECC are unsuitable for herring spawning, based on the seabed being largely dominated by sandy sediments. Coarser sediments containing Gravelly sand are located across part of the array area and Offshore ECC and are correspondingly categorised as ‘Suitable’ or ‘Sub-prime’ for herring spawning. 'Suitable' to 'Prime' substrates are also present across the coarser sediments in the southern area of the study area and along the coastal areas off Howth (Figure 7).

4.6.22 The datasets discussed above indicate that sediments suitable for herring spawning are present across parts of the Bray and Kish Banks and within the Offshore ECC. However, data from Coull *et al.* (1998) and other sources (e.g., ICES, 1994; O'Sullivan *et al.*, 2013) indicate that these areas are not active spawning grounds. This is further supported by the AEPM larval dataset (Cefas, 2000), which provides a proxy for spawning activity. Within the study area, herring larval densities are low, suggesting that whilst there are suitable substrates for spawning, these are not actively used by herring for spawning (Figure 3).



- Array Area
- Temporary Occupation Area
- Export Cable Corridor
- Sedimentary ZoI (17km)
- Underwater Noise ZoI (30km)
- Potential Suitable Herring Spawning Ground (Dundalk Bay) (MPA Advisory Group, 2023)
- Traditional Mourne Herring Spawning Area (Dickey-Collas *et al.*, 2001)

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

- Herring

INFOMAR Seabed Substrate

- Rock
- Coarse Sediment
- Mixed Sediment
- Sand
- Mud to Muddy Sand
- Unclassifed Substrate

Herring Habitat Suitability (Reach *et al.*, 2013)

- Preferred (Prime)
- Preferred (Sub-Prime)
- Suitable
- Unsuitable

DRAWING STATUS

FINAL

MAP NOTES / DATA SOURCES:
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PROJECT TITLE

Dublin Array

DRAWING TITLE

Seabed Substrates and Herring Habitat Suitability

DRAWING NUMBER: 7

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 3 6 9 12 km
0 2 3 5 6 nm

N
GRID NORTH

SCALE	1:350,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

Diadromous species

4.6.23 Diadromous fish are species that spend part of their lives in freshwater and part in saltwater, migrating between freshwater and marine habitats at points in their life cycle. Such species are not generally present in the vicinity of the study area for much of their life cycle. However, they may pass through the study area when migrating to and from rivers and other freshwater bodies in the area.

4.6.24 Diadromous fishes that may occur in the fish and shellfish study area are Atlantic salmon (*Salmo salar*), brown trout *(Salmo trutta*), European eel, sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra fluviatilis*) and Twaite shad (*Alosa fallax*). Distribution data for these species in the marine environment are sparse, and the potential for their presence in the study area has therefore been inferred from records in nearby river systems.

4.6.25 The rivers Tolka, Liffey and Dodder all flow into Dublin Bay. Reports of sea trout, Atlantic salmon and European eel have been documented in these river systems (e.g., IFI, 2018, 2022; Millane *et al*., 2023), with the Lower River Liffey also being a migratory corridor for river lamprey.

4.6.26 The nearest river designated as Salmonid waters under the European Communities (Quality of Salmonid Waters) Regulations 1988 (S.I. No. 293) is the River Dargle, which drains into the study area at Bray to the south of the Offshore ECC (EPA, 2024a). The marine phase of Atlantic salmon begins between spring and early summer when large numbers of young salmon (smolts) leave Irish rivers to migrate northward towards the rich feeding grounds of the Norwegian Sea (e.g., Gilbey *et al.*, 2020; Holm *et al.*, 2000). The return migration of salmon into rivers peaks during spring and summer, and spawning occurs during the following autumn and winter (Finstad *et al.*, 2005). Acoustic telemetry data suggest that salmon smolts from rivers along Ireland's east coast 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 currents, which can assist their journey to the oceanic feeding grounds in the north-east Atlantic (Barry *et al.*, 2020).

4.6.27 Sea trout are widespread in all major rivers and lakes systems of Ireland, including the Boyne, Nanny, Dargle and Varty (Cocoran *et al.*, 2022; CSTP, 2016; IFI, 2022). Environmental DNA (eDNA) samples collected upstream in rivers surrounding the onshore export cable route showed the presence of brown/sea trout within the Shanganagh River, the Carrickmines Stream and the Kill of the Grange Stream, confirming the wide distribution of trout in rivers draining into the study area (Biodiversity technical baseline).

4.6.28 European eel are also found in many Irish rivers and streams, including the rivers Dargle, Varty, Avoca, Broad Meadow, Nanny, and Shanganagh as well as the Carrickmines Stream and the Kill of The Grange Stream (IFI, 2018; Technical Expert Group on Eel, 2021; Biodiversity technical baseline). 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), while upstream migration of glass eels and elvers peaks in spring and summer (Aquatic Services Unit, 2020).

4.6.29 On the east coast of Ireland, river lamprey have been reported from the Rivers Boyne, 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 River Liffey (Igoe *et al.*, 2004; RPS, 2014). Little is known about the movements of river and sea lampreys at sea. River lamprey are reported to typically remain in estuarine areas during their marine stage (Maitland, 2003), while 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; Maitland, 2003). In northwest Europe, adult sea lamprey typically migrate into rivers throughout spring and early summer, while the seaward movement of newly metamorphosed young adults takes place during autumn and early winter (Kelly and King, 2001; Maitland, 2003). 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 young adults migrate downstream into estuaries between summer and late autumn/early winter (Kelly and King, 2001; Maitland, 2003).

4.6.30 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).

Shellfish

4.6.31 The site-specific fish (Aquafact, 2019) and benthic (Aquafact, 2018; Ecoserve, 2008; Fugro 2021) ecological baseline surveys were not designed to target shellfish species, and consequently only a small number of shellfish and other larger invertebrates were recorded. Species typically observed were hermit crabs (*Pagurus* spp.), swimming crabs (*Liocarcinus* spp.), common whelk (*Buccinum undatum*), queen scallop (*Aquipecten opercularis*), and blue mussel (*Mytilus edulis*). Other species recorded include brown crab (*Cancer pagurus*), European lobster (*Hommarus gammarus*), spider crab (*Inachus* sp.), razor clams (*Ensis* spp.), horse mussel (*Modiolus modiolus*), and native oyster (*Ostrea edulis*).

4.6.32 Epibenthic invertebrates present within trawls undertaken across the Dublin shipping channel and inner Dublin Bay (Aquatic Services Unit, 2019, 2020) included common whelk, brown shrimp (*Crangon crangon*) and green crab (*Carcinus maenas*); the latter two species numerically dominated the epibenthic assemblages in the mid to inner sections of the Dublin port shipping channel. Common invertebrates observed in underwater videos taken across the outer Dublin Bay area (near the Poolbeg Lighthouse) were hermit crabs and masked crabs (*Corystes* sp.) were common across the area, with whelk, razor clam and shrimp also being present (RPS, 2014).

4.6.33 Commercially important shellfish species within the region on account of their landings weight and value include Norway lobster (*Nephrops norvegicus*), common whelk, European lobster, brown crab, velvet crab, scallops and razor shells (Commercial Fisheries technical baseline; Tully, 2017). Common whelk are identified as a species of high commercial importance in the study area and south-west Irish Sea region (e.g. Fahy *et al.*, 2002), with landings of the species increasing considerably in the last few years. The array area is understood to be almost exclusively targeted by the whelk potting fishery as part of a fishery that extends over a large area off the east coast of Ireland from Howth to Wexford (Commercial Fisheries technical baseline; Tully, 2017).

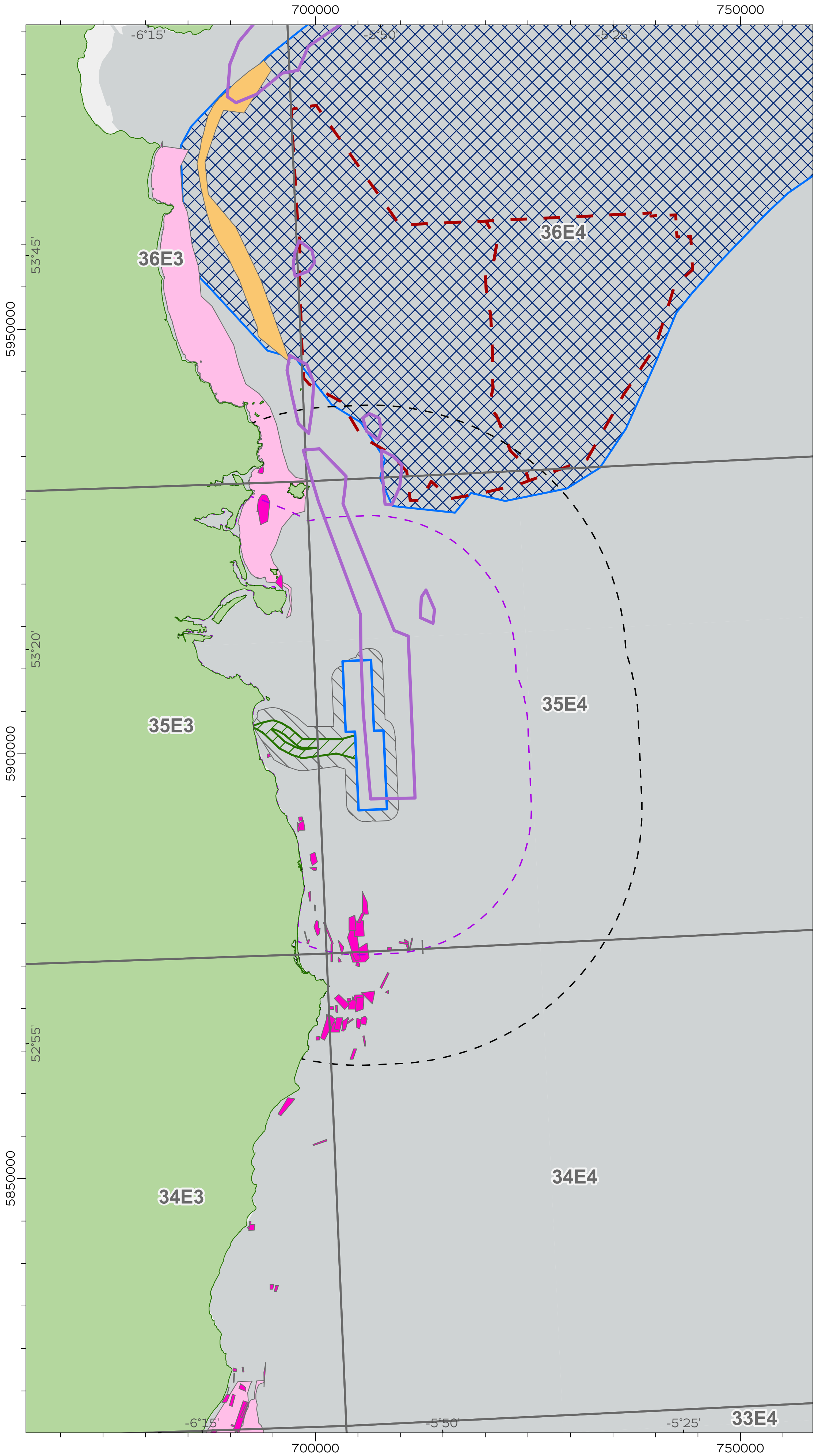
4.6.34 Whelk, brown crab, velvet crab, lobster and brown shrimp are fished using baited traps (pots and creels). Whelks are fished year-round with landings from the study area peaking between January and June, with less fishing activity occurring from July to August (Volume 4, Appendix 4.3.9-1 Technical Report – Commercial Fisheries). The main potting effort for whelk overlaps with the temporary occupation area, array area and Offshore ECC (Figure 8).

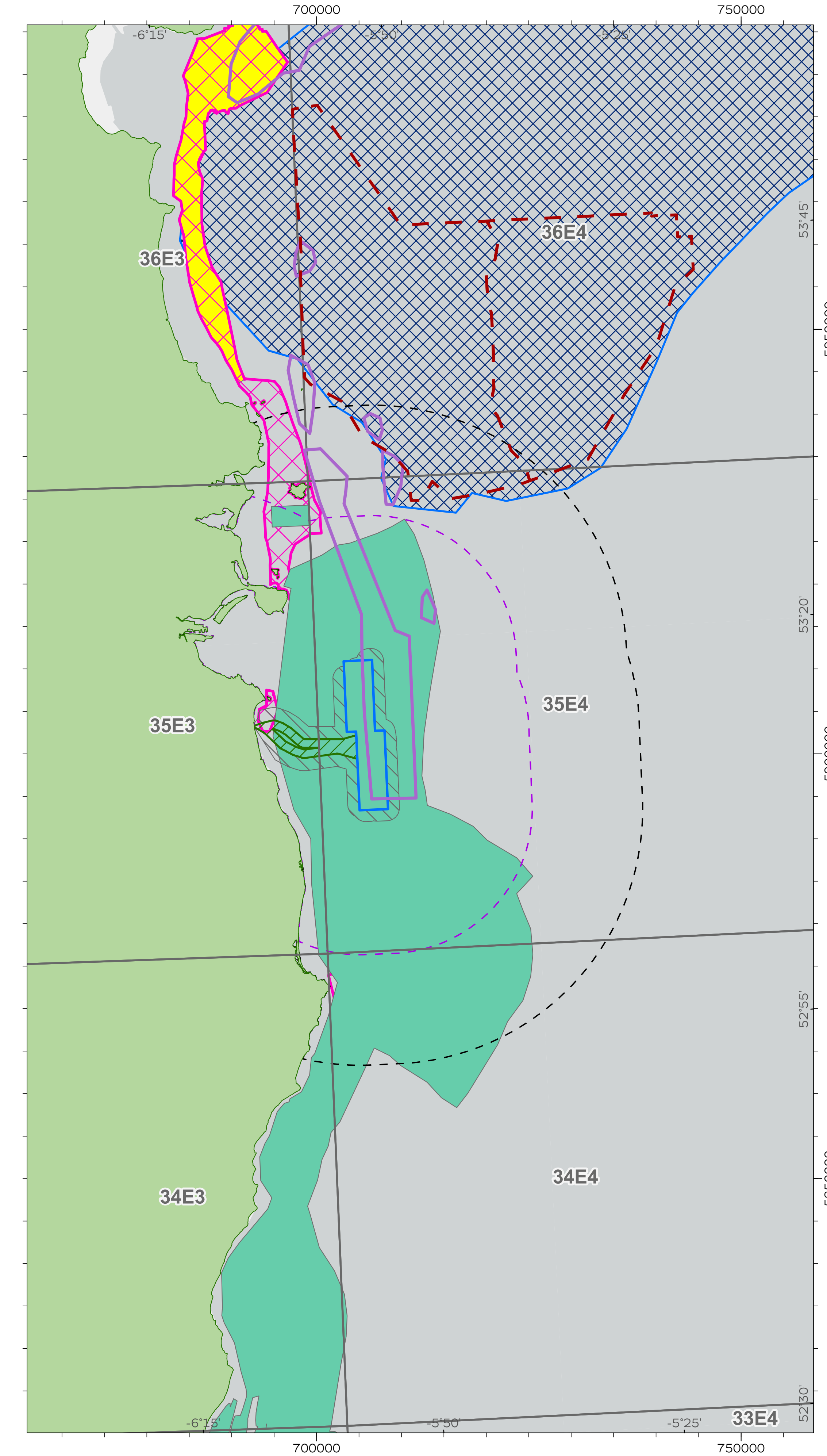
4.6.35 Fishing for crab and lobster takes place all year, with fishing activity for brown crab typically increasing throughout summer and autumn, while landings for lobster peak from late March to early October (Commercial Fisheries Technical baseline; Tully, 2017). Potting vessels targeting brown crab and lobster tend to be more prominent in inshore areas across the Offshore ECC, and less prominent within the array area (Commercial Fisheries technical baseline; Figure 8).

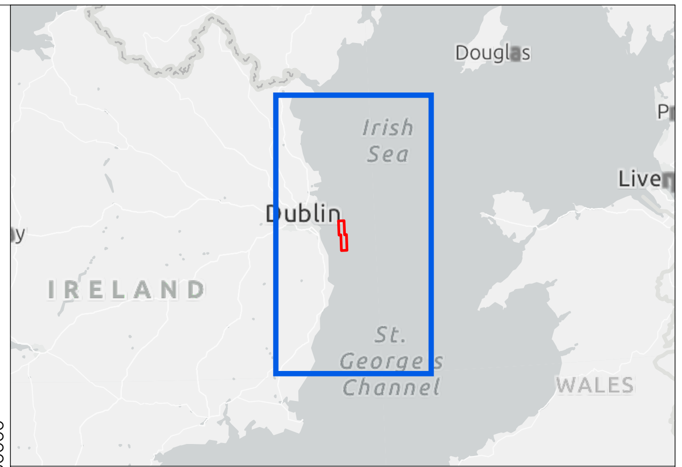
4.6.36 Razor clams and scallops are fished using commercial dredges. Fishing grounds for razor clams are located close to the coast from Portmarnock to north Dundalk Bay in water depths of about 4-14 m (Figure 8; Marine Institute and Bord Iascaigh Mhara, 2023). Notable King scallop beds within the study area are located along the eastern edge of the array area (known as the Bray Offshore bed) and inshore between Bray Head and Dalkey (known as the Bray Inshore bed) (Marine Institute and Bord Iascaigh Mhara, 2023). The scallop ground located along the eastern edge of the array area was surveyed by the Marine Institute in 2023; the presence of scallops was confirmed by the survey and correlates with the areas identified as being targeted by the dredge fishery (Marine Institute and Bord Iascaigh Mhara, 2023). Queen scallops are mainly targeted in areas to the east of Bray Bank (Commercial Fisheries technical baseline).

4.6.37 Nephrops are fished using demersal otter trawls; fishing effort is concentrated in ICES rectangles 36E4 and 37E4 to the north of the array area, overlapping with the northern section of the underwater noise ZoI (Figure 8).

4.6.38 In addition to the species commercially fished, juvenile (seed) blue mussels are dredged from licensed beds for use by the aquaculture industry. Current seed mussel beds overlapping the study area are located inshore to the south of the array area and Offshore ECC and between Rush and Howth to the north of the Offshore ECC (Figure 8)..







- Array Area
- Temporary Occupation Area
- Export Cable Corridor
- Sedimentary ZoI (17km)
- Underwater Noise ZoI (30km)
- ICES Statistical Rectangles
- Historical King Scallop Fishing grounds (ICES, 2020)
- Nephrops Grounds (Marine Institute, 2016)
- Main Nephrops Fishing Grounds (Marine Institute, 2016)

Inshore Dredge Fishing - Target Species (Marine Institute, 2016)

- Razor Clam
- Scallop
- Seed Mussel

Inshore Pot Fishing - Target Species (Marine Institute, 2016)

- Lobster & Crab
- Shrimp
- Whelk

DRAWING STATUS

FINAL

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Shellfish Fishing Grounds Relative to the Study Area

DRAWING NUMBER: 8

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 6 12 18 24 km
0 3 6 9 12 nm

SCALE	1:650,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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Dublin Array — Generation for generations

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Marine turtles

4.6.39 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*) (King and Berrow, 2009). Of these, leatherback turtle is the most regularly reported around the coast of Ireland, accounting for just over 80% of all records (King and Berrow, 2009). Most leatherback sightings or stranding records are from the south and west coasts of Ireland; however, there are also records of leatherback turtles along the east coast of Ireland including the study area (Doyle, 2007; King and Berrow, 2009; Penrose *et al.*, 2022). Rare vagrant species to southern Irish waters include hawksbill turtle (*Eretmochelys imbricata*) and green turtle (*Chelonia mydas*) (King and Berrow, 2009).

4.7 Species of Conservation Importance and Designated Sites

4.7.1 The desk-based review identified a number of marine and estuarine species protected under national and international legislation that have potential to be present within the fish and shellfish study area. These are discussed in full in the Fish and Shellfish technical baseline report.

4.7.2 Of the species having the potential to occur within the study area, four are listed as Annex II species under the EU Habitats Directive: river lamprey, 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 all utilise marine habitats during certain life-stages, though the migratory and offshore ranging behaviours of these species are generally not well-known.

4.7.3 The nearest designated European sites for migratory fish to the study area are the River Boyne and River Blackwater Special Area of Conservation (SAC) designated for river lamprey and Atlantic salmon located approximately 52 km to the north-west of the array area and the Slaney River Valley SAC designated for sea lamprey, river lamprey, twaite shad and Atlantic salmon about 96 km to the south of the array area (Figure 9). Whilst these designated sites lie outside of the ZoIs, they have been given due consideration due to the migratory nature of the features, and therefore the potential for migrants from the SAC populations to be present in the study area during migratory periods or while living at sea.

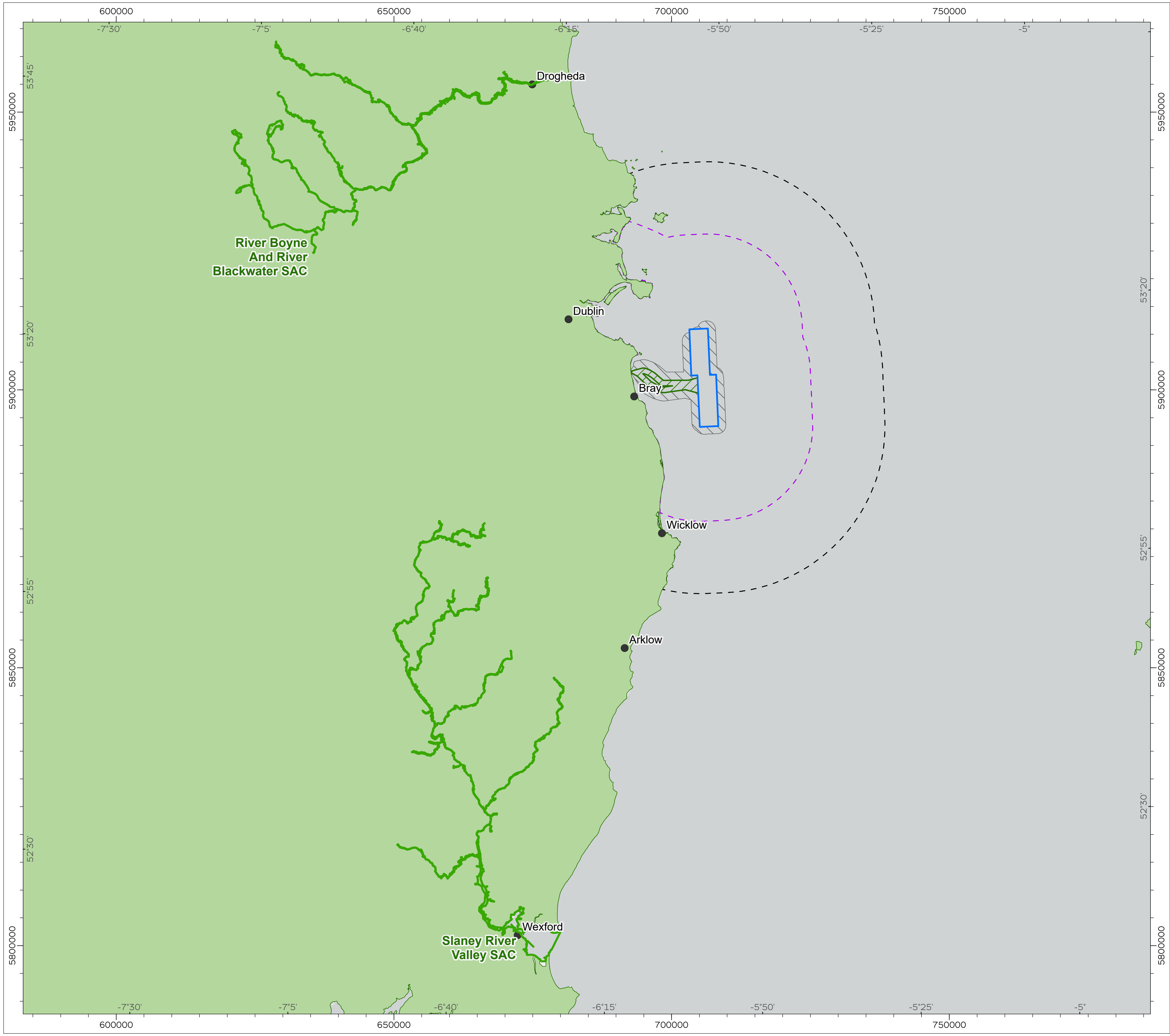
4.7.4 Another SAC relevant to the protection of fish species is the Rockabill to Dalkey Island SAC, whose southern boundary marginally overlaps with the Offshore ECC. The Conservation Objectives (COs) for this site set out that any human activities should occur at levels that do not adversely affect the harbour porpoise (*Phocoena phocoena*) community at the site (NPWS, 2013a). This includes any activities and operations that may result in the deterioration of key resources upon which harbour porpoise depend, such as key prey stocks for feeding. Similarly, the Lambay Island SAC, designated for harbour porpoise, grey seal *(Halichoerus grypus*) and harbour seal (*Phoca vitulina*), provides for the protection against activities that may affect key resources for feeding (NPWS, 2013b). Moreover, several Special Protection Areas (SPAs) designated for ornithology features including the South Dublin Bay and River Tolka Estuary SPA (NPWS, 2015), the Rockabill SPA (NPWS, 2013c), and the North-west Irish Sea candidate SPA (cSPA) (NPWS, 2023) include COs that provide for the protection of key bird foraging grounds and prey species, including fish and crustaceans. Table 7 summarises the NATURA sites that were identified to be of relevance to fish and shellfish ecology.

4.7.5 Elasmobranch species listed on Ireland's Red List (Clarke *et al.*, 2016) that have the potential to occur within the study area include basking shark, tope, spiny dogfish, cuckoo ray, blonde ray, nursehound, spotted ray, thornback ray, starry smooth-hound, and small-spotted catshark. Since 2021, basking sharks are also protected under Irish law by the Wildlife Act (1976) (as amended). European eel, listed on the Ireland Red List as Critically Endangered (King *et al.*, 2011), also have the potential to occur within the study area. 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). Species identified by OSPAR as being threatened and/ or declining in OSPAR Region III and that have the potential to be present within the study area include sea lamprey, Atlantic salmon, European eel, Atlantic cod, basking shark, spiny dogfish, spotted ray, and leatherback turtle.

Table 7 European sites relevant to fish and shellfish receptors

Site code	Site name	Relative location to the offshore infrastructure	Qualifying/supporting fish and shellfish features	Relevance for fish and shellfish receptors
SACs				
002299	River Boyne and River Blackwater SAC	Located inland; the mouth of the River Boyne is located 43 km from the array area and 42 km from the Offshore ECC	River lamprey and Atlantic salmon	COs provide protection of features.
000781	Slaney River Valley SAC	The Slaney estuary is located 96 km from the array area and Offshore ECC	Twaite shad, river lamprey, Brook lamprey, sea lamprey, Atlantic salmon, freshwater pearl mussel	COs provide protection of features.
003000	Rockabill to Dalkey Island SAC	Overlaps with the Offshore ECC and is located 1.8 km west of the array area	Harbour porpoise	COs provide for protection against activities that have the potential to adversely affect the harbour porpoise community at the site, which includes activities that may affect key fish prey resources.
000204	Lambay Island SAC	Located 18.4 km north of the Offshore ECC and 19.2 km north of the array area.	Harbour porpoise, grey seal, harbour seal	COs provide for the protection against activities that have the potential to adversely affect the harbour porpoise and seal communities at the site, which includes activities that may affect key resources (e.g., water quality and feeding).
003015	Codling Fault Zone SAC	Located 14.5 km south of the array area and 18.3 km south of the Offshore ECC.	Harbour porpoise	No COs published for the harbour porpoise qualifying interest.

Site code	Site name	Relative location to the offshore infrastructure	Qualifying/supporting fish and shellfish features	Relevance for fish and shellfish receptors
SPAs				
004024	South Dublin Bay and River Tolka Estuary SPA	Located 5.9 km from the Offshore ECC and 12.1 km from the array area	Designated for ornithology features, including roseate tern (*Sterna dougallii*), common tern (*S. hirundo*), and Arctic tern (*S. paradisaea*)	COs provide for the protection of prey biomass, with key prey items including crustaceans and small fish, mainly clupeids, sandeel and gadoids.
004236	North-west Irish Sea cSPA	Located 3.4 km to the north of the array area and 10.5 km from the Offshore ECC	Designated for several ornithology features	COs provide for the protection of foraging grounds and forage biomass of species the protected bird species rely on as prey, which include fish and crustaceans.
004014	Rockabill SPA	Located 28.5 km from the array area and 35.3 km from the Offshore ECC	Designated for ornithology features, including roseate tern, common tern and Arctic tern	COs provide for the protection of prey biomass, with key prey items including crustaceans and small fish, mainly clupeids, sandeel and gadoids.



- Array Area
- Temporary Occupation Area
- Export Cable Corridor
- Underwater Noise ZoI (30km)
- Sedimentary ZoI (17km)
- Special Areas of Conservation

DRAWING STATUS

FINAL

MAP NOTES / DATA SOURCES:

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Designated Natura 2000 Sites for Diadromous Fish Relative to the Study Area

DRAWING NUMBER: 9

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 6 12 18 24 km

0 3 6 9 12 nm

N GRID NORTH

SCALE	1:700,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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Dublin Array Generation for generations

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4.8 Valuable Ecological Receptors (VERs)

4.8.1 Based on the baseline characterisation summarised above, VERs within the fish and shellfish study area were selected to include:

- Species showing spawning, nursery and migratory behaviour within the fish and shellfish study area;
- Species of commercial, conservation and ecological interest, including species important in supporting species of higher trophic levels (e.g., prey species for bird and marine mammal species); and
- Species potentially sensitive to specific impacts of offshore wind farm development (e.g., electro-magnetic fields (EMF) and underwater noise).

4.8.2 The VERs included in the impact assessment are listed in Table 8 below. A detailed justification for the identification of the VERs is provided in the Fish and Shellfish technical baseline report.

Table 8 Valued Ecological Receptors included in the impact assessment

VER	Valuation	Justification
Demersal VERs		
Plaice	Regional	Study area overlaps high intensity spawning and low intensity nursery grounds. Plaice was regularly caught in site-specific surveys and was also abundant in regional surveys. A species of commercial importance in the study area.
Common dab	Regional	Dab was regularly caught in site specific surveys and was also recorded in regional surveys. The array area is likely to overlap with important dab nursery grounds.
Common sole	Regional	Study area overlaps with spawning grounds. Recorded in low numbers during 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 site-specific and regional surveys.
Atlantic cod	International	Study area overlaps low and high intensity spawning grounds and high intensity nursery grounds. Cod was also recorded in site-specific and regional surveys. A species of conservation importance listed on the OSPAR list of threatened and/or declining species and as Vulnerable on the International Union for Conservation of Nature (IUCN) Red List.
Whiting	Regional	Study area overlaps low intensity spawning and high intensity nursery grounds. Whiting was also recorded in site-specific surveys and was abundant in regional surveys.
Haddock	Regional	Study area overlaps spawning and nursery grounds. Haddock was also abundant in site-specific and regional surveys. A species of commercial importance in the study area. A species of conservation importance listed as Vulnerable on the global IUCN Red List.

VER	Valuation	Justification
Poor cod	Regional	Recorded in site-specific and regional surveys. Study area likely to overlap with spawning and nursery grounds.
Anglerfish	Regional	Recorded in low numbers during site-specific and regional surveys. Study area is likely to overlap nursery grounds. A species of commercial importance in the study area.
Pelagic VERs		
Sprat	Regional	Study area overlaps spawning grounds. Sprat was also recorded in site-specific surveys and was abundant in regional surveys.
Atlantic mackerel	Regional	Study area overlaps low intensity spawning and low intensity nursery grounds. Mackerel was also recorded in site-specific and regional surveys.
Atlantic horse mackerel	Regional	Study area overlaps spawning and nursery grounds. Atlantic horse mackerel was also recorded in site-specific and regional surveys. A species of commercial importance.
Substrate-spawning VERs		
Atlantic herring	Regional	Study area overlaps nursery grounds. Herring was recorded in regional surveys. Important prey species for larger fish, birds and marine mammals.
Sandeel	Regional	Study area overlaps low intensity spawning and nursery grounds. Sandeel was also recorded in site-specific and regional surveys. Important prey species for fish, birds and marine mammals.
Diadromous VERs		
European eel	International	A species of conservation importance listed on the OSPAR list of threatened and/or declining species, in Appendix I of the Bonn Convention, and as Critically endangered on the Ireland and IUCN Red Lists. Protected under the Irish Eel Management Plan. Potential for this species to transit the study area.
Atlantic salmon	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 and European Red List and as Near threatened on the IUCN Red List. Potential for this species to migrate through the study area.
Sea lamprey	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 be present within 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 be present within the study area.
Sea trout	Regional	Potential for this species to be present within the study area.

VER	Valuation	Justification
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.
Elasmobranch VERs		
Basking shark	International	A species of conservation importance listed on the OSPAR list of threatened and/or declining species, in Appendices I and II of the Bonn Convention, and as Endangered on the Ireland and IUCN Red Lists. Protected under the Irish Wildlife Act.
Small-spotted catshark	Regional	Study area may overlap with breeding and nursery grounds. Small-spotted catshark was abundant in site-specific and regional surveys. A species of commercial importance.
Nursehound	Regional	Nursehound was recorded in site-specific and regional surveys. A species of conservation importance listed as Vulnerable on the IUCN Red List and as Least concern on the Ireland Red List.
Spiny dogfish	International	Spiny dogfish were recorded in regional surveys. Study area overlaps with nursery grounds. A species of conservation importance listed on the OSPAR list of threatened and/or declining species, on 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.
Tope	International	Study area is likely to overlap with nursery grounds. Tope was also recorded in site-specific and regional surveys. A species of conservation importance listed on Appendix II of the Bonn Convention, and as Vulnerable on the Ireland Red List and as Critically endangered on the IUCN Red Lists.
Starry smooth-hound	Regional	Starry smooth-hound was recorded regularly in site-specific and regional surveys. A species of conservation importance listed as Near threatened on the IUCN Red List.
Thornback ray	Regional	Study area overlaps nursery grounds. Thornback rays were regularly recorded in site-specific and regional surveys. A species of commercial importance. A species of conservation importance listed as Near threatened on the IUCN Red List.
Spotted ray	International	Study area overlaps nursery grounds. Spotted rays were observed in site-specific and regional surveys. A species of conservation importance listed on the OSPAR list of threatened and/or declining species.
Blonde ray	Regional	Blonde ray was recorded in site-specific and regional surveys. A species of commercial importance in the study area. A species of conservation importance listed as Near threatened on the Ireland and IUCN Red Lists.
Cuckoo ray	Regional	Cuckoo rays were observed in site-specific and regional surveys. A species of conservation importance listed as Vulnerable on the Ireland Red List.

VER	Valuation	Justification
Shellfish VERs		
Common whelk	Regional	A species of commercial importance in the study area.
Brown crab	Regional	A species of commercial importance in the study area.
European lobster	Regional	A species of commercial importance in the study area.
King and Queen scallop	Regional	A species of commercial importance in the study area.
Razor clams	Regional	A species of commercial importance in the study area.
Nephrops	Regional	A species of commercial importance in the study area.
Blue mussels	Regional	A species of commercial importance in the study area.
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 Appendix I and II of the Bonn Convention, with leatherback turtle also considered under threat and/or declining within the Celtic Seas OSPAR region. Potential for these species to transit the study area.

4.9 Future receiving environment

4.9.1 Fish and shellfish populations are subject to year-to year variations in population size and distributions as a result of natural variation in recruitment success and anthropogenic effects such as climate change and overfishing. 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 (e.g., EPA, 2020, 2024). 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; EPA, 2024b). However, overall consequences are difficult 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 predictions.

4.9.2 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 and abundances in the North-East Atlantic region (e.g., Heath *et al.*, 2012; Townhill *et al.*, 2023). Climate effects can influence fish and shellfish species in a variety of ways, from changes to 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 is at the edge of the geographical range of several species, potentially making these species more susceptible to environmental variation (ICES, 2022). In addition, habitat requirements are likely to become important, with some species with specific habitat requirements unable to extend their distribution into deeper waters.

4.9.3 Climate change may also affect key life history stages of fish and shellfish species, including the timing of spawning behaviour and migrations (BEIS, 2016). Sea temperature is known to regulate the spawning and recruitment of many fish species in the Irish and Celtic Seas. Fish are also affected by climate indirectly, in particular through changes in the availability of prey species. For example, declining recruitment of sandeel in parts of its range has been linked to changes in the distribution of their copepod prey, which in turn has been correlated with increasing water temperature (Heath *et al*., 2012; Regnier *et al.*, 2019). 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 Dublin Array project.

4.9.4 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. In addition, fish and shellfish are important prey items for top marine predators including elasmobranchs, seabirds and cetaceans, and small planktivorous species such as sandeel and herring act as important links between zooplankton and top predators (Frederiksen *et al.*, 2006).

4.9.5 In addition to climate change, overfishing, by-catch and heavy-impact fishing techniques such as bottom trawling subject the populations of many fish and shellfish species to considerable pressure, reducing the abundance and biomass of commercially valuable species, and non-target species. The impacts of fishing may also reduce the resilience of fish and shellfish populations to other pressures, including climate change and other anthropogenic impacts. For example, a modelling study using Baltic cod indicated that cod populations are more resilient to climate-driven changes when subject to lower fishing pressure (Lindegren *et al*., 2010).

4.9.6 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.

4.9.7 ICES's recent ecosystem overview of the Celtic Sea (ICES, 2022), which includes a large part of the Irish Exclusive Economic Zone (EEZ), 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, 2022).

4.9.8 The fish and shellfish baseline characterisation described in the preceding sections represents a 'snapshot' of the fish and shellfish assemblages of the study area, within a gradual and continuously changing environment. Any changes that may occur during the lifetime of Dublin Array should be considered in the context of natural variability and sustained trends occurring on national and international scales in the marine environment. Together with the changes that would be expected to occur in the absence of the proposed development, including climate change, overfishing and other environmental impacts.

4.10 Do nothing environment

4.10.1 In the event that the development of the Dublin Array did not proceed, no alterations to the receiving environment are anticipated in addition to those presented in the future receiving environment section above.

4.11 Defining the sensitivity of the baseline

4.11.1 The sensitivity for the receptors to each potential effect, using the criteria outlined in Section 4.5, are presented in Sections 4.16 to 4.19.

4.12 Uncertainties and technical difficulties encountered

4.12.1 This section seeks to identify areas of uncertainty and potential data gaps. Mobile species such as fish, by their nature, exhibit varying spatial and temporal patterns and their distribution and standing stocks may vary considerably both seasonally and annually. The data collected during the site-specific surveys, therefore, inevitably represent 'snapshots' of the fish and shellfish assemblage within the study area at the time of sampling. Therefore, the baseline description has not relied solely on site-specific survey data but was also informed by historic regional and industry-specific data and information from the scientific literature to ensure a more comprehensive and precautionary baseline.

4.12.2 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) as efficiently as a pelagic trawl. Likewise, a 2m scientific beam trawl would not be as efficient at collecting sandeel (*Ammodytes* spp.) 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 assemblage in the survey area.

4.12.3 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; Marine Institute, 2016). The maps produced by Coull *et al.* (1998) are based on historic data and, therefore, they 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 are 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 spawning grounds mapped by Coull *et al.* (1998), Ellis *et al.* (2010, 2012) and the Marine Atlas (Marine Institute, 2016) are 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.

4.12.4 Active or particularly important spawning grounds for some species may be smaller in extent and spawning periods may be shorter than indicated in Coull *et al.* (1998), Ellis *et al.* (2010, 2012) and by the Marine Institute data. Therefore, where available, additional research publications and data were reviewed to provide more contemporary and site-specific information on fish and shellfish spawning and nursery behaviour.

4.12.5 When considering demersal spawners that display substrate dependency (i.e., herring and sandeel), site-specific PSA data from recent grab (Fugro, 2021) and dredge surveys (Aquafact, 2018) were analysed to ground truth the Coull *et al.* (1998) and Ellis *et al.* (2010, 2012) datasets. In addition, INFOMAR (2023) broadscale marine habitat maps were used to support the identification of preferred sandeel and herring 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 surveys. Nevertheless, it is important to review all available datasets to develop a clear overview of potential sandeel and herring spawning habitat.

4.12.6 Accounting for uncertainties associated with the composition, extent and duration of sediment plumes and accompanying changes to bed levels due to construction related activities, a series of potential sediment release and deposition scenarios have been modelled that align with the MDO and ADO, as described in the Physical Processes Modelling Report and summarised in the Physical Processes chapter. Uncertainties associated with the composition, extent and duration of sediment plumes and accompanying changes to bed levels arise regarding how the seabed geology will respond to construction activities such as drilling and jetting. The exact volume of material entrained into the water column will be dependent upon several factors including the type of drilling/ cable installation equipment used, the properties of the seabed to be affected and the metocean conditions at the time of the works. Together, these scenarios are intended to capture the maximum extent of impacts in terms of the highest concentration of suspended sediments, the most persistent sediment plumes, the maximum changes in bed level elevation and the greatest spatial extent of changes in seabed level.

4.12.7 Despite the uncertainties detailed above, there is robust data available on the fish and shellfish communities present within the study area and their supporting habitats. In addition, project-specific sediment modelling has provided information on potential changes in sediment dynamics and deposition. As such, the available evidence base is considered to be sufficiently robust to underpin the assessment presented here, and an overall high confidence is placed on the assessment.

4.13 Scope of the assessment

4.13.1 The impacts that will be assessed are detailed in Table 9.

Table 9 Potential impacts considered within the fish and shellfish ecology assessment

Potential impact / change	Impact
Construction	
Temporary increase in SSC and sediment deposition as a result of construction activities	Impact 1
Damage and disturbance of the seabed during construction activities	Impact 2
Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination	Impact 3
Introduction of underwater noise and vibration leading to mortality, injury, behavioural changes, or auditory masking	Impact 4
Operation and Maintenance (O&M)	
Temporary increase in SSC and sediment deposition as a result of O&M activities	Impact 5
Temporary damage and disturbance of the seabed during O&M activities	Impact 6
Long-term loss of benthic habitat due to placement of subsea infrastructure	Impact 7
Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination	Impact 8
Increase in hard substrate and structural complexity due to the placement of subsea infrastructure	Impact 9
Potential barriers to movement through the presence of seabed infrastructure and EMF from cables	Impact 10
Changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes	Impact 11
Decommissioning	
Temporary increase in SSC and sediment deposition as a result of decommissioning activities	Impact 12
Damage and disturbance of the seabed during decommissioning activities	Impact 13
Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination	Impact 14
Introduction of underwater noise and vibration leading to mortality, injury, behavioural changes, or auditory masking	Impact 15
Cumulative	
Cumulative increases in SSC and associated sediment deposition during construction activities	Effect 16
Cumulative damage and disturbance of the seabed during construction activities	Effect 17
Cumulative underwater noise and vibration during construction activities	Effect 18
Cumulative long-term loss of benthic habitat due to placement of subsea infrastructure	Effect 19
Cumulative barriers to movement through the presence of seabed infrastructure and EMF from cables	Effect 20
Cumulative changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes	Effect 21

4.14 Key parameters for assessment

4.14.1 As set out in the Application for Opinion under Section 287B of the Planning and Development Act 2000, flexibility is being sought where details or groups of details may not be confirmed at the time of the Planning Application. In summary, and as subsequently set out in the ABP Opinion on Flexibility (detailed within Volume 2, Chapter 3: EIA Methodology) the flexibility being sought relates to those details or groups of details associated with the following components (in summary - see further detail in see Volume 2, Chapter 6: Project Description):

- WTG (model – dimensions and number);
- OSP (dimensions);
- Array layout;
- Foundation type (WTG and OSP; types and dimensions and scour protection techniques); and
- Offshore cables (IAC and ECC; length and layout).

4.14.2 To ensure a robust, coherent, and transparent assessment of the proposed Dublin Array project for which development consent is being sought under section 291 of the Planning Act, the Applicant has identified and defined a Maximum Design Option (MDO) and Alternative Design Option(s) (ADO) for each environmental topic/receptor. The MDO and ADO have been assessed in the EIAR to determine the full range and magnitude of effects, providing certainty that any option within the specified parameters will not give rise to environmental effects more significant than that which could occur from those associated with the MDO. The extent of significant effects is therefore defined and certain, notwithstanding that not all details of the proposed development are confirmed in the application.

4.14.3 The range of parameters relating to the infrastructure and technology design allow for a range of options in terms of construction methods and practices, which are fully assessed in the EIAR. These options are described in the project description and are detailed in the MDO and ADO tables within each offshore chapter of the EIAR. This ensures that all aspects of the proposed Dublin Array project are appropriately identified, described and comprehensively environmentally assessed.

4.14.4 In addition to the details or groups of details associated with the components listed above (where flexibility is being sought), the confirmed design details and the range of normal construction practises are also assessed within the EIAR (see Volume 2, Chapter 6: Project Description). Whilst flexibility is not being sought for these elements (for which plans and particulars are not required under the Planning Regulations), the relevant parameters are also incorporated into the MDO and alternative option(s) table herein (Table 10) to ensure that all elements of the project details are fully considered and assessed.

4.14.5 With respect to project design features where flexibility is not being sought, such as trenchless cable installation methodology at the landfall, the MDO and alternative design option(s) are the same (as there is no alternative). With respect to the range of normal construction practises that are intrinsic to installation of the development, such as the nature and extent of protection for offshore cables and the design of cable crossings, but which cannot be finally determined until after consent has been secured and detailed design is completed, the parameters relevant to the receptor being assessed are quantified, assigned and assessed as a maximum and alternative, as informed by the potential for impact upon that receptor. In the event of a favourable decision on the Planning Application, they will be agreed prior to the commencement of the relevant part of the development by way of compliance with a standard 'matters of detail' planning condition (see Volume 2, Chapter 2: Consents, Legislation, Policy and Guidance). Throughout, an explanation and justification is provided for the MDO and alternative(s) within the relevant tables, as it relates the details or groups of details where statutory design flexibility is being sought, and wider construction practises where flexibility is provided by way of planning compliance condition.

4.14.6 See the Physical Processes chapter for full supporting calculations and volumes disturbed.

Table 10 Maximum and Alternative Design Options assessed

Maximum design option	Alternative design options	Justification
Construction		
Impact 1: Temporary increase in Suspended Sediment Concentrations (SSC) and sediment deposition arising during construction activities		
Dredging prior to foundation installation: Trailer suction hopper dredger (TSHD). - Option B: 45 WTGs - One Offshore Substation Platform (OSP) requiring seabed preparation 100% of WTGs requiring seabed preparation	Alternative options include the potential for varying percentages of locations requiring seabed preparation. All seabed preparation operations of this type will take place using TSHD. Preparation for alternative foundation types and WTG options may also give rise to varying areas of seabed affected and volumes of sediment disturbed, all generating less SSC than the maximum design option.	The MDO for seabed preparation prior to foundation installation would result in the largest seabed footprint thus greatest volumes of SSC generated from construction activities. For drilling of foundation piles which produce drill cuttings, the realistic worst-case is represented by the largest volume of fine sediments released into the water column over the shortest interval which then has the potential to greatest SSC within a plume that advects away from the point of discharge. For both Inter-array cable installation and Export cable installation Mass Flow Excavation (MFE) will produce both a wide trench and also have the greatest potential to fluidise and raise fine sediments into suspension and is therefore considered as the realistic worst-case option for cable installation. With regards to increases in turbidity due to release of drilling fluid from trenchless techniques, this scenario represents the maximum volumes of drilling mud discharges (bentonite) into the marine environment for trenchless works. Alternative foundation types and WTG options will give rise to varying volumes of drill arisings, all less than the maximum design option.
Disposal: For all options where seabed preparation prior to foundation installation will take place, the material is dredged by a TSHD.	**Disposal:** For all options where seabed preparation prior to foundation installation will take place, the material is dredged by a TSHD with drilling spoil released at, or above the water surface.	
Foundation installation Option C: 39 WTGs with four-legged jacket foundations; Jacket pin-piles foundations for one OSP Drilling required at 100% of foundations	**Foundation installation** There will be no drill arisings generated with foundation installation using driven piles and vibro-piles. This approach would not result in the creation of any SSC plumes and would therefore represent the minimum scale of effect. Alternative options include the potential for varying percentages, less than 50%, of foundation locations requiring drilling.	
IAC - Cable Installation: - Inter-array cable: 120 km maximum total length. Although the total length may be less than this, depending on final routeing options yet to be decided, the total value will not exceed 120 km. **- Method**: ploughing of a V shaped trench 12m width x 3m depth; -Controlled displacement of sediment onto the seabed with approximately 15% of sediment ejected from trench; - **Method**: mass flow excavator (MFE); Assumes up to 100% of material elevated above the seabed with up to two backfill passes expected (for spoil mounds either side of the trenches).	**IAC - Cable installation:** Alternative options for cable installation involve the use of different cable installation methodologies including jet trenching, rock cutting and mechanical chain excavating in addition to ploughing and MFE (which are outlined within the maximum design option). **Method**: The alternative option will result in the smallest volume of fine sediment release into the water column is simultaneous lay and burial (ploughing).	
IAC - Sandwave Clearance (excluding Sandbank Crossing): - Method: TSHD - Maximum total length of IAC = 120 km, - Up to 50% requiring seabed preparation; - 40 m (maximum width of disturbance);	IAC (excluding Sandbank Crossing) -Method: TSHD - Maximum total length of IAC = 120 km, - Up to 25% requiring seabed preparation; - 40 m (maximum width of disturbance)	

Maximum design option	Alternative design options	Justification
IAC - Sandbank Crossing Method: TSHD Dredging to be undertaken for sandwave clearance across the Kish and Bray sandbanks at two locations with three cables at each site, to allow the IAC cables to cross the sandbank. 6 X 1000 m crossings with 100% requiring seabed preparation	**IAC: Sandbank Crossing** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	(See previous page)
Export Cables Dredging using TSHD to undertake sandwave clearance and disposal - Two cables; - Maximum length of one export cable = 18.35 km; - up to 70% requiring seabed preparation.	**Export Cables** Dredging using TSHD to undertake sandwave clearance and disposal - Two cables; - Maximum length of one export cable = 18.35 km; - Up to 25% requiring seabed preparation.	
Landfall methodology: Trenchless installation (via HDD or direct pipe) beneath the beach, cliffs and intertidal area to be undertaken at Shanganagh. Drilling punch out to be excavated and reinstated using back hoe dredge. Material will be stored to minimise loss of sediment as far as is reasonably practicable. - Drilling punch out location: Subtidal; - One per cable (2); - Drilling punch out: Up to one per cable (2); - Maximum drilling punch out dimensions: 30 m (long) x 5 m (wide) x 2.5 m (depth); - Estimated maximum excavated volume = 375 m^3 x 2 (number of cables) = 750 m^3; - Maximum length of drill = 856 m; and - Maximum installation period: 40 weeks subject to suitable weather conditions, inclusive of site mobilisation and demobilisation.	No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option. No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	
Use of drilling fluid (landfall): Trenchless installation The drilling fluid is anticipated to be a low concentration bentonite/water mixture. Drill exit head to will stop short of punch out, flush bentonite, and complete the final 10 m in order to mitigate bentonite release on punch out. For the purposes of the assessment this is assumed to be an instantaneous release as this is the most conservative assumption for the purposes of the study/assessment model.	No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	

Maximum design option	Alternative design options	Justification
Impact 2: Temporary damage and disturbance of the seabed during construction activities		
Seabed preparation prior to foundation installation: - Option B: Up to 45 WTGS - 100% requiring seabed preparation - One OSP	Dredging prior to foundation installation: Seabed preparation in advance of foundation installation may not be required at any location. Foundations would be installed onto the seabed in its existing condition and so no dredging or similar methodologies would be employed, therefore resulting in the creation of no SSC plumes. This approach would represent the design option with the minimum scale of effect, i.e. 0 m^2 of seabed. Alternative options include the potential for varying percentages of locations between 0% and 100% requiring seabed preparation. All seabed preparation operations of this type will take place using TSHD.	The temporary disturbance relates to seabed preparation for foundations and cables, jack up and anchoring operations, and cable installation. The footprint of permanent infrastructure is assessed as a permanent impact in Operations and Maintenance.
Jack up and anchoring operations: - Option A: 50 WTGs - WTG/OSP installation jack up vessel (JUV) footprint - 6 jack-up operations required per turbine - WTG/OSP installation of foundation vessel anchor footprints	**Jack up and anchoring operations:** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option. However, lower number of WTGs will reduce the number of operations and reduce the level of seabed disturbance.	
IAC Sandbank Crossing Dredging using TSHD to undertake sandwave clearance, in two locations with three cables at each site, to allow the IAC cables to cross the sandbank. Maximum area of seabed affected: 6 x 1,000 m crossings, 100% of which requiring seabed preparation;	**IAC sandbank crossing** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	
IAC Sandwave Clearance (excluding Sandbank Crossing): Dredging using TSHD to undertake sandwave clearance - Maximum total length of IAC = 120 km, up to 50% requiring seabed preparation; - 40 m (maximum width of disturbance)	**IAC Sandwave Clearance (excluding Sandbank Crossing):** Alternative options for cable installation involve the potential for varying percentages of total cable lengths requiring sandwave clearance than the MDO resulting in lower area of seabed disturbance. Similarly, lower number of WTGs will have concomitantly reduced overall length of IAC cable.	
IAC Sandbank Crossing Dredging using TSHD to undertake sandwave clearance, in two locations with three cables at each site, to allow the IAC cables to cross the sandbank. Maximum area of seabed affected: 6 x 1,000 m crossings, 100% of which requiring seabed preparation;	**IAC sandbank crossing** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	
IAC Pre-Lay Grapnel Run (PLGR): - 50 m (maximum width pre-sweeping disturbance) - 120 km (maximum total length of IAC)	As for the MDO	
IAC Seabed preparation: - 40 m (maximum width of disturbance) - 120 km (maximum total length of IACs) - 50% (proportion of array cable length subject to seabed preparation	Alternative options for cable installation involve the potential for varying percentages of total cable lengths requiring seabed preparation than the MDO resulting in lower area of seabed disturbance.	

Maximum design option	Alternative design options	Justification
IAC Cable installation - Ploughing: - 12 m (width of seabed disturbance) - 95% of 120 km maximum total length of IAC **IAC Cable installation MFE:** - 15 m (width of seabed disturbance) - 5% of 120 km maximum total length of IAC	**IAC - Cable installation:** Alternative options for cable installation involve the use of different cable installation methodologies including jet trenching, rock cutting and mechanical chain excavating in addition to ploughing and MFE (which are outlined within the maximum design option). **Method**: The alternative option will result in the smallest are of disturbance with simultaneous lay and burial (ploughing).	(See previous page)
Export Pre-Lay Grapnel Run: - 50 m (maximum width seabed disturbance) - 18.35 km (maximum length of one export cable; cable route B)	As for the MDO	
Export cable seabed preparation: - 40 m (maximum width of seabed disturbance - 18.35 km (maximum length of one export cable; cable route B) - 70% subject to seabed preparation)	**Export cable seabed preparation** Alternative options for cable installation involve the potential for varying percentages of total cable lengths requiring seabed preparation than the MDO resulting in lower area of seabed disturbance.	
Export Cables Dredging using TSHD to undertake sandwave clearance - Two cables; - Maximum length of one export cable = 18.35 km, - up to 70% requiring seabed preparation.	**Export Cables** Dredging using TSHD to undertake sandwave clearance - Two cables - Maximum length of one export cable = 18.35 km - up to 25% requiring seabed preparation	
Landfall methodology: Trenchless techniques will be used beneath the beach, cliffs and intertidal area to be undertaken at Shanganagh. - Drilling punch out location: Subtidal; - Up to one per cable; - Drilling punch out: Up to one per cable; - Maximum drilling punch out dimensions: 25 m (long) x 5 m (wide)	**Landfall methodology:** No alternative options have been considered for this operation, as trenchless techniques are considered the most appropriate option.	
Impact 3: Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination		
The MDO for seabed disturbance are presented in Impact 1 and 2.	The alternative design options for seabed disturbance are presented in Impact 1 and 2.	This option represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during construction activities.

Maximum design option	Alternative design options	Justification
Impact 4: Introduction of underwater noise and vibration leading to mortality, injury, TTS and/or behavioural changes, or auditory masking		
Offshore construction programme Construction period lasting a maximum of **30 months**. **Spatial MDO:** **WTG Monopiles** - Max pile diameter: 13 m - Max hammer energy: 6,372 kJ - One monopile foundation installed in a 24-hour period OR WTG pin-piles - Max pile diameter: 5.75 m - Max hammer energy: 4,695 kJ - Four pin-piles installed in a 24-hour period **Temporal MDO:** **WTG pin piles** - Max pile diameter: 5.75 m - Max hammer energy: 4,695 kJ - Max 4 piles installed per day (12 hours active piling time per 24 hours) **Other structures** - One offshore platforms - Max hammer energy: 4,695 kJ **UXO Clearance** A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ)) and number of possible detonations and duration of UXO clearance operations is not known at this stage. Data acquired to date and pUXO assessment indicates a low likelihood of UXO to be present. The MDO is for up to four high order detonations in the assessment, which could take place anywhere within the array area, offshore ECC and wider temporary occupation area. Only one detonation will take place at any one time. For all detonations standard mitigation will be applied (bubble curtain or other suitable alternative). Confirmation of the most appropriate mitigation to be applied will be dependent on the consideration of further site-specific data (including, but not limited to; ground conditions, sea conditions, location of UXO, status of UXO).	**Offshore construction programme** Construction period lasting a minimum of **18 months** or a mean of **24 months**. **Spatial MDO**: Foundation installation using alternative methods such as drilled piles and suction-installed buckets piles would result in lower underwater noise levels compared to impact pile driving. **Temporal MDO:** Alternative turbine sizes will result in fewer WTGs installed resulting in fewer piling days compared to the MDO **UXO Clearance** As for the MDO, the type, size and number of possible detonations and duration of UXO clearance operations is not known at this stage. Data acquired to date and pUXO assessment indicates a low likelihood of UXO to be present. The alternative design option for UXO disposal involve avoidance of any targets by project routing and micrositing of infrastructure, relocation of UXO to a safe area within the development boundary or in situ detonation using low order. The Alternative Design Option (ADO) will be for up to four low order detonations in the assessment, which could take place anywhere within the array area, offshore ECC and wider temporary occupation area. Only one detonation will take place at any one time. For all detonations standard mitigation will be applied (bubble curtain or other suitable alternative). Confirmation of the most appropriate mitigation to be applied will be dependent on the consideration of further site-specific data (including, but not limited to; ground conditions, sea conditions, location of UXO, status of UXO).	For underwater noise from impact piling, the MDO presented is based on the maximum spatial extent of noise propagation and the longest duration of piling. In line with the modelling, the piling scenario with the largest noise impact ranges represents the maximum spatial design scenario. The maximum number of piled jacket foundations would represent the temporal maximum design scenario for disturbance from impact piling. The maximum predicted impact range for underwater noise for piled foundations would represent the spatial maximum design scenario for underwater noise impacts including noise generated during UXO clearance and other construction activities. The maximum design option identifies the greatest underwater noise impact from geophysical surveys as it includes all possible survey equipment and the greatest spatial area over which the surveys will be completed.

Maximum design option	Alternative design options	Justification
<u>**Other construction noise**</u> **Other construction noise:** Noise emitted from construction vessels and arising during construction activities (e.g., cable laying, dredging, rock placement and trenching), consistent with the longest construction programme of 30 months on site and MDO for greatest area of seabed preparation as detailed in the Physical processes chapter. **Construction Vessels:** Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **66** vessels on site at any time. Up to **813** round trips to port from construction vessels and an additional **1,825** round trips from small vessels such as CTVs during construction period.	<u>**Other construction noise**</u> **Other construction noise**: Noise emitted from construction vessels and arising during construction activities (e.g., cable laying, dredging, rock placement and trenching), consistent with the shortest construction programme of 18 months on site and alternative design options for smallest area of seabed preparation as detailed in the Physical processes chapter. Up to **three** large installation vessels and associated support craft operating simultaneously with a total of **51** vessels on site at any time Up to **774** round trips to port from construction vessels and an additional **538** round trips from small vessels such as CTVs during construction period.	(See previous page)
Pre and post construction surveys will be undertaken using a combination of DP and anchored vessels across the array area and offshore ECC. The same surveys will be required for Option A: up to 50 WTG, Option B: Up to 45 WTG, and Option C: 39 WTGs. Surveys may require the use of the following equipment: - Multi-Beam Echo Sounder (MBES) - Side Scan Sonar (SSS) - Sub Bottom Profiler (SBP) - 2D / 3D UHR Seismic reflection profiling - Seismic refraction - Ultra-short Baseline (USBL) - underwater positioning - Drop-Down Video (DDV) - Magnetometer (MAG) - Passive measurement - Additional survey activities may also be required including Remotely Operated Vehicle (ROV) or diver inspections of cable routes and identified seabed anomalies.	Alternative options include the potential for varying spatial areas requiring survey, however all survey operations of this type will include the equipment listed in the maximum design option and will take place using a combination of DP and anchored vessels across the array area and offshore ECC. Note that the same surveys will be required for Option A: up to 50 WTG, Option B: Up to 45 WTG, and Option C: 39 WTGs.	

Maximum design option	Alternative design options	Justification
Operation and Maintenance		
Impact 5: Temporary increase in SSC and sediment deposition during maintenance activities		
Cable Repairs: - Methodology: remedial burial of cables including rock dumping and / or concrete mattress installation/rock bags installation; - Array and ECC cable repairs 600m (length repaired) x 10 m (trench width) x - 7 (events/lifetime) Array and ECC cable remedial reburial 10 km (length reburied) - x 5 (reburial events/lifetime) Array and ECC cable repairs will be 2000m x 10 m (trench width) - x7 (repairs/lifetime)	**Cable repairs:** Method: Jetting tools potentially followed by rock dumping and / or concrete mattress installation Remedial burial of cables: 10 km per event; x 3 reburial events assumed over the project lifetime; Array and ECC cable repairs will be 600 m (cable length of repair) x 10 m (trench width) -x4 (repairs/lifetime)	The maximum design option presented results in the greatest disturbance to the seabed and associated suspension and deposition of sediments from Operations and Maintenance activities during the lifetime of the Project.
Impact 6: Temporary damage and disturbance of the seabed during maintenance activities		
WTG/OSP Operations and Maintenance activities - Option A: 50 WTGs - maintenance jack up vessel (JUV) footprint - 3 jack-up operations per WTG and 1 OSP	Alternative options for the use of jack-up vessels and maintenance activities involve the requirement for fewer maintenance events to be required over the lifetime of the Project. Details of the parameters that inform these alternative design options are provided in Annex B: Physical Processes Design Options Annex (hereafter referred to as the Physical Processes Design Options Annex).	Defined by the maximum number of jack-up vessel operations and maintenance activities that could have an interaction with the seabed anticipated during operation.
Cable Repairs: - Methodology: remedial burial of cables including rock dumping and / or concrete mattress installation/rock bags installation; - Array and ECC cable repairs 600m (length repaired) x 10 m (trench width) x - 7 (events/lifetime) Array and ECC cable remedial reburial 10 km (length reburied) - x 5 (reburial events/lifetime) Array and ECC cable repairs will be 2000m x 10 m (trench width) - x7 (repairs/lifetime)	**Cable repairs:** Method: Jetting tools potentially followed by rock dumping and / or concrete mattress installation Remedial burial of cables: 10 km per event ; x 3 reburial events assumed over the project lifetime; Array and ECC cable repairs will be 600 m (cable length of repair) x 10 m (trench width) -x4 (repairs/lifetime)	
Impact 7: Long-term and permanent loss of benthic habitat due to placement of subsea infrastructure		
Lifetime of the proposed development: 35 years (operating life)	**Lifetime of the proposed development:** 35 years (operating life)	The MDO is defined by the maximum area of seabed lost as a result of the placement of structures, scour protection, cable protection and cable crossings.
The WTG/OSP foundation and scour protection: - Option B: 45 foundations with 4 suction feet multileg WTGs presents the largest turbine foundation footprint with scour protection; - OSP maximum scour protection area for site	**WTG/OSP foundation and scour protection:** Alternative foundation types and WTG options will give rise to varying areas of scour protection, all less than the maximum design option. Option C: 39 WTGs with monopile foundations presents the minimum scour protection area	

Maximum design option	Alternative design options	Justification
IAC cable protection Cable protection measures secured to the seabed if considered necessary and subject to license approval; - Length of IAC cable requiring additional protection where optimum burial is not achieved = 24.6 km; - Total footprint of all IAC cable protection includes footprint of the berm and mattresses x two crossings.	**Cable protection:** Cable protection measures may not be required at any location, if the desired burial depth is achieved at all points. This approach would represent the design option with the minimum scale of effect. Alternative options include the potential for varying percentages of the cable routes to require cable protection, ranging from 0% up to that assessed as the maximum design option. Alternative options for cable crossings include the use of concrete mattresses placed in isolation, rather than in addition to rock berms as in the maximum design option.	(See previous page)
Export cable protection: - Maximum footprint of cable protection = 12 km (up to 6km per cable) - Total footprint of all export cable protection includes footprint of the berm and mattresses x six crossings	**Export cable protection:** The alternative option involves no cable protection required; Cable protection measures may not be required at any location, if the desired depth of cover is achieved at all points. This approach would represent the design option with the minimum scale of effect. Alternative options include the potential for varying percentages of the cable routes to require cable protection, ranging from 0% up to that assessed as the maximum design option	
Cable crossings - Assumes a maximum of two cable crossings of Dublin Array cables; - Assumed to be constructed of both concrete mattresses (six per crossing) and rock berm	**Cable crossings:** Alternative options for cable crossings include the use of concrete mattresses placed in isolation, rather than in addition to rock berms as in the maximum design option.	
Permanent vessel moorings Two moorings permanently moored to the seabed	**Permanent vessel moorings** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	
Impact 8: Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination		
Cable Repairs: - Methodology: remedial burial of cables including rock dumping and / or concrete mattress installation/rock bags installation; - Array and ECC cable repairs 600m (length repaired) x 10 m (trench width) x - 7 (events/lifetime) Array and ECC cable remedial reburial 10 km (length reburied) - x 5 (reburial events/lifetime) Array and ECC cable repairs will be 2000m x 10 m (trench width) - x7 (repairs/lifetime)	**Cable repairs:** Method: Jetting tools potentially followed by rock dumping and / or concrete mattress installation Remedial burial of cables: 10 km per event ; x 3 reburial events assumed over the project lifetime; Array and ECC cable repairs will be 600 m (cable length of repair) x 10 m (trench width) -x4 (repairs/lifetime)	This scenario represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during Operations and Maintenance activities.

Maximum design option	Alternative design options	Justification
Impact 9: Increase in hard substrate and structural complexity due to the placement of subsea infrastructure		
As above. See Impact 7: Long-term loss of habitat due to placement of subsea infrastructure		The maximum design option presented represents the maximum area of hard surfaces placed on the seabed and in the water column that are accessible to fish and shellfish receptors. This includes the surface area of scour protection, cable protection and cable crossing protection material and the surface area of vertical structures.
Impact 10: Potential barriers to movement through the presence of seabed infrastructure and EMF from cables		
Cable burial depths: Inter array cables: Minimum depth of 0.6m with a target depth of 3m Export cables: Minimum depth of 0.6m with a target depth of 3m **IACs:** Maximum total length = 120 km Nominal operating voltage **66 kV to 132 kV** **Export cables:** Maximum total length = **2 x 18.35 km** Nominal voltage **220 kV to 400 kV** with High Voltage Alternating Current (HVAC)	**Cable burial depths:** Inter array cables: Target depth 3 m Export cables: Target depth 3m **IACs:** Maximum total length = **120 km** Nominal operating voltage **66 kV to 132 kV** **Export cables:** Maximum total length = **2 x 17.95 km** Nominal voltage **220 kV to 400 kV** with (HVAC)	The impact is defined by the length of cable and the depth of cable burial. The MDO for impacts from EMF is assumed to be 0 m in the event that cables cannot be buried.
Impact 11: Changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes		
Lifetime of the proposed development: 35 years (operating life) **Presence of foundations:** - Option B: Up to 45 WTGs on 4-legged suction bucket foundations (with stiffeners); - One OSP on 4-legged multi-leg foundations; **Cable protection** Cable protection measures may be required, where the desired burial depth is not achieved. **IAC:** Cable protection measures may be placed alone or in combination, and may be secured to the seabed if considered necessary and subject to license approval; maximum footprint of cable protection = 34.8 km (total length requiring protection) x 6 m (width at base) **Export cables:** Cable protection measures may be placed alone or in combination and may be secured to the seabed where appropriate; Up to 6 km per cable x 2	**Lifetime of the proposed development:** 35 years (operating life) **Presence of foundations:** - Option C: Up to 39 WTGs on monopile foundations; - One OSP on 4-legged multi-leg foundations; **Cable protection** Cable protection measures may not be required at any location, if the desired burial depth is achieved at all points. This approach would represent the design option with the minimum scale of effect. Alternative options include the potential for varying percentages of the cable routes to require cable protection, ranging from 0% up to that assessed as the maximum design option. **IAC:** No cable protection required. **Export cables:** No cable protection required.	This impact is defined by any anticipated changes to physical processes as defined in Volume 3, Chapter 1: Physical Processes.
Cable crossings The MDO considered cable crossings in addition to rock berms.	**Cable crossings** Alternative options for cable crossings include the use of alternative materials, namely that of concrete mattresses placed in isolation, rather than in addition to rock berms as in the maximum design option.	(See previous page)

Maximum design option	Alternative design options	Justification
IACs: Assumes a maximum of two cable crossings of Dublin Array cables; Assumed to be constructed of both concrete mattresses (six per crossing) and rock berm; **Export cables:** Assumes a maximum of 6 cable crossings for all of the export cable **Foundation scour protection:** Maximum scour protection area for WTG foundations (50 WTGs (Option A) with 4-legged multi-leg foundations with suction buckets) and Maximum scour protection volume for WTG foundations (45 WTGs (Option B) with 3-legged multi-leg foundations with suction buckets **OSPs** Maximum scour protection area for the OSP foundation (jacket with suction bucket)	**IACs:** - Assumes a maximum of two cable crossings of Dublin Array cables; - Assumed to be constructed of concrete mattresses (18 per crossing); **Export cables:** Assumes a maximum of 6 cable crossings for all of the export cable; **Foundation scour protection:** Alternative foundation types and WTG options will give rise to varying areas and volumes of scour protection, all less than the maximum design option. Minimum scour protection area for WTG foundations (39 WTGs (Option C) with monopile foundations Minimum scour protection area for the OSP foundation (monopile): 1	
Decommissioning		
Impact 12: Temporary increases in SSC and sediment deposition arising during decommissioning activities		
Removal of structures is expected to be undertaken as an approximate reverse of the installation process; - It is anticipated that piled foundations will be cut at a level just below the seabed; - Buried cables to be cut and left in situ (but to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time of decommissioning); - Scour and cable protection left in situ; and - Decommissioning activities lasting approximately three years for both onshore and offshore works. **Removal of foundations:** - Up to 50 WTGs; and - One OSP. - Landfall infrastructure will be left in situ where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees; and - It is likely judged that cable removal will bring about further environmental impacts. At present it is therefore proposed that the cables will be left in situ, but this will be reviewed over the design life of the project.	Decommissioning activities are expected to be the same for all design options. Alternative design options are represented by varying numbers of total structures within the array area (represented by different WTG options), as shown below. **Removal of foundations:** - Option C: 39 WTGs and Option B: 45 WTGs; and - One OSP. As for the MDO Landfall infrastructure will be left in situ where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees; and - It is likely judged that cable removal will bring about further environmental impacts. At present it is therefore proposed that the cables will be left in situ, but this will be reviewed over the design life of the project.	The MDO is the option with the greatest number of WTGs (50). All alternatives have a lower potential for disturbance to the seabed and associated changes in SSC and sediment deposition.
Impact 13: Temporary damage and disturbance of the seabed during decommissioning activities		
As above. See Impact 12: Temporary increases in SSC and sediment deposition as a result of decommissioning activities		
Impact 14: Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination		
As above. See Impact 12: Temporary increases in SSC and sediment deposition as a result of decommissioning activities		
Impact 15: Introduction of underwater noise and vibration leading to mortality, injury, TTS, behavioural changes, or auditory masking		
As above. See Impact 12: Temporary increases in SSC and sediment deposition as a result of decommissioning activities		

4.15 Project Design Features and Avoidance and Preventative Measures

4.15.1 As outlined within the EIA Methodology Chapter (Volume 2, Chapter 3) and in accordance with the EPA Guidelines (2022), this EIAR describes the following:

- Project Design Features: These are features of the Dublin Array project that were selected as part of the iterative design process, which are demonstrated to avoid and prevent significant adverse effects on the environment in relation to fish and shellfish receptors. These are presented within Table 11.
- Other Avoidance and Preventative Measures: These are measures that were identified throughout the early development phase of the Dublin Array project, also to avoid and prevent likely significant effects, which go beyond design features. These measures were incorporated in as constituent elements of the project, they are referenced in the project description chapter of this EIAR and they form part of the project for which development consent is being sought. These measures are distinct from design features and are found within our suite of management plans. These are also presented within Table 10.
- Additional Mitigation: These are measures that were introduced to the Dublin Array project after a likely significant effect was identified during the EIA assessment process. These measures either mitigate against the identified significant adverse effect or reduce the significance of the residual effect on the environment. The assessment of impacts is presented in Sections 4.16 to Section 4.18 of this EIAR chapter.

4.15.2 All measures are secured within Volume 8, Chapter 2: Schedule of Commitments.

4.15.3 Where additional mitigation is identified as being required to reduce the significance of any residual effect in EIA terms, this is presented in Sections 4.16 to 4.18.

Table 11 Project design features/other avoidance and preventative measures relating to fish and shellfish

Project design feature/other avoidance and preventative measures	Where secured
Installation of cables to an optimum cable burial depth - offshore cables will, where possible, be buried in the seabed to the optimal performance burial depth for the specific ground conditions. Where optimum burial depth cannot be achieved secondary protection measure will be deployed e.g. concrete mattress, rock berm, grout bags or an equivalent in key areas. Burial of cables will provide shielding for any electric fields generated in the cables.	Volume 2, Chapter 6: Project Description details the requirement for a Cable Installation Plan (CIP) and Cable Burial Risk Assessment (CBRA) which will be developed upon award of consent and in advance of construction. The CIP and CBRA will provide information on the installation plan for subsea cables. The CBRA, will provide a risk assessment and evaluation for cable protection, unburied or shallow buried cables. The CIP will detail pertinent mitigation measures to be used during cable installation and will be applied throughout the construction phase. The CIP and CBRA will be submitted to the consenting authority in advance of construction phase. "
Applicant will implement the following, in line with the Sea Pollution Act 1991 and MARPOL convention and other similar binding rules and obligations imposed on ship owners and operators by inter alia the International Maritime Organisation as relevant: ▪ Marine Pollution Contingency Plan to cover accidental spills, potential contaminant release and include key emergency contact details (e.g., the Irish Coast Guard (IRCG) and will comply with the National Maritime Oil/ HNS Spill Contingency Plan (IRCG, 2020). Measures include Storage of all chemicals in secure designated areas with impermeable bunding (up to 110% of the volume); and double skinning of pipes and tanks containing hazardous materials to avoid contamination.	The PEMP includes measures outlined within the Marine Pollution Contingency Plan compliant with relevant legal obligations and frameworks
During the lifetime of the project, the Applicant and its contractors will comply with all measures outlined in the Marine Biosecurity Plan to include: ▪ All vessels of 400 gross tonnage (gt) and above to be in possession of a current international Anti-fouling System (AFS) certificate; ▪ Details of all ship hull inspections and biofouling management measures be documented by the Contractor.	The PEMP includes details of the Marine Biosecurity plan those details requirements and relevant legislation.

Project design feature/other avoidance and preventative measures	Where secured
▪ All vessels to be compliant (where applicable) with the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention, developed and adopted by the International Maritime Organisation (IMO)	
A code of conduct will be implemented by all vessel operators when encountering marine species. In addition, vessel movements to and from construction sites and ports will, where feasible, follow existing routes. While these measures are primarily targeted towards marine mammals and birds at sea, they would equally reduce the risk of injury and disturbance to marine turtles and other larger mobile receptors, such as basking sharks.	The PEMP incorporates all measures within an environmental Vessel Management Plan While these measures are primarily targeted towards marine mammals and birds at sea, they would equally reduce the risk of injury and disturbance to marine turtles and other larger mobile receptors, such as basking sharks.
Disposal of spoil from TSHD generated by seabed preparation (for foundations and cables) works to be redeposited in the project area within areas of similar sediment type, and in areas where current speeds are such that dredged material would be redistributed into the sediment transport system.	Outlined in the Project Description Chapter
No simultaneous (concurrent) piling of foundations	Outlined in the Project Description Chapter
Procedures for impact piling, will include: ▪ Implementation of a 1000m mitigation zone; ▪ Pre-piling Marine Mammal Observer (MMO) watches; ▪ pre-piling Passive Acoustic Monitoring (PAM) (if required to supplement the MMO); ▪ Acoustic Deterrent Device (ADD), as an additional mitigation tool prior to the start of piling activities at night; ▪ Soft start procedure; and ▪ Breaks in piling procedure.	Outlined within the MMMP. The MMMP has been developed to comply with all relevant guidance, specifically NPWS, (2014); DAHG (2014); IDWG (2020) The use of soft start procedure allows fish and shellfish receptors to vacate the area before sound energy levels reach levels where lethal or sublethal effects may occur.
The Applicant commits to the implementation of at-source noise mitigation methods (e.g. bubble curtains, casings, resonators) to reduce the source level of the underwater noise from pile driving by at least 10 decibels (dB).	Outlined within the Project Description chapter with further details relevant to marine mammals within the MMMP.

Project design feature/other avoidance and preventative measures	Where secured
Procedures for UXO detonation will include: ▪ Implementation of a mitigation zone of 1000 m; ▪ Pre-detonation MMO and PAM; ▪ Soft start charges for high order clearance; ▪ Use of bubble curtains for high order UXO; and ▪ Post detonation searches.	Outlined within the MMMP. The MMMP has been developed to comply with all relevant guidance, specifically NPWS, (2014); DAHG (2014); IDWG (2020).
Procedures for geophysical surveys using 3D UHRS (sparker) equipment, will include: ▪ Implementation of a 1000m mitigation zone; ▪ Pre-shooting (in relation to survey start) Marine Mammal Observer (MMO) watches; ▪ Delay of operations if marine mammals detected for at least 30 mins; ▪ Soft start procedure; ▪ Line changes longer than 40 minutes will be stopped with a pre watch of 30 mins, followed by soft start to resume; ▪ Breaks in operation of between 5-10 mins will prompt a MMO watch.	Outlined within the MMMP. The MMMP has been developed to have regard to all relevant guidance, specifically NPWS, (2014); DAHG (2014); IDWG (2020)
Scour protection measures, options include rock protection or concentrated mattresses, flow energy dissipation devices, protective aprons or bagged solutions.	Volume 2, Chapter 6: Project Description sets out the methods for scour protection and outlines the requirement for a Scour Protection Management Plan (SPMP) developed prior to construction for all offshore infrastructure which will include details of the need, location, type, quantity and installation methods for scour protection which will be undertaken in accordance with the design options, quantities & methods outlined in the Project Description.

4.16 Environmental Assessment: construction phase

4.16.1 The effects of the construction of the Dublin Array have been assessed on fish and shellfish VERs within the fish and shellfish study area, as defined in Section 4.1. The environmental impacts arising from construction of Dublin Array are listed in Table 10, along with the MDO and ADOs against which each construction phase impact has been assessed.

4.16.2 A description of the significance of effect upon fish and shellfish VERs caused by each identified impact is provided below. An assessment of impacts on any qualifying interests of European sites is undertaken within Supporting Information for Screening for Appropriate Assessment (SISAA) (Part 4: Habitats Directive Assessment, Volume 3 Supporting Information Screening for Appropriate Assessment) and the NIS (included in Part 4: Habitats Directive Assessments, Volume 4: NIS of the Planning Application).

Impact 1: Temporary increase in SSC and sediment deposition arising during construction activities.

4.16.3 Temporary increases in SSCs and associated sediment deposition are expected from construction works that will disturb the seabed and from the release of dredged material and drill cuttings. Understanding the potential changes in the physical environment is critical to inform the assessment for fish and shellfish resources as these may lead to smothering of receptors and key habitats, and barrier effects which can impede migration.

4.16.4 The MDOs for activities resulting in the increase of SSC and sediment deposition are detailed in Table 10. These have provided the basis for site-specific modelling of sediment plumes and deposition resulting from seabed preparation and infrastructure installation activities. The simulated release events have been designed to capture the full range of realistic worst-case outcomes as the maximum:

- Sediment plume concentrations;
- Sediment plume extent;
- Vertical sediment deposition; and
- Horizontal extent of deposition.

4.16.5 A range of combinations have been considered in the modelling, based on representative locations and project specific information, including a range of construction activities (e.g., jetting, drilling, dredging) and sediment particle sizes. Full details of the scenarios modelled and the results of the modelling study including the fate of sediment plumes and subsequent deposition under different tidal states are provided in the Physical Processes Modelling report. The magnitude of increase in SSC and subsequent sediment deposition to the seabed are predicted for each construction activity, and the potential changes to the environment are assessed as pathways in the Physical Processes chapter. The following pathways are of relevance to the fish and shellfish impact assessment:

- Pathway 1: Increases in SSC and deposition of disturbed sediments to the seabed due to dredging within the array area for seabed preparation prior to foundation installation;
- Pathway 2: Increases in SSC and deposition of disturbed sediments to the seabed due to the release of drill arisings during foundation installation;
- Pathway 3: Increases in SSC and deposition of disturbed sediments to the seabed due to inter-array cable (IAC) installation;
- Pathway 4: Increases in SSC and deposition of disturbed sediment to the seabed due to export cable installation;
- Pathway 5: Increases in SSC and deposition of disturbed sediments to the seabed due to release of drilling mud; and

- Pathway 6: Increases in SSC and deposition of disturbed sediments to the seabed due to sandwave clearance.

Sensitivity of receptors

4.16.6 The increase in SSC and sediment deposition following seabed disturbances and the release of drill cuttings and dredged material could smother sedentary or less mobile receptors, potentially leading to injury or mortality. Receptors considered at higher risk from this impact include suspension feeding species (e.g., mussels), species that bury in the sediment (e.g., sandeel), and less mobile and burrowing shellfish species (e.g., common whelk and brown crab). In addition, adverse effects on fish and shellfish populations may arise through direct damage or loss of early life stages (i.e., eggs and larvae) or indirectly through the disturbance of spawning and nursery grounds.

4.16.7 The sensitivity of fish and shellfish VERs to elevated levels of suspended sediments and associated changes in bed levels has been assessed in Table 12, based on the methodology outlined in Section 4.5. The sensitivity assessment assumes that dredged material (e.g. material removed during sandwave clearance) will be deposited close to the point of dredging. Therefore, it is considered unlikely that sediments will be deposited in the same location twice, and the sensitivity assessments are consequently based on a single, discrete deposition event per release location.

Table 12 Determination of receptor sensitivities to increased SSC and sediment deposition during construction activities

Receptor	Justification
Marine turtles, basking shark	Marine turtles and basking shark are highly mobile species and would be able to move away from intermittent, localised sediment plumes and associated sediment deposition (e.g., Wilson *et al.*, 2020). In addition, these species show no dependence on the seabed for reproduction, with basking shark bearing live young (Wilson *et al.*, 2020) and marine turtles nesting on tropical grounds (Rowley, 2005). Therefore, the receptors are considered to have a high capacity to avoid and accommodate sediment plumes and deposition (high adaptability and tolerance). Recoverability is assessed as high as any displacement of individuals is likely to be temporary, with individuals expected to return quickly after sediment plumes have dissipated. Taking this into consideration, the sensitivity of marine turtles and basking sharks to temporary increases in SSC and sediment deposition during the construction phase is deemed **Negligible**.
Pelagic VERs (Atlantic mackerel, Atlantic horse mackerel, sprat)	Atlantic mackerel, Atlantic horse mackerel and sprat are mobile and expected to move away from localised sediment plumes (high adaptability). Any displacement is assessed to be temporary (high recoverability), with individuals expected to return shortly after sediment plumes have dissipated. In addition, these receptors are pelagic spawners, and therefore sediment deposition within the study area would not result in any potential disturbance or loss of available spawning locations. Consequently, these species are assessed to be broadly insensitive to sediment deposition. However, high levels of suspended sediments in the water column may affect early life stages (pelagic eggs and larvae) as these would have no or only limited capacity to avoid the impact. Effects of high levels of suspended sediments on fish eggs and larvae may include abnormal development, delayed hatching, reduced foraging success, and increased mortality rates (e.g., Corell *et al.*, 2023; Farkas *et al.*, 2021; Westerberg *et al.*, 1996). On this basis, eggs and larvae of pelagic VERs are assessed as having a moderate capacity to accommodate increased concentrations of suspended sediments (medium tolerance). Sprat spawning areas are widely distributed across the Irish and North Sea (Coull *et al.*, 1998), while low intensity spawning grounds for mackerel are found within the northern and central Irish Sea, and low intensity spawning areas of horse mackerel are widely spread across the outer continental shelf off western Ireland and within the northern Irish Sea (Ellis *et al.*, 2012). Based on the wide distribution of spawning locations, effects on early life stages are assessed to be localised and temporary to short-term, with recovery from any potential mortality of early life stages anticipated through the dispersal of eggs and larvae from surrounding unaffected areas or through recruitment in subsequent years. Taking into consideration the regional importance of the receptors together with their overall high adaptability, medium tolerance, and medium to high recoverability, the sensitivity of Atlantic mackerel, Atlantic horse mackerel and sprat to increases in SSC and sediment deposition is deemed to be **Low**.

Receptor	Justification
	The receptors typically depend on the seabed for feeding but based on their mobile nature they would be able to relocate to nearby unimpacted areas (high adaptability and tolerance). Any potential displacement would likely to be temporary (high recoverability), with individuals able to return shortly after construction activities have ceased. In addition, all receptors are pelagic spawners, and therefore sediment deposition would not result in any potential disturbance or loss of available spawning locations. Consequently, these receptors are assessed as being broadly insensitive to sediment deposition.
Demersal VERs (Atlantic cod, poor cod, plaice, lemon sole, common sole, common dab, whiting, haddock, anglerfish)	Juvenile and adult demersal fish are mobile and would be able to move away from disruptive sediment plumes, and as such they are assessed as having a high capacity to avoid the impact (high adaptability). Any potential displacement would likely to be temporary, with individuals able to return shortly after sediment plumes have dissipated (high recoverability). However, high levels of suspended sediments during spawning periods may lead to injury or loss of early life stages, in particular pelagic eggs and larvae, which may be unable to avoid sediment plumes. Effects of suspended sediments on fish eggs and larvae may include abnormal development, delayed hatching, reduced foraging success, and increased mortality rates (e.g., Corell *et al.*, 2023; Farkas *et al.*, 2021; Westerberg *et al.*, 1996). On this basis, eggs and larvae of all demersal VERs are assessed as having medium capacity to accommodate increased concentrations of suspended sediments (medium tolerance). The effects on early life stages are assessed to be temporary to short-term, with recovery from any potential mortality of early life stages anticipated through the dispersal of eggs and larvae from surrounding unaffected areas or through recruitment in subsequent years (medium to high recoverability). Taking into consideration the international (cod) or regional (remaining demersal VERs) importance of the receptors together with their overall medium tolerance and medium to high recoverability to elevated levels of SSC, the overall sensitivity of demersal VERs to the impact is deemed to be **Low**.
Tope, starry-smooth-hound, spiny dogfish	Tope, starry smooth-hound and spiny dogfish are mobile species and expected to move away from sediment plumes (high adaptability). These receptors depend on the seabed for feeding but based on their mobile nature they would be able to relocate to nearby unimpacted areas (high tolerance). Any potential displacement is expected to be temporary, with individuals able to return shortly after construction activities have ceased (high recoverability). In addition, these receptors bear live offspring, and therefore they show no dependence on the seabed for reproduction. Consequently, these species are assessed to be broadly insensitive to temporary increases in SSC and sediment deposition, and therefore the sensitivity of tope, starry smooth-hound and spiny dogfish to temporary increases in SSC and sediment deposition during the construction phase is deemed to be **Negligible**.

Receptor	Justification
Small-spotted catshark, nursehound and skate species (thornback ray, spotted ray, blonde ray, cuckoo ray)	Small-spotted catshark, nursehound and skate species are mobile and expected to move away from sediment plumes (high adaptability). These receptors depend on the seabed for feeding and based on their mobile nature they would be able to relocate to nearby unimpacted areas. However, these receptors are oviparous, attaching egg cases onto the seabed. Smothering of egg cases due to sediment plumes and deposition may disrupt the development of embryos and consequently may lower the recruitment to the receptor's populations. Therefore, these receptors are assessed as having a medium tolerance to the impact. Any potential displacement of individuals is expected to be temporary, with individuals able to return shortly after construction activities have ceased (high recoverability). Recovery from any potential decrease in recruitment success is assessed to occur within the short to medium-term (medium to low recoverability). Taking into consideration the regional importance of the receptors (except for spotted ray), together with their general high adaptability, medium tolerance and high to low recoverability, the sensitivity of the receptors to temporary increases in SSCs and sediment deposition is deemed to be **Low**. On a precautionary basis, the sensitivity of spotted ray to the impact is classed as **Medium**, considering the international importance of the receptor.
Diadromous fish (European eel, Atlantic salmon, sea lamprey, river lamprey, twaite shad)	Migratory species are highly mobile and would be able to relocate to nearby unimpacted areas (high adaptability). Localised avoidance reactions and changes in swimming and feeding behaviour might occur in areas of high SSC (e.g., Carlson *et al.*, 2001; Wilber and Clarke, 2001). For example, a study by Carlson *et al.* (2001) documented the behavioural responses of salmonids to maintenance dredging activities and observed avoidance responses of migrating salmon upon encountering sediment plumes. However, given the localised and temporary nature of the predicted changes in SSC, in particular the highly localised and momentary to brief nature of maximum SSC, any displacement is unlikely to result in a barrier effect that would prevent the receptors from accessing or leaving their freshwater habitats. The diadromous VERs are therefore considered to be of high tolerance to increases in SSC, with the recoverability of any potential behavioural changes also assessed as high. In addition, these receptors reproduce in freshwater habitats, and therefore they show no dependence on the seabed within the study area. Based on their high adaptability, tolerance and recoverability, all diadromous VERs are assessed to be broadly insensitive to temporary increases in SSC and sediment deposition, and therefore their sensitivity to the impact is deemed to be **Negligible**.

Receptor	Justification
Sandeel	Due to their burrowing habit and reliance on specific substrates, sandeel are susceptible to seabed disturbance impacts, inclusive of impacts from increased SSC and sediment deposition. They are considered less able to avoid the impact during spawning when they are less mobile, with their demersal eggs also considered to be unable to avoid this impact (low or no adaptability). The capacity of juvenile and adult sandeel to accommodate increases in SSC and sediment deposition is assessed as high given the nature of resuspension and deposition within their natural high energy environments. Sandeel eggs are also likely to have some tolerance to increases in SSC and smothering from sediment deposition (medium tolerance). Suspended particles may become attached to the adhesive egg membranes, and tidal currents can cover sandeel eggs with sand to a depth of a few centimetres. However, experiments have shown that the eggs can develop normally and hatch as soon as currents uncover them again (Winslade, 1971). Buried eggs experiencing reduced current flow, and therefore lower oxygen tension, can have delayed hatching periods, which is considered a necessary adaptation to survival in a dynamic environment (Hassel *et al.*, 2004). Recruitment success could nevertheless be affected through the damage or loss of demersal eggs; recovery from such effects is considered to occur in the short-term (medium recoverability). Considering the regional importance of sandeel and their medium tolerance and medium recoverability, the sensitivity of sandeel to temporary increases in SSC and sediment deposition during the construction phase is deemed to be **Low**.
Herring	Impacts from increased SSC and sediment deposition are of greatest concern for herring eggs, which are attached on benthic substrates by an adhesive mucus (de Groot, 1980). The eggs rely on a high energy and well-ventilated environment (Frost and Diele, 2022). Smothering of the eggs by sediments may retard the growth of embryos when the eggs encounter high SSCs in the first few hours after laying. In addition, the development of embryos may be affected through a reduction in oxygen availability around the eggs (Cohen and Strathman, 1996; von Nordheim *et al.*, 2018 in Frost and Diele, 2022). However, herring spawn over coarser grounds and water currents in these areas will naturally be higher, which will aid the dispersion of sediment plumes and the re-suspension and re-distribution of any material deposited on the seabed, thereby reducing the duration and as such the severity of any potential adverse effects on herring eggs. Based on this, spawning herring are considered to have low tolerance to accommodate increases in sediment plumes and deposition. Recovery from potential embryo mortality and reduction in recruitment success is anticipated to take place within the short-term (medium recoverability). Taking into account the regional importance of herring, and their low tolerance and medium recoverability, the sensitivity of herring to increases in SSC and sediment deposition from construction activities is deemed to be **Medium**.

Receptor	Justification
Common whelk	Common whelk are broadly distributed across the Irish Sea, and are found across a range of substratum types, including rock, cobbles, gravel and coarse and muddy sands (e.g., Himmelman and Hamel, 1993). They are mobile but typically remain stationary when not actively searching for food, either resting on the seafloor or being to some degree buried within the sediment (Himmelman and Hamel, 1993). They are therefore considered to have a limited capacity to avoid the impact (low adaptability), with their demersal egg cases unable to avoid the impact (no adaptability). The tolerance of whelk to temporary increases in SSC and the deposition of sediment is assessed as being medium given their ability to bury and re-locate to nearby unaffected areas. Any potential displacement would likely to be temporary (high recoverability), with individuals able to return shortly after plume and sediment deposition events. Recovery from any potential effects on recruitment success due to impacts on the survival and development of demersal eggs is assessed to occur within the short-term to medium-term (medium to low recoverability). Based on their medium tolerance and medium to low recoverability and taking into consideration their regional importance, the sensitivity of common whelk to temporary increases in SSC and sediment deposition is deemed to be **Low**.
Brown crab	Active brown crab are likely to avoid sediment plumes (Roegner *et al.*, 2021) as they rely on visual cues during predation (Neal and Wilson, 2008). Consequently, they are considered to have a high adaptability and tolerance to increases in SSC. Any potential displacement would likely to be temporary (high recoverability), with individuals able to return shortly after sediment plumes have dissipated (Roegner *et al.*, 2021). On the contrary, brown crab, particularly juveniles, recently molted individuals, and gravid (egg-bearing) females, are likely to be more susceptible to sediment deposition (Roegner *et al.*, 2021). Berried females exhibit a largely sedentary lifestyle during the overwintering period whilst brooding eggs. During this time, they are considered a stationary receptor, burying themselves into soft mud and sand, and are therefore unlikely to avoid disturbances to the seabed including sediment burial (no adaptability). They may however be able to avoid deleterious effects by lifting themselves clear of unfavourable sediment deposition (Neal and Wilson, 2008), with survival likely to be dependent on burial depth, age and gender. For example, burial experiments by Vavrinec *et al.* (2007) showed that the survival of the Dungeness crab (*Cancer magister*) during single sediment deposition events begins to decrease at burial depths greater than 10-13 cm, with higher tolerance to sediment deposition observed in male crabs and larger specimens. Similar results have been reported for mature female blue crabs (*Callinectes sapidus*) (Saluta *et al.*, 2023), with immediate mortality observed at burial depth > 10 cm and mortality being inversely correlated with crab size. Given that the sediment deposition depths during the construction of Dublin Array can be locally high (> 30 cm) (Table 13), there might be some mortality of brown crab in addition to decreases in reproductive rates. Consequently, brown crab are assessed as having a low tolerance to the impact. Recovery from any mortality and potential effects on the reproductive success of brooding females is assessed to occur within the short-term (medium recoverability).

Receptor	Justification
	Based on their low tolerance and medium recoverability and taking into consideration their regional importance, the sensitivity of brown crab to temporary increases in SSC and sediment deposition is deemed to be **Medium**.
European lobster	Unlike brown crab, European lobster are not thought to exhibit a sedentary overwintering habitat (Pawson, 1995), being typically more mobile, and they are therefore considered able to move away from areas affected by increased SSC and sediment deposition (high adaptability and tolerance). Any potential displacement would likely to be temporary (high recoverability), with individuals able to return shortly after sediment plumes have dissipated. However, gravid females are likely to be more susceptible to elevated SSC and smothering impacts as the eggs carried require regular aeration. Consequently, their tolerance to the impact is assessed as medium. In addition, juvenile lobsters are known to spend large amounts of time within their burrows (e.g., Smith *et al.*, 1998), and therefore they may be considered a stationary receptor unlikely to move away from disturbances. They are however considered to be able to lift themselves clear of unfavourable sediment deposition, and consequently juvenile lobster are assessed to also have a moderate capacity to accommodate the impact (medium tolerance). Recovery from any potential decrease in the reproductive success of brooding females is assessed to occur within the short-term (medium recoverability). Based on their medium to high tolerance and medium to high recoverability and taking into consideration their regional importance, the sensitivity of European lobster to temporary increases in SSC and sediment deposition is deemed to be **Low**.
Scallops	Scallops are of commercial value to fisheries within the region. They can undertake limited swimming, although this is considered to be at a high energy cost and generally associated with predator avoidance (Marshall and Wilson, 2008). This species is therefore not expected to be able to travel large distances to avoid elevated SSC and sediment deposition, and adaptability is consequently assessed as medium. Prolonged increases in suspended solids have been shown to affect growth rates or increase the energetic costs for feeding (Marshall and Wilson, 2008). For example, Szostek *et al.* (2013) observed an increase in shell claps to remove excess sediments and a decrease in growth rates of juvenile King scallop when exposed to SPM concentrations >200 mg/l during an 18-day exposure experiment. The MarLIN sensitivity review has assessed king scallop as having a low intolerance (i.e., medium tolerance) to light smothering (< 5 cm) and an increase in suspended sediments on the basis that they can lift themselves clear of sediment layers and areas of unfavourable SSCs (Marshall and Wilson, 2008). However, burial experiments on juvenile King scallop showed approximately 20% and 54% mortality after 2 and 4 days of burial with 5 cm of sediment (Szostek *et al.*, 2013). Survival rates varied with sediment type and emergence from a burial depth of 5 cm was observed. Queen scallop appear to be less tolerant to sediment, with burial experiments showing very low survival rates in Queen scallop following the burial with 2 cm, 5 cm and 7 cm of sediment (Hendrick *et al.*, 2016). Over 70% of buried specimens were lost after 2 days of burial and the ability to emerge from the sediment was restricted to shallow (2 cm) deposition events.

Receptor	Justification
	Factoring in the above, scallops are considered to have a medium to low tolerance to the impact. Any effects on growth or feeding rates are likely to be temporary (high recoverability), while potential changes in survival and/or reproductive rates are estimated to be of short-term duration (medium recoverability). Based on their medium adaptability, medium to low tolerance, and medium recoverability, and considering their regional importance, the sensitivity of scallops to temporary increases in SSC and sediment deposition is deemed to be **Medium**.
Nephrops	The MarESA sensitivity review has assessed *Nephrops* as not being sensitive to increases in suspended sediments and smothering from sediment deposition, based on their active burrowing habit and ability to excavate any material deposited within their burrow systems (Durkin and Tyler-Walters, 2022). However, berried females may be considered more susceptible to smothering from sediment deposition, as the eggs require regular aeration. In addition, localised sediment deposition larger than the 30 cm considered by the MarESA assessment may occur locally during construction activities. Therefore, for the purpose of this assessment, *Nephrops* are considered to have a moderate capacity to accommodate the impact (medium tolerance) with medium to high recoverability. Based on their medium tolerance and medium to high recoverability and taking into consideration their regional importance, the sensitivity of *Nephrops* to temporary increases in SSC and sediment deposition is deemed to be **Low**.
Razor clams	The razor clam *Ensis siliqua* is of commercial value to the fisheries within the region. Razor clams are efficient burrowers (Winter and Hosoi, 2011) and have been shown to rapidly dig to depths of more than 1 m or leave their burrows when disturbed (Fraser *et al.*, 2018). They are also capable of swimming short distances along the seabed (Fraser *et al.*, 2018). This suggests that razor clams are able to adapt and tolerate sediment deposition (high adaptability and tolerance). The susceptibility of razor clams to increases in SSC is likely to be low given their suspension-feeding habit. Larger increases in suspended solids may affect reproductive success or increase the energetic costs for feeding (Hill, 2024). Therefore, the tolerance of razor clams to increases in SSC is assessed as medium. Any effects on feeding rates are likely to be temporary (high recoverability), while potential effects on reproductive rates are estimated to be of short-term duration (medium recoverability). Taking into consideration the regional importance of razor clams together with their medium tolerance to, and medium to high recoverability from increases in SSCs, the overall sensitivity of the receptor to the impact is deemed to be **Low**.

Receptor	Justification
Blue mussel	Blue mussels are sedentary and are therefore assessed as being unable to avoid the impact (negligible adaptability). The MarESA sensitivity review has assessed blue mussels to be broadly insensitive to increases in suspended solids, based on their common occurrence in areas where turbidity is frequently high and their ability to remove sediment from the mantle cavity (de Vooys, 1987; Tillin *et al.*, 2023). Increased expenditure for feeding or impairment to growth may occur in areas of high SSC (>250 mg/l), but given the temporary nature of the sediment plumes, any effects are likely to be temporary (Wilber and Clarke, 2001). The tolerance of blue mussels to light smothering (i.e., sediment deposition of up to 5 cm) has been assessed by MarESA as being medium, as some organisms may not be capable of moving to the surface when disturbed by sediment deposition. However, mortality may be avoided during single deposition events in areas where sediments are redistributed by wave or tidal action. Similarly, while the deposition of larger amounts of sediment (> 5 cm) could result in substantial mortality in blue mussels due to their limited capacity to re-surface from sediment deposition deeper than 2 cm, mortality may be limited or possibly avoided in areas where sediments are re-distributed by tidal currents (Tillin *et al.*, 2023), such as in the study area. Therefore, for the purpose of this assessment, blue mussels are considered to have a medium to low tolerance to the impact. Any effects on growth or feeding rates are likely to be temporary (high recoverability), while effects on survival and reproductive rates are estimated to be of short-term duration (medium recoverability). Based on their medium to low tolerance, and medium to high recoverability, and considering their regional importance, the sensitivity of blue mussel to temporary increases in SSC and sediment deposition is deemed to be **Medium.**
Maximum sensitivity	*The maximum sensitivity of fish and shellfish VERs to this impact is rated as* ***Medium****.*

4.16.8 In summary, marine turtles, diadromous VERs, and viviparous and ovoviviparous elasmobranchs (including basking sharks) have been assessed as not being sensitive to the impact. The sensitivity of the remaining VERs has been assessed as Medium for herring, spotted ray, brown crab, scallops and blue mussel and as Low for all pelagic and demersal VERs, ovigerous elasmobranchs (except for spotted ray), sandeel, and all remaining shellfish VERs. The maximum sensitivity of fish and shellfish VERs for this impact is therefore Medium.

Magnitude of impact

4.16.9 Ambient levels of SSC within the study area vary seasonally, with highest concentrations typically found throughout winter and lowest levels occurring during summer in June and July. Long-term data of non-algal Suspended Particulate Matter (SPM)[16] derived from satellite data (Silva, 2016) show a general trend of decreasing SPM concentrations with distance offshore, with the highest concentrations recorded around Dublin Bay and within the southern sections of the sedimentary ZoI in nearshore waters off Wicklow. Within the array area, monthly mean sea surface SPM concentrations vary from about 2 mg/l in June to about 8 mg/l in December (Physical Processes technical baseline).

[16] SPM refers to all suspended particles within the water column including organic particles. SSC refers to the suspended particles that are not organic in origin.

4.16.10 The different pathways that will result in increases in SSC and sediment deposition during construction are listed in Table 13 along with modelled plume dispersal and sediment deposition patterns. The full details of the design and environmental scenarios modelled are available in the Physical Processes Modelling Report which was based on an earlier design iteration. Not all scenarios modelled are consistent with the current MDO identified in Table 10 and assessed within this EIAR chapter , however, as detailed in the Physical Processes Chapter, the MDO will not give rise to an effect that is more significant than those of the modelled scenarios and therefore the results of sediment plume modelling are considered to be appropriate for the assessments provided below.

4.16.11 The results of the site-specific modelling indicate that construction activities will create discrete sediment plumes that would quickly dissipate after cessation of the activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels. Plumes with SSC above ambient background levels are predicted to disperse over a maximum distance of 10 km from the source. Suspended sediments around the Kish and Bray Banks would typically be transported with the tidal flow towards the south during the ebb tide and to the north during the flood tide, with the flood dominant flow favouring a net transport of suspended sediments to the north. Sediment deposition will consist primarily of coarser sediments deposited close to the source, with the deposition of finer material reducing with distance from the source.

Table 13 Modelled increases in SSC and sediment deposition during construction activities

Predicted increase in SSC and sediment deposition
Pathway 1 - Seabed preparation prior to foundation installation
Release of sediments as overspill into surface waters during dredging The sediment released as overspill will typically comprise fine fractions. ▪ **Duration:** Plumes of fine sediment are predicted to dissipate within one hour following release, with most of the suspended sediment predicted to settle out of the water column within 30 minutes. Coarse grained sediment (e.g., gravels and coarse sand) are predicted to fall out of suspension in the order of minutes. ▪ **Concentration:** SSC within sediment plumes associated with overspill of fine material are predicted to reach a maximum of 50 mg/l on spring tides, and 140 mg/l on neap tides. The level of SSC caused by all sediment types together is expected to be locally high (in the order of tens to hundreds of thousands of mg/l) at the release location. ▪ **Spatial extent:** Plumes consisting of fine sediments form in the direction of the tidal stream (N-S direction) and will be detectable up to a maximum of 900 m from the point of overspill release. Plumes consisting of coarse grains will only be present over that seabed being actively dredged. ▪ **Bed level change:** Deposition depths of fines sediment on the seabed are predicted to be up to approximately 0.01 m, with the deposition footprint for all thicknesses typically being 600 m by 200 m. **Disposal of dredged material at designated disposal locations** ▪ **Duration:** The sediment in suspension during disposal is predicted to fall out within the order of minutes if deposited near the seabed. ▪ **Concentration:** For the fine fraction, a maximum SSC of 300 mg/l is predicted. ▪ **Spatial extent:** The sediment plume resulting from disposal (fine fractions) is anticipated to extent between tens to low hundreds of metres, typically of the order of 250 m by 250 m. SSC in plumes consisting of fine and coarse fractions are anticipated to reduce to thousands or high hundreds of mg/l within tens to low hundreds of metres. ▪ **Bed level change:** The maximum deposition depth of fine sediment fractions is predicted to be less than 0.045 m. The maximum deposition depth of coarse fractions for one dredger load is predicted to be 1.77 m when deposited on a slack tide low water in the northern extent of the array area and 0.7 m within the southern extent of the array area. The maximum footprint, exceeding heights of 0.3 m, is predicted to be 581 m^2 and 4,355 m^2 for the north and south sites, respectively, under slack tide at low water. It should be noted that these predictions are highly precautionary, in terms of height, as sediment will naturally 'slump' as opposed to making steep sided cones. Furthermore, the sediment will naturally disperse laterally in the water column and along the bed when released from the surface by through the hopper doors of a barge in a near instantaneous release of all of material. This will result in lower depositional heights but a larger spatial extent of the disposed material on the seabed.
Pathway 2 - Drilling of foundations within the array area
Continuous release of drill cuttings into surface waters during the drilling of foundations ▪ **Duration:** All sediments are predicted to have settled out of suspension and been deposited within approximately three hours following the end of the release. The coarse fraction is predicted to fall out of suspension in the order of minutes. ▪ **Concentration:** Modelled SSC associated with the release of fine drill cuttings are predicted to reach a maximum of 200 mg/l on spring tides, and 600 mg/l on neap tides. These concentrations are observed within circa 150 m of the release location. The level of SSC caused by all sediment types together is expected to be in the order of tens to hundreds of thousands of mg/l at the release location, which will be highly localised and momentary in nature. ▪ **Spatial extent:** Due to the continuous sediment release throughout the tidal cycle, plumes of the fine fractions may extend up to approximately 10 km from the source; however, at this distance these concentrations will be close to ambient conditions and well within the natural variability of the study area.

Predicted increase in SSC and sediment deposition
▪ **Bed level change:** Under both the neap and spring tidal release scenarios a relatively large depositional footprint will result for fine fractions, with a thickness less than approximately 0.002 m. Within circa 2 km of the drilling location, the thickness of fine fractions is predicted to be less than 0.02 m. The coarse fractions will be deposited as mounds within tens of metres of the drill locations with an average thickness in the orders of tens of centimetres to a few metres in height.
Pathway 3 - Installation of IACs
▪ **Duration:** Fine fractions settle to the bed within, approximately, 30 to 60 minutes during spring and neap tidal releases, respectively. Coarse grained sediments (gravels and coarse sands) will typically fall out of suspension in the order of minutes. ▪ **Concentration:** During trenching, the predicted plumes of fine fractions have high concentrations up to approximately 5,000 mg/l over the trench, before decreasing rapidly to between circa 5 mg/l and 20 mg/l within approximately 200 m of the trench. During MFE activity, high concentrations at the release point are predicted, which will reduce to background levels (e.g., 5 mg/l) within a few hundred metres. The level of SSC caused by all sediment types together is expected to be in the order of tens to hundreds of thousands of mg/l at the release location, which will be highly localised and momentary in nature. ▪ **Spatial extent:** Any sediment fractions larger than fine sand are expected to rapidly fall out of suspension, with a proportion predicted to fall back into the trench. SSC of fine sediment plumes will decrease rapidly from the trench line to between, circa 5 mg/l and 20 mg/l within approximately 200 m of the trench. The deposition of coarse fractions will be limited to within metres to tens of metres of the cable trench. ▪ **Bed level change:** Fine sediment fractions are predicted to be deposited on the seabed as linear features along the trench route at heights of between approximately 0.1 to 0.75 m. A proportion of the coarse fraction will settle into the trench, burying the cable with a deposition height in the order of tens of centimetres to a few metres.
Pathway 4 - Installation of export cables
▪ **Duration:** For both spring and neap tide modelled scenarios the fine sediment fraction fully disperses within approximately 60 minutes of the completion of sediment release at the (now obsolete) Poolbeg-associated ECC route and within approximately 30 minutes of the completion of sediment release at the southern Offshore ECC route. Coarse grained sediments (e.g. gravels to medium sands) will typically fall out of suspension in the order of minutes without opportunity to be advected substantially away from the release location. ▪ **Concentration:** Model simulations on both spring and neap tides show SSC for fine fractions of circa 500 mg/l at the release point of the southern Offshore ECC route. The fine sediment plume at this location is predicted to be approximately 250 m^2 with a concentration of approximately 50 mg/l, before dissipating to ambient conditions. The level of SSC caused by all sediment types together is expected to be in the order of tens to hundreds of thousands of mg/l at the release location, which will be highly localised and momentary in nature. ▪ **Spatial extent:** Fine sediment fractions are predicted to be deposited on the seabed as linear features along the trench route up to 2 km from the trench line within the southern offshore ECC cable route associated with the landfall. The coarse fractions from all locations in the Offshore ECC are expected to be deposited within metres to tens of metres of the trench, with a proportion predicted to fall back into the trench. ▪ **Bed level change:** The maximum deposition depth of fine fractions is predicted to be between 0.1 m and 0.5 m in the area being actively trenched for the Offshore ECC associated with the landfall, with this sediment predicted to infill the trench. The deposition height of the coarse fractions is predicted to be in the order of tens of centimetres to a few metres outside of the trench, depending on the specific sediment present.

Predicted increase in SSC and sediment deposition
Pathway 5 - Release of drilling mud (bentonite or another inert mud)
Release of drilling mud such as bentonite (or another inert mud) and associated chemicals within the intertidal or shallow subtidal at the drilling punch out point ▪ **Spatial extent:** If the punchout location occurs in the subtidal zone then the currents advecting the plume are aligned parallel to the coast and so it is reasonable to assume that the plume will largely remain a similar distance from the coast. If the plume experiences sufficient lateral diffusion to reach the adjacent shoreline, then the corresponding SSC would be very low (within the range of naturally occurring values). ▪ **Bed level change:** It is considered most likely that most or all of the released drilling mud (bentonite or another inert mud) will be held in suspension for days before settling. In this time, the individual grains will become dispersed widely over very large areas and so will not result in any measurable thickness of bentonite accumulation or change in seabed sediment type or texture.
Pathway 6 - Sandwave clearance
Release of sediments as overspill into surface waters during dredging ▪ **Duration:** Plumes of fine sediment are predicted to dissipate within one hour following release, with most of the suspended sediment predicted to settle out of the water column within 30 minutes. ▪ **Concentration:** SSC within sediment plumes associated with overspill of fine material are predicted to reach a maximum of between approximately 110 mg/l and 160 mg/l at slack water, with the highest concentrations predicted when released within the south of the array area. The level of SSC caused by all sediment types together is expected to be locally high (in the order of tens to hundreds of thousands of mg/l) at the release location. ▪ **Spatial extent:** Plumes consisting of fine sediments from overspill will disperse (above 5 mg/l) for a distance of approximately 1 km. Plumes consisting of coarse grains will only be present over that seabed being actively dredged. ▪ **Bed level change:** Overspill footprints are larger and elongated in the direction of the tidal stream. The footprints for the overspill plume are generally 2 km long for a spring tide release, and 1.5 km for a neap tide release, with depths of typically 0.001 m to 0.002 m, with a maximum depth less than 0.01 m. Typically, they cover an area of approximately 900 m by 200 m, with settled depths of circa 0.002 m to 0.006 m. **Disposal of dredged material at designated disposal locations** ▪ **Concentration:** A maximum SSC of 600 mg/l is predicted before settling immediately to the bed. ▪ **Spatial extent:** The sediment plumes consisting of fine sediments are anticipated to extent between tens to low hundreds of metres, typically of the order of 250 m by 250 m. SSC in plumes consisting of fine and coarse fractions are anticipated to reduce to thousands or high hundreds of mg/l within tens to low hundreds of metres. ▪ **Bed level change:** The footprint of fine fractions is predicted to cover an area of approximately 250 m by 250 m, with a maximum depth of approximately 0.04 to 0.06 m. The maximum deposition depth of coarse fractions for one dredger load is predicted to be circa 1.2 m when deposited on a slack tide low water in the northern extent of the array area. For a single dredger load deposited in the southern extent of the array, the maximum spatial extent of deposited material exceeding a height of 30 cm was predicted to be approximately 9,523 m^2, while the maximum spatial extent of deposited material exceeding a height of 0.05 m was predicted to be approximately 23,226 m^2.

4.16.12 The largest volume of surficial sediment to be removed and subsequently deposited would result from dredging during sandwave clearance prior to the installation of inter-array and export cables (Table 10). The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the sandwave (height, length and shape) and the level to which the sandwave must be reduced (also accounting for stable sediment slope angles) (Physical Processes chapter). All dredged material will be deposited within the array area within areas of similar sediment type, and in areas where current speeds are such that dredged material would be redistributed into the sediment transport system.

4.16.13 The disposal of material may result in a slight change in the particle size composition of seabed sediments at the disposal location. However, the material generated from sandwave clearance being deposited is the same as that already present in the array area and so will not affect seabed sediment character or be any more or less susceptible to remobilisation than the baseline environment, once initially deposited. Deposited sediments will be rapidly incorporated into the seabed and local accumulations will be subject to redistribution under the prevailing hydrodynamic conditions (Physical Processes chapter).

Table 14 Determination of impact magnitude of temporary increases in SSC and sediment deposition

Criteria	Assessment of maximum design option	Assessment of alternative design options
Extent	Modelling indicates that any increases in SSC above background levels caused by seabed preparation and construction activities would be restricted to the near-field and adjacent far-field within the sedimentary ZoI. The highest SSC) would be confined to the points of discharge (e.g., WTG locations, cable trench line). Sediment deposition would consist primarily of coarser material deposited close to the source (i.e., around the area of disturbance), with the deposition of finer material decreasing from the point of release.	In line with the maximum design option; impacts will be restricted to the near field and adjacent areas of the far field; however, the volume of sediment released into the water column and any associated sediment deposition will be less, leading to smaller deposition footprints and bed level changes.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Duration	Sediment plumes are expected to quickly dissipate after cessation of the construction activities due to settling and wider dispersion, with SSC reducing within a couple of tidal cycles to background levels. Spoil mounds generated, for example, during cable installation and the disposal of dredge sediments are predicted to be temporary or of short-term duration, with sediments being re-distributed by natural processes (Physical Processes chapter). Consequently, the impact will be restricted to the construction phase of the project (maximum of 30 months) and will therefore be short-term (one to seven years), although works in any given discrete location and associated changes in SSC will be temporary (less than one year). In addition, construction activities are largely expected to be carried out on a sequential basis with minimal opportunity for successive periods of sediment disturbance to develop overlapping sediments plumes (i.e., plumes are expected to fully disperse with material settling out of suspension prior to the occurrence of a subsequent sediment disturbance event).	In line with the maximum design option; impacts will be short-term with a minimum construction period of 18 months and a mean of 24 months.
Frequency	The impact will occur frequently during the construction phase, originating from discrete locations within the array area and Offshore ECC.	As the maximum design option; however, there will be less activities that result in increases in SSC and sediment deposition.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Consequences for fish and shellfish VERs		
Marine turtles, basking shark	Marine turtles and basking shark are pelagic species known to migrate through the Irish Sea. They are highly mobile and expected to move away from intermittent, localised sediment plumes. In addition, these species show no dependence on the seabed for their reproduction. Therefore, the degree of overlap between these receptors and those areas subject to temporary increases in SSC is predicted to be small in the context of available pelagic habitat. Also, any local changes in the species' distributions resulting from avoidance behaviour are expected to be indiscernible from baseline conditions. Consequently, the magnitude of the impact on these receptors is deemed to be **Negligible**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.
Pelagic VERs -Atlantic mackerel, Atlantic horse mackerel, sprat	It has been determined that the impact may affect pelagic VERs predominantly through the effects of high SSC on pelagic eggs and larvae. All pelagic VERs including their known spawning locations are widely distributed throughout the study area and wider region, and therefore the degree of overlap between these receptors and those areas subject to increases in SSC is predicted to be small in the context of available spawning habitat. Moreover, the potential for adverse effects on eggs and larvae would be confined to areas experiencing high levels of SSC and as such would be restricted close to the point of release within the near-field. Based on this together with the short-term, intermittent, and localised nature of the impact, any effects upon pelagic VERs are assessed to be either not discernible or barely discernible from baseline conditions. Consequently, the magnitude of the impact is deemed to be **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the MDO.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Demersal VERs	Cod, plaice, lemon sole, common sole, whiting, and haddock all have spawning grounds within the fish and shellfish study area (Coull *et al.*, 1998; Ellis *et al.*, 2010, 2012; Marine Institute, 2016). Spawning grounds of these receptors are widely distributed across the study area and within the Irish Sea. Therefore, the degree of overlap between sediment plumes and the receptors, including early life stages sensitive to elevated SSC, is anticipated to be small in the context of available spawning habitat and the areas likely to be affected by high SSC and sediment deposition. Similarly, later life stages of the receptors are highly mobile and widely distributed within the wider region, and therefore the interaction between the receptors and the impact is assessed to be low. Considering the wide distribution of the receptors and their spawning locations within the study area and Irish Sea, and the short-term, intermittent and localised nature of the impact arising during construction, any effects on demersal VERs are assessed to be either not discernible or barely discernible from baseline conditions, and consequently the magnitude of the impact is deemed to be **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.
Tope, starry smooth-hound, spiny dogfish	The receptors are widely distributed within the study area and wider region, and therefore the interaction between the receptors and the impact is assessed to be low in the context of available habitat. In addition, the receptors are assessed as being insensitive to increases in SSC and sediment deposition as they would be able move away from intermittent, localised sediment plumes and do not depend on the seabed throughout their life cycle. Given the nature of the impact, any avoidance of sediment plumes would likely be localised and intermittent, with changes in species distributions indiscernible from baseline conditions. Consequently, the magnitude of the impact on these receptors is deemed to be **Negligible**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Small-spotted catshark, nursehound and skate species	It has been determined that the impact may predominantly affect these receptors through the smothering of egg cases attached to the seabed. Areas affected by high SSC and sediment deposition will be localised. In addition, the receptors are widely distributed within the study area, and therefore the interaction between the receptors and the impact is predicted to be small relative to available egg deposition sites. Based on this together with the intermittent and short-term nature of the impact, any effects upon the receptors are assessed to be barely discernible from baseline conditions. Consequently, the magnitude of the impact is deemed to be **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.
Diadromous VERs	It has been determined that increases in SSC have the potential to result in localised and temporary avoidance reactions in migrating species in areas of high SSC near construction activities within the near-field. However, given their mobile nature, the receptors would be able to move away from unfavourable sediment plumes and as such would not be prevented from accessing or leaving their natal rivers during migration. In addition, the degree of overlap between these receptors and areas subject to temporary, intermittent and localised increases in SSC is predicted to be small in the context of available habitat and migration routes within the study area. Therefore, any local changes in the species' distributions resulting from temporary avoidance behaviour are expected to be either not discernible or barely discernible from baseline conditions. Consequently, the magnitude of the impact on these receptors is deemed to be at most **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Sandeel	Site-specific survey data confirmed the presence of sandeel within the study area, with sandeel regularly recorded across the shallower sections of the Kish and Bray Banks. Analysis of PSA data also indicate 'Prime' sandeel spawning habitats to be present within the array area, particularly across the Kish Bank, and along the northern route of the offshore ECC. It is therefore likely that sandeel including their spawning grounds would be subject to increased SSC and smothering from sediment deposition during construction activities. The deposition of coarser sediments resulting from construction activities would be restricted to areas close to the points of release, e.g. within the trenching line. Plumes of finer sediments will disperse more widely. 'Low' intensity sandeel spawning grounds are predicted to be distributed across large parts of the Irish Sea (Ellis *et al.*, 2010, 2012). In addition, PSA data collected through INFOMAR (2023) confirms the presence of suitable sandeel habitats within the study area and wider regions. Taking this into consideration, any effects from increased SSC and sediment deposition on sandeel habitats including spawning grounds are assessed to be relatively small in the context of available suitable substrate in the study area and wider region. Based on this together with the short-term and intermittent nature of the impact, any effects upon sandeel populations and their spawning grounds are considered to be barely discernible from baseline conditions, and therefore the magnitude of the impact is deemed to be **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Herring	The closest known spawning beds for herring are located north of Dundalk Bay (Mourne spawning ground) to the north of the study area (Figure 7). Therefore, no discernible changes are anticipated on spawning herring grounds from the impact during the construction phase, and consequently the magnitude of the impact is deemed to be **Negligible**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.
Common whelk	Fishing data indicate that common whelk are widely distributed within the study area and wider area off the east coast of Ireland from Howth to Wexford (Commercial Fisheries technical baseline, Figure 8). In addition, length and age frequency data suggest that the main spawning and nursery grounds of whelk within the study area are located on Codling Bank and across the areas between Codling and Bray Banks (Fahy *et al.*, 2000, 2002), i.e., outside the areas subject to heavy sediment deposition and high SSCs. Considering the short-term and intermittent nature of the impact together with the limited spatial extent of increases in SSC and sediment deposition in the context of the wide distribution of whelk within and adjacent to the study area, any potential changes in the distribution and abundance of common whelk as a result of the impact are anticipated to be localised and barely discernible from baseline conditions. Therefore, the magnitude of the impact is deemed to be **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.
Brown crab and European lobster	Considering the spatially discrete and intermitted nature of the impact, the magnitude of impact on brown crab and European lobster is considered to be **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Scallops	Site-specific survey and fishing activity data indicate that the main scallop grounds are located to the east of the Kish and Bray Banks within the eastern part of the array area. In addition, scallops have been recorded along the Offshore ECC. It is therefore likely that some proportion of scallop grounds would be subject to increased SSCs and smothering from sediment deposition during construction activities. However, adverse effects on scallops are predicted to mainly result from heavy sediment deposition, which would be restricted to areas close to the point of sediment release and deposition. Factoring in the above and considering the short-term and intermitted nature of the impact, any potential effects upon scallops as a result of increases in SSC and sediment deposition are assessed to be barely discernible from baseline conditions, and the magnitude of the impact is deemed to be **Low adverse**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.
Razor clams	Fishing data indicate that grounds targeted for razor clams do not overlap with the offshore infrastructure, with the closest grounds located approximately 8 km north of the Offshore ECC (Figure 8; and Commercial Fisheries technical baseline). Moreover, it is believed that no large beds of razor clams occur outside of those areas commercially fished (Marine Institute and Bord Iascaigh Mhara, 2023). Given the distance of Dublin Array to the razor clam beds, the low number of razor clams recorded during site-specific grab (Fugro, 2021) and dredge (Aquafact, 2018; Ecoserve, 2008) surveys, and the high tolerance of razor clams to sediment deposition (Table 12), no discernible changes to baseline conditions are anticipated as a result of sediment deposition.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.

Criteria	Assessment of maximum design option	Assessment of alternative design options
	The largest dispersal distance of fine sediment plumes is predicted during the drilling of foundations (up to 10 km; Table 13); however, given that sediments would typically be transported in a N-S direction, the likelihood of fine sediment plumes to reach the main razor clam beds within the shallow subtidal is low. Moreover, SSC at these distances will be close to ambient conditions and well within the natural variability of the study area. Therefore, no discernible changes are anticipated for razor clams from the impact, and consequently the magnitude of the impact is deemed to be **Negligible**.	
Nephrops	Site-specific surveys and PSA data showed that the substrates within the study area are mainly unsuitable for *Nephrops*, with the closest known *Nephrops* grounds located at the northern boundary of the underwater noise ZoI, outside the sedimentary ZoI (Figure 8). Therefore, no discernible changes on the distribution and abundance of *Nephrops* are anticipated from the impact, and consequently the magnitude of the impact is deemed to be **Negligible**.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.
Blue mussel	The site-specific baseline surveys recorded low numbers of blue mussels, with no indication of mussel aggregations to be present within the array area and Offshore ECC. Seed mussel beds are known from inshore waters within the sedimentary ZoI, with the majority of beds located off Wicklow at the southern boundary of the sedimentary ZoI (Figure 8). At these distances, SSC in dispersed sediment plumes are predicted to be close to ambient conditions and well within the natural variability of the study area. Therefore, no discernible changes to blue mussel are anticipated as a result of increases in SSC.	Similar to the maximum design option with impacts restricted to the near field and adjacent areas of the far-field, although the total volume of sediment released and any associated sediment deposition will be less than the maximum design option.

Criteria	Assessment of maximum design option	Assessment of alternative design options
	Likewise, no discernible changes are anticipated for blue mussel from sediment deposition given the low number of blue mussel present within the array area and Offshore ECC and the location of the seed mussel beds outside the areas affected by sediment deposition (Table 13). Based on the above and considering the short-term and intermittent nature of the impact, the magnitude of the impact for blue mussels is deemed to be **Negligible**.	
Overall magnitude	*The potential magnitude of the predicted changes is rated as **Low adverse.***	*The potential magnitude of the predicted changes is rated as **Low adverse.***

4.16.14 In summary, elevated levels of suspended sediments above background levels and associated sediment deposition during construction activities are expected to be short-term, intermittent, and restricted to the near-field and adjacent far-field. The magnitude of the impact has been assessed as Negligible for marine turtles, herring, razor clams, *Nephrops*, blue mussel, and viviparous and ovoviviparous elasmobranchs (including basking sharks). Potential effects on the remaining receptors, i.e., sandeels, pelagic VERs, demersal VERs, diadromous VERs, small-spotted catshark, skates, common whelk, brown crab, European lobster, and scallops, have been predicted to be of Low adverse magnitude. The maximum magnitude of this impact has therefore been assessed as **Low adverse for both the MDO and the alternative options**.

Significance of effects

4.16.15 The maximum magnitude of the impact for fish, shellfish and marine turtle receptors has been assessed as **Low adverse for both the MDO and the alternative design options**, with the maximum sensitivity of the receptors being **Medium**. Therefore, the maximum significance of effects arising from temporary increases in SSC and deposition on fish, shellfish and marine turtle receptors is **Slight adverse**, which is not significant in EIA terms.

4.16.16 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

*In relation to both the MDO and the ADOs, the maximum significance of effects on fish, shellfish and marine turtle receptors resulting from temporary increases in SSC and sediment deposition has been assessed as **Slight adverse**, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. **No significant adverse residual effects** on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 2: Temporary damage and disturbance of the seabed during construction activities

4.16.17 Direct temporary physical 'damage' and 'disturbance' to the seabed will occur within the array area and along the Offshore ECC during seabed preparation works, jack-up and anchoring operations and the installation of inter-array and export cables. It should be noted that in this instance, 'damage' and 'disturbance' refer to temporary physical impacts to the seabed during the construction phase of Dublin Array and any associated effects on fish and shellfish receptors. The effects of long-term habitat loss due to the installation of foundations, scour protection and cable protection are assessed in full in the O&M section under Impact 7. These construction phase activities have the potential to disturb or displace mobile species and to damage or kill sedentary or less mobile receptors. In addition, essential seabed areas (e.g., spawning, nursery or feeding grounds) may be damaged or disturbed.

4.16.18 The sensitivity of fish and shellfish receptors to physical damage and disturbance of the seabed and the magnitude of the impact have been assessed in Table 15 and Table 16, respectively, based on the methodology outlined in Section 4.5. No specific project design features or avoidance and preventative measures relevant to the impact have been identified as necessary (see Table 11).

Sensitivity of receptors

4.16.19 Physical disturbance of the seabed during construction activities has the potential to injure or kill sedentary or slow-moving receptors. This includes receptors which bury in the sediment (e.g., sandeel) and less mobile and burrowing shellfish species (e.g., common whelk, scallops), including those of regional socio-economic importance. In addition, adverse effects on fish and shellfish populations may arise through direct damage or loss of early life stages (i.e., eggs and egg cases deposited on the seabed) or indirectly through the disturbance or damage of benthic spawning and nursery grounds.

Table 15 Determination of receptor sensitivities to temporary seabed damage and disturbance during construction activities

Receptor	Justification
Marine turtles, basking shark, and pelagic VERs (Atlantic mackerel, Atlantic horse mackerel, sprat)	Marine turtles, basking sharks and all pelagic VERs do not depend upon benthic habitats for part or all of their life cycle and therefore are not considered susceptible to the physical damage or disturbance of the seabed that would arise during construction activities. Consequently, the sensitivity of these species to the impact is deemed to be **Negligible**.

Receptor	Justification
Demersal VERs, diadromous VERs, tope, starry smooth-hound, spiny dogfish	All receptors are mobile and would be able to move away from temporary seabed disturbances, and consequently they are assessed as having a high adaptability to the impact. Many of the receptors depend partly or fully on the seabed for feeding but based on their mobile nature they are considered to be able to relocate to nearby unimpacted areas (high tolerance). Any potential displacement would likely to be temporary (high recoverability), with individuals able to return after construction activities have ceased. In addition, these receptors are pelagic spawners (demersal fish VERs), do not spawn within the study area (diadromous VERs), or bear live young (tope, starry smooth-hound and spiny dogfish), and therefore physical damage or disturbance of the seabed within the study area would not result in any potential disturbance or loss of available spawning locations. Based on their high adaptability, tolerance and recoverability, the receptors are considered to be not sensitive to temporary damage and disturbance of the seabed during construction activities, and their sensitivity to the impact is therefore deemed to be **Negligible**.
Small-spotted catshark, nursehound and skate species (thornback ray, spotted ray, blonde ray, cuckoo ray)	As detailed in Table 12, small-spotted catshark, nursehound and skate species are considered to have a high adaptability and tolerance to seabed disturbance events as they are mobile and therefore would be able to avoid the impact and relocate to nearby unimpacted areas. However, the physical disturbance of the seabed may damage or dislodge egg cases deposited on the seabed and consequently may lower the receptor's recruitment success. Therefore, the receptors are assessed as having a medium tolerance to the impact. Any potential displacement of individuals is expected to be temporary, with individuals able to return shortly after construction activities have ceased (high recoverability). Recovery from any potential decrease in recruitment success is assessed to occur within the short to medium-term (medium to low recoverability). Taking into consideration the regional importance of the receptors (with the exception of spotted ray) together with their general high adaptability, medium tolerance and potential low recoverability, the sensitivity of the receptors to direct damage and disturbance of the seabed during construction activities is deemed to be **Low**. On a precautionary basis, the sensitivity of spotted ray to the impact is classed as **Medium**, considering the international importance of the receptor.

Receptor	Justification
Sandeel	Sandeel exhibit strong site fidelity and spend large amounts of time buried in the sediment. In addition, sandeel are demersal spawners, with eggs remaining attached to the seabed during their development. Therefore, for the purposes of the assessment, sandeel are considered a stationary receptor that has limited to no ability to avoid physical impacts to the seabed (low to no adaptability). Seabed disturbances may result in some mortality of individuals, or it may damage or dislodge eggs, which may lead to increased egg mortality rates and reduced recruitment success. Based on this, sandeel are assessed as having a very low tolerance to the impact. Any potential displacement of individuals is expected to be temporary, with individuals able to return shortly after construction activities have ceased (high recoverability). Recovery from any reduced recruitment to the population is assessed to occur within the short-term (medium recoverability). Taking into consideration the low adaptability, very low tolerance and the medium recoverability from damage to early life stages, together with the regional importance of the receptor, the sensitivity of sandeel to the temporary damage and disturbance of the seabed during construction activities is deemed to be **Medium**.
Herring	As discussed previously, herring are demersal spawners, reliant upon the presence of suitable substrates for spawning and egg development. Their eggs are most susceptible to seabed disturbances as they would be unable to avoid the impact. Seabed disturbance may directly damage or dislodge eggs, which may lead to increased egg mortality rates and reduced recruitment success. Moreover, physical damage to the seabed may alter seabed conditions, making them potentially less favourable for egg deposition and development. Therefore, herring are assessed as having a very low tolerance to the impact. Any potential displacement of individuals is expected to be temporary, with individuals able to return shortly after construction activities have ceased (high recoverability). Recovery from any reduced recruitment to the population is assessed to occur within the short-term (medium recoverability). Taking into consideration the regional importance of herring together with its low adaptability, very low tolerance and the medium recoverability from damage to early life stages, the sensitivity of herring to the temporary damage and disturbance of the seabed during construction activities is deemed to be **Medium**.
Common whelk	Adult common whelk are not thought to make extensive movements (Bolger, 2016; Hancock, 1963), they are therefore considered to have a limited capacity to avoid physical impacts to the seabed (low adaptability). Seabed disturbances may damage or kill some specimens. In addition, egg cases deposited on the seabed may also be lost. The tolerance of common whelk to the impact is therefore assessed as being low with recovery considered to occur within the short-term (medium recoverability). Based on their low adaptability and tolerance and medium recoverability and taking into consideration their regional importance, the sensitivity of common whelk to temporary damage and disturbance of the seabed during construction activities is deemed to be **Medium**.

Receptor	Justification
Brown crab	Berried female brown crab exhibit a largely sedentary lifestyle during the overwintering period, remaining buried in the sediment (Bennett, 1995). For the purposes of the assessment brown crab are therefore considered a stationary receptor with a limited ability to move away from physical impacts to the seabed (low adaptability). Seabed disturbances may damage or kill some specimens, and eggs carried by brooding females maybe lost. The tolerance of brown crab to the impact is therefore assessed as being low with recovery considered to occur within the short-term (medium recoverability). Based on their low tolerance, medium recoverability and taking into consideration their regional importance, the sensitivity of brown crab to temporary damage and disturbance of the seabed during construction activities is deemed to be **Medium**.
European lobster	European lobster are not known to exhibit a sedentary overwintering habit, being typically mobile, and therefore this species is considered to have a greater ability to move away from disturbances by comparison to brown crab. The tolerance of European lobster to temporary seabed disturbances is assessed as high and recovery is expected to occur within the short-term (medium recoverability). Consequently, the sensitivity of the receptor to temporary seabed disturbance impacts is deemed to be **Low**.
Nephrops	*Nephrops* construct and inhabit complex burrows. Berried females are largely sedentary whilst brooding eggs, generally remaining within their burrows to overwinter. For the purposes of the assessment *Nephrops* are considered a stationary receptor, as they are unlikely to move away from physical impacts to the seabed (low adaptability). Disturbance of the seabed will likely damage *Nephrops* burrow systems and displace its inhabitants. Some individuals may be damaged or lost. In addition, eggs carried by berried females may be lost, potentially resulting in a decline in reproduction rates (Durkin and Tyler-Walters, 2022). Consequently, *Nephrops* are considered to have a low tolerance to the impact. *Nephrops* have shown the ability to rebuild damaged burrows within several days (Durkin and Tyler-Walters, 2022), and therefore effects of damaged or disturbed burrow networks are likely to be temporary (high recoverability). Recovery from lost individuals or a decrease in recruitment success is considered to occur within the short-term to medium-term (medium to low recoverability) following larval dispersal and successful recruitment after the impact has ceased. Based on their low tolerance and low to medium recoverability and taking into consideration their regional importance, the sensitivity of *Nephrops* to temporary damage and disturbance of the seabed during construction activities is deemed to be **Medium**.

Receptor	Justification
Razor clams	The MarLIN sensitivity review has assessed razor clams as having a high intolerance (i.e., very low to low tolerance) to abrasion and physical disturbance of the seabed on the basis that they have a very brittle shell that is highly susceptible to damage (Hill, 2024). Spatfall of razor clams has been reported to be sporadic and therefore the MarLIN sensitivity review concluded that recovery may occur within one year in years of good recruitment but may take up to 10 years for larger beds and/or sporadic recruitment (Hill, 2024). Therefore, for the purpose of this assessment, the recoverability of razor clams to the impact is deemed to be low. Based on their very low tolerance and low recoverability and taking into consideration their regional importance, the sensitivity of razor clams to the impact is deemed to be **Medium**.
Scallops	Scallops exhibit limited swimming ability, with this behaviour generally limited to predator avoidance (Marshall and Wilson, 2008). The species is therefore considered to have a limited ability to avoid physical impacts to the seabed (medium adaptability). It is possible that some individuals may be crushed and killed during construction activities. The tolerance of scallop to the impact is therefore assessed as being low, with recovery considered to occur within the short-term (medium recoverability). Based on their low tolerance and medium recoverability and taking into consideration their regional importance, the sensitivity of scallop to temporary damage and disturbance of the seabed during construction activities is deemed to be **Medium**.
Blue mussel	Blue mussels are sedentary, which makes them highly susceptible to physical impacts to the seabed during construction activities (no adaptability). The MarESA sensitivity review considers blue mussels to have a low resistance (i.e., low tolerance) to activities disturbing surface and shallow subsurface sediments, as individuals are likely to be affected directly through damage or indirectly through the weaking of their connecting byssus threads, which makes them vulnerable to displacement (Tillin *et al.*, 2023). Recovery from the loss of large parts of blue mussel beds is assessed to occur within 2-10 years (medium to low recoverability) as a result of a repopulation by larvae during episodic recruitment events (Tillin *et al.*, 2023). Based on their low tolerance and low to medium recoverability and taking into consideration their regional importance, the sensitivity of blue mussels to the impact is deemed to be **Medium**.
Maximum sensitivity	The maximum sensitivity of the receptors is rated as **Medium**.

4.16.20 In summary, marine turtles, viviparous and ovoviviparous elasmobranchs (including basking sharks), and all pelagic, demersal and diadromous VERs have been assessed as not being sensitive to the impact. The sensitivity of European lobster, small spotted catshark, nursehound, thornback ray, blonde ray and cuckoo ray has been assessed as low. The sensitivity of the remaining VERs, i.e., herring, sandeel, spotted ray, common whelk, brown crab, *Nephrops*, razor clams, scallops and blue mussel, has been assessed as medium. The maximum sensitivity of fish and shellfish VERs for this impact is therefore Medium.

Magnitude of impact

4.16.21 Up to 17.7 km^2 of seabed is predicted to be temporarily impacted within the array area and Offshore ECC during the construction phase of the proposed development. Of this total area, within the array area a total maximum of approximately 14.3 km^2 is predicted to be temporarily damaged, disturbed and lost because of seabed preparation works, jack-up and anchoring operations, and the installation of inter-array cables including associated seabed sweeping and sandwave clearance activities. Within the intertidal and subtidal areas of the Offshore ECC, a maximum of approximately 3.4 km^2 will be temporarily disturbed during installation of export cables including seabed sweeping and sandwave clearance.

4.16.22 It should be noted that the maximum design option for direct damage and disturbance of the seabed presents a precautionary approach because it counts the total footprint of pre-sweeping, seabed preparation (including sandwave clearance) and cable installation across both the array area and Offshore ECC. This approach effectively counts the footprint of seabed to be temporarily impacted by construction activities in the same area multiple times. However, this precautionary approach has been taken because there is some potential for recovery of habitats between the activities due to timescales of the construction activities.

4.16.23 The largest temporary disturbance and loss of surficial sediments would result from dredging during sandwave clearance prior to the installation of inter-array and export cables. The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the sandwave (height, length and shape) and the level to which the sandwave must be reduced (also accounting for stable sediment slope angles). While these activities will result in localised changes to seabed topography, they are not expected to alter the characteristics of surficial sediments.

Table 16 Determination of impact magnitude of habitat disturbance during construction activities

Criteria	Assessment of maximum design option	Assessment of alternative design options
Extent	Disturbance and damage to the seabed will be restricted to within the immediate footprint of the infrastructure and associated installation activity. Consequently, the maximum extent of the impact will be restricted to the near-field.	In line with the maximum design option; impacts will be restricted to the near field; however, the total area of seabed disturbed will be less.
Duration	The impact will be restricted to the construction phase of the project (maximum of 30 months) and will therefore be short-term (one to seven years), although works in any given discrete location within the array area and Offshore ECC will often be temporary (less than one year),	In line with the maximum design option; impacts will be short-term with a minimum construction period of 18 months and a mean of 24 months.
Frequency	The impact will occur frequently in discrete locations within the array area and Offshore ECC during the construction phase.	In line with the maximum design option; however, there will be less activities that will temporary damage or disturb the seabed.
Consequences for fish and shellfish VERs		
Marine turtles, basking shark, pelagic VERs	Marine turtles, basking sharks and all pelagic VERs do not depend upon benthic habitats for part or all of their life cycle and therefore are not considered susceptible to the physical damage or disturbance of the seabed that would arise during construction activities. Consequently, the impact would not affect the receptors (neutral impact), and therefore the magnitude of the impact is assessed as being **Negligible**.	The magnitude of the impact is assessed as being Negligible in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Demersal VERs, diadromous VERs, tope, starry smooth-hound, spiny dogfish	It is predicted that the impact may affect the receptors through the temporary damage or loss of available benthic feeding grounds. All these receptors are mobile and therefore able to move away to adjacent areas both within and outside the study area. The receptors are widely distributed within the study area and Irish Sea, and any damages or loss to the seabed during construction activities are considered small compared to the overall extent of feeding grounds across the study area and wider region. Therefore, considering the localised and short-term nature of the impact, no discernible changes to the receptors are anticipated, and consequently the magnitude of the impact for these receptors is assessed as being **Negligible**.	The magnitude of the impact is assessed as being Negligible in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.
Sandeel	Construction activities will result in the temporary loss and/or disturbance of discrete areas of the seabed at the construction sites. As described previously, PSA data indicate 'Prime' sandeel spawning habitats to be present within the array area, particularly across the Kish Bank, and along the northern route of the offshore ECC. Therefore, construction activities, in particular those associated with seabed preparation activities, may lead to noticeable, localised changes to the distribution of sandeel and sandeel spawning behaviour within the near-field. However, Prime' and 'Subprime' sandeel habitats have also been identified within the wider study area, and the likelihood of direct effects on juvenile and adult sandeel will likely be reduced during spring and early summer when sandeel emerge from the seabed during the day to feed in the water column. Factoring in the above and considering the short-term duration of the impact, the magnitude of the impact is deemed to be **Low adverse**.	The magnitude of the impact is assessed as being Low adverse in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Herring	The closest known active spawning beds for herring are located north of Dundalk Bay to the north of the study area. Therefore, no discernible changes are anticipated on herring spawning grounds from the impact during the construction phase, and consequently the magnitude of the impact is deemed to be **Negligible**.	The magnitude of the impact is assessed as being Negligible in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.
Common whelk	Fishing activity data indicate the widespread occurrence of common whelk within the array area and it is therefore likely that common whelk will be affected by physical impacts to the seabed during construction activities, with the potential for injury and/or death of common whelk to occur at the local scale. However, as discussed in section 4.6.33, common whelk are widely distributed within the study area and wider western Irish Sea (Figure 8). In addition, current evidence (Fahy *et al.*, 2000, 2002) suggests that the array area and Offshore ECC are unlikely to overlap with key whelk spawning and nursery grounds. Therefore, the number of whelks directly affected by physical impacts to the seabed is considered to be small when compared to the whelk population inhabiting the study area and wider western Irish Sea. Based on this and considering the short-term nature of the impact, any effects on common whelk are considered to be barely discernible from baseline conditions, and the magnitude of the impact is assessed as being **Low adverse**.	The magnitude of the impact is assessed as being Low adverse in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.
Brown crab, European lobster and scallops	Considering the spatially discrete and intermitted nature of the impact, the magnitude of impact on brown crab, European lobster and scallops is considered to be **Low adverse**.	The magnitude of the impact is assessed as being Low adverse in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.

Criteria	Assessment of maximum design option	Assessment of alternative design options
Razor clams	As discussed previously (Table 14), fishing data indicate that grounds targeted for razor clams do not overlap with the offshore infrastructure, and no large beds of razor clams occur outside of those areas commercially fished (Marine Institute and Bord Iascaigh Mhara, 2023). Therefore, the number of razor clams directly affected by physical impacts to the seabed is likely to be small when compared to the extent of commercial beds to the north of the study area. Based on this together with the short-term nature of the impact, no discernible changes in razor clam distribution and abundance are anticipated from physical impacts to the seabed during construction activities, and the magnitude of the impact is consequently assessed as being **Negligible**.	The magnitude of the impact is assessed as being Negligible in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.
Nephrops	As discussed previously (Table 14), the substrates across the array area and Offshore ECC are unsuitable for *Nephrops.* Therefore, no discernible changes in the distribution and abundance of *Nephrops* are anticipated from the impact, and consequently the magnitude of the impact is deemed to be **Negligible**.	The magnitude of the impact is assessed as being Negligible in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.
Blue mussel	As discussed previously (Table 14), site-specific data indicate low numbers of blue mussels within the array area and Offshore ECC, with no known seed mussel beds (Figure 8). Therefore, no discernible changes in the distribution and abundance of blue mussel are anticipated from the impact, and consequently the magnitude of the impact is deemed to be **Negligible**.	The magnitude of the impact is assessed as being Negligible in line with the maximum design option; however, the total area of seabed to be temporarily disturbed or damaged will be less.
Overall magnitude	*The potential magnitude of the predicted changes is rated as **Low adverse**.*	*The potential magnitude of the predicted changes is rated as **Low adverse.***

4.16.24 In summary, temporary damage and disturbance of the seabed during construction activities will be localised and restricted to the near-field. Furthermore, any changes to the seabed are expected to be temporary to short-term, intermittent, and reversible. The magnitude of the impact has been assessed as Negligible for marine turtles, herring, *Nephrops*, razor clams, blue mussel, oviparous elasmobranchs and all pelagic, demersal and diadromous VERs. Potential effects on the remaining receptors, i.e., sandeel, common whelk, brown crab and European lobster, have been assessed as being of Low adverse magnitude. The maximum magnitude of this impact has therefore been assessed as **Low adverse for both the MDO and the alternative design options**.

Significance of effects

4.16.25 The maximum magnitude of the impact has been assessed as **Low adverse for both the MDO and the alternative design options**, with the maximum sensitivity of the receptors being **Medium**. Therefore, the maximum significance of effects on fish and shellfish receptors due to direct damage and disturbance to the seabed during construction activities is **Slight adverse**, which is not significant in EIA terms.

4.16.26 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

*In relation to both the MDO and the ADOs, the maximum significance of effects on fish, shellfish and marine turtle receptors resulting from direct physical damage and disturbance of the seabed has been assessed as **Slight adverse**, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. **No significant adverse residual effects** on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 3: Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination

4.16.27 As assessed under Impact 1, construction activities will result in the release of sediments into the water column. While in suspension, there is potential for sediment bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and affect fish and shellfish receptors.

4.16.28 With respect to accidental pollution, good construction practice standards will be adhered to and control measures will be adopted to ensure necessary levels of environmental performance are being met and environmental risks are appropriately managed. Protocols will be put in place to ensure that there is a timely, measured, and effective response to all marine pollution incidents in the marine environment arising from any activities associated with construction and operation. Those protocols and standards will be compliant with relevant legislation (including MARPOL and the Sea Pollution Act).

4.16.29 Whilst substances such as grease, oil, fuel, anti-fouling paints and grouting materials may be accidentally released or spilt into the marine environment, no discharges (continuous or intermittent) of chemicals or materials, which may be toxic or persistent within the marine environment, will be used during any phase of Dublin Array (see Project Description Chapter).

4.16.30 The likelihood of an incident will be reduced by implementation of the avoidance and prevention measures included within a marine pollution contingency plan (MPCP) (Table 11).

4.16.31 In addition, a chemical risk review will be undertaken prior to construction activities commencing to include information regarding how and when chemicals are to be used, stored and transported in accordance with recognised best practice guidance. Adoption of these measures will reduce the likelihood of potentially harmful pollutants to be released into the marine environment, thereby reducing the likelihood of pollution impacts on fish and shellfish receptors. A full assessment of the impacts to water quality from accidental spills, accidental releases and releases of contaminated sediments is presented in the Marine Water and Sediment Quality chapter. The potential for a reduction in water and sediment quality due to accidental pollution and the potential effects on fish and shellfish receptors are not considered any further in the assessment.

4.16.32 The magnitude of changes in water and sediment quality resulting from the release of sediment-bound contaminants and any effects on fish and shellfish receptors are assessed in Table 17, based on the methodology outlined in Section 4.5.

Sensitivity of receptors

4.16.33 There is limited data on the effects of sediment-bound contaminants released into the water column on fish and shellfish species. Bivalve molluscs, including blue mussels and razor clams, are known to bioaccumulate contaminants including hydrocarbons, metals and Polychlorinated Biphenyls (PCBs). Other known effects on bivalves include the development of tumours, a reduction in growth rates, fitness and life expectancies, and contaminant induced mortality, with embryonic and larval stages often found to be the most vulnerable to toxic effects (Hill, 2024; Tillin *et al.*, 2023).

4.16.34 Ingestion of harmful compounds and storage in body tissues have been observed for fish and elasmobranch species (e.g., Alves *et al.*, 2022; van der Oost *et al.*, 2003). Other reported effects of environmental contaminants in fish include structural and functional changes in sensory organs and associated changes in foraging behaviour, feeding and growth rates (e.g., Kasumyan, 2001). Direct damage of body tissues such as gills, kidneys and liver have also been observed, which in turn may alter buoyancy behaviour, osmoregulation, respiration, growth and survival rates (e.g., Khoshnood, 2017; Wang *et al.*, 2013). As for bivalves, current evidence indicates that fishes are most sensitive to toxic effects during their early development stages (i.e., embryonic and larval stages) (Khoshnood, 2017), while elasmobranchs are highly susceptible to accumulate pollutants throughout their life given their long life span and higher trophic position (Alves *et al.*, 2022).

4.16.35 The likelihood and severity of toxic effects strongly depends on the concentrations of contaminants within the water column, the type of substance encountered, and the duration of exposure. For the purpose of this assessment, a pre-cautionary approach has been taken, and the tolerance of all fish and shellfish VERs to the release of contaminated sediments has been rated as low to very low, acknowledging that some species will be more tolerant than others. Recoverability has been assessed as medium to low, which takes account of the potential of adverse effects on reproductive rates and early life stages.

4.16.36 Based on the low to very low tolerance and medium to low recoverability, and taking into consideration their regional, national and international importance, the sensitivity of all fish and shellfish VERs to the impact is rated as **Medium**.

Magnitude of impact

4.16.37 An assessment of sediment bound contaminants within the array area and Offshore ECC and the potential impacts to water quality from releases of contaminated sediments is presented in the Marine Water and Sediment Quality chapter. This assessment has adopted the thresholds outlined in the 'Guidelines for The Assessment of Dredge Material For Disposal In Irish Waters' (Marine Institute, 2006, 2019) (hereafter referred to as the Irish Action Levels) to evaluate the contamination levels recorded within seabed sediments sampled within the array area and Offshore ECC.

4.16.38 The site-specific contaminants sampling provided confirmation that the levels of sediment bound contaminants are low in the array area and within the majority of the Offshore ECC. One sample taken within the south of the array area (to the south of the Bray Bank) exceeded the Lower Irish Action Levels for arsenic. No samples exhibited Polycyclic Aromatic Hydrocarbon (PAH) levels in exceedance of the Irish Sediment Quality Guidelines. Furthermore, no elevated levels of Total Hydrocarbon (THC) and n-Alkanes were detected, and levels of Dibutyl Tin (DBT) and Tributyl Tin (TBT) were well below the Irish Sediment Quality Lower Level (Marine Water and Sediment Quality chapter).

Table 17 Determination of impact magnitude of reduction in water and sediment quality

Definition	Maximum design option	Alternative design option
Extent	As discussed in Impact 2, the majority of sediments released or re-suspended during construction activities are expected to be deposited in the immediate vicinity of the works within the near-field and adjacent far-field. Sediment bound contaminants are likely to quickly dissipate due to settling and wider dispersion by the prevailing tidal currents.	In line with the maximum design option; impacts will be restricted to the near-field and adjacent areas of the far-field; however, the volume of sediment released into the water column will be less.

Definition	Maximum design option	Alternative design option
Duration	The impact will be restricted to the construction phase of the project (maximum of 30 months) and will therefore be short-term (one to seven years), although activities in any given discrete location within the array area and offshore ECC will often be temporary (less than one year). Sediment plumes are expected to quickly dissipate after cessation of individual construction activities due to settling and wider dispersion with concentrations reducing within a couple of tidal cycles to background levels. In addition, construction activities are largely expected to be carried out on a sequential basis with minimal opportunity for successive periods of sediment disturbance to develop overlapping sediments plumes.	In line with the maximum design option; impacts will be short-term with a minimum construction period of 18 months and a mean of 24 months.
Frequency	The impact will occur intermittently in discrete areas throughout the construction phase of the development.	In line with the maximum design option; however, there will be less activities that disturb the seabed, reducing the frequency at which contaminated sediments might be released into the water column.
Probability	The release of contaminants from fine sediments is likely to be rapidly disturbed with the tide and/or currents and therefore increased bio-availability that could result in adverse eco-toxicological effects to fish and shellfish receptors and their prey is not expected to occur.	In line with the maximum design option.
Consequence	Given the fates of the plumes, the low concentrations of sediment-bound contaminants, and the very low likelihood of increased bio-availability of contaminants in the water column[17], the impact is not considered to result in any discernible change to fish, shellfish and marine turtle receptors from baseline conditions. Therefore, the magnitude of the impact is deemed to be **Negligible**.	In line with the maximum design option; however, there will be less activities that disturb the seabed, reducing the likelihood of contaminated sediments to be released into the water column.

[17] Very small concentrations of contaminants enter the dissolved phase, with the majority adhering to the sediment particles when temporarily entering suspension in the water column. Partition coefficients may be applied to estimate the concentration of the contaminants entering the dissolved phase, which will result in a reduction of several orders of magnitude than the concentrations associated with suspended sediments. As such, it is considered highly unlikely that the Maximum Allowable Concentration Environmental Quality Standards threshold, as prescribed by the Irish Action Levels, will be exceeded for any of the substances as a result of disturbing sediment in the water body from the proposed activities (Marine Water and Sediment Quality chapter).

Definition	Maximum design option	Alternative design option
Overall magnitude	*The potential magnitude of the predicted changes is rated as **Negligible.***	*The potential magnitude of the predicted changes is rated as **Negligible.***

4.16.39 In summary, the potential release of sediment-bound contaminants during construction activities is expected to be restricted to the near-field and adjacent far-field. Given the fate of the sediment plumes and the low concentrations of sediment-bound contaminants within the array area and Offshore ECC, potential effects on fish and shellfish receptors have been assessed as being not discernible from baseline conditions. The magnitude of this impact has therefore been assessed as **Negligible for both the MDO and alternative design options**.

Significance of effects

4.16.40 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **Medium**. Therefore, the significance of effects associated with the release of contaminated sediments during construction activities is a **Neutral Effect (Not significant)**, which is not significant in EIA terms.

4.16.41 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

*In relation to both the MDO and the ADOs, the significance of potential effects on fish, shellfish and marine turtle receptors resulting from the release of sediment bound contaminants has been assessed as **Neutral (Not significant)**, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. **No significant adverse residual effects** on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 4: Introduction of underwater noise and vibration leading to mortality, injury, TTS and/or behavioural changes, or auditory masking

4.16.42 Several activities during the construction phase have the potential to introduce underwater sounds and vibration that can adversely affect fish, shellfish and marine turtle receptors. Effects range from behavioural changes to physiological responses, physical injury and mortality. The following sections provide a brief overview of underwater noise and hearing in fish and shellfish receptors. This is followed by the impact assessment for a range of likely significant effects that may arise from underwater sounds generated during construction activities. A detailed description of the characteristics of underwater sounds is provided in the Underwater noise assessment (Volume 4, Appendix 4.3.5-7).

Potential noise sources

4.16.43 During the construction phase, the following noise producing activities have the potential to affect fish and shellfish receptors:

- Impact piling and/or drilling during the installation of WTG and OSP foundations;
- Low order and high order clearance of Unexploded Ordnance (UXO);
- General construction noise from vessels and marine works such as cable laying, dredging, drilling and rock placement; and
- Geophysical pre-construction surveys.

4.16.44 As detailed within the Underwater noise assessment, there are clear differences in the potential impact ranges from differing underwater noise sources from construction activities at Dublin Array. The largest impact ranges will likely arise from pile driving of foundations (i.e., impact piling of monopiles or pin piles in the array area). These activities will generate impulse sounds, which are characterised by high acoustic energy levels with a rapid rise time followed by a rapid decay (Popper and Hawkins, 2019). Impulsive sounds will also be produced during the controlled explosion of UXO, though any detonation would represent a short-term (i.e., seconds) increase in underwater noise. General construction noise arising from vessel movements, dredging and seabed preparation works will generate low levels of non-impulse sounds throughout the construction phase. In addition, non-impulse sounds will be generated during geophysical surveys, which will take place during the construction phase. Further detail on the differences between these potential noise sources and the consequences from these have been incorporated within the determination of the magnitude and sensitivity of the receptors to underwater noise.

4.16.45 To inform the assessment of potential impacts associated with underwater noise, project-specific underwater noise modelling has been undertaken. The modelling utilises the INSPIRE noise model, which has been developed based on an extensive database of previous sound pressure monitoring data at a range of locations and for a variety of sound sources. A detailed description of the noise modelling including input data, results and uncertainties are provided in the Underwater noise assessment. For the purposes of the modelling, baseline data of the acoustic environment at the modelling location is not required; therefore, no site-specific underwater noise data has been collected specifically for the noise modelling.

4.16.46 The MDO for the piling of foundations is presented in Table 18 together with the parameters used in the underwater noise modelling. Information is provided for each of the two foundation types under consideration (i.e., steel monopiles and jacket foundations with pin piles) for both the maximum spatial and temporal extents of the impact, which have been defined as follows:

- The maximum spatial extent of the impact equates to the largest area to be affected by subsea noise during impact piling. In the context of the proposed development, the largest maximum spatial extent of noise emissions during the piling of foundations will result from the piling of four 5.75 m diameter pin piles in a 24-hour period.

- The maximum temporal extent of the impact represents the longest duration of the impact, which would result from the sequential piling of pin piles for jacket foundations.

4.16.47 It is important to note that the maximum hammer energies assumed in the maximum design scenario are likely to be highly precautionary as for many piling events a lesser hammer energy will be required to complete the pile installation. The energy needed at each foundation location will depend on the specific ground conditions, with the maximum hammer energy considered in the modelling being based on the location that would require the largest hammer energies during piling. The hammer energies listed in Table 18 represent the upper limit of the equipment, rather than the likely energy that will be required to install any given foundation.

4.16.48 The underwater noise modelling also provides potential noise impact ranges from other activities (i.e., high order UXO clearance and non-impulse sounds generated during construction activities), with the details of the modelling scenarios presented in the Underwater noise assessment.

Table 18 Modelled and maximum design scenarios for the piling of foundations within the array area

	Monopile	Jacket foundation
Noise modelling parameters		
Pile diameter and maximum hammer energy	13 m diameter monopile with a maximum blow energy of 6,372 kJ	5.75 m diameter pin pile with a maximum blow energy of 4,695 KJ
Piling duration	One monopile per 24-hours	Four pin piles per 24-hours
Maximum design options		
Maximum pile diameter and maximum hammer energy	13 m diameter monopiles installed using a maximum hammer energy of 6,372 kJ	Three-leg structure: 5.75 m diameter pin pile installed using a maximum hammer energy of 4,695 kJ. Four-leg structure: 5.5 m diameter pin pile installed using a maximum hammer energy of 4,695 kJ
WTG - Maximum active piling time	WTG Options B and C (45 or 39 WTG monopile foundations): 3.9 hours per pile	WTG Option A (50 4-leg WTG jacket foundations): 3 hours per pin pile with a maximum of four pin piles installed per day, i.e., 12 hours active piling time per 24 hours.
Maximum piling duration (WTG and OSP)	WTG Option B (45 WTG monopile foundations) and Option C (39 WTG monopile foundations) and one OSP: installed over **57 days over 4 months** (piling schedule S2) during the construction period.	WTG Option A (50 WTG jacket foundations) and one OSP: installed over **125 days over 19 months** (piling schedule S9) during the construction period.

Receptor sensitivity and functional hearing groups

4.16.49 Fish and shellfish species vary in their sensitivity to noise due to differences in the morphology of their auditory structures. Fish and shellfish species sense underwater noise by detecting the acoustic pressure and/ or the particle motion element of a sound field[18]. All fish species can sense particle motion, while only some groups can also detect sound pressure. Elasmobranchs are also considered capable of detecting particle motion; studies on various species have shown them to be less sensitive that teleost fish across a range of frequencies (Casper *et al.*, 2012).

4.16.50 Particle motion is primarily detected by sensory organs within the inner ear called the otolith organs. These contain numerous mechanosensory hair cells that are in close contact with a dense calcium-carbonate structure, the otolith. Mechanical energy such as particle motion leads to differential motion between the otolith and the sensory hairs cells, resulting in the deformation of the hair cells and the subsequent release of neurotransmitters, which initiates the transmission of the sound signal to the brain (Popper and Hawkins, 2019; Putland *et al.*, 2019). A secondary means by which fish can detect particle motion is the lateral line (Popper and Hawkins, 2019). Lateral lines run along the body and are comprised of sensory epithelial cells that can detect vibration and pressure changes over short ranges. Lateral lines are known to be used to detect prey, and for predator avoidance in the near field (Higgs and Radford, 2013).

4.16.51 The ability of fish to utilize sound pressure in hearing depends on several factors, with the key factors being:

- Presence and size of a swim bladder or other gas-filled cavities. Pressure waves impinging upon a fish cause gas-filled chambers, such as the swim bladder, to oscillate, which allows the pressure component of the sound field to be converted into particle motion, which can then be detected by the inner ear (Higgs *et al.*, 2004; Popper and Hawkins, 2019); and
- Mechanical coupling of the swim bladder to the ear, present in some species, such as herring, where the sound pressure energy is transmitted directly from the swim bladder to inner ear (Popper and Hawkins, 2019).

[18] Acoustic pressure is the stress (or energy) level imposed on an individual through the sound and is measured in terms of force per unit area, typically either in N/m^2 or Pascal (Pa). In contrast, particle motion describes the back-and forth movement of water, substrate or other media as a sound wave passes; it contains information on the directionality of the sound wave and can be measured as the displacement (m), velocity (m/s), or acceleration (m/s2) of particles in the sound field (Popper et al., 2014).

4.16.52 The sensitivity of fishes to sounds is strongly dependent upon the morphology of their auditory structures, which determines the range of frequencies (or bandwidth) over which a species is able to detect sound and the lowest sound level that they can perceive, which is known as the hearing threshold. Fish species in which hearing is enhanced through the presence of swim bladder are more sensitive to underwater noise than species without a swim bladder owing to their wider hearing bandwidths and lower hearing thresholds. Mechanical links between the swim bladder and the sensory organs in the inner ear allow sound signals to be transmitted without attenuation, further increasing the sensitivity to noise (Popper and Hawkins, 2019).

4.16.53 For the impact assessment, the fish and elasmobranch VERs were grouped into four groups based on their sound detection mechanism and hearing capabilities, following the categories recommended by Popper *et al.* (2014) and Popper and Hawkings (2019) (Table 19). It is important to note that there are differences in impact thresholds for the different hearing groups, with the exception of Groups 3 and 4. It is on this basis, that Groups 3 and 4 are assessed together, although additional sensitivity scores have been assigned to Group 4 receptors where appropriate. Eggs and larvae are considered separately in the assessment (as recommended by Popper *et al.*, 2014) due to reduced mobility, and small size, and lack of peer reviewed literature on the responses of eggs and larvae to man-made underwater noise sources.

4.16.54 There are limited data on the hearing abilities of marine turtles, their uses of sound and their sensitivity to sound exposure. Examinations of green and loggerhead sea turtles (Lenhardt *et al.*, 1985; Ridgway *et al.*, 1969; Wever, 1978) revealed marine turtles to possess a reptilian ear with underwater adaptations that allow the retention of air in the middle ear, suggesting the ability to detect sound pressure waves. The current standing in the scientific community is that fish hearing as opposed to mammalian hearing is the preferred model for marine turtles until more data becomes available (Popper *et al.*, 2014).

Table 19 Hearing categories of fish and shellfish receptors (Popper *et al.,* 2014; Popper and Hawkins, 2019)

Category	Fish receptors relevant to Dublin Array
Group 1: Fishes lacking swim bladders or other gas chambers. These species are sensitive only to sound particle motion within a narrow band of frequencies. Some barotrauma may occur from the exposure to sound pressure.	Lemon sole, common dab, plaice, witch flounder, sandeel, Atlantic mackerel, Atlantic horse mackerel, elasmobranchs (small-spotted catshark, tope, nursehound, spiny dogfish, starry smooth-hound, skate species, basking shark), river and sea lamprey
Group 2: Fishes with a swim bladder or other gas filled cavities that are not involved in hearing. Hearing in these species only involves sound particle motion within a narrow band of frequencies. Some barotrauma may occur from the exposure to sound pressure.	Atlantic salmon, brown/sea trout

Category	Fish receptors relevant to Dublin Array
Group 3: Fishes with swim bladders that are close but not intimately connected to the ear. These species can detect both particle motion and sound pressure and show a more extended frequency range than groups 1 or 2, extending up to about 500 Hz. These species are susceptible to barotrauma.	Atlantic cod, poor cod, haddock, whiting, European eel*, anglerfish*
Group 4: Fishes that have special structures mechanically linking the swim bladders to the ear. These species are sensitive primarily to sound pressure, although they also detect sound particle motion. They have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in groups 1, 2, or 3. These species are susceptible to barotrauma.	Herring, sprat, twaite shad
Marine turtles	Leatherback turtle, loggerhead turtle, Kemp's Ridley turtle, hawksbill turtle, green turtle.
Eggs and larvae	Species with spawning grounds in the study area.
Shellfish	All shellfish VERs.

* Denotes uncertainty or lack of current knowledge with regards to the potential role of the swim bladder in hearing.

Noise impact criteria

4.16.55 The range of potential effects from intense sound sources, such as pile driving and underwater explosions, includes immediate death, permanent or temporary tissue damage, temporary shifts in hearing, and behavioural changes and masking effects (Popper *et al.*, 2014).

4.16.56 The extent to which underwater sounds might cause an adverse environmental impact in a particular fish or shellfish species is dependent upon the level of sound pressure or particle motion, its frequency, duration and/or repetition (Hastings and Popper, 2005). In general, physical injuries as a result of underwater noise are either related to a sudden, large pressure change (barotrauma) or to the total quantity of sound energy received by a receptor over a period of time. Barotrauma injury can result from exposure to a high intensity sound even if the sound is of short duration. However, when considering injury occurring due to the energy of an exposure, the time of the exposure becomes important.

4.16.57 The range of potential effects on fish, shellfish and marine turtle receptors can be grouped into the following effect categories (Popper *et al.*, 2014):

- **Mortality and potential mortal injury:** Exposure to sound may result in instantaneous or delayed mortality through physical trauma to organs and tissues such as the swim bladder. The potential for mortality or mortal injury is likely to only occur in extreme proximity to intense sounds, such as those emitted during pile driving. For mobile species, the risk of mortality and potential mortal injury occurring will be reduced by use of soft start techniques at the start of the piling sequence. This means that fish in close proximity to piling operations will move outside of the impact range before noise levels reach a level likely to cause irreversible injury.

- **Recoverable injury:** Recoverable injury is a survivable injury with full recovery occurring after exposure, although decreased fitness during the recovery period may result in increased susceptibility to predation or disease (Popper *et al.*, 2014). The impact ranges for recoverable injury and mortality/potential mortal injury are more or less the same due to the sound thresholds used. The potential for recoverable injury is likely to only occur in extreme proximity to the pile, although for mobile species the risk of this occurring will be reduced by use of soft start techniques at the start of the piling sequence. This means that fish in close proximity to piling operations will move outside of the impact range before noise levels reach a level likely to cause recoverable injury.

- **Temporary Threshold Shift (TTS):** TTS is a temporary reduction in hearing sensitivity caused by exposure to intense sounds or sounds of long duration (e.g., tens of minutes to hours). TTS has been demonstrated in some fishes, resulting from the loss or damage of sensory hair cells of the inner ear and/or damage to auditory nerves. However, sensory hair cells are constantly added to fishes and are replaced when damaged, and therefore the extent of TTS is of variable duration and magnitude. Normal hearing ability returns following cessation of the noise causing TTS, though the recovery period is variable between species, lasting between a few hours to several days. When experiencing TTS, fish may have decreased fitness until hearing recovers, due to a reduced ability to communicate, detect predators or prey, and/or assess their environment (Popper and Hawkins, 2019).

- **Behavioural effects:** Behavioural effects as a result of construction related underwater noise include a wide variety of responses including startle responses (C-turn), strong avoidance behaviour, changes in swimming or schooling behaviour, or changes of position in the water column (e.g., Hawkins *et al.*, 2014). Depending on the intensity, timing and duration of exposure there is the potential for some of these responses to lead to significant effects at an individual level (e.g., reduced fitness, increased susceptibility to predation) or at a population level (e.g., interference with foraging, avoidance or delayed migration to key spawning grounds) (e.g., Popper and Hawkins, 2019). Some behavioural responses may only be short-term with no wider effects for the individual or population, particularly once acclimatisation to the sound has taken place (Popper and Hawkins, 2019). There is also evidence that behavioural responses can vary depending on the activity in which the receptors are engaged during sound emission (Skaret *et al.*, 2005). For example, Wardle *et al.,* 2001 have shown that the interaction between hearing and vision can alter the response to a noise source, with fish responses to a seismic airgun being greater when the airgun was visible. Even when disturbed by a noise source, fish rapidly returned to the swimming track they were on prior to the noise source within seconds or minutes following exposure (Wardle *et al.*, 2001). As such, the context in which a fish is exposed to underwater noise is as important if not more so than the received sound level.

4.16.58 Quantitative noise thresholds for the onset of mortality, recoverable injury and TTS in fish have been recommended by Popper *et al.* (2014) for a range of noise sources. Table 20 lists the respective thresholds for sounds emitted during impact piling; the corresponding thresholds for continuous (non-impulse) noise sources and sound from explosions are included in the Underwater Noise Modelling Report. These thresholds represent current best practice sound exposure criteria for fish and have consequently been applied in the impact assessment.

4.16.59 Popper *et al.* (2014) present impact thresholds for pile driving as both single strike, unweighted peak Sound Pressure Levels (SPL_{peak}) and cumulative unweighted Sound Exposure Levels (SEL_{cum}). SPL_{peak} represents the maximum sound energy level of individual impulse sounds measured as differential pressure from positive to zero. This is calculated using the maximum variation of the pressure from above zero within the sound wave, representing the maximum change in pressure as the pressure wave passes a fixed point. By contrast, SEL_{cum} is a measure of the accumulated sound energy an animal is exposed to over an exposure period. It takes account of repeated impulsive sounds such as those emitted during pile driving (Popper *et al.*, 2014), and as such enables an assessment of the impact of the total energy received by a receptor over a set time period, such as a full piling sequence. The dual criteria of SPL_{peak} and SEL_{cum} are commonly used to assess the risk of mortality and injury to marine receptors to multiple impulsive sounds. For single impulsive sound events, such as triggered underwater explosions during the clearance of UXO, Popper *et al.* (2014) recommend the use of SPL_{peak} thresholds, while impact thresholds for continuous sounds (e.g., from shipping) are typically presented as root-mean-square (rms) sound pressure levels (SPL_{rms}), which represent the average of the sound pressure over a specified time interval.

4.16.60 It is important to note that all recommended impact criteria are based on received sound pressure levels. However, as discussed previously, many species of fish only detect particle motion rather than acoustic pressure (e.g., Popper and Hawkins, 2019). Modelling of particle motion in the marine environment and research into the effects of particle motion on fish and shellfish species are scarce, with no criteria for assessment currently available. Therefore, the Popper *et al*. (2014) guidance is still recommended as the most suitable reference source for assessing impacts of underwater noise on fish (Popper and Hawkins, 2019).

4.16.61 Existing measurements of particle motion indicate a rapid attenuation of particle motion with distance from piling operations. For example, Mueller-Blenkle *et al.* (2010) demonstrated a rapid attenuation of particle motion up to 30 m from a piling sound play-back source and slower reduction beyond that distance. This is supported by a study conducted by Ceraulo *et al.* (2016), whereby measurements of piling operations within a flooded dock (with a simulated seabed area) were taken at different ranges. The SEL for particle motion was found to be 102 dB re 1 nanometre per second (nm/s) at a distance of 2 m from the pile and this dropped to 86 dB re 1 nm/s at 30 m.

4.16.62 It should be acknowledged, however, that predicting the levels of particle motion from anthropogenic sound sources in the marine environment is difficult. There are limited data available on which predictions can be based, with a range of data that are not directly applicable to offshore wind turbine foundations installation. For example, in the case of Ceraulo *et al.* (2016), measurements were taken from the piling of small piles within a flooded dock. The movement of particles within a tank or other small-scale systems differs from the open ocean; additionally, the agitation of particles also differs between the use of a speaker, as used by Mueller-Blenkle *et al.* (2010) and the piling of a pile with an exposed length in a water column.

4.16.63 Nevertheless, current evidence shows that particle motion dominates the acoustic information within the area close to the sound source, while at larger distances from the sound source the majority of the acoustic information is dominated by the propagating pressure wave (Radford *et al.*, 2012). This indicates that particle motion effects are contained within the sound pressure impact ranges, and therefore the lack of quantitative thresholds for particle motion is not expected to alter the conclusions of the impact assessment.

4.16.64 There are also no quantitative thresholds advised to be used to assess behavioural effects; however, Popper *et al.* (2014) provide qualitative behavioural criteria for fish from a range of sources. These categorise the risks of effects in relative terms as 'high', 'moderate' or 'low' at three distances from the noise source: near (10s of metres), intermediate (100s of metres), and far (1000s of metres), respectively (Table 20). Given the current absence of quantitative thresholds to assess behavioural effects, a separate qualitative assessment has been undertaken below.

4.16.65 There is also a lack of data on the effects of pile driving on marine turtles; however, Popper *et al.* (2014) proposes the adoption of underwater noise thresholds for Group 2 fish as a precautionary approach. Due to their rigid external anatomy, it is considered likely that marine turtles are highly protected from impulsive sound effects, such as those from pile driving.

4.16.66 Information on the impact of underwater noise on marine invertebrates is also scarce, and no attempt has been made to set quantitative or qualitative exposure criteria (Hawkins and Popper, 2014). Therefore, an assessment has been based on a review of peer-reviewed literature on the current understanding of the potential effects of underwater noise on shellfish species. Studies on marine invertebrates have shown sensitivity of marine invertebrates to substrate borne vibration (Roberts *et al.*, 2016). It is generally their hairs which provide the sensitivity, although these animals also have other sensory systems that could be capable of detecting vibration. It has also been reported that slow rolling interface waves that move out from a source like a pile driver can produce large particle motion amplitudes, which can travel considerable distances (Hawkins and Popper, 2016), with implications for demersal and sediment dwelling shellfish (e.g., Nephrops), particularly those located in close proximity to piling operations.

Table 20 Impact thresholds used in the assessment of piling noise on fish and shellfish VERs (Popper *et al.*, 2014)

Hearing group	Mortality and potential mortal injury	Recoverable injury	TTS	Behavioural changes
Group 1	> 219 dB SEL_{cum} or > 213 dB SPL_{peak}	> 216 dB SEL_{cum} or > 213 dB SPL_{peak}	>> 186 dB SEL_{cum}	N - High I - Moderate F - Low
Group 2	210 dB SEL_{cum} or > 207 dB SPL_{peak}	203 dB SEL_{cum} or > 207 dB SPL_{peak}	> 186 dB SEL_{cum}	N - High I - Moderate F - Low
Groups 3 and 4	207 dB SEL_{cum} or > 207 dB SPL_{peak}	203 dB SEL_{cum} or > 207 dB SPL_{peak}	186 dB SEL_{cum}	N - High I - High F - Moderate
Marine turtles	210 dB SEL_{cum} or > 207 dB SPL_{peak}	N - High I - Low F - Low	N - High I - Low F - Low	N - High I - Moderate F - Low
Eggs and Larvae	> 210 dB SEL_{cum} or > 207 dB SPL_{peak}	N - Moderate I - Low F - Low	N - Moderate I - Low F - Low	N - Moderate I - Low F - Low

Notes: Sound levels are usually expressed in decibel (dB) with respect to a reference value. For underwater sounds, the reference value is 1 micropascal (µPa). SPL_{peak} values are presented as dB re 1 µPa; SEL_{cum} values are represented as dB re 1µPa^2. Decibels are expressed on a logarithmic scale, which means that a 6 dB increase equates to a doubling of the loudness of the sound, and, as such, small changes in higher numerical dB values can equate to significant increases in loudness.
For qualitative assessments, the relative risk (high, moderate, low) is given at three distances from the sound source, defined in relative terms as near (N), intermediate (I) and far (F).

Predicted impact ranges

4.16.67 To determine potential spatial extent of underwater noise for the different effect categories listed in Table 20, noise modelling has been undertaken for two representative locations at opposite corners of the array area (north-west and south-east). For fish receptors, the modelling provides impact ranges for 'instantaneous' SPL_{peak} and SEL_{cum}, the latter for both fleeing receptors (with the receptors assumed to flee from the noise source at a consistent rate of 1.5 m/s) and stationary receptors to account for spawning activity of less mobile demersal spawners and for less mobile receptors such as eggs and larvae. Of the fish receptors included in the impact assessment, sandeel and herring are considered a stationary receptor on the basis that they exhibit strong substrate dependence for all or part of their life cycle, respectively. All received sound levels and impact ranges were calculated considering soft-start procedures, the total duration of piling, maximum hammer strike rates and the use of a noise abatement system (NAS) that reduces the expected sound levels from pile strikes by at least 10 dB.

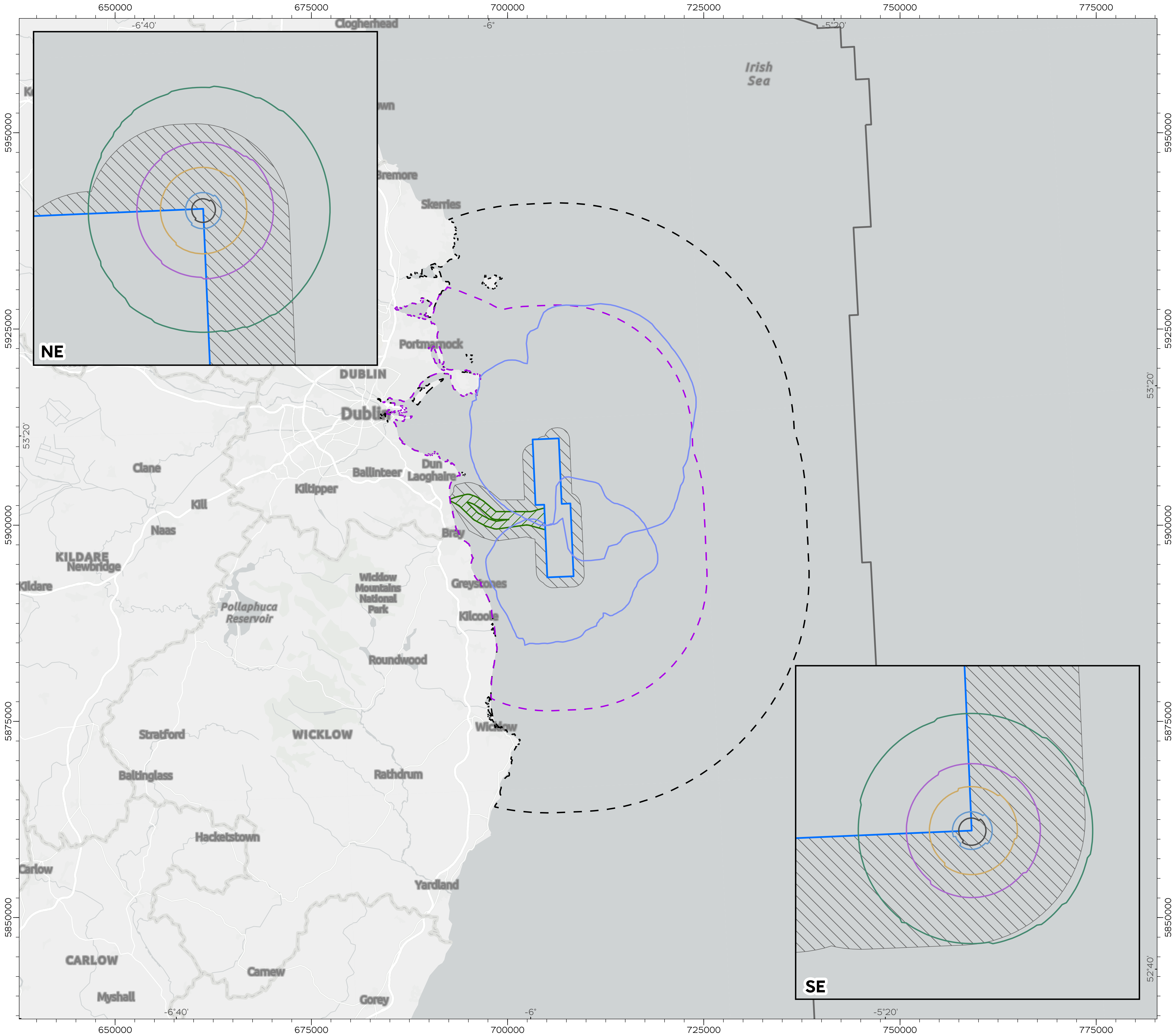
4.16.68 The results of the noise modelling for the piling of foundations are presented in Table 21 for each of the relevant impact thresholds recommended by Popper *et al.* (2014). The predicted maximum impact ranges for the onset of mortality and potential mortal injury, recoverable injury and TTS from piling operations are shown for stationary receptors in Figure 10 and Figure 11, and for fleeing receptors in Figure 12 and Figure 13. Note that modelled impact ranges less than 100 m from the piling source are not shown in the figures.

Table 21 Modelled maximum impact ranges for fleeing and stationary receptors from the piling of foundations within the array area

Criteria	Impact threshold	Maximum impact range[19] Monopile foundation NE	SE	Jacket foundation NE	SE
Mortality and Potentially Mortal Injury					
SPL_{peak}	213 dB	< 50 m	< 50 m	< 50 m	< 50 m
SPL_{peak}	207 dB	70 m	60 m	60 m	60 m
SEL_{cum} (static)	219 dB	200 m	180 m	350 m	280 m
SEL_{cum} (fleeing)	219 dB	< 100 m	< 100 m	< 100 m	< 100 m
SEL_{cum} (static)	210 dB	700 m	550 m	1.4 km	980 m
SEL_{cum} (fleeing)	210 dB	< 100 m	< 100 m	< 100 m	< 100 m
SEL_{cum} (static)	207 dB	1.1 km	830 m	2.1 km	1.5 km
SEL_{cum} (fleeing)	207 dB	< 100 m	< 100 m	< 100 m	< 100 m
Recoverable Injury					
SPL_{peak}	213 dB	< 50 m	< 50 m	< 50 m	< 50 m
SPL_{peak}	207 dB	70 m	60 m	60 m	60 m
SEL_{cum} (static)	216 dB	300 m	250 m	550 m	430 m
SEL_{cum} (fleeing)	216 dB	< 100 m	< 100 m	< 100 m	< 100 m
SEL_{cum} (static)	203 dB	2.0 km	1.5 km	3.8 km	2.6 km
SEL_{cum} (fleeing)	203 dB	< 100 m	< 100 m	< 100 m	< 100 m
TTS					
SEL_{cum} (static)	186 dB	19.0 km	13.0 km	29.0 km	19.0 km
SEL_{cum} (fleeing)	186 dB	8.5 km	3.3 km	9.3 km	3.0 km

4.16.69 The following sections present the assessment of likely significant effects on fish and shellfish receptors for the piling of foundations, UXO clearance and other noise generating activities during the construction phase. The assessments are presented by hearing group, with consideration given to the sensitivity of the VERs within each hearing group, before characterising the scale and magnitude of the impact and providing the overall conclusion with regard to the predicted significance of effects. Of those considered, the noise source most important for the impact assessment is impact piling owing to the noise levels generated and the duration noise will be present in the marine environment. As such, likely significant effects related to impact piling have been the primary focus of the impact assessment.

[19] The Applicant commits to the use of noise mitigation technology to reduce the source level of the underwater noise from pile driving by at least 10 dB. The modelling results presented in Table 21 are based on a 10 dB reduction in source noise levels.



- Array Area
- Temporary Occupation Area
- Export Cable Corridor
- Sedimentary ZoI (17km)
- Underwater Noise ZoI (30km)
- EEZ Boundary

Monopile SELcum Stationary - 6,372 kJ Hammer Energy

- 186
- 203
- 207
- 210
- 216
- 219

DRAWING STATUS

FINAL

MAP NOTES / DATA SOURCES:

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Predicted Maximum Impact Ranges for Stationary Receptors from the Piling of Monopile Foundations within the Array Area (6,372 KJ)

DRAWING NUMBER: 10

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 5 10 15 20 km
0 2.5 5 7.5 10 nm

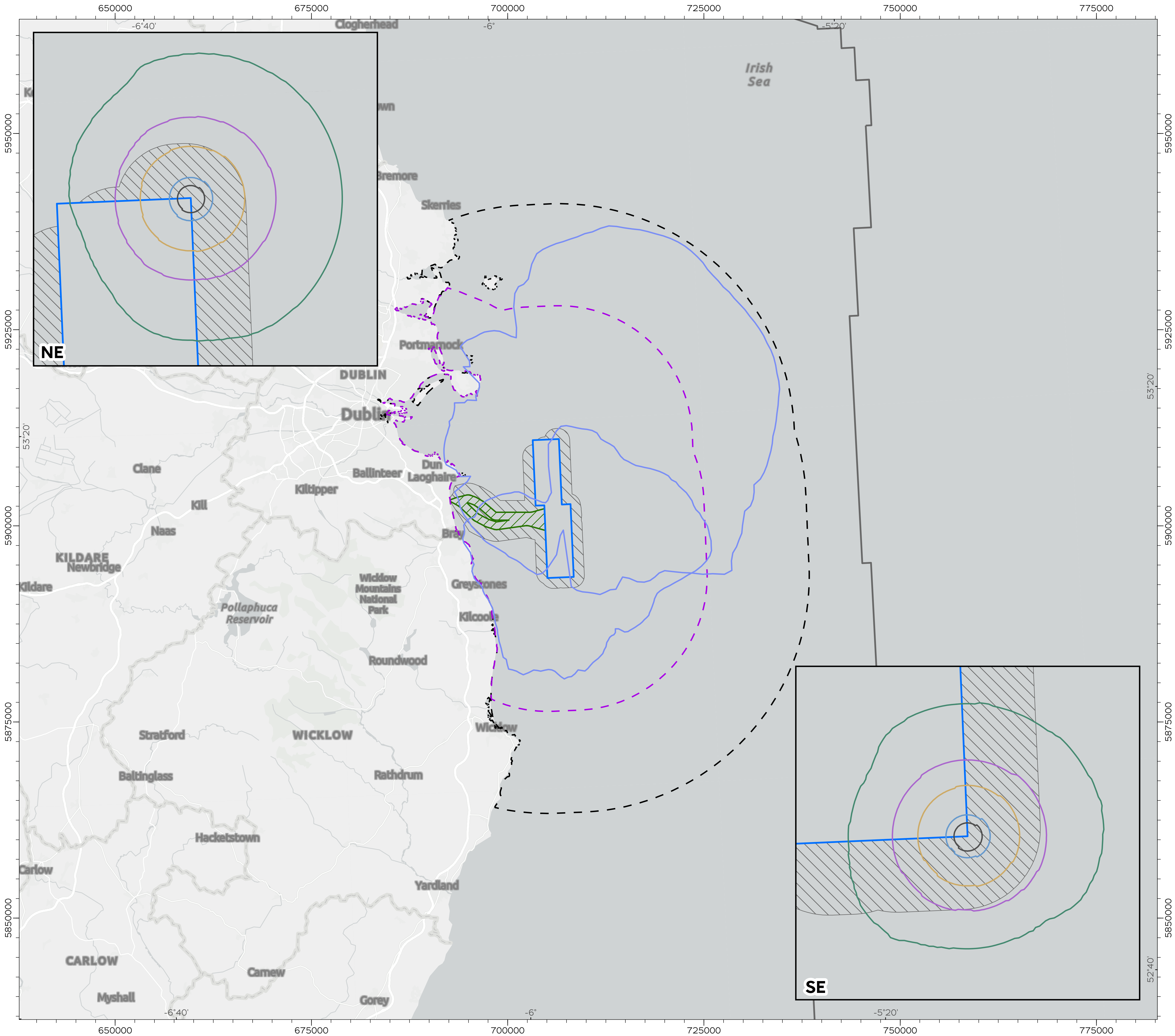
N GRID NORTH

SCALE	1:500,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array Generation for generations

Kish Offshore Wind Limited - Bray Offshore Wind Limited



- Array Area
- Temporary Occupation Area
- Export Cable Corridor
- Sedimentary ZoI (17km)
- Underwater Noise ZoI (30km)
- EEZ Boundary

Jacket SELcum Stationary - 4,695 kJ Hammer Energy

- 186
- 203
- 207
- 210
- 216
- 219

DRAWING STATUS

FINAL

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Predicted Maximum Impact Ranges for Stationary Receptors from the Sequential Piling of Jacket Foundations within the Array Area (4,695 KJ)

DRAWING NUMBER: 11

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 5 10 15 20 km
0 2.5 5 7.5 10 nm

N
GRID NORTH

SCALE	1:500,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

GoBe APEM Group

Dublin Array
Generation for generations
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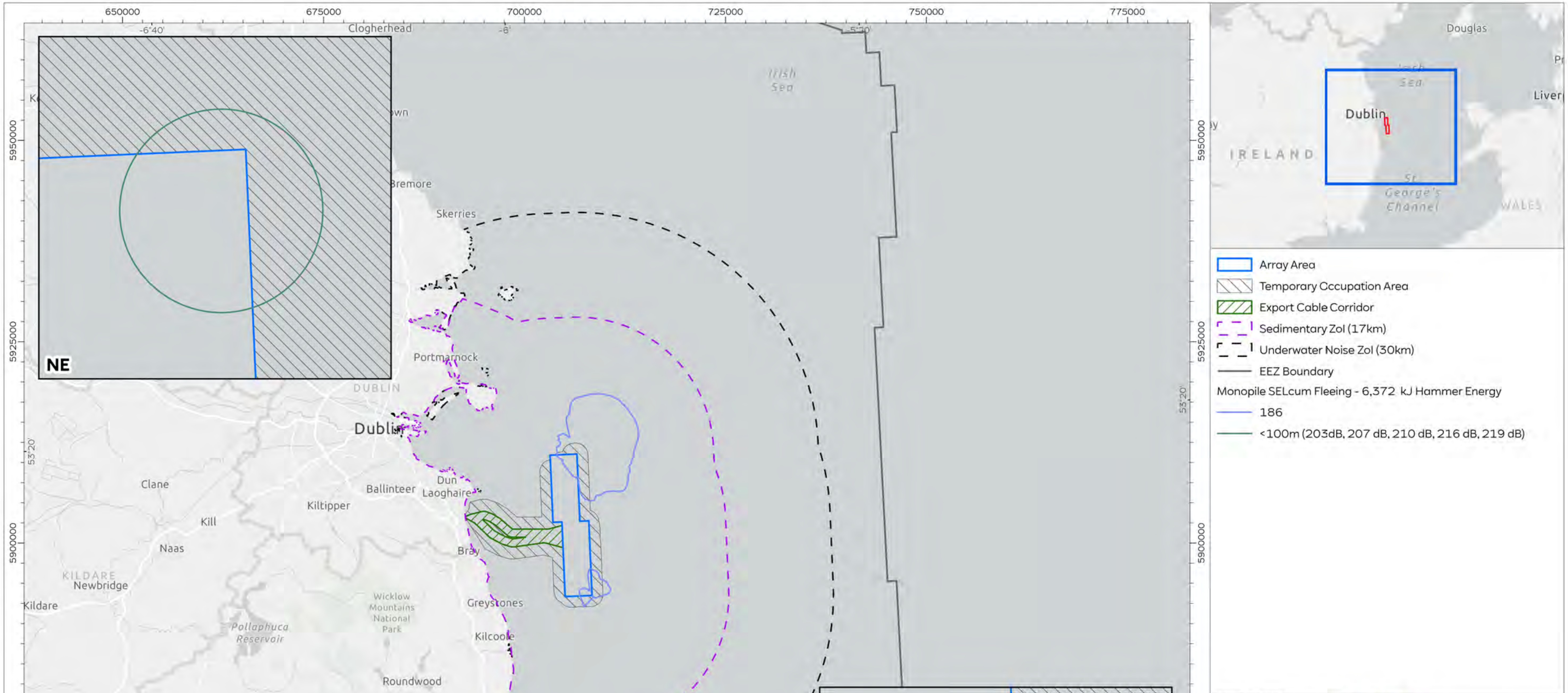

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Predicted Maximum Impact Ranges for Fleeing Receptors from the Piling of Monopile Foundations within the Array Area (6,372 KJ)

DRAWING NUMBER: 12

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

SCALE	1:500,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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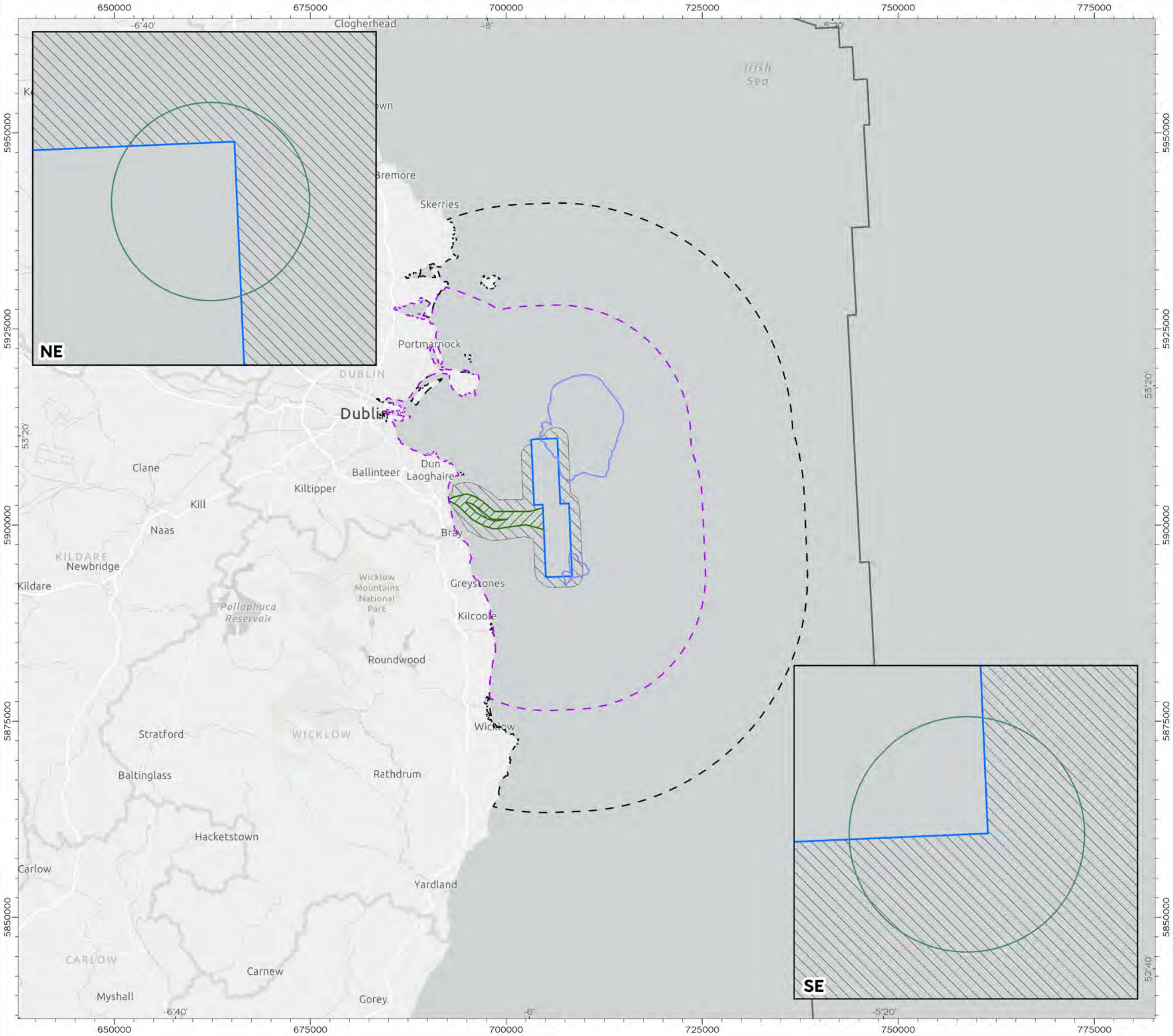

Legend	
	Array Area
	Temporary Occupation Area
	Export Cable Corridor
	Sedimentary ZoI (17km)
	Underwater Noise ZoI (30km)
	EEZ Boundary
Jacket SELcum Fleeing - 4,695 kJ Hammer Energy	
	186
	<100m (203 dB, 207 dB, 210 dB, 216 dB, 219 dB)

DRAWING STATUS

FINAL

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Predicted Maximum Impact Ranges for Fleeing Receptors from the Sequential Piling of Jacket Foundations within the Array Area (4,695KJ)

DRAWING NUMBER: 13

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

SCALE	1:500,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

Generation for generations

Kish Offshore Wind Limited - Bray Offshore Wind Limited

Potential effects from underwater noise during piling on Group 1 VERs

4.16.70 The sensitivity of Group 1 VERs to piling noise and the magnitude of impact have been assessed in Table 22 and Table 23, respectively, based on the methodology outlined in Section 4.5. Avoidance and preventative measures relevant to the impact include the use of a noise reduction technology and the implementation of soft-start and ramp-up procedures during the piling of foundations (Table 11). In addition, all foundations will be installed sequentially, with no concurrent piling to be undertaken at any time.

Table 22 Determination of sensitivity of Group 1 VERs to underwater noise and vibration

Receptor	Justification
Sandeel	Group 1 VERs including sandeel lack a swim bladder and are therefore considered less sensitive to underwater noise than other species. For the purpose of this assessment, sandeel are considered a stationary receptor given their burrowing nature, substrate dependence, and demersal spawning behaviours. Sandeel are thought to be affected by vibration through the seabed, so are particularly sensitive to recoverable injury and mortality when buried in the seabed during hibernation (autumn to spring). Therefore, sandeel are assessed as having a low adaptability and low tolerance to the impact. Sandeel have a high fecundity, quick maturation and short-term egg hatching rate and therefore, recovery at the population level from any potential mortality or potential mortal injury through barotrauma is assessed to occur in the short-term (medium recoverability). No published data are available on TTS in fish from pile driving (Popper *et al.*, 2014). However, it is suggested that TTS in fishes may decrease the receptor's fitness by impairing its ability to communicate, detect predators or prey and/or assess its environment (Popper *et al.*, 2014). Existing studies suggest that fish affected by TTS recovered to normal hearing levels within 18-24 hours to several days after noise exposure, depending on the intensity and duration of exposure (Popper *et al.*, 2014; Popper and Hawkins, 2019) (high recoverability). Any potential behavioural responses are also expected to be temporary (high recoverability), with individuals anticipated to resume normal behaviours shortly after noise disturbance has ceased (e.g., Hassel *et al.*, 2004). Based on the regional importance of sandeel together with their low adaptability, low tolerance and medium (mortality and mortal injury) to high (recoverably injury, TTS, behavioural changes) recoverability, the sensitivity of sandeel to underwater noise and vibration from piling operations is deemed to be **Medium**.

Remaining Group 1 VERs	Like sandeel, the remaining Group 1 VERs lack a swim bladder and other air-filled cavities and are therefore considered less sensitive to underwater noise than other species. In addition, these receptors are mobile and would therefore be able to move away from noise disturbance with the onset of soft-start procedures, thereby reducing the likelihood of mortal injuries occurring. There is also potential for recoverable injuries and TTS in addition to behavioural responses. Therefore, the receptors have been assessed as having a medium adaptability and medium to high tolerance to the impact. As discussed previously, information on the consequences of TTS in fishes is limited; however, current evidence suggests that effects would be temporary, and these mobile receptors are expected to recover quickly, return to normal behaviours, recolonising areas shortly after disturbance (high recoverability). Taking into consideration the regional to international importance of the receptors together with their medium adaptability, medium to high tolerance, and high recoverability, the sensitivity of the remaining Group 1 VERs to underwater noise emitted during piling is deemed to be **Low**.
Maximum sensitivity	*The maximum potential sensitivity of the Group 1 receptors to underwater noise from piling is rated as **Medium**.*

Table 23 Determination of impact magnitude for Group 1 VERs for underwater noise and vibration

Definition	Maximum design option	Alternative design option
Extent	As stated above, noise modelling for piling (inclusive of monopiles and pin piles) was undertaken for both fleeing (mobile fish species) and stationary receptors (to account for spawning species, such as sandeel). Therefore, the extent of the impact from noise has been provided for both receptor types in this instance: **Mortality and Potential Mortal Injury** Underwater noise modelling predicted that mortality and potential mortal injury to Group 1 stationary receptors (sandeel) during the course of piling may occur up to 350 m from the installation of jacket foundations and up to 200 m from monopile installation (>219 dB SEL_{cum}). Mortality and potential mortal injury to fleeing receptors was predicted to occur <100 m from the noise source for both jacket foundations and monopiles. Instantaneous mortality or mortal injury is likely to occur < 50 m from the sound source during the installation of both monopile and jacket foundations (>213 dB SPL_{peak}).	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
	Recoverable Injury Recoverable injury in Group 1 stationary receptors during the course of piling was predicted to occur up to 550 m from the installation of jacket foundations and 300 m from monopiles (>216 dB SEL_{cum}). Recoverable injury in Group 1 fleeing receptors was predicted to occur <100 m from the noise source during both monopile and jacket foundation piling. Instantaneous recoverable injury may occur up to 50 m during the installation of both monopile and jacket foundations (>213 dB SPL_{peak}). **TTS** TTS in Group 1 stationary receptors was predicted to occur up to 29 km from the installation of jacket foundations and up to 19 km from monopile piling (>>186 dB SEL_{cum}). TTS in Group 1 fleeing receptors was predicted to occur up to 9.3 km from the installation of jacket foundations and up to 8.5 km from monopile piling. **Behavioural Changes** The relative risk of behavioural responses is likely to be low at distances of 1000s of metres from the sound source, moderate at intermediate distances (100s of metres), and high close to the sound source (10s of metres) (Popper *et al.*, 2014).	
Duration	The impact will occur over 19 months during the piling of jacket foundations and over four months during the piling of monopile foundations. The impact will therefore be temporary (less than one year in the case of installing monopile foundations) to short-term (one to seven years in the case of installing jacket foundations).	Under the alternative design options, fewer WTGs will be installed, resulting in fewer piling days.
Frequency	The impact will occur intermittently during the construction phase.	In line with the maximum design option.
Consequences for Group 1 VERs		
Sandeel	Impacts from piling may cause mortality or potential mortal injury in the near-field and other temporary physiological and behavioural changes in the near-field and far-field. The largest impact ranges were predicted for sandeel, based on the stationary receptor modelling. As discussed previously, suitable sandeel habitats are located across most of the array area and it is therefore likely that sandeel would be affected by piling noise, in particular during their hibernation period between autumn and spring.	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
	Analysis of PSA data further indicates the presence of suitable sandeel substrates outside the array area, including within the Offshore ECC and the sedimentary ZoI outside of the areas where sandeel might potentially experience mortal or recoverable injuries (Figure 6). Therefore, any potential mortality and/ or recoverable injuries are anticipated to be small in the context of the sandeel population in the study area and wider environment. Based on this and given the intermittent and short-term nature of the impact, any potential mortality or potential mortal injury and recoverable injury to sandeel during impact piling is considered to be barely discernible from baseline conditions, and the magnitude of the impact is deemed to be **Low adverse**. Similarly, any TSS and/or behavioural responses are assessed to be barely discernible from baseline conditions given the wide distribution of potential sandeel habitats including spawning substrates. In addition, the modelled maximum impact ranges for the onset of TTS / hearing damage of stationary Group 1 receptors such as sandeel are based on sound levels of 186 dB SEL_{cum}. However, current evidence suggests that higher sound levels are likely to be needed to induce TTS in Group 1 receptors (i.e., the onset threshold for TTS is likely to be much higher than 186 dB SEL_{cum}) (Popper *et al.*, 2014). Therefore, the modelled impacts ranges are likely to overestimate the spatial area over which TTS in sandeel might occur. Factoring in the above and considering the intermittent nature of the impact and the temporary nature of the effects, the magnitude of any potential TTS and behavioural reactions in sandeel is deemed to be **Low adverse**.	
Pelagic and demersal Group 1 VERs	The Group 1 pelagic and demersal VERs are all pelagic spawners and are therefore not limited to specific sedimentary areas for spawning, and consequently they are considered likely to move away during soft-start procedures before sound pressure reaches levels that could cause lethal or recoverable injuries. The respective spawning and nursery grounds of the VERs are distributed widely within the study area and across the western Irish Sea (Figure 2 to Figure 5). Based on this together with the localised nature of any potential mortality and/ or recoverable injury and the short-term and intermittent nature of the impact, any effects upon Group 1 receptors are assessed to be barely discernible from baseline conditions, and therefore the magnitude of the impact is deemed to be **Low adverse**.	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
	Similarly, any TSS and/or behavioural responses are assessed to be barely discernible from baseline conditions given the wide distribution of the receptors including spawning and nursery grounds and considering the intermittent nature of the impact and the temporary nature of the effects. Consequently, the magnitude of any potential TTS and behavioural reactions is also deemed to be **Low adverse**.	
Diadromous VERs	The Group 1 diadromous VERs include the two lamprey species with marine life stages, river lamprey and sea lamprey. Current evidence suggests that hearing in lamprey species is limited to low frequency sounds up to about 300 Hz (Mickle *et al.*, 2019). Low frequency tones within the hearing range of lampreys have been shown to disrupt normal behaviour in juvenile and adult sea lamprey, initiating an increase in swimming behaviour and a decrease in resting behaviour (Mickle *et al.*, 2019). While pile driving typically generates broadband sounds over a wider frequency range, there is potential for lamprey species to exhibit behavioural responses during pile driving. River lamprey are reported to typically remain in estuarine areas during their marine stage (Maitland, 2003). This suggests that the predicted impact ranges for the onset of mortality and recoverable injuries (Figure 12 and Figure 13) do not overlap with the areas of primary importance for river lamprey. Therefore, and given their low susceptibility to pressure-related injuries, the risk of lethal or sublethal physical injuries to river lamprey during piling is assessed as low. Any potential TTS or behavioural response would be temporary. Based on this, and considering the intermittent and short-term nature of piling, the magnitude of the impact for this species is deemed to be at most **Low adverse**.	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
	Sea lamprey are much more widely distributed during their marine stage, and have been found within shallow coastal regions and deep offshore waters (Maitland, 2003). It is therefore assumed that there is a higher potential for sea lamprey to be present within the study area during piling activities. Sea lamprey are not thought to specifically migrate back to their natal rivers (Bergstedt and Seelye, 1995; Waldman *et al.*, 2008); instead, they are thought to return to rivers within the regional area, navigating primarily by detection of larval pheromones within shallow coastal waters to identify suitable rivers (reviewed in Hansen *et al.*, 2016). This flexibility in migration behaviour suggests that underwater noise will not result in a barrier effect to any upstream or outgoing migration preventing the receptors from accessing a particular river to breed. In addition, like all Group 1 receptors, the risk of lethal or sub-lethal physical injuries in sea lamprey during piling is assessed as low, based on the receptor's low susceptibility to pressure-related injuries. Based on this and considering the intermittent and short-term nature of piling, any potential effects on sea lamprey from piling noise are considered to be barely discernible from baseline conditions, and consequently the magnitude of the impact for this species is deemed to be **Low adverse**.	
Overall magnitude	*The potential magnitude of the predicted changes for Group 1 receptors is rated as **Low adverse**.*	*The potential magnitude of the predicted changes for Group 1 receptors is rated as **Low adverse**.*

Significance of effects

4.16.71 The maximum magnitude of the impact for Group 1 receptors has been assessed as **Low adverse**, with the maximum sensitivity being **Medium**. Therefore, the maximum significance of effects on Group 1 VERs from underwater noise generated during piling is **Slight adverse**, which is not significant in EIA terms.

4.16.72 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Potential effects from underwater noise during piling on Group 2 VERs

4.16.73 The sensitivity of Group 2 VERs to piling noise and the magnitude of impact have been assessed in Table 24 and Table 25, respectively, based on the methodology outlined in Section 4.5. Avoidance and preventative measures relevant to the impact include the use of a noise reduction technology and the implementation of soft-start and ramp-up procedures during the piling of foundations (Table 11). In addition, all foundations will be installed sequentially, with no concurrent piling to be undertaken at any time.

Table 24 Determination of sensitivity of Group 2 VERs to underwater noise and vibration

Criteria	Justification
Atlantic salmon, sea trout	Group 2 species identified as of relevance to the proposed development are Atlantic salmon and sea trout. Both species are considered to primarily sense underwater sounds through particle motion despite the presence of a swim bladder (Popper *et al.*, 2014). Evidence suggests that the presence of a swim bladder increases the likelihood of injury to body tissues as sound-induced volume changes to the swim bladder can damage nearby organs (Popper *et al.*, 2014). As such, Group 2 receptors are generally considered more susceptible to recoverable and potential mortal injuries in comparison to Group 1 receptors (Popper and Hawkins, 2019). However, given their mobile nature, Atlantic salmon and sea trout would be able to adapt their behaviour and vacate the area during soft-start procedures to avoid mortal or recoverable injuries. Therefore, like fleeing Group 1 receptors, Atlantic salmon and sea trout are considered to have a medium adaptability to the impact. Given their general higher susceptibility to pressure-related injuries, the tolerance of these receptors to mortality and potential mortal injury and recoverable injury impact is deemed to be medium. TTS and behavioural responses might occur, with any TTS likely to be temporary (Popper *et al.*, 2014). Few studies have investigated behavioural reactions of sea trout and Atlantic salmon to piling noise, providing unconclusive results with some studies showing a lack of behavioural responses and others reporting changes in the abundance and distribution of Atlantic salmon due to avoidance reactions (reviewed by Gillson *et al.*, 2022). There is, however, evidence that behavioural responses in fish as a result of underwater noise might be reduced when fish are engaged in life history critical activities such as spawning and feeding (e.g. Doksaeter *et al.*, 2009; Pena *et al.*, 2013; Skaret *et al.*, 2005). While a similar damping of behavioural reactions might occur in sea trout and Atlantic salmon during migration, the implications of experiencing temporary avoidance or stress responses remain not fully understood, and it cannot be excluded that such responses delay migration in the short-term. Based on this, the receptors are assessed as having a medium tolerance to TTS and behavioural changes. Taking into consideration the regional importance of sea trout together with their medium adaptability, medium tolerance, and medium recoverability, the sensitivity of sea trout to underwater noise from impact piling is deemed to be **Low**. Based on the national and international importance of Atlantic salmon, the sensitivity of this receptor is rated as **Medium**.

Table 25 Determination of impact magnitude for Group 2 VERs for underwater noise and vibration

Definition	Maximum design option	Alternative design option
Extent	Both Atlantic salmon and sea trout are considered fleeing receptors within this assessment, as they are both mobile species. Therefore, the magnitude of impact on static Group 2 receptors is not considered. **Mortality and Potential Mortal Injury** Mortality and potential mortal injury to Group 2 fleeing receptors was predicted to occur <100 m from the noise source from monopile and jacket foundation piling (210 dB SEL_{cum} and >207 dB SPL_{peak}). **Recoverable Injury** Recoverable injury in fleeing Group 2 receptors was predicted to occur <100 m from the noise source from monopile and multileg foundation piling (>203 dB SEL_{cum} and >207 dB SPL_{peak}). **TTS** Based on the 186 dB SEL_{cum} threshold, TTS in Group 2 fleeing receptors was predicted to occur up to 9.3 km from the installation of jacket foundations and up to 8.5 km from monopile piling. Like Group 1 receptors, the threshold for the onset of TTS in Group 2 receptors is >186 dB SEL_{cum}, meaning that sound levels larger than 186 dB would be needed to induce TTS. Therefore, the modelled TTS impact ranges for Group 2 receptors are precautionary and the maximum ranges over which TTS may be experienced will likely be smaller than the ranges presented above. **Behavioural Changes** Considering the Popper *et al.* (2014) criteria, any risk of behavioural effects in Group 2 species from piling is expected to be high near the sound source (10s of metres), moderate at intermediate distances (100s of metres), and low at far distances (1000s of metres).	In line with the maximum design option.
Duration	The impact will occur over 19 months during the piling of jacket foundations and over four months during the piling of monopile foundations. The impact will therefore be temporary (less than one year in the case of installing monopile foundations) to short-term (one to seven years in the case of installing jacket foundations).	Under the alternative design options, fewer WTGs will be installed, resulting in fewer piling days.
Frequency	The impact will occur intermittently during the construction phase.	In line with the maximum design option.

Consequences for Group 2 VERs		
Atlantic salmon	As outlined above, there is potential for Group 2 fleeing receptors to experience mortality, potential mortal injury, or recoverable injury during impact piling close to the sound source (<100 m, i.e., within the near-field). Atlantic salmon smolts migrate out to sea to feed during late spring and summer and return as adults to their riverine spawning grounds mainly in late spring to early summer. As such, piling activities, which are expected to take place over a period of 19 months may coincide with the peak migration periods of Atlantic salmon. The migratory process associated with Atlantic Salmon away from coastal waters to the open ocean is generally poorly understood. However, there is evidence from tracking data that salmon smolts within the east coast of Ireland (where the study area is located) move quickly into deeper offshore waters upon leaving their home rivers (Barry *et al.*, 2020). There is therefore potential that migratory smolts from rivers on Ireland's east coast (e.g., River Dargle) would pass through the study area, including areas where noise levels may induce mortal or recoverable injuries. No information is available on the movement patterns of returning salmon; however, a similar pathway to that of outward moving smolts may be assumed. Atlantic salmon are mobile and would therefore be able to vacate the area during soft-start procedures before sounds reach levels that can cause lethal or sublethal physical injuries, thereby reducing the likelihood of mortal and/ or recoverable injuries. In addition, due to their migratory nature Atlantic salmon are anticipated to be transient across the study area, and therefore any exposure of salmon to high levels of sound pressure or particle motion is anticipated to be limited and temporary. Based on this and considering the short-term and intermittent nature of the impact together with the small area potentially affected, any potential lethal or recoverable injuries in Atlantic salmon are anticipated to be barely discernible from baseline conditions, and therefore, the magnitude for this aspect of the impact is deemed to be **Low adverse**.	In line with the maximum design option.

	There is also the potential for salmon to experience TTS or exhibit temporary avoidance reactions during piling. This is of particular concern for adult individuals returning to their natal rivers, with the potential of behavioural responses delaying migration, which subsequently may affect the reproductive success to some individuals. However, behavioural responses would be temporary, with affected individuals anticipated to resume normal behaviours and continue their migration shortly after piling has ceased, including during piling-free days. Effects of TTS would also be temporary, with existing studies suggesting that fish affected by TTS recovered to normal hearing levels within a few hours to several days after noise exposure (Popper *et al.*, 2014; Popper and Hawkins, 2019). In addition, the modelled maximum impact ranges for the onset of TTS in Group 2 receptors do not reach the coastline (Figure 12 and Figure 13), with the risk of behavioural response within nearshore areas also likely to be low. Therefore, any potential TTS and behavioural changes in Atlantic salmon during impact piling are not considered to present a long-term barrier to Atlantic salmon from accessing or leaving their natal rivers. Therefore, the magnitude of TTS and disturbance effects associated with piling on salmon is deemed to be **Low adverse**.	
Sea trout	Tracking data indicate that sea trout remain closer to their spawning rivers and swim closer to the coast and river mouths (Barry *et al.*, 2020). This suggests that sea trout might mostly avoid the area over which mortality and potential mortal injury, recoverable injury, TTS and/ or behavioural response are likely to occur (Figure 12 and Figure 13). Therefore, the magnitude of the impact for sea trout is deemed to be at most **Low adverse**.	
Overall Magnitude	*The potential magnitude of the predicted changes for Group 2 receptors is rated as **Low adverse**.*	*The potential magnitude of the predicted changes for Group 2 receptors is rated as **Low adverse**.*

Significance of effects

4.16.74 The maximum magnitude of the impact for Group 2 receptors has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Medium**. Therefore, the maximum significance of effects on Group 2 VERs from underwater noise generated during piling is **Slight adverse**, which is not significant in EIA terms.

4.16.75 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Potential effects from underwater noise during piling on Group 3 and Group 4 VERs

4.16.76 The sensitivity of Group 3 and Group 4 VERs to piling noise and the magnitude of impact have been assessed in Table 26 and

4.16.78 Table 27 respectively, based on the methodology outlined in Section 4.5. Avoidance and preventative measures relevant to the impact include the use of a noise reduction technology and the implementation of soft-start and ramp-up procedures during the piling of foundations (Table 11). In addition, all foundations will be installed sequentially, with no concurrent piling to be undertaken at any time.

Table 26 Determination of sensitivity of Group 3 and Group 4 VERs to underwater noise and vibration

Receptor	Justification
Group 3 and Group 4 VERs (except herring)	**Mortality and potential mortal injury and recoverably injury** Group 3 and Group 4 receptors have a swim bladder, which in Group 4 species is directly involved in hearing through its connection to the inner ear. These species are the most sensitive to underwater noise, with direct detection of sound pressure, rather than just particle motion. The presence of a swim bladder makes them highly susceptible to tissue damage, and given their good hearing ability, they are also at higher risk to experience TTS and behavioural effects (Popper *et al.*, 2014; Popper and Hawkins, 2019). However, all pelagic and demersal receptors are mobile and not dependent on specific sedimentary areas for spawning. Moreover, eel spawn in the Sargasso Sea, while twaite shad spawn in freshwater. Consequently, all receptors are considered able to move away from the piling location during soft-start procedures, thereby reducing the likelihood of mortal and sub-lethal injuries. Therefore, like fleeing Group 1 and 2 receptors, fleeing Group 3 and 4 receptors are considered to have a medium adaptability to the impact. Given their higher sensitivity to underwater sounds including pressure-related injuries, the tolerance of the receptors to mortality and potential mortal injury and recoverable injury is deemed to be medium to low. Recovery at the population level from any potential mortality or potential mortal injury through barotrauma is expected to occur in the short-term through recruitment in subsequent years (medium recoverability). Taking into consideration the international (European eel), European/national (twaite shad) and regional (remaining receptors) importance of the receptors together with their medium adaptability, medium to low tolerance, and medium recoverability, the sensitivity of the Group 3 and Group 4 VERs to mortal and recoverable injuries during piling is deemed to be **Medium**. **TTS and behavioural changes** Given their good hearing ability, Group 3 and Group 4 receptors are also at higher risk of experiencing TTS and behavioural effects. As discussed previously, no published data are available on TTS in fish from pile driving and the possible consequences of TTS are unknown, although it is suggested that TTS in fishes may decrease the receptor's fitness by impairing its ability to communicate, detect predators or prey and/or assess its environment (Popper *et al.*, 2014).

	Existing data suggest that while some Group 3 and Group 4 receptors (e.g., clupeids) can be highly reactive to underwater noise, the type and strength of behavioural response may vary depending on the activity individuals were involved in during noise exposure. Studies examining the effects of seismic airguns and naval sonars in herring showed strong responses during overwintering period but limited change in swimming behaviour during feeding migrations (Doksaeter *et al.*, 2009; Pena *et al.*, 2013). Similarly, strong vessel avoidance has been observed in overwintering herring period (Vabø *et al.*, 2002), while no avoidance behaviour was observed in spawning herring (Skaret *et al.*, 2005). Whilst there are currently no studies on TTS and behavioural changes in Group 3 and Group 4 fish during pile driving specifically, similar damping of behavioural reactions may occur as for other stimuli. Taking the above into consideration and considering the non-lethal nature of TTS and behavioural effects, the tolerance of the receptors to these effects is deemed to be medium. Any TTS and behavioural responses would likely be temporary (high recoverability), with affected individuals anticipated to resume normal behaviours and/ or recolonise areas shortly after piling has ceased. Taking into consideration the international (European eel, Atlantic cod), European/national (twaite shad) and regional (remaining receptors) importance of the receptors together with their medium tolerance and high recoverability, the sensitivity of the Group 3 and Group 4 VERs to TTS and behavioural changes during piling is deemed to be **Low**.
Herring	Herring are considered highly sensitive to the sound pressure component of underwater noise owing to the presence of a swim bladder and two pairs of air bubbles in the inner air that aid sound detection (Mann *et al.*, 2005; Popper *et al.*, 2022). The presence of these air-filled chambers increases their hearing sensitivities and makes them also more prone to suffer from pressure-related injuries (Popper *et al.*, 2014). Unlike the other Group 3 and Group 4 VERs, herring are demersal spawners, reliant upon the presence of suitable substrates for spawning and egg development. Therefore, the likelihood of herring leaving the area during piling may be reduced when engaged in spawning activity. However, the closest known active spawning beds for herring are located north of Dundalk Bay (Mourne ground) outside the study area (Figure 7). Therefore, no discernible changes are anticipated from piling on spawning herring. Consequently, the sensitivity of herring to the impact is rated the same as for the other Group 3 and Group 4 receptors, with the sensitivity to mortality and recoverable injuries deemed to be **Medium** and the sensitivity to TTS and behavioural changes deemed to be **Low**.
Maximum sensitivity	*The maximum potential sensitivity of the Group 3 and Group 4 receptors to underwater noise from piling is rated as **Medium**.*

Table 27 Determination of impact magnitude for Group 3 and Group 4 VERs for underwater noise and vibration

Definition	Maximum design option	Alternative design option
Extent	All Group 3 and Group 4 receptors are considered fleeing receptors, on the basis that no spawning grounds of demersal spawning receptors (e.g. herring) are located within the study area. The nearest known active herring spawning grounds are located off County Down and the northern sections of County Louth approximately 70 km to the north of the array area (ICES, 1994). Twaite shad and European eel are both migratory species and are therefore likely to be transient receptors within the site; these receptors are therefore also considered to be fleeing receptors. Therefore, the magnitude of impact for Group 3 and Group 4 receptors is assessed based on the modelling for fleeing receptors. **Mortality and Potential Mortal Injury** Mortality and potential mortal injury to Group 3 and Group 4 fleeing receptors was predicted to occur <100 m from the noise source from monopile foundations and multileg foundation piling (207 dB SEL_{cum} and >207 dB SPL_{peak}). **Recoverable Injury** Recoverable injury in fleeing Group 3 and Group 4 receptors was predicted to occur < 100 m from the noise source from monopile and multileg foundation piling (203 dB SEL_{cum} and >207 dB SPL_{peak}). **TTS** TTS in Group 3 and Group 4 fleeing receptors was predicted to occur up to 9.3 km from the installation of jacket foundations and up to 8.5 km from monopile piling (186 dB SEL_{cum}). **Behavioural Impacts** The Popper *et al.* (2014) criteria suggest that there is a high risk of behavioural reactions in Group 3 and Group 4 VERs close to the piling location (10s of metres) and at intermediate distances (100s of metres) and a moderate risk in the far-field (1000s of metres), with the level of risk based on individuals not being involved in activities with a strong biological driver (i.e., spawning or feeding) (see Table 26).	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
Duration	The impact will occur over 19 months during the piling of jacket foundations and over four months during the piling of monopile foundations. The impact will therefore be temporary (less than one year in the case of installing monopile foundations) to short-term (one to seven years in the case of installing jacket foundations).	Under the alternative design options, fewer WTGs will be installed, resulting in fewer piling days.
Frequency	The impact will occur intermittently during the construction phase.	In line with the maximum design option.
Consequences for Group 3 and Group 4 VERs		
Group 3 and Group 4 VERs	**Mortality and potential mortal injury and recoverable injury** As discussed above, there is potential for Group 3 and 4 receptors to experience mortality and potential mortal injury or recoverable injury during impact piling close to the sound source (<100 m). However, given their mobile nature, these receptors have the ability to re-locate to nearby areas during soft-start and ramp up procedures, thereby reducing the likelihood of irreversible or recoverable injuries. Given the potential for piling to occur over 19 months (piling schedule S9), receptors may be disturbed throughout the entirety of the spawning period. All Group 3 and Group 4 non-migratory fish VERs and their respective spawning and nursery grounds are distributed widely in the study area and wider Irish Sea. Based on this, considering the small impact ranges together with the intermittent and short-term nature of the impact, any mortality and/ or recoverable injuries to Group 3 and Group 4 non-migratory fish are assessed to be barely discernible from baseline conditions.	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
	European eel and twaite shad are also considered able to vacate the area during soft-start procedures before irreversible effects would occur. Moreover, due to their migratory nature, these VERs are anticipated to be transient across the study area, and therefore any exposure of these receptors to underwater noise is anticipated to be minimal. Given the mobile and transient nature of the receptors, the small impact ranges and the temporary and intermittent nature of the impact, any likely mortality and recoverably injury to European eel and twaite shad are also assessed as being barely discernible from baseline conditions. Consequently, the magnitude of mortality and recoverably injury for all Group 3 and Group 4 VERs is deemed to be **Low adverse**. **TTS and behavioural changes** TTS and behavioural impacts are predicted to occur over larger areas within the near-field and adjacent far-field (Figure 12 and Figure 13). Spawning grounds for a number of Group 3 (Atlantic cod, whiting, haddock) and Group 4 (sprat) species overlap with the study. Whilst the Popper *et al.* (2014) criteria suggest a high risk of behavioural disturbance in the intermediate field and a moderate risk in the far field, the risk assessment is likely to predicate on the individuals not being involved in activities with a strong biological driver like spawning or feeding. As such, it is likely that any behavioural impacts to fish would be reduced when spawning, with consequently limited impact on spawning potential for the relevant species. Whilst there is a paucity of evidence on migratory behaviour of European eel, it is possible that migration would be an equally strong biological driver, with similar damping of behavioural reactions. Based on this combined with the intermittent and short-term nature of the impact and the temporary nature and reversibility of effects, any TTS and behavioural changes in Group 3 and Group 4 VERs during piling are assessed to be barely discernible from baseline conditions. Consequently, the magnitude of changes in Group 3 and Group 4 VERs due to TTS and behavioural reactions is deemed to be **Low adverse**.	

Definition	Maximum design option	Alternative design option
Overall magnitude	*The potential magnitude of the predicted changes on Group 3 and Group 4 receptors is rated as **Low adverse**.*	*The potential magnitude of the predicted changes on Group 3 and Group 4 receptors is rated as **Low adverse**.*

Significance of effects

4.16.79 The maximum magnitude of the impact for Group 3 and Group 4 receptors has been assessed as **Low adverse**, with the maximum sensitivity being **Medium**. Therefore, the maximum significance of effects on Group 3 and Group 4 VERs from underwater noise generated during piling is **Slight adverse**, which is not significant in EIA terms.

4.16.80 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Potential effects from underwater noise during piling on eggs and larvae

4.16.81 The sensitivity of eggs and larvae to piling noise and the magnitude of impact have been assessed in Table 28 and Table 29, respectively, based on the methodology outlined in Section 4.5. Avoidance and preventative measures relevant to the impact include the use of a noise reduction technology and the implementation of soft-start and ramp-up procedures during the piling of foundations (Table 11). In addition, all foundations will be installed sequentially, with no concurrent piling to be undertaken at any time.

Table 28 Determination of sensitivity of eggs and larvae to underwater noise and vibration

Receptor	Justification
Fish eggs and larvae	Plaice, lemon sole, mackerel, sandeel, cod, whiting, sprat, haddock, and horse mackerel all have spawning grounds within or in the vicinity of the study area. Eggs and larvae are considered organisms of concern by Popper *et al.* (2014), due to their reduced mobility, small size and susceptibility to damage from sound waves and vibration. Therefore, both the adaptability and the tolerance of fish eggs and larvae to underwater noise is deemed to be low. Recovery from any potential decrease in recruitment success due to mortality or physical injury is assessed to occur within the short-term (medium recoverability). Based on this and taking into consideration the regional to international importance of the receptors, the sensitivity of eggs and larvae to underwater noise from piling is deemed to be **Medium**.
Maximum sensitivity	*The maximum potential sensitivity of fish eggs and larvae to underwater noise from piling is rated as **Medium**.*

Table 29 Determination of impact magnitude for eggs and larvae for underwater noise and vibration

Definition	Maximum design option	Alternative design option
Extent	Given their reduced mobility, eggs and larvae are considered static receptor to inform the magnitude assessment. **Mortality and Potential Mortal Injury** Based on the underwater noise modelling mortality and potential mortal injury to eggs and larvae during the course of piling may occur up to 1.4 km from the installation of jacket foundations and up to 700 m from monopile installation (>210 dB SEL_{cum}). Instantaneous mortality or mortal injury to eggs and larvae during piling may occur up to 70 m from monopile installation and up to 60 m from the installation of jacket foundations (>207 dB SPL_{peak}). **Recoverable Injury** Based on the qualitative criteria by Popper *et al.* (2014), the relative risk of recoverable injury to eggs and larvae during piling is moderate near the piling location (10s of metres) and low at both intermediate (100s of metres) and far (1,000s metres) distances from the piling operations. **TTS** The Popper *et al.* (2014) criteria for TTS are the same as those for recoverable injury, and therefore the impact assessment for eggs and larvae replicates that undertaken for recoverable injury. Eggs and larvae were assessed as having medium sensitivity to underwater noise impacts, with a moderate degree of disturbance at a near field distance from the source predicted on the receptors.	In line with the maximum design option.
Duration	The impact will occur over 19 months during the piling of jacket foundations and over four months during the piling of monopile foundations. The impact will therefore be temporary (less than one year in the case of installing monopile foundations) to short-term (one to seven years in the case of installing jacket foundations).	Under the alternative design options, fewer WTGs will be installed, resulting in fewer piling days.
Frequency	The impact will occur intermittently during the construction phase.	In line with the maximum design option.
Consequences for eggs and larvae		
Eggs and larvae	**Mortality and potential mortal injury and recoverable injury**	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
	Given the potential for piling to occur over 19 months (piling schedule S9), receptors may be disturbed throughout the entirety of their spawning periods. However, spawning grounds of all spawning fish receptors that overlap the area where mortal and recoverable injuries are likely to occur are widely distributed across the study area and western Irish Sea, and therefore in the context of the wider environment, any potential mortality or irreversible injury are considered to be of local scale. Based on this together and considering the intermittent and short-term nature of the impact, any potential mortality and/ or recoverable injuries to eggs and larvae as a result of underwater noise from piling are considered to be barely discernible from baseline conditions, and consequently the magnitude of mortality and recoverable injury for eggs and larvae is assessed as being **Low adverse**. **TTS and behavioural changes** The Popper *et al.* (2014) criteria for TTS and behavioural changes in larvae during piling are the same as those for recoverable injury, and therefore the magnitude assessment for TTS and behavioural changes in larvae replicates that undertaken for recoverable injury. Potential recoverable injuries in eggs and larvae were assessed as being barely discernible from baseline conditions, and consequently the magnitude of TTS and behavioural changes for eggs and larvae has also been assessed as being **Low adverse**.	
Overall Magnitude	*The potential magnitude of the predicted changes on eggs and larvae is rated as **Low adverse**.*	*The potential magnitude of the predicted changes on eggs and larvae is rated as **Low adverse**.*

Significance of effects

4.16.82 The maximum magnitude if the impact for eggs and larvae has been assessed as **Low adverse**, with the maximum sensitivity being **Medium**. Therefore, the maximum significance of effects on eggs and larvae from underwater noise generated during piling is **Slight adverse**, which is not significant in EIA terms.

4.16.83 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Potential effects from underwater noise on marine turtles

4.16.84 The sensitivity of eggs and larvae to piling noise and the magnitude of impact have been assessed in Table 30 and Table 31, respectively, based on the methodology outlined in Section 4.5. Avoidance and preventative measures relevant to the impact include the use of a noise reduction technology and the implementation of soft-start and ramp-up procedures during the piling of foundations (Table 11). In addition, all foundations will be installed sequentially, with no concurrent piling to be undertaken at any time.

Table 30 Determination of sensitivity of marine turtles to additional underwater noise and vibration

Receptor	Justification
Marine turtles	Studies on hearing in marine turtles are limited, but available data indicate that turtles can detect low frequency acoustic stimuli, such as those generated during piling (Nelms *et al.*, 2016). In addition, the retention of air in the middle ear of marine turtles suggests that they are able to detect sound pressure (Popper *et al.*, 2014). Marine turtles are mobile species, and on this basis are anticipated to move away from noise disturbance and are therefore assessed as fleeing receptors. There is limited information on the effects of underwater sounds on turtles; however, it has been suggested that marine turtles are highly protected from the effects of impulsive sounds owing to their rigid external anatomy (Popper *et al.*, 2014). Some temporary physiological effects and behavioural responses might occur (Nelms *et al.*, 2016), and therefore, marine turtles have been assessed as having a medium adaptability and tolerance to the impact. Given their low fecundity, recovery at the population level from any potential mortality or potential mortal injury through barotrauma is assessed to occur in the medium-term (low recoverability). Any potential TTS and/ or behavioural reactions are likely be temporary (high recoverability), with affected individuals anticipated to resume normal behaviour or recolonise areas shortly after piling has ceased (high recoverability). Taking into consideration the international importance of the receptors together with their medium adaptability, medium tolerance and high to low recoverability to the impact, the sensitivity of marine turtles to underwater noise from piling is rated as **Medium**.
Maximum sensitivity	*The maximum potential sensitivity of marine turtles to underwater noise from piling is rated as* ***Medium****.*

Table 31 Determination of impact magnitude for marine turtles for underwater noise and vibration

Criteria	Maximum design option	Alternative design option
Extent	Marine turtles are considered fleeing receptors for the purpose of the assessment given they are mobile species. **Mortality and Potential Mortal Injury** Mortality and potential mortal injury to fleeing marine turtles was predicted to occur <100 m from the noise source from jacket foundations and monopile piling (210 dB SEL_{cum}). **Recoverable Injury** In accordance with the Popper *et al.* (2014) qualitative assessment criteria, the relative risk of recoverable injury on sea turtles during pile driving is high at the near field (10s of metres) distance from the noise source and low at both intermediate (100s of metres) and far (1,000s metres) distances from the piling operations. **TTS** TTS on sea turtles was determined to have a 'high' effect on marine turtles in the near field (tens of metres), and a low effect in the intermediate (hundreds of metres) and far field (thousands of metres).	In line with the maximum design option.
Duration	The impact will occur over 19 months during the piling of jacket foundations and over four months during the piling of monopile foundations. The impact will therefore be temporary (less than one year in the case of installing monopile foundations) to short-term (one to seven years in the case of installing jacket foundations).	Under the alternative design options, fewer WTGs will be installed, resulting in fewer piling days.
Frequency	The impact will occur intermittently during the construction phase.	In line with the maximum design option.

Criteria	Maximum design option	Alternative design option
Consequences for marine turtle VERs		
Marine turtles	**Mortality and potential mortal injury and recoverable injury** Given their mobile nature, marine turtles would be able to leave the area during soft-start procedures before sound levels reach levels that could cause lethal or sublethal injuries. Based on this and considering the small area potentially affected together with the intermittent and short-term nature of the impact and the transient nature of the receptors, any effects upon marine turtles are assessed to be barely discernible from baseline conditions. Consequently, the magnitude of mortality and recoverable injuries for marine turtles is deemed to be **Low adverse**. **TTS and behavioural changes** The Popper *et al.* (2014) criteria for TTS in marine turtles during piling are the same as those for recoverable injury, and therefore the magnitude assessment for TTS in marine turtles replicates that undertaken for recoverable injury. Potential recoverable injuries in marine turtles were assessed as being barely discernible from baseline conditions, and consequently the magnitude of TTS and behavioural changes for these receptors has also been assessed as being **Low adverse**.	In line with the maximum design option.
Overall magnitude	*The potential magnitude of the predicted changes for marine turtles is rated as **Low adverse**.*	*The potential magnitude of the predicted changes is rated as **Low adverse**.*

Significance of effects

4.16.85 The maximum magnitude if the impact for marine turtles has been assessed as **Low adverse**, with the maximum sensitivity being **Medium**. Therefore, the maximum significance of effects on marine turtles from underwater noise generated during piling is **Slight adverse**, which is not significant in EIA terms.

4.16.86 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Potential effects from underwater noise during piling on shellfish

4.16.87 On the basis that shellfish do not possess swim bladders or other gas filled organs, it is considered that shellfish are primarily sensitive to particle motion rather than sound pressure (e.g. Popper and Hawkins, 2018). Likely significant effects of particle motion to marine invertebrates are relatively sparsely studied, with assumed sensitivity of many species based on a limited number of studies on a small number of species (Lewandowski *et al.*, 2016).

4.16.88 As there are currently no criteria for assessing particle motion, it is not possible to undertake a threshold-based assessment of the potential for injury to shellfish in the same way as can be done for fish. As such, a qualitative assessment of the potential for mortality or mortal injury has been made based on an assessment of the available peer-reviewed literature.

4.16.89 Several invertebrates are known to detect particle motion associated with sound waves owing to the presence of a structure called a statocyst (a fluid filled chamber containing a dense mass, the statolith), which along with associated sensory hairs may play a role in orientation. This has been noted in various invertebrate groups by a number of researchers (e.g., Nedwell *et al.*, 2007; Popper and Hawkins, 2018).

4.16.90 Shellfish do not possess gas filled cavities, and therefore there is less potential for tissue damage to occur as a result of pressure changes associated with sound waves (Popper *et al.*, 2001). To date no lethal effects of underwater noise have been described for edible crab, European lobster and *Nephrops* (e.g., Payne *et al.*, 2007). Similarly, studies on molluscs (e.g., blue mussel and periwinkles *Littorina* spp.) exposed to a single airgun at a distance of 0.5 m have shown no effects after exposure (Kosheleva, 1992). Another study investigated the response of snow crabs to seismic airgun sounds and found no differences in behaviour, physiological responses and physical damage between exposed crabs and crabs at control sites (Christian *et al.,* 2003).

4.16.91 A study of the impact of wind farm construction on European lobster in the area of the Westermost Rough[20] wind farm off the Northeast coast of the UK showed that, following temporary closure of the area to fishing during construction, the size and abundance of lobster were higher on reopening than pre-construction. This infers that construction noise and disturbance were not sufficient to adversely affect the resident lobster population (Roach *et al.*, 2018).

4.16.92 Dependent on the distance to the sound source, particle motion is currently considered more likely to cause behavioural responses rather than injury (Hawkins, 2009). For example, Roberts *et al.* (2016) suggested that vibroacoustic stimuli may elicit and affect anti-predator responses, such as startle response in crabs and valve closure in mussels. Such responses would effectively be distractions from routine activities such as feeding. Behavioural changes in mussels have also been observed in response to simulated pile-driving, with increased filtration rates observed in blue mussels (Spiga *et al.*, 2016). In addition to this, Samson *et al.* (2014) recorded a range of behavioural responses to underwater noise in cephalopods, including inking, colour changes and startle responses.

[20] The Westermost Rough OWF is located within one of the main areas targeted by lobster fisheries (Roach et al., 2018). It consists of 35 turbines located in water depths of between 15 to 23 m, comparable in scale with Dublin Array.

4.16.93 For shellfish species, substrate-borne particle motion has the potential to have similar or greater relevance than water-borne particle motion (Roberts and Breithaupt, 2016). As the concussive force associated with piling is directed into the seabed, the acoustic signal not only propagates through the water column, but also through the seabed (Nedwell and Howell, 2004). Studies on hermit crabs (*Pagurus bernhardus*) have observed sensitivity behavioural thresholds to substrate-borne vibrations, where particle motion has been considered the main stimulator, of approximately 0.11 to 0.29 m/s^2 with greatest sensitivity at 90 Hz (Roberts, 2015). Preliminary studies by Roberts (2015) suggest that the barnacle species *Balanus crenatus* may also be sensitive to substrate borne particle motion. The behavioural changes in mussels in response to simulated pile-driving (Spiga *et al.*, 2016) were hypothesised to occur as a result of increased energetic demands as a result of a stress response to the substrate-borne element of particle motion produced during piling.

4.16.94 The sensitivity of shellfish to piling noise and the magnitude of impact have been assessed in Table 32 and Table 33, respectively, based on the methodology outlined in Section 4.5. Avoidance and preventative measures relevant to the impact include the use of a noise reduction technology and the implementation of soft-start and ramp-up procedures during the piling of foundations (Table 11). In addition, all foundations will be installed sequentially, with no concurrent piling to be undertaken at any time.

Table 32 Determination of sensitivity of shellfish to additional underwater noise and vibration

Receptor	Justification
Shellfish VERs	Many shellfish will be broadly insensitive to underwater noise in the far-field, including from piling. However, they are considered likely to have reduced capability to adapt to particle motion in the near-field, very close to a noise source, given their generally lower mobility, all shellfish species are considered to have a limited capacity to avoid the impact (low adaptability). However, as detailed above, current studies indicate that, while underwater noise may cause behavioural and physiological changes in shellfish, mortality or physical injury are unlikely to occur. The possible consequences of physiological changes, such as changes in filtration rates, are unknown, and therefore, on a precautionary basis, shellfish are assessed as having a medium tolerance to underwaters noise generated during pile driving. All shellfish VERs have some measure of mobility and would be able to recolonise any affected areas from adjacent locations following the cessation of piling. Effects are therefore likely to be temporary and recoverability is assessed as high. Taking into consideration the regional importance of the receptors together with their medium tolerance and high recoverability, the sensitivity of the receptors to underwater noise from piling is deemed to be **Low**.
Maximum sensitivity	*The maximum potential sensitivity of shellfish to underwater noise from piling is rated as* ***Low****.*

Table 33 Determination of magnitude on shellfish of additional underwater noise and vibration

Definition	Maximum design option	Alternative design option
Extent	Impacts from particle motion are likely to occur local to the source within the near-field (Hazelwood and Macey, 2016, with studies having demonstrated the rapid attenuation of particle motion with distance (Mueller-Blenkle *et al.*, 2010).	In line with the maximum design option.
Duration	The impact will occur over 19 months during the piling of jacket foundations and over four months during the piling of monopile foundations. The impact will therefore be temporary (less than one year in the case of installing monopile foundations) to short-term (one to seven years in the case of installing jacket foundations).	Under the alternative design options, fewer WTGs will be installed, resulting in fewer piling days.
Frequency	The impact from piling will occur intermittently (see Table 10)) during the construction phase. As outlined in Table 10; - 57 piling days over four months for monopiles; and - 125 piling days over 19 months for jackets.	In line with the maximum design option.
Consequence	Pile driving is recognised as a source of particle motion, with increased levels of particle motion likely to occur in the near-field (Hazelwood and Macey, 2016). **Mortality and potential mortal injury and recoverable injury** As discussed above, current evidence suggests that piling is unlikely to cause mortality and mortal injury. Therefore, it is considered unlikely that there will be discernible changes to shellfish population, and consequently, the magnitude of mortality and recoverable injury for the shellfish VERs is deemed to be **Negligible**.	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
	TTS and behavioural changes TTS and behavioural changes in shellfish during piling are likely to occur local to the sound source. Based on this and given the broad distribution of the receptors combined with the temporary and intermittent nature of the impact and the reversibility of effects, at most barely discernible changes in shellfish populations from baseline conditions are anticipated as a result of TTS and behavioural reactions. Consequently, the magnitude of changes in shellfish due to TTS and behavioural reactions is assessed as being **Low adverse**.	
Overall magnitude	*The potential magnitude of the predicted changes on all shellfish VERs is rated as **Low adverse**.*	*The potential magnitude of the predicted changes on all shellfish VERs is rated as **Low adverse**.*

Significance of effects

4.16.95 The maximum magnitude of the impact for shellfish VERs has been assessed as **Low adverse**, with the maximum sensitivity being **Low**. Therefore, the maximum significance of effects on shellfish VERs from underwater noise generated during piling is **Slight adverse**, which is not significant in EIA terms.

4.16.96 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the MDO.

Potential effects from underwater noise during UXO clearance

4.16.97 A detailed UXO survey will be completed prior to construction. The type, size (net explosive quantities (NEQ)) and number of possible detonations and duration of UXO clearance operations is not known at this stage. However, data acquired to date and pUXO assessment indicates a low likelihood of UXO to be present across the array and Offshore ECC and within the wider offshore temporary occupation area, and it has therefore been assumed that a maximum of four UXO detonations will be required.

4.16.98 There is a possibility that UXO of varying sizes may be present within the array area and Offshore ECC, which would need to be cleared before construction can begin. Depending on the characteristics of the UXO, the presence of UXO can be managed in a number of ways: avoidance (through micro-siting), non-destructive clearance (through moving or removal of the UXO), or destructive clearance (i.e., in-situ detonation).

4.16.99 In the event that a UXO is identified, the preference will be to avoid UXO targets where practicable through micro-siting of infrastructure. Where avoidance is not possible, relocating the UXO to a safe place away from any future planned operations will be considered. Where clearance of UXO is required (i.e., avoidance or relocation of the UXO are not practicable), low order clearance (i.e., burn out of UXO without detonation) will be the preferred clearance method and will be attempted on all suitable UXO. The low order technique uses a user filled shaped-charge to create a plasma-jet, which causes a build-up of pressure within the UXO target, leading to a burst of the UXO casing, disrupting the contents by introducing heat to ignite the explosive fill to rapidly burn.

4.16.100 Where low order deflagration of the UXO is not feasible or has been unsuccessful, high order detonation will be used as a last resort. High order clearance requires an external 'donor charge' initiator to detonate the explosive material in the UXO, producing a blast wave equivalent to the full detonation of the device. Destructive clearance through detonation of the UXO can introduce a further underwater noise effect-receptor pathway that may result in an effect on noise sensitive receptors. Due to the early stage for the proposed development, the exact number of potential UXO that will need to be cleared will be unknown until further pre-construction surveys are undertaken across the array area and Offshore ECC.

4.16.101 High order clearance of UXO would generate the largest sound levels during UXO clearance and has consequently been used as the MDO for underwater noise modelling and the impact assessment for fish and shellfish receptors. In addition, the impact assessment also considers the potential for adverse effects from low order clearance as this option represents the preferred clearance method.

4.16.102 The maximum equivalent charge weight for high order UXO clearance is 525 kg with an additional donor weight of 0.5 kg included to initiate detonation. This has been modelled alongside a range of smaller devices, at charge weights of 25, 55, 120 and 240 kg each with 0.5 kg donor weight. The maximum source level from the 525 kg charge weight and donor charge has been calculated at 298.4 dB re 1 µPa @ 1 m (SPLpeak) and 236.4 dB re 1 µPa^{2}s @ 1 m (SELss). The maximum source level from the low order charge weight and 250 g donor charge has been calculated at 269.8 dB re 1 µPa @ 1 m (SPLpeak) and 215.2 dB re 1 µPa^{2}s @ 1 m (SELss).

Sensitivity of receptors

4.16.103 The high order detonation of UXO generates high amplitude sound levels that, like piling noise, are detectable over large spatial scales (10s of kms) (Lepper *et al.*, 2024). Any detonation of UXO would result in a short-term (i.e., seconds) increase in underwater noise (i.e., increase in SPL and particle motion) to levels that could cause mortality and potential mortal injury, recoverable injury, TTS and/ or behavioural effects on fish and shellfish species, with the severity of effects depending on the proximity of the individuals to the UXO location and the size of the UXO.

4.16.104 Small scale mortality and physical injury in fish as a result of underwater explosions have been reported by several authors, with physical injuries including rupture of the swim bladder and haemorrhage caused by the rupture of blood vessels (Dahl *et al.*, 2020; Popper *et al.*, 2014). No published data are available on the effects of explosions on hearing (e.g., TTS) or fish behaviour; however, it is suggested that there may be temporary or partial loss of hearing at high sound levels, especially in species where the swim bladder enhances sound pressure detection (Popper *et al.*, 2014). Behavioural effects are likely to include startle reactions, but it is suggested that such responses are of short duration and do not necessarily cause longer-term changes in behaviour (Popper *et al.*, 2014). The detonation of UXO is considered to have a lower likelihood of triggering a population level effect than that associated from piling operations, due to the significantly reduced temporal footprint that would arise (Popper *et al.*, 2014).

4.16.105 Taking account of the severity of the impact particularly at close range but acknowledging that impacts would occur at individual rather than at population levels and considering that any TTS or behavioural responses would likely be reversible and at most temporary, the maximum sensitivity of the fish and shellfish receptors to underwater noise generated during high order UXO clearance is assessed as being **Medium**.

Magnitude of impact

4.16.106 An estimation of the potential impact ranges for mortality and potential mortal injury in fish from high order UXO clearance has been made based purely on the charge weight of the UXO. This estimation does not consider the design, composition, age, position, orientation, and sediment coverage of the UXO, which leads to a high degree of uncertainty. Due to these uncertainties, the largest impact scenario and therefore precautionary estimation has been used for the calculations, assuming the UXO is not buried, degraded or subject to any other characteristics that would decrease the sound levels produced during detonation.

4.16.107 Mortality and potential mortal injury from high order UXO clearance in all fish receptors is predicted to occur up to 810 m from the detonation site when considering a maximum equivalent charge weight of 525 kg and an additional donor weight of 0.5 kg to initiate detonation (Underwater Noise Modelling Report). The modelling has assumed no degradation or burial of the UXO, and no smoothing of the impact wave over distance, and consequently the noise levels predicted are likely to be overestimated. For lower order clearance events, mortality and recoverable injuries are likely to occur up to 65 m from the detonation site, based on a charge weight of 0.25 kg. The maximum extent of lethal effects from high and low order UXO detonation would therefore be restricted to the near-field. The impact is anticipated to occur on a maximum of two days and would be momentary (i.e., lasting seconds to minutes).

4.16.108 Given the high intensity nature of sounds generated during high order UXO detonation and their potential for adverse effects on marine species, mitigation is included by implementation of specific avoidance and preventative measures should UXO detonation be required (see Table 11). Each identified UXO will be subject to a technical risk assessment and the most appropriate situation-specific mitigation method will be selected. In addition, if high order UXO clearance is required, bubble curtains will be deployed as a noise abatement measure to reduce the noise propagated through the water column during detonations. It is considered that adoption of these measures will reduce the likelihood of lethal injuries in sensitive receptors. In addition, these measures are considered to reduce the number of individuals at risk of recoverable injuries, TTS and/ or behavioural reactions, through a reduction in the potential impact ranges.

4.16.109 The relative risk of recoverable injury and TTS in the most sensitive fish species (i.e., Group 3 and Group 4 receptors) is considered to be high at near (10s of metres) and intermediate (100s of metres) distances from the sound source and low at far (1000s of metres) distances (Popper *et al.*, 2014). It is possible that UXO operations will be planned to take place year-round during the UXO clearance campaign pre-construction and therefore have the potential to interact with key spawning, nursery or migration periods of different fish and shellfish species. However, each UXO clearance is a discrete event and while this may result in some temporary disturbance to fish and shellfish receptors, it is not anticipated to cause widespread and long-term displacement of receptors from specific spawning or nursery grounds or migration routes.

4.16.110 Factoring in the mitigation measures above and considering the infrequent and momentary nature of the impact together with the highly localised nature of potential lethal injuries and the temporary nature of potential TTS or behavioural changes, any effects upon the fish and shellfish VERs from high order UXO clearance are assessed to be at most barely discernible from baseline conditions. Therefore, the maximum magnitude of the impact for all receptors is assessed as being **Low adverse**. For the most likely scenario of low order clearance, the magnitude is assessed as being at most **Low adverse**, given the infrequent nature of UXO clearance, the momentary nature of the sounds generated and the low proportion of fish and shellfish species likely to be affected.

Significance of effects

4.16.111 The maximum magnitude of the impact for all fish and shellfish receptors has been assessed as **Low adverse**, with the maximum sensitivity being **Medium**. Therefore, the maximum significance of effects on fish and shellfish receptors from underwater noise generated during UXO clearance is **Slight adverse**, which is not significant in EIA terms.

4.16.112 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Potential effects from other noise sources

4.16.113 Besides piling and the detonation of UXO, there will be several other construction activities that will produce underwater noise, namely dredging, drilling, cable laying, rock placement, geophysical surveys, and vessel noise. These may occur either alongside piling and UXO clearance or separately. In addition, there might be the potential that turbine foundations will be installed using drilling rather than piling. All these activities will produce non-impulsive sounds.

4.16.114 Sound levels generated during construction activities such as dredging, drilling and rock placement have received less attention than sounds generated during piling and very little monitoring data are available. Among the non-piling construction activities associated with Dublin Array, suction dredging is predicted to generate the largest sound levels of 186 dB re 1 µPa at 1 m (Underwater Noise Modelling Report). Rock placement is generally considered to be the nosiest external protection method, since the rocks fall down a fall pipe from the rock placement vessel, which may result in underwater noise. Other external protection measures such as mattresses and grout bags are typically placed onto the seabed using an ROV or crane, and as such these are unlikely to result in any significant underwater noise. The estimated source levels of underwater noise from rock placement at the proposed development is 172 dB re 1 µPa at 1 m, and the noise emitted from large vessels is estimated at 168 dB re 1 µPa at 1 m (Underwater Noise Modelling Report).

4.16.115 Vessel noise would occur from jack-up vessels during the piling of foundations and WTG installations and from other large and medium sized vessels that carry out other construction tasks and anchor handling. Additional small vessels will be required for crew transport and maintenance on site. The estimated source levels of underwater noise from large vessels is 168 dB re 1 µPa @ 1 m (RMS) and for medium vessels is 161 dB re 1 µPa @ 1 m (RMS) (Underwater noise assessment). The study area is subject to relatively high levels of shipping activity currently, and it is expected that the vessel activity would be no greater than the baseline during construction activities (due to construction Advisory Safety Zones reducing current shipping activity and the number of construction vessels expected to be much lower than that which currently transit the area). The underwater noise impacts from vessel noise are generally spatially limited to the immediate area around the vessel rather than having impacts over a wide area (e.g., Mitson, 1993).

4.16.116 Additional surveys will be required in the array area and along the Offshore ECC immediately prior to construction, as part of the seabed preparation phase, which are included as part of this Planning Application. These surveys will be required to further characterise the seabed conditions and morphology and identify any potential obstructions or hazards to the construction works. These surveys will also confirm the feasibility of the installation techniques.

4.16.117 Geophysical surveys are non-intrusive and will utilise towed equipment such as side-scan sonar (SSS), sub-bottom profiler (SBP), multi-beam echosounder (MBES) and magnetometer to gather detailed information on the bathymetry, seabed sediments, geology, and anthropogenic features (e.g., existing seabed infrastructure, UXO that exist across the offshore development area). Remotely Operated Vehicles (ROV) may also be used for further identification of findings from the geophysical surveys; however, ROVs do not emit noise and are therefore not considered herein for auditory impacts to fish and shellfish receptors. Details on each of the geophysical survey equipment that may be used during pre-construction surveys are outlined below:

- Multi-Beam Echo Sounder (MBES): MBES is used to acquire detailed seabed topography and water depth by emitting a fan shaped swath of acoustic energy (sound waves) along a survey transect. The sound waves are reflected from the seabed to enable high resolution seafloor mapping. The MBES can be either hull- or ROV-mounted. Typical equipment generates sound pressure levels of 210-240 dB re 1 µPa (SPL_{peak}) for multiple beams (Lurton and Deruiter, 2011) and 197 dB re 1µPa (SPL_{peak}) for a single beam at operational frequencies of 200-400 kHz (Hartley Anderson Ltd, 2020; Risch *et al.*, 2017).

- Side-Scan Sonar (SSS): SSS utilises conical or fan-shaped pulses of sounds directed at the seafloor to provide information on the surface of the seabed through analysis of reflected sound. Operating frequencies are approximately 300 and 900 kHz with sound pressure levels of 210 dB re1 µPa at 1m (SPLpeak) (Crocker and Fratantonio, 2016, Crocker *et al.*, 2019).

- Sub-Bottom Profiler (SBP): The SBP is a type of geophysical survey tool that uses low-frequency or high frequency sounds (pings) to identify acoustic impedance of the sub-surface geology and to identify transitions from one stratigraphic sequence to another. Sound sources that produce lower frequency pulses can penetrate through and be reflected by subsurface sediments (low-resolution data), whilst higher frequency pulses achieve higher resolution images but do not penetrate the subsurface sediments. Typical equipment generates sound pressure levels of 210-220 dB re 1µPa (SPL_{peak}) using operational frequencies of between 2015 kHz, with a peak frequency of 3.5 kHz (Hartley Anderson Ltd, 2020).

- 2D / 3D Ultra-high resolution seismic reflection profiling (UHRS): Ultra high-resolution surveys of the subsurface using frequencies of about 100 Hz to 5 kHz and generating source levels of about 200-226 dB re 1µPa (SPL_{peak}).

- Ultra-short Baseline (USBL): A USBL system is used to obtain accurate equipment positioning during sampling activities. This system consists of a transceiver mounted under the vessel, and a transponder on deployed equipment. The transceiver transmits an acoustic pulse which is detected by the transponder, followed by a reply of an acoustic pulse from the transponder. This pulse is detected by the transceiver and the time from transmission of the initial pulse is measured by the USBL system and converted into a range. Frequencies emitted range between 19-34 kHz with recorded sound pressures of 187-206 dB re 1 µPa (SPL_{rms}).

- Magnetometer: A magnetometer is used to measure the variation in the earth's total magnetic field to detect and map ferromagnetic objects on or near the sea floor along the survey's vessel tracks. Often, two magnetometers are mounted in a gradiometer format to measure the magnetic gradient between the two sensors. The magnetometer is a passive system and, therefore, does not emit any noise, it is therefore scoped out of assessment.

Sensitivity of receptors

4.16.118 There is currently no evidence that non-impulsive sounds, such as those emitted during cable installation, the drilling of foundations and vessel operations, cause mortality or potential mortal injury in fish, and therefore the relative risk of lethal effects occurring is considered to be low (Popper *et al.*, 2014). The limited data on other effects on fish hearing indicate the potential for auditory tissue injuries and associated TTS in species with enhanced sensitivities to sound pressure (e.g., Group 3 and 4 species). TTS, which has been observed in a few noise- sensitive species, were temporary, with full recovery taking up to fourteen days following noise exposure (reviewed in Popper *et al.*, 2014). Observations of behavioural responses of fish to continuous noise sources are also sparse but so far have included avoidance reactions, alteration of schooling behaviour and changes in swimming speed and direction (Popper *et al.*, 2014).

4.16.119 Based on the above and given the comparatively wide distribution of the fish and shellfish receptors (including spawning and nursery grounds) in the study area in comparison to the areas potentially affected by construction noise from activities other than piling at any given time, the maximum sensitivity of the fish and shellfish VERs to underwater noise from construction activities other than piling is deemed to be **Low**.

4.16.120 Acoustic signals emitted during geophysical surveys (e.g., from SSS, MBES and SBP) produce higher sound levels within the mid (1-10 kHz), high (10-20 kHz) and ultrasound (>20 kHz) frequency range. Data on the effects of these systems on fish and shellfish receptors is limited; however, it has been suggested that fish lacking a swim bladder are unlikely to suffer from lethal or sublethal tissue injuries (Popper *et al.*, 2014). Physical injuries might occur in receptors sensitive to sound pressure changes (i.e., those with air-filled cavities, Groups 2 to 4). Typical SSS and MBES systems operate outside of the hearing range of all receptors and are therefore not anticipated to result in any TTS or disturbance impacts. There is however evidence that low to mid frequency acoustic signals, such as those used by some sub-bottom profiling systems, may induce TTS or result in behavioural responses in some Group 4 receptors (e.g., herring and twaite shad), given their wider hearing bandwidth (Popper *et al.*, 2014). These changes would the temporary with affected individuals anticipated to resume normal behaviours or recolonise areas shortly after survey work has ceased. Based on the above, the maximum sensitivity of fish and shellfish receptors to underwater sounds generated during geophysical surveys is deemed to be **Low**.

Magnitude of impact

4.16.121 As discussed above, there is currently no evidence that non-impulse (i.e., continuous) sounds, such as those emitted during construction activities and vessel operations, cause mortality and potential mortal injury in fish. Using the unweighted SEL_{RMS} thresholds recommended by Popper *et al.* (2014), underwater noise modelling predicts that recoverable injuries and TTS in the most sensitive fish receptors (i.e., Group 3 and Group 4 species) would occur less than 50 m from the noise source (Underwater Noise Modelling Report). For such an effect occurring, an animal would have to stay within the immediate vicinity of the noise source for 12 hours to induce TTS and 48 hours to incur recoverable injury. The risk of non-lethal injuries in the remaining receptors is considered to be low at all distances from the sound source, while the risk of TTS is likely to be moderate near (10s of metres) the noise source and low at intermediate (100s of metres) and far (1,000s metres) distances (Popper *et al*., 2014). The relative risk of behavioural changes in marine turtles and Group 3 and Group 4 receptors is likely to be high at the near field (10s of metres) distance from the noise source, moderate at intermediate (100s of metres) distances and low at far (1,000s metres) distances from the construction activities (Popper *et al.*, 2014). For the remaining receptors (Group 1 and Group 2 receptors and eggs and larvae), the likelihood of behavioural responses is considered to be moderate at near and intermediate distances and low at far field distances from the noise source (Popper *et al.*, 2014).

4.16.122 Based on the above, any effects arising from continuous sounds generated by vessel operations and construction activities at Dublin Array will mostly be restricted to the near-field. Furthermore, these changes are expected to be temporary to short-term, intermittent, and reversible. Given their lower hearing capabilities and the low risk of recoverable injury and lower risk of TTS, any effects on marine turtles, shellfish, eggs and larvae and Group 1 and Group 2 receptors are expected to be indiscernible from baseline conditions, and consequently the magnitude of the impact for these receptors is deemed to be **Negligible**. Given their better hearing capabilities and subsequently higher susceptibility to injuries, TTS or behavioural reactions, Group 3 and 4 receptors may exhibit barely discernible changes in baseline condition, and consequently the magnitude of the impact for these receptors is deemed to be **Low adverse**.

4.16.123 Any noise generated during geophysical surveys would also be restricted to the near-field and adjacent far-field. The impact would occur infrequently and would be temporary. Therefore, any effects on marine turtles, shellfish, eggs and larvae and Group 1 and Group 2 receptors are expected to be indiscernible from baseline conditions, and consequently the magnitude of the impact for these receptors is deemed to be **Negligible**. Given their better hearing capabilities and subsequently higher sensitivity to underwater noise, Group 3 and 4 receptors may exhibit barely discernible changes in baseline condition, and consequently the magnitude of the impact for these receptors is deemed to be **Low adverse**.

Significance of effects

4.16.124 The maximum magnitude of the impact for all fish and shellfish receptors has been assessed as **Low adverse**, with the maximum sensitivity being **Low**. Therefore, the maximum significance of effects on fish and shellfish receptors from non-impulse sounds generated during construction activities and geophysical pre-construction surveys is **Slight adverse**, which is not significant in EIA terms.

4.16.125 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Significance of effects from all noise sources

4.16.126 As outlined previously (Table 10), no simultaneous piling will be carried at Dublin Array during the installation of foundations. There is however the potential that other construction activities, such as dredging or drilling, occur at the same time as piling or UXO clearance. As discussed in the previous section, the noise levels emitted during these activities may potentially cause temporary TTS in the most sensitive VERs (i.e., Group 3 and Group 4 species) as well as behavioural reactions but are not thought to cause mortal injuries. Any TTS are predicted to be restricted to the near-field (< 50m from the noise source) while behavioural reactions will be confined to within the areas over which behavioural changes might occur as a result of piling and UXO clearance. It is therefore concluded that any underwater noise effects on fish and shellfish receptors during simultaneous construction activities (e.g., dredging and piling or dredging and UXO clearance) will be no greater in magnitude than those predicted for piling and UXO clearance alone. This would result in a **Slight adverse** effect, which is not significant in EIA terms.

Residual Effect assessment

*In relation to both the MDO and ADOs, the maximum significance of potential effects on fish, shellfish and marine turtle receptors resulting from underwater noise to fish and shellfish receptors has been assessed as **Slight adverse**, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. **No significant adverse residual effects** on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

4.17 Environmental assessment: operational phase

4.17.1 The effects of operation and maintenance of Dublin Array have been assessed on fish and shellfish VERs within the fish and shellfish study area, as defined in Section 4.1. The environmental impacts arising from operation and maintenance of Dublin Array are listed in Table 10, along with the MDO and ADOs against which each impact has been assessed.

4.17.2 A description of the significance of effect upon fish and shellfish VERs caused by each identified impact is provided below.

Impact 5: Temporary increase in SSC and sediment deposition during maintenance activities.

4.17.3 During the operational phase of the proposed development, jack-up and anchoring operations and cable inspection and repair work will lead to localised seabed disturbances, which will result in short-term periods of increased SSC and sediment deposition. The use of jack-up vessels and anchors will result in the suspension of sediment close to the seabed, which will rapidly settle from suspension within the immediate area. Cable repair and maintenance activities may result in the suspension of larger volumes of sediment, in particular if cable re-burial is required. A thorough cable burial risk assessment will be conducted, and it is unlikely that cables will become exposed throughout the lifetime of the project. However, if a section of the cable became exposed or damaged it will require reburial and/ or replacement. Reburial (and replacement) will be undertaken using similar techniques to that set out in the assessment of SSC and deposition associated with cable installation activities (see Impact 1). The lengths of exposed cable will be shorter, and the potential impacts will likely be even more localised and over a considerably shorter duration than those considered during the construction phase. This is supported by BERR (2008), which noted that the impact of cable reburial operations mainly relates to a localised and temporary re-suspension and subsequent settling of sediments.

4.17.4 Overall, it is predicted that the volumes of sediment released during offshore maintenance activities will be less compared to those predicted for the construction phase (Section, 4.16, Impact 1 and Table 10) due to the redundancy of sandwave clearance and other seabed preparation activities. The impact would occur intermittently through the operational phase, with individual maintenance activities (e.g., cable re-burial) expected to be temporary. Consequently, any effects on fish and shellfish receptors would be no greater in magnitude than those encountered during construction activities (Impact 1, Table 14, maximum magnitude: **Low adverse**). The sensitivities of fish and shellfish receptors to the impact remain as described for the construction phase (Table 12, maximum sensitivity: **Medium**).

Significance of effects

4.17.5 The significance of effects associated with temporary increases in SSC and deposition during the operational phase are expected to be less than those of the construction phase (Impact 1), which were not significant in EIA terms.

4.17.6 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

In relation to both the MDO and the ADOs, the significance of potential effects resulting from temporary increases in SSC and sediment deposition during maintenance activities has been assessed as not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 6: Temporary damage and disturbance of the seabed during maintenance activities

4.17.7 During the operational phase of the proposed development, the maintenance and repair of foundations and cables will result in temporary and localised disturbances to the seabed. The extent of the impact will be restricted to the immediate footprint of operational and maintenance activities, which will include cable reburial, and repair works and the use of jack-up vessels for the maintenance of foundations, WTGs and the OSP. Reburial (and replacement) of cables will be undertaken using similar techniques to that during cable installation activities; however, the lengths of exposed cable will be shorter, and the potential impacts will likely be more localised and over a considerably shorter duration than those considered during the construction phase (Table 10). Similarly, jack-up and anchoring operations associated with the maintenance of foundations will affect discrete areas of seabed. It is predicted that a maximum of approximately 1 km^2 of seabed will be temporarily damaged and/ or disturbed during maintenance activities, which is about 17 times less than the maximum area of seabed to be affected during the construction phase (Table 10). Given that the benthic habitats within the development area are common and widespread throughout the region, impacts from the individual O&M activities will affect a very small proportion of habitats compared to their overall extent. Moreover, the impact would occur infrequently during the operational phase, with individual maintenance activities anticipated to be temporary (i.e., less than one year). Consequently, any effects on fish and shellfish receptors would be no greater in magnitude than those resulting from construction activities (Impact 2, Table 16, maximum magnitude: **Low adverse**). The sensitivities of fish and shellfish receptors to the impact remain as described for the construction phase (Table 15, maximum sensitivity: **Medium**).

Significance of effects

4.17.8 The significance of effects of temporary damage and disturbance of the seabed on fish and shellfish ecological receptors during the operational phase will be no greater, and are expected to be less, than those of the construction phase (Impact 2), which were not significant in EIA terms.

4.17.9 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

In relation to both the MDO and the ADOs, the significance of effects resulting from direct physical damage and disturbance of the seabed has been assessed as not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 7: Long-term and permanent loss of benthic habitat due to placement of subsea infrastructure

4.17.10 The placement of infrastructure including WTG and OSP foundations and the associated scour protection, along with the placement of cable protection at cable crossings and areas where cable burial is not possible, will lead to a change from a sedimentary habitat to one characterised locally by hard substrate. This has the potential to impact sensitive fish and shellfish receptors via the localised alteration of the structure and function of supporting habitats (e.g. spawning, nursery and foraging habitats), and has therefore been assessed as habitat loss. Potential beneficial effects of introducing hard substratum (e.g., providing new habitats for faunal assemblages to colonise, resulting in potential benefits for fish and shellfish populations) are assessed under Impact 9 'Increase in Hard Substrate and Structural Complexity'. Table 10 identifies the foundation, scour and cable protection footprint. No cable protection will be required within the intertidal area and therefore impacts within the intertidal have not been considered further.

4.17.11 The sensitivity of all fish and shellfish receptors to the predicted changes and the magnitude of the impact have been assessed in Table 34 and Table 35, respectively, based on the methodology outlined in Section 4.5. No specific avoidance or preventative measures relevant to the impact have been identified as necessary (see Table 11).

Sensitivity of receptors

4.17.12 As discussed above in relation to direct damage and disturbance impacts during construction activities (Impact 2), those species which are directly reliant on the seabed for either all, or part of their life cycle, are susceptible to the effects of long-term or permanent loss of benthic habitats. This includes burrowing fish (sandeel) and shellfish species that live within the sediment (e.g., *Nephrops*, razor clams) and bottom-dwelling fish, shellfish and elasmobranch species that depend on benthic prey. In addition, adverse effects on fish and shellfish populations may arise through the loss of benthic spawning and nursery grounds.

Table 34 Determination of sensitivities of fish and shellfish to long-term loss of benthic habitat

Receptor	Justification
Marine turtles, basking shark, pelagic VERs (Atlantic mackerel, Atlantic horse mackerel, sprat)	Marine turtles, basking sharks and all pelagic VERs do not depend upon the seabed for part or all of their life cycle and therefore are not considered susceptible to the long-term loss of subtidal sediments that would arise during the operational phase of the proposed development. Consequently, the sensitivity of these species to the impact is deemed to be **Negligible**.
Demersal VERs, diadromous VERs, tope, starry smooth-hound, spiny dogfish	The receptors depend partly or fully on the seabed for feeding but based on their mobile nature they would be able to relocate to nearby unimpacted areas, and consequently they are assessed as having a high capacity to avoid and accommodate the loss of seabed habitat (high adaptability and tolerance). In addition, these receptors are pelagic spawners (demersal fish VERs), do not spawn within the study area (diadromous VERs) or bear live young (tope, starry smooth-hound and spiny dogfish), and therefore the physical loss of benthic habitats within the study area would not result in any loss of available spawning locations. Based on this, the sensitivity of all demersal and diadromous VERs and tope, starry smooth-hound and spiny dogfish to long-term habitat loss is deemed to be **Negligible**.
Small-spotted catshark, nursehound and skate species (thornback	Small-spotted catshark, nursehound and skates are oviparous that attach egg cases onto the seabed. In addition, these receptors depend to some degree on the seabed for feeding. All receptors are mobile and would be able to relocate to nearby suitable feeding and egg-deposition grounds. Therefore, they are assessed as having a high capacity to avoid or accommodate the loss of seabed habitat (high adaptability and tolerance). Based on this, the sensitivity of small-spotted catshark, nursehound and skate species to long-term habitat loss is deemed to be **Negligible**.
Sandeel	As discussed previously, sandeel are susceptible to the long-term loss of sedimentary habitats as they exhibit strong site fidelity and have specific substrate requirements throughout their juvenile and adult life history. Therefore, they have been assessed as having a low tolerance to the impact. Although the loss of habitat will persist over the long-term, sandeel are able to recover by resettling in nearby unaffected areas. Site-specific and publicly available sediment data indicate the presence of 'Prime' and 'Sub-Prime' sandeel habitats within the array area, offshore ECC and wider study area (Figure 6). In addition, sandeel spawning grounds are predicted to be distributed across the wider Irish Sea (Ellis *et al.*, 2010, 2012; Figure 6). Recovery from any localised decline in population numbers or reproductive success during the initial loss of habitat is anticipated to occur within the short-term through larval dispersal and recruitment into surrounding unaffected areas (medium recoverability). Taking this into consideration together with their regional importance, the sensitivity of sandeel to long-term habitat loss is deemed to be **Medium**.

Receptor	Justification
Herring	Herring are demersal spawners, reliant upon the presence of suitable substrates for spawning, which makes them susceptible to long-term changes in substratum type within spawning grounds. The closest known spawning beds for herring are located north of Dundalk Bay outside the study area (> 75 km from the northern boundary of the array area). Therefore, no direct damage or disturbance to herring spawning grounds are predicted from physical impacts to the seabed during the construction phase, and consequently, the sensitivity of herring to the impact is deemed to be **Negligible.**
Nephrops	Berried female *Nephrops* are considered largely sedentary, remaining in their burrows during the overwintering period. Furthermore, *Nephrops* are confined to particular substrate types and exhibit some site fidelity. Therefore, they are considered to have a low adaptability and very low tolerance to the permanent loss of sedimentary habitat. Although the loss of habitat will persist over the long-term, given their burrowing nature, *Nephrops* are likely to recover by resettling in nearby unaffected areas. Recovery from any localised decline in population numbers or reproductive success is anticipated to occur within the short-term to medium-term through larval dispersal and recruitment into surrounding unaffected areas (medium to low recoverability). Taking into consideration the regional importance of *Nephrops* together with their low adaptability, very low tolerance and low to medium recoverability, the sensitivity of *Nephrops* to long-term habitat loss is deemed to be **Medium**.
Brown crab, European lobster, common whelk, , scallops, razor clams, blue mussels	Like *Nephrops*, the remaining shellfish VERs are substrate dependent and are therefore susceptible to the long-term loss of sedimentary habitats. Whelk typically remain stationary when not actively searching for food, either resting on the seafloor or being to some degree buried within in the sediment. Cockles are found in surface sediments, and King scallop typically prefer clean firm sand, fine or sandy gravel substrates. Brown crab occur on a range of substrate types, including boulders, mixed coarse grounds, and offshore sands, and berried females overwinter in pits dug in the sediment or under rocks. Adult European lobster typically inhabit rocky substrata, living in holes and excavated tunnels, while juvenile lobsters are known to spend large amounts of time within their burrows. Based on their dependence on sedimentary habitats, these receptors are considered to have a very low tolerance to the permanent loss of habitat during the operational phase. Although the loss of habitat will persist over the long-term, the receptors would be able to recover by resettling in nearby unaffected areas. Recovery from any localised decline in population numbers or reproductive success is anticipated to occur within the short-term to medium-term through larval dispersal and recruitment into surrounding unaffected areas (medium to low recoverability). Taking into consideration the regional importance of the receptors together with their low adaptability, very low tolerance and low to medium recoverability, the sensitivity of the remaining shellfish VERs to the long-term loss of benthic habitats is deemed to be **Medium**.

4.17.13 In summary, marine turtles, herring, and all pelagic, demersal, diadromous and elasmobranch VERs have been assessed as not being sensitive to the impact. The sensitivity of the remaining VERs, i.e., sandeel, *Nephrops*, brown crab, European lobster, common whelk, scallops, razor clams and blue mussel, has been assessed as medium. The maximum sensitivity of fish and shellfish VERs for this impact is therefore **Medium**.

Magnitude of impact

4.17.14 The predicted long-term loss of sedimentary benthic habitats during the operational phase of Dublin Array would fall within the seabed area subject to direct damage and disturbance during the construction phase (Impact 2). Within the array area, a maximum of approximately 0.94 km^2 is predicted to be lost after the installation of cable protection measures and WTG and OSP foundations and associated scour protection. This equates to approximately 1.6 % of the total seabed area within the array area. Within the Offshore ECC, a maximum of approximately 0.09 km^2 of sedimentary habitat would be lost due to the installation of export cable protection material, while the combined total habitat loss within the array area and Offshore ECC would equate to approximately 1.02 km^2 (Table 10).

Table 35 Determination of impact magnitude of long-term loss of habitat

Definition	Maximum design option	Alternative design option
Extent	The loss of sedimentary habitat will be restricted to the footprint of the installed infrastructure and associated protection material. Consequently, the maximum extent of the impact will be restricted to the immediate vicinity of infrastructure.	In line with the maximum design option.
Duration	As a minimum, the impact will occur throughout the operational period (35 years) and therefore would be long-term (15-60 years), as defined in the assessment methodology (Table 5). Seabed infrastructure left in place following the decommissioning of the proposed development will result in a permanent change in substratum type.	In line with the maximum design option.
Frequency	The impact will occur constantly throughout the operational phase.	In line with the maximum design option.
Marine turtles, pelagic VERs, demersal VERs, diadromous VERs, elasmobranch VERs	All receptors are widely found within the study area, and as such, it is assessed that there will be no discernible loss of resource for these species in the context of the Irish Sea populations. Consequently, the magnitude of the impact for these receptors is deemed to be **Negligible**.	In line with the maximum design option, impacts restricted to the near field and adjacent areas of the far field however total area of seabed disturbed will be less.

Definition	Maximum design option	Alternative design option
Sandeel	As described previously, low intensity sandeel spawning grounds have been mapped throughout the study area as well as the wider Irish Sea. Site-specific sediment data indicate that the Kish Bank (within the northern array area) contains 'Prime' sandeel habitat. 'Prime' and 'Sub-Prime' sandeel habitats are also likely to be present outside the array area and offshore ECC, within the ZoI. Based on this and considering the localised nature of the impact, any long-term or permanent habitat loss is considered to be small in the context of available suitable sandeel habitat throughout the study area and wider region. Therefore, any effects upon sandeel populations and their spawning grounds are considered to be barely discernible from baseline conditions, and consequently the magnitude of the impact for sandeel is deemed to be **Low adverse**.	In line with the maximum design option.
Common whelk	As discussed previously (Table 14), fishing data indicate that common whelk are widely distributed within the study area and wider western Irish Sea and that the array area and Offshore ECC are unlikely to overlap with key whelk spawning and nursery grounds. Based on this and considering the localised nature of the impact, no discernible loss of seabed habitats are anticipated for the species in the context of the western Irish Sea populations. Consequently, the magnitude of the impact for common whelk is deemed to be at most **Low adverse**.	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
Brown crab, European lobster, scallops	It is predicted that the impact may affect the receptors through the long-term or permanent loss of sedimentary habitats, including potential overwintering grounds. The subtidal benthic substrates that would be affected are common and widespread within the study area and throughout the wider region. Therefore, any long-term or permanent loss of soft sedimentary habitats is considered small in the context of their overall extent. Based on the highly localised nature of the impact, no to barely discernible changes to the receptors are anticipated, and consequently the magnitude of the impact for these receptors is assessed as being at most **Low adverse**.	In line with the maximum design option.
Nephrops	As discussed previously (Table 14), the substrates within the offshore array area and Offshore ECC are unsuitable for *Nephrops.* Therefore, no discernible changes on the distribution and abundance of *Nephrops* are anticipated from the impact, and consequently the magnitude of the impact is deemed to be **Negligible**.	In line with the maximum design option.
Razor clams	As discussed previously (Table 14), the array area and Offshore ECC do not overlap with important razor clam grounds. Therefore, the number of razor clams affected by the loss of sedimentary habitat is likely to be small when compared to the extent of commercial beds to the north of the study area. Based on this combined with the localised nature of the impact, no discernible changes in razor clam distribution and abundance are anticipated within the study area from the long-term loss of habitat at Dublin Array, and the magnitude of the impact is consequently assessed as being **Negligible**.	In line with the maximum design option.

Definition	Maximum design option	Alternative design option
Blue mussel	As discussed previously (Table 14), site-specific data indicate low numbers of blue mussels within the array area and Offshore ECC, with no known seed mussel beds (Figure 8). Therefore, no discernible changes in the distribution and abundance of blue mussel are anticipated from the impact, and consequently the magnitude of the impact is deemed to be **Negligible**.	In line with the maximum design option.
Overall magnitude	*The potential magnitude of the predicted changes is rated as **Low adverse.***	*The potential magnitude of the predicted changes is rated as **Low adverse.***

4.17.15 In summary, the long-term or permanent loss of benthic habitats will be localised and restricted to the immediate vicinity of subsea infrastructure, with changes in the distribution and abundance of sensitive fish and shellfish receptors assessed barely discernible from baseline conditions for sandeel, common whelk, brown crab, European lobster and scallops, and as being not discernible for the remaining receptors. The maximum magnitude of this impact for fish and shellfish receptors has therefore been assessed as being **Low adverse**.

Significance of effects

4.17.16 The maximum magnitude of the impact has been assessed as **Low adverse**, with the maximum sensitivity of the receptors being **Medium**. Therefore, the maximum significance of effects associated with the long-term or permanent loss of benthic habitat on fish, shellfish and marine turtle receptors is **Slight adverse**, which is not significant in EIA terms.

4.17.17 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

*In relation to both the MDO and the ADOs, the maximum significance of effects on fish, shellfish and marine turtle receptors resulting from long-term or permanent loss of benthic habitats has been assessed as **Slight adverse**, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. **No significant adverse residual effects** on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 8: Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination

4.17.18 As described for Impact 5, the use of jack-ups and anchored vessels and cable inspection work during the operational phase will lead to localised seabed disturbance, which is likely to result in short-term periods of increased SSC and sediment deposition. This has the potential for sediment bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and lead to effects on fish and shellfish receptors.

4.17.19 As discussed for Impact 3, with respect to accidental pollution, good construction practice standards will be adhered to and control measures will be adopted to ensure necessary levels of environmental performance are being met and environmental risks are appropriately managed. Protocols will be put in place to ensure that there is a timely, measured, and effective response to all marine pollution incidents in the marine environment arising from any activities associated with construction and operation. Those protocols and standards will be compliant with relevant legislation (including MARPOL and the Sea Pollution Act).

4.17.20 Whilst substances such as grease, oil, fuel, anti-fouling paints and grouting materials may be accidentally released or spilt into the marine environment, no discharges (continuous or intermittent) of chemicals or materials, which may be toxic or persistent within the marine environment, will be used during any phase of Dublin Array (see Project Description Chapter).

4.17.21 The potential for a reduction in water and sediment quality due to accidental pollution and potential effects on fish and shellfish receptors is therefore not considered further in the assessment.

4.17.22 Elevated levels of suspended sediments and associated releases of sediment bound contaminants during the operational phase will be less to those experienced during the construction phase (Section 4.16, Impact 1 and Table 10). Sediments are likely to be rapidly dispersed by the prevailing tidal currents, and increased bio-availability resulting in adverse eco-toxicological effects to fish and shellfish receptors and their prey are therefore not expected. In addition, any maintenance activities to support the ongoing operation will be temporary and intermittent. Consequently, any impacts on fish and shellfish receptors will be no greater in magnitude than those encountered during the construction phase (Impact 3, Table 17, maximum magnitude: **Negligible**). The sensitivities of the receptors to the impact remain as described for the construction phase (maximum sensitivity: **Medium**).

Significance of effects

4.17.23 The significance of effects associated with the release of contaminated sediments during the operational phase will be no greater, and are expected to be less, than that during the construction phase, which were not significant in EIA terms.

4.17.24 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

In relation to both the MDO and the ADOs, the significance of potential effects on fish, shellfish and marine turtle receptors resulting from the release of sediment- bound contaminants has been assessed as ***Neutral (Not significant)****, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary.* ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 9: Increase in hard substrate and structural complexity due to the placement of subsea infrastructure

4.17.25 Any introduction of infrastructure such as WTG and OSP foundations and scour and cable protection will result in the introduction of hard substrate to the current sedimentary seabed habitats within the array area and Offshore ECC. The heterogeneity of the seabed substrate will be increased, and a subsequent change in the composition of the benthic communities will result. This in turn will represent a change to the structure and function of supporting habitats (e.g., spawning, nursery and foraging habitats) for fish and shellfish receptors.

4.17.26 The loss of habitat for those species which are directly reliant on the sediment for either all, or part of their life cycle (e.g., demersal spawners, overwintering crustaceans) has been assessed as Impact 7. With regard to increasing habitat complexity however, the placement of infrastructure will lead to an alteration of the structure and dynamics of benthic communities where infrastructure exists, with increased structural complexity often leading to greater species diversity, abundance or productivity of benthic assemblages (e.g., Smith *et al.*, 2014). This increase in diversity and productivity as a result of the colonisation of seabed structures may have an impact on fish and shellfish receptors, resulting in either attraction or displacement.

4.17.27 The sensitivity of fish and shellfish receptors to the increase in hard surfaces and structural complexity and the magnitude of the impact have been assessed in Table 36 and Table 37 respectively, based on the methodology outlined Section 4.5. An offshore PEMP with a detailed biosecurity plan will be implemented to ensure that the risk of potential introduction and spread of IAS will be minimised (see Table 11).

Sensitivity of receptor

4.17.28 Hard substrate habitats are rare within the fish and shellfish ecology study area, and as such their introduction would represent a shift in the baseline condition. The presence of artificial structures and hard substrate materials would increase the structural complexity of the seabed environment and provide settlement opportunities for epibenthic faunal and invertebrate species (e.g., Causon and Gill, 2018). This in turn has the potential to increase local benthic biodiversity and biomass, as has been, for example, observed at the Egmond aan Zee Offshore Windfarm in Dutch territorial waters (Lindeboom *et al.*, 2011).

4.17.29 Fish and shellfish receptors may react to these changes in different ways, both beneficial and negative. Some species may benefit directly from the presence of hard structures and associated epifaunal communities, as these may provide shelter from predation or surfaces for egg deposition (Hermans *et al.*, 2020). For example, the attraction of both brown crab and Atlantic cod to wind and wave power foundations is well documented (e.g., Krone *et al.*, 2017; Langhamer and Wilhelmsson, 2009; Lindeboom *et al.*, 2011; Reubens *et al.*, 2013), and juvenile cod, in particular, are known to benefit from structurally complex habitats to seek shelter from predators (Froese and Pauly, 2023). Studies at the Horns Rev Offshore Windfarm in Denmark provided evidence that OWF structures can provide successful nursery habitats for edible crabs (BioConsult 2006). Receptors may also profit indirectly from the presence of artificial structures by taking advantage of the increase in biomass and diversity of prey species. For example, fish communities living around oil and gas platforms off the coast of California have been shown to have higher rates of production compared to fish communities in other coastal and offshore environments within the region (Claisse *et al.*, 2014).

4.17.30 The implications of these structures for the wider fish and shellfish assemblages remain unknown. Fish and shellfish species potentially attracted to artificial hard substrates may induce indirect and adverse effects through increased predation on, or competition with, neighbouring soft sediment species. However, such effects are difficult to predict.

Table 36 Determination of sensitivities to increased hard substrate and structural complexity as a result of the introduction of infrastructure

Receptor	Justification
Marine turtles, basking shark, pelagic VERs (Atlantic mackerel, Atlantic horse mackerel, sprat)	Marine turtles, basking sharks and all pelagic VERs do not depend upon the seabed for part or all of their life cycle and therefore are not considered susceptible to the introduction of hard substrate to the seabed during the operational phase of the proposed development. Consequently, the sensitivity of these species to the impact is deemed to be **Negligible**.
Demersal VERs, diadromous VERs, elasmobranch VERs	Given their mobile nature, these receptors are expected to avoid or adapt to changing substratum conditions (high adaptability). Depending upon the species, individuals may either forage and/ or find refuge in the artificial structures, thereby benefitting from them, or relocate to nearby suitable habitats for feeding (high tolerance). In addition, ovigerous elasmobranch species may use artificial hard surfaces as egg deposition sites. The extent of available spawning locations for the remaining receptors is not expected to be affected by changes in substratum type as these receptors are pelagic spawners (demersal fish VERs), do not spawn within the study area (diadromous VERs) or bear live young (tope, starry smooth-hound and spiny dogfish). Based on this, the sensitivity of all demersal, diadromous and elasmobranch VERs to the impact is deemed to be **Negligible**.
Herring	As discussed previously, for the purpose of this assessment, herring are assessed as not being sensitive to the long-term or permanent loss of benthic habitats given that no active spawning grounds are located within the array area and Offshore ECC. Consequently, the sensitivity of herring to the introduction of hard substrate has also been assessed as **Negligible**.

Receptor	Justification
Sandeel	As assessed for Impact 7 (Table 34), sandeel are susceptible to the long-term loss of sedimentary habitats as they have specific substrate requirements throughout their juvenile and adult life history. Their tolerance to changes in substratum type is therefore assessed as very low. Recovery is expected to occur in the long-term, only following the removal of seabed infrastructure after the decommissioning of the proposed development. However, PSA data indicate that suitable sandeel habitats are present within the study area and wider region (Table 16; Figure 6), and displaced sandeel would therefore be able to relocate to nearby unimpacted areas. Taking this into consideration together with their regional importance, the sensitivity of sandeel to the introduction of hard substratum and increased structural complexity is deemed to be **Medium**.
Brown crab, European lobster, blue mussel	As discussed above, there is high potential for positive effects on some crustacean species, such as brown crab and European lobster owing to the expansion of favourable habitats and refuge areas created from foundations and scour protection installed in areas of soft sediments (e.g., BioConsult, 2016; Krone *et al.*, 2017; Taormina *et al.*, 2020a). In addition, blue mussels may benefit through the increase in hard surfaces, which may favour the settlement of larvae. The sensitivity of these receptors to an increase in hard substratum and structural complexity during the operational phase is therefore assessed as **Negligible**.
Nephrops, King scallop, common whelk, razor clams	As detailed in Table 34, the remaining shellfish VERs are confined to particular soft substratum types and are therefore susceptible to long-term changes in seabed conditions. Their sensitivity to the long-term loss of soft substratum (and the simultaneous increase in the extent of hard substratum) is deemed to be **Medium** (Table 34). The colonisation of new habitats by shellfish receptors could lead to the introduction of non-indigenous and invasive species (see Volume 3, Chapter 3: Benthic, Subtidal and Intertidal Ecology for detailed discussion). This may have indirect adverse effects on shellfish populations as a result of competition. The implementation of a PEMP, which will include a biosecurity plan, would ensure that the risk of potential introduction and spread of IAS will be minimised.

Magnitude of impact

4.17.31 Any introduction of hard substrates due to the placement of subsea infrastructure and associated protection measures will lead to a permanent change in seabed conditions throughout the operational phase of the windfarm development. The impact may be reversible if the infrastructure is removed; however not all introduced hard substrate is likely to be removed, with cable and scour protection assumed to be remaining in-situ.

4.17.32 The extent of the impact will be restricted to the area covered by subsea infrastructure and associated protection material. Under the maximum design option, the seabed footprint of introduced hard substrate within the array area and Offshore ECC will equate to approximately 0.9 km^2, which equates to approximately 0.5 % of the array area and offshore ECC (Table 10). Additional area of hard substrate will be introduced as lateral surfaces through the placement of WTG and OSP foundations.

Table 37 Determination of magnitude of increased hard substrate and structural complexity as a result of the introduction of infrastructure

Definition	Maximum design option	Definition
Extent	The extent of the impact will be largely restricted to the placement of infrastructure which will be within the near-field, with only de-minimis potential impacts within adjacent far-field areas.	In line with the maximum design option; impacts restricted to the near-field with only de-minimis potential impacts within adjacent far-field areas. However, the total area of hard surface to be introduced to the seabed will be less.
Duration	The impact is anticipated to persist for the lifetime of the project and therefore is considered to be long-lasting.	In line with the maximum design option.
Frequency	The impact will occur constantly throughout the operational phase of the development.	In line with the maximum design option.
Probability	The impact can reasonably be expected to occur.	In line with the maximum design option.
Consequences for fish and shellfish VERs		
Basking shark and pelagic VERs	Basking sharks and all pelagic VERs do not depend upon the seabed for part or all of their life cycle, and as such, it is assessed that there will be no discernible gain of resource for these species in the context of the Irish Sea populations. Consequently, no discernible impact in either direction is anticipated for these receptors and therefore the magnitude is rated as **Negligible**.	In line with the maximum design option.

Definition	Maximum design option	Definition
Pelagic, demersal, diadromous and elasmobranch VERs	It is predicted that the impact may benefit some receptors, by providing habitats suitable for shelter, or indirectly through the increase in the abundance of prey species. Therefore, there is potential for changes in the composition and standing stocks of local fish assemblages. Considering the limited spatial extent of the impact, any changes are assessed to be barely discernible from baseline conditions in the context of the fish assemblages present throughout the study area and wider region. The magnitude of this impact on these receptors has therefore been assessed as **Low adverse to Low beneficial**.	In line with the maximum design option.
Herring	As discussed previously, no known active herring spawning grounds are located within the array area and Offshore ECC. Therefore, no loss of herring spawning grounds are predicted from the introduction of hard substrate, and the magnitude of the impact has consequently been assessed as being **Negligible**.	In line with the maximum design option.
Sandeel	As discussed previously, any long-term loss of soft substratum (and the associated increase in hard substratum) is considered to be small in the context of available suitable sandeel habitat throughout the study area and wider region. Therefore, any effects upon sandeel populations and their spawning grounds because of an increase in hard substrate are considered at most to be barely discernible from baseline conditions, and consequently the magnitude of the impact is deemed to be **Low adverse**.	In line with the maximum design option.

Definition	Maximum design option	Definition
Brown crab, European lobster, blue mussel	It is predicted that the receptors may benefit from refuge areas (crab, European lobster) and surfaces for attachment (blue mussel) created from foundations and scour protection installed in areas of soft sediments. Any loss and subsequent alteration of seabed habitats will be highly localised and as such any potential beneficial effects on the distribution and abundance of these receptors are anticipated to be barely discernible from baseline conditions. Therefore, the magnitude of the impact for these receptors is assessed as being **Low beneficial**.	In line with the maximum design option
Nephrops, scallops, common whelk, razor clams	As discussed in Table 35, given the localised spatial extent of the impact and the wide distribution of supporting benthic habitats, any increase in hard substrate (and the associated loss of soft sediments) is considered to result in at most barely discernible changes from baseline conditions for these receptors. The magnitude of the impact is therefore deemed to be at most **Low adverse**.	In line with the maximum design option
Overall magnitude	*The potential magnitude of the predicted changes is rated as **Low adverse**.*	*The potential magnitude of the predicted changes is rated as **Low adverse**.*

Significance of effects

4.17.33 The maximum magnitude of the impact has been assessed as **Low adverse for both the MDO and alternative design option**, with the maximum sensitivity of the receptors being **Medium**. Therefore, the significance of effects associated with the introduction of hard substrate and structural complexity is **Slight adverse**, which is not significant in EIA terms.

4.17.34 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

*In relation to both the MDO and ADOs, the maximum significance of effects on fish, shellfish and marine turtle receptors resulting from increased hard substrate and structural complexity has been assessed as **Slight adverse**, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. **No significant adverse residual effects** on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 10: Potential barriers to movement through the presence of seabed infrastructure and EMF from cables

4.17.35 The transmission of power through subsea cables from the WTGs to shore during the operational phase of the proposed development will produce EMFs in the surrounding sediment and water column. These fields have the potential to affect fish and shellfish receptors that use electric or magnetic senses for foraging, navigation or communication.

4.17.36 Artificial EMFs are generated as a result of the electric currents passing through power cables (e.g., inter-array and export cables). Two types of EMFs are produced directly: electric fields (E-fields), which are generated by static electric charges of the cable, and magnetic fields (B-fields), which are produced by moving electric currents. A third type of EMF, induced electric fields (iE-fields), is generated indirectly from B-fields, either by the movement of alternating B-fields (in the case of alternating current (AC) transmission) through seawater or by the movement of seawater and/or an organism through a static B-field (in the case of direct current (DC) transmission).

4.17.37 EMFs also occur naturally in the marine environment from a variety of sources, including the Earth's geomagnetic field and small bioelectric fields generated by electrical currents moving through living organisms (e.g., Normandeau Associates *et al.*, 2011). These are the signals that magneto- and electrosensitive species rely on, for example, for navigation, orientation and prey detection.

4.17.38 At Dublin Array, EMFs will result from the operation of up to 120 km of inter-array cables and two 18.35 km long HVAC export cables, with proposed voltages between 66 kV and 132 kV for the inter array cables and 220 kV for the two export cables. All cables will carry alternate currents. The sensitivity of fish and shellfish receptors to the EMFs produced by these cables and the magnitude of the impact have been assessed in Table 38 and Table 39 respectively, based on the methodology outlined in Section 4.5.

4.17.39 Specific avoidance and preventative measures relevant to the impact are listed in Table 11. All cables will contain industry standard shielding, which prevents E-fields from passing into the marine environment, and therefore E-fields are not considered further in the assessment. Cable shielding and/or burial does not however prevent or reduce the emission of B-fields, which consequently can emanate into the water column, where they are likely to create iE-fields.

4.17.40 All cables will be buried where possible, to a target depth of 3 m in mobile sediment areas to ensure they will not become exposed during the operational phase (Table 11). Although cable burial does not prevent EMFs from emanating into the marine environment, it increases the distance between the EMF source and sensitive receptors, thereby reducing the EMF strengths to which individuals are subjected.

Sensitivity of receptors

4.17.41 Many marine species are known to possess magnetic or electric senses. These magneto- and electro-receptive species utilise natural EMFs for a range of ecological processes, such as short- and long-range spawning and feeding migrations and the detection of prey, predators and sexual mates (Béguer-pon *et al.*, 2015, cited in Gill *et al.*, 2023; Rivera-Vicente *et al.*, 2011). Perhaps the most well recognised use of electric fields is by elasmobranchs, which use electro-receptors to detect prey that may be buried in sediment or under rocks. Migratory fishes such as salmonids and eels can detect EMFs via magneto-reception, while some shellfish species also have well-developed magneto-sensory systems. The EMFs generated during the operational phase of the proposed development may affect magneto- and electrosensitive species by disrupting bioelectric or geomagnetic cues, thereby masking prey or altering migratory behaviour.

4.17.42 Potential impacts of anthropogenic EMFs on marine organisms are relatively sparsely investigated, with studies having so far focussed on a small number of species. Additionally, due to challenges of monitoring a wide variety of marine organisms in single studies in situ, many studies have been laboratory based, which has limited ability to determine behavioural reactions that may or may not occur in real world scenarios.

4.17.43 Table 38 provides a literature review on the potential impacts of EMF from subsea cables for various species, thereby providing information on the potential sensitivity of species groups and the EMF levels required to cause effects to marine species. As discussed previously, the cables that will be installed at Dublin Array are designed with shielding surrounding the cores, which prevents E-fields to emanate into the marine environment. For the purposes of the literature review, studies on the reactions of receptors to both E-fields and iE-fields have been drawn upon. However, for the purposes of impact assessments, only references to iE fields have been made.

Table 38 Determination of receptor sensitivities to EMFs from cables

Receptor	Justification
Marine turtles	Marine turtles are known to use the Earth's magnetic field amongst other senses to migrate between nesting beaches and feeding grounds (Lohmann *et al.*, 2008). Whilst turtles are potentially sensitive to magnetic fields from EMFs, adverse effects on their ability to follow migration routes would be expected to occur in the absence of other cues (e.g. sunlight) (Tricas and Gill, 2011). Furthermore, marine turtles are primarily pelagic species and will only interact with the fields generated by subsea cables when diving in most cases. The rapid attenuation of the EMF from cables will ensure that any interaction between EMF and marine turtles is limited. Therefore, the sensitivity of marine turtles to EMFs is deemed to be **Negligible**.

Receptor	Justification
Elasmobranch VERs	Elasmobranchs, especially demersal species, are known to be the most electro-sensitive of all fish. All species within this group have specialised organs, called ampullae of Lorenzini, which contain a large array of individual receptors that can detect E-fields. The electro-receptors are primarily used to detect bioelectric fields emitted by potential prey (Kalmijn, 1971, cited in Hutchison *et al.*, 2021). Observations of behavioural reactions of elasmobranchs to iE-fields caused by offshore electricity cables is limited, with some studies showing small changes in behaviour when the cable is powered compared to when not, suggesting that elasmobranchs can detect EMFs generated by underwater cables (Gill *et al.*, 2009). Current evidence suggests that elasmobranchs show behavioural reactions to electrical fields greater than 5-30 µV/m (e.g., Hutchison *et al.*, 2020a; Kalmijn, 1966; Kajiura and Holland, 2002; Kajiura and Fitzgerald, 2009). Behavioural changes may manifest themselves in either attraction or repulsion depending on the field strengths experienced (Gill and Taylor, 2001; Kimber *et al.*, 2011). The threshold for the change between attraction and avoidance of iE-fields in elasmobranchs is between about 400-1,000 µV/m (reviewed in Centre for Marine and Coastal Studies (CMACS), 2012). Behavioural changes in elasmobranchs in response to EMF from cables appear to be dependent on the individual and species observed, and as such consequences at the population level are uncertain. A more recent study by Hutchison *et al.* (2020b) quantified behavioural responses of the electro-sensitive little skate (*Leucoraja erinacea*) to EMF emissions of a subsea high voltage direct current (HVDC) transmission cable. The study observed an increase in exploratory/foraging behaviour in the skates in response to EMFs. A study commissioned by the British Marine Management Organisation (MMO) (2014) found no evidence to suggest that EMF posed a significant risk to elasmobranchs at the site or population level. In a review by Tricas and Gill (2011), it was noted that the sensitivity of elasmobranchs to E-fields was highest at frequencies of 1-10 Hz, with a broader response frequency range of 0.01-25 Hz where fields intensities of 10x or greater were required to elicit a reaction. This suggests that weak fields such as those generated by offshore wind AC cables are likely to be mostly undetectable. Overall, current knowledge suggests that elasmobranch species may exhibit some behavioural changes to the localised EMFs generated during the operational phase of the proposed development. No significant changes to populations or distributions of species have so far been recorded (Hvidt *et al.*, 2004; Love *et al.*, 2017; MMO, 2014). Taking this into consideration, the sensitivity of all elasmobranchs VERs to impacts from EMFs is deemed to be **Low**.

Diadromous VERs	Most research on the sensitivity of teleost fishes to EMFs has been undertaken in migratory species, such as Salmonidae, Anguillidae and Scombridae (reviewed in Tricas and Gill, 2011). Some of these species, such as Atlantic salmon and the European eel, have magneto-receptors, which are thought to primarily be used for navigation using the Earth's magnetic field (Gill and Bartlett, 2010; Hutchison *et al.*, 2020a). There have therefore been suggestions (Gill *et al.*, 2005) that the presence of B-fields generated by submarine cables may interrupt navigation and consequently migration in these species. Field studies investigating the response of magneto-sensitive species to artificial EMF emissions are limited. Using acoustic transmitters, Wyman *et al.* (2018) studied the movement patterns of Chinook salmon smolts before and after the installation of a high-voltage current cable within San Francisco Bay. Their data showed mixed effects with salmon smolts swimming parallel to the cable observed to swim faster, and some possible attraction to the active cable leading to misdirection and increased transit times. However, the survival and outward migration success of salmon smolts was not affected (Wyman *et al.*, 2018). Minor route deviations and short-term delays in migration have also been observed in the European eel in response to AC and DC B-fields (low (5 uT) DC B-fields; however, the effects were of short duration and not considered to impact the overall migration (reviewed in Öhman *et al.*, 2007). Of importance to the proposed development, no effects were seen in European eel from AC fields of 9.6 µT (Orpwood *et al.*, 2015), suggesting that there may be differences in effects between DC and AC cabling. European eel are known to be magneto-sensitive to B fields of 5 µT (Westerberg, 2000; Öhman *et al.*, 2007) and studies have shown reactions to E fields, however, only at tens of thousands of µV/m which is far greater than those expected to be generated by the Dublin Array. Overall, the current evidence suggests that magneto-receptive diadromous fishes like Atlantic salmon and European eel may exhibit short-term, localised behavioural changes to magnetic fields emitted by subsea power cables, which, however, are unlikely to affect their migratory patterns and behaviour in the long-term. Taking this into consideration, Atlantic salmon and European eel are deemed to be of low sensitivity to impacts from EMFs. Some migratory species may be sensitive to electric fields. Lampreys possess specialised ampullary receptors that are responsive to weak, low frequency E-fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983), but information regarding what use they make of the electric sense is limited. Observations by Chung-Davidson *et al.* (2008) suggest that weak E-fields may play a role in the reproduction of sea lamprey, with electric stimuli thought to be important in detecting potential mates, retaining lampreys in their nests or in regulating sexual behaviour. Others have suggested that adult sea lamprey may use their electric senses to locate prey over short distances or to navigate by using the electric fields induced in the water column by the Earth's magnetic fields (Bodznick and Preston, 1983). Laboratory tests conducted on adult sea lamprey (i.e. individuals at their marine stage) showed strong reductions in swimming behaviour at electric fields strengths of 30 µV/cm and above (Chung-Davidson *et al.*, 2004).

Receptor	Justification
	Overall, current evidence suggests that the threshold for behavioural response in sea lamprey lies within the range of electric field induced by subsea power cables (CMACS, 2003; Normandeau Associates *et al.*, 2011). Taking the above into consideration, river and sea lamprey are deemed to be of low sensitivity to impacts from EMFs from subsea power cables. Information on the impact of EMFs on the other diadromous species (sea trout and twaite shad) is limited. A broad scale study of fish aggregations and directional movement around subsea cables at the Nysted offshore wind farm in Denmark showed no evidence of any change in directionality or distribution of species as a result of the cable installation (Hvidt *et al.*, 2004). Taking this into consideration, these species are deemed to be at most of low sensitivity to impacts from EMF. In summary, the sensitivity of all diadromous VERs to impacts from EMFs is deemed to be **Low**.
Pelagic, demersal and bentho-pelagic VERs	Information on the impact of EMFs on other fish species is limited. A broad scale study of fish aggregations and directional movement around subsea cables at the Nysted offshore wind farm in Denmark showed no evidence of any change in directionality or distribution of species as a result of the cable installation (Hvidt *et al*., 2004). Furthermore, given the mobile nature of these VERs, they have the ability to demonstrate avoidance behaviour and relocate to nearby unaffected areas. Taking this into consideration, the sensitivity all other fish VERs is assessed as being **Low**.
Shellfish VERs	Many marine invertebrates are thought to be magneto-sensitive, with this often being used for navigational purposes, such as during migration. However, evidence for potential impacts from anthropogenic B-fields is limited and has been contradictory even within the same species. Studies on the green shore crab have been directly contradictory, with one study demonstrating reduced aggression in response to AC, B -fields matching those from an offshore wind farm (Everitt, 2008), while another study showed no effects from static B-fields (Bochert and Zettler, 2004). Behavioural responses were also observed in the Dungeness crab (*Metacarcinus magiste*), with more frequent changes in behaviour observed within the first two days of EMF exposure (Woodruff *et al.*, 2012). Brown shrimp were recorded as being attracted to B-fields of the magnitude expected from offshore wind cabling (ICES, 2003). A recent study (Hutchison *et al.*, 2020b) indicated potential subtle changes to exploratory behaviour in American lobster (*Homarus americanus)* in response to DC B-fields when in tanks placed near a subsea cable. However, the authors noted that there was no indication that the behavioural change was related to the differing EMF strengths within the enclosure. Conversely, no behavioural responses were observed in an aquarium study of juvenile European lobsters to an artificial magnetic field gradient with a maximum intensity of 200 µT (Taormina *et al.*, 2020b).

Receptor	Justification
	Recent studies have also identified both behavioural (Scott *et al.*, 2018) and physiological (Scott *et al.*, 2021) reactions in brown crab from EMF. Scott *et al.* (2018) suggests that the natural roaming behaviour, where individuals will actively seek food and/or mates has been overridden by an attraction to the source of the EMF (strength 2,800 µT to 40,000 µT). However, the exposure to EMF does not affect the activity levels of the crabs but affects their ability to select a site to rest. Scott *et al.* (2021) investigated the effects of EMF (strengths 250 µT, 500 µT and 1000 µT) from submarine power cables on edible crab and showed limited physiological and behavioural effects on the crabs exposed to EMF of 250 µT. EMF of 500 µT or above showed physiological stress in crabs, and changes to behavioural trends, specifically an attraction to EMF. It is to be noted however, that these studies investigated EMF strengths significantly higher than those that receptors will typically be exposed to as a result of offshore wind cables in the marine environment. Specifically, the lowest experimental EMF used in Scott *et al.* (2021) was a factor of 10 higher than that expected for the proposed development, with no impacts identified at this EMF strength. Effects were only noted in these studies using EMF strengths which were a factor of 20-1,000 higher than those expected from the Dublin Array cables. A very small number of studies have suggested that some invertebrates may also be able to detect E-fields (Patullo and Macmillan, 2007; Steullet, *et al.*, 2007). However, E-fields are thought to trigger chemo- and mechano-sensory neurons rather than specialised E-field receptors (unlike the ampullae of Lorenzini present in elasmobranchs) (Tricas and Gill, 2011). The studies were undertaken using voltages which were orders of magnitude greater than those predicted from the proposed development (Patullo and Macmillan, 2007; Steullet, *et al.*, 2007). Taking the above into consideration, it is concluded that B-fields generated during the operational phase may lead to behavioural changes in some shellfish species. Such changes would be restricted to the immediate vicinity of the cable, and therefore, the sensitivity of the shellfish VERs to EMFs is deemed to be **Low**.

4.17.44 In summary, the sensitivity of all fish and shellfish VERs to the introduction of EMFs from power cables is deemed to be **Low**.

Magnitude of impact

4.17.45 B-fields generated by subsea power cables attenuate horizontally and vertically away from the cable, with the field strength directly related to the power of the current passing through the cable. The power passing through a cable is typically measured in amperes (A), rather than specifically related to the voltage, though the cable voltage rating often increases the power carrying capabilities of a cable, so the two are related. The proposed voltages for the Dublin Array cables will be between 66 kV to 132 kV for the inter array cables and 220 kV to 400 kV for the two export cables.

4.17.46 B-fields are measured as Teslas (T), with the strength of the fields existing naturally (i.e., Earth magnetic field) and those seen from submarine cables generally presented as micro-Teslas (µT) due to the strength of the fields recorded. The magnetic fields generated by AC and direct current (DC) cables are significantly different, with DC cables typically generating much larger EMFs than AC cables (e.g., Tricas and Gill, 2011). Dublin Array will use AC cabling only.

4.17.47 Assuming a power (current) of 1,200 A for the Offshore export cables used for Dublin Array, the B-field at the seabed is predicted to be up to 30 µT based on internal project calculations and assuming cable buried to 1 m. This is similar to the B-field calculated using the method from Tricas and Gill (2011) that estimates a B-field of 29.4 µT from the power (current) alone and also agrees with similar modelling of B-fields from other offshore wind farms in Scotland, which predicted a maximum B-field of approximately 25 µT for a AC 220 kV export cable for a trench depth of 1 m (Beatrice Offshore Windfarm Limited (BOWL), 2016). The B-fields from the inter array cables will inherently be much less due to the lower current (max of 1,000 A) from only a small number of turbines per string.

4.17.48 B-fields attenuate rapidly away from the central line of the cable (Figure 14 and Figure 15), and therefore are likely to be detectable above background levels only in close proximity to the cables (i.e., within about 10 metres either side of the cable) (e.g. Normandeau Associates *et al.*, 2011). At 1 m above the export cable, the artificial magnetic field will be less than 30 µT, much less than the Earth's natural magnetic field, which is approximately 49 µT in the Irish Sea (National Oceanic and Atmospheric Administration (NOAA), 2020).

4.17.49 The iE-field strength is directly related to the B-field, being strongest closest to the cable and attenuating horizontally and vertically away from the cable. iE-fields are measured as volts per metre (V/m), with values seen in the marine environment from cabling being within the µV/m range.

4.17.50 Calculation of iE-fields from AC cables is challenging due to iE-fields being generated by the fluctuation of the current (typically at a frequency of 50 Hz for European cables) and the movement of organisms or water through the magnetic field, with the size of the organism moving through the B-field also affecting the strength of the resulting iE-fields. Based on the magnetic field strengths estimated for the proposed Dublin Array, the iE-field at the seabed is likely to be >700 µV/m (assuming cable burial to 1 m). As the iE-field is directly related to the B field strength, there is the same rapid decrease in field strength with distance vertically and horizontally from the cable, with iE-field strengths down to tens of µV/m within 5 m of the cable line (e.g., Tricas and Gill, 2011). Previous assessments have identified that iE-field strengths from array cable specifications likely to be used at Dublin Array (up to 132 kV, assuming 1 m burial) would be a maximum of 91 µV/m at the seabed, decreasing to 10 µV/m within 8 m (CMACS, 2012).

4.17.51 In summary, B-fields and iE-fields generated by the power cables are likely to be detectable above background levels only in close proximity to the cables (i.e. within metres). The maximum extent of the impact will therefore be restricted to the immediate vicinity of the cables, i.e., within < 10 m each side of the cables. The impact will occur constantly throughout the 35-year operational phase of the development when the cables are carrying a current, and therefore the impact will be long-term (15-60 years).

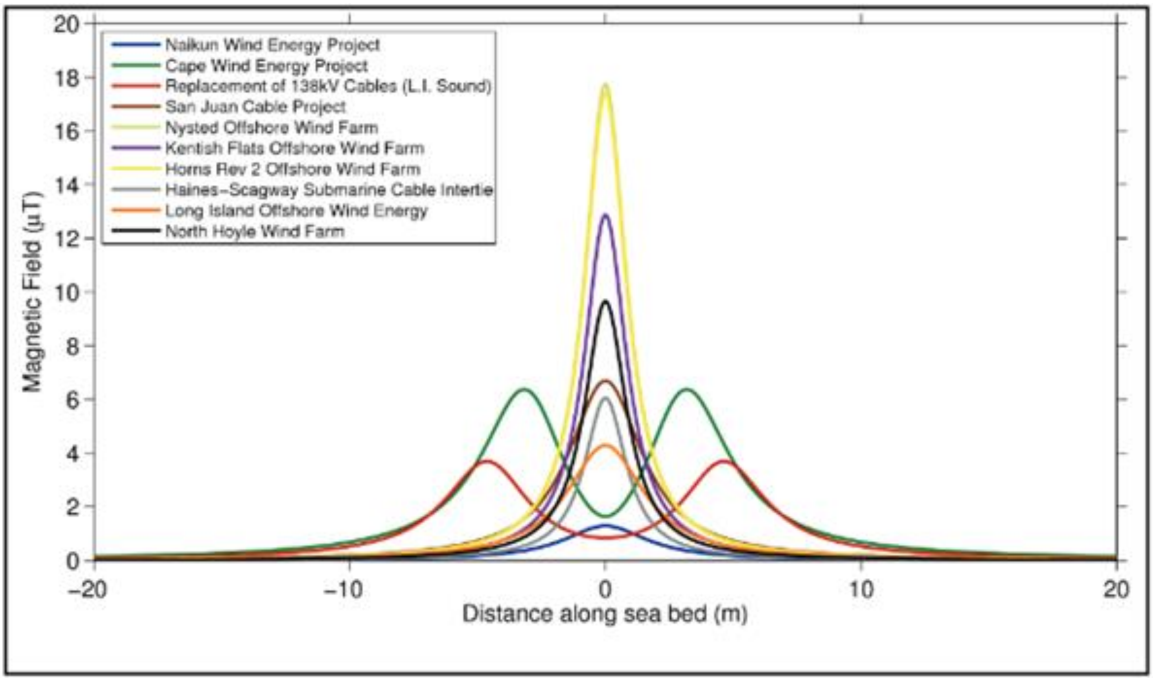

Figure 14 Modelled AC magnetic field profiles across the surface of the seabed for OWF cable systems (from Normandeau *et al.*, 2011)

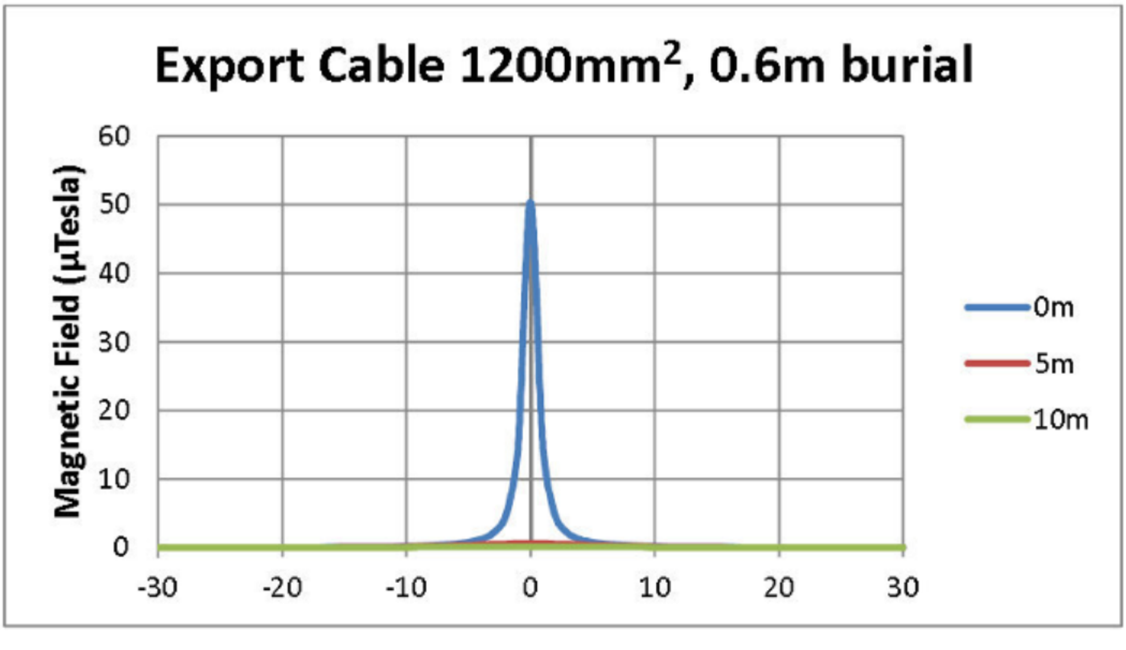

Figure 15 Modelled magnetic field strengths at seabed, 5 m and 10 m above the seabed for an AC 220 kV export cable buried 0.6 m under the seabed surface (from BOWL, 2016)

Table 39 Determination of impact magnitude of EMFs from cables

Definition	Maximum design option	Alternative design option
All VERs	The impact will be highly localised and restricted to discrete areas within the array area and ECC. It is predicted that the impact may affect sensitive fish and shellfish receptors directly, potentially leading to behavioural changes within the near-field. Diadromous VERs will be transient across the study area, while the remaining receptors are widely distributed within the study area and Irish Sea. Therefore, any localised behavioural changes are considered small compared to the overall extent of available habitat across the study area and wider region. Based on this, any effects of EMFs on fish and shellfish receptors are assessed as being at most barely discernible from baseline conditions. Consequently, the maximum magnitude of the impact is deemed to be **Low adverse**.	In line with the maximum design option

Significance of effects

4.17.52 The maximum magnitude of the impact for fish, shellfish and marine turtle receptors has been assessed as **Low adverse for both the MDO and alternative design option**, with the maximum sensitivity of the receptors being **Low**. Therefore, the maximum significance of effects associated with EMFs arising from cables during the operational phase is **Slight adverse**, which is not significant in EIA terms.

4.17.53 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

*In relation to both MDO and ADO, the maximum significance of effects on fish, shellfish and marine turtle receptors resulting from EMFs has been assessed as **Slight adverse**, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. **No significant adverse residual effects** on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 11: Changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes

4.17.54 The presence of foundations, scour protection and cable protection material may introduce changes to the local hydrodynamic regime, resulting in changes to the sediment transport pathways and associated effects on the benthic habitats that support fish, marine turtles and shellfish receptors. Scour and increases in flow rates can change the characteristics of the sediment, potentially making the habitat less suitable for some species. Marine turtles will not be affected by changes in seabed conditions as they do not display substrate dependency.

4.17.55 Sandbank and sand wave supporting habitats could potentially be impacted by the interruption of the supply of sediment from the system via alterations in the tidal and wave regimes. Such impacts will have the greatest effect on those fish and shellfish receptors that are directly reliant on the benthos for either all, or part of their life cycle, such as demersal spawners.

4.17.56 The Physical Processes assessment has considered potential changes to local hydrodynamic, wave and sediment transport processes occurring during the operational phase in the array and Offshore ECC areas. Changes to the tidal and wave regime and sediment transport processes were predicted to be Negligible, which is not significant in EIA terms. As a result, no significant pathway of effect on fish, marine turtles and shellfish receptors exists for these aspects.

4.17.57 Scour resulting from the placement of WTG foundations were predicted to result in localised changes in seabed topography and flow patterns around the foundations, which were assessed to be of Low magnitude. Information on the sensitivity of fish and shellfish receptors to seabed scour is limited. Therefore, as a worst-case precaution, the sensitivity scores for Impact 7 'Long-term loss of benthic habitats' were applied, with the maximum sensitivity of the receptors being rated as **Medium**. The magnitude of the impact has been assessed as **Negligible**, given that the supporting benthic habitats are common and widespread throughout the study area and wider region and any changes will represent a very small footprint compared to their overall extent, with no discernible effects for fish and shellfish receptors predicted.

Significance of effects

4.17.58 The magnitude of the impact has been assessed as a **Negligible for both the MDO and alternative design option**, with the maximum sensitivity of the receptors being **Medium**. Therefore, the significance of effects associated with changes to supporting seabed habitats arising from effects on physical processes (including scour effects and sediment transport) and wave regimes on fish, marine turtles and shellfish ecological receptors is a **Neutral Effect (Not significant)**, which is not significant in EIA terms.

4.17.59 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

The significance of potential effects on fish, marine turtles and shellfish receptors resulting from changes to supporting seabed habitats has been assessed as ***Neutral (Not significant)****, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary.* ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

4.18 Environmental assessment: decommissioning phase

4.18.1 As referenced in the Project Description, the Decommissioning and Restoration Plan (Volume 7, Appendix 2), including the three rehabilitation schedules attached thereto, describes how the Applicant proposes to rehabilitate that part of the maritime area, and any other part of the maritime area, adversely affected by the permitted maritime usages that are the subject of the MACs (Reference Nos. 2022-MAC-003 and 004 / 20230012 and 240020).

4.18.2 It is based on the best scientific and technical knowledge available at the time of submission of this Planning Application. However, the lengthy passage of time between submission of the Planning Application and the carrying out of decommissioning works (expected to be in the region of 35 years as defined in the MDO) gives rise to knowledge limitations and technical difficulties. Accordingly, the Decommissioning and Restoration Plan will be kept under review by the Applicant as the project progresses, and an alteration application will be submitted if necessary. In particular, it will be reviewed having regard to the following:

- The baseline environment at the time rehabilitation works are proposed to be carried out,
- What, if any, adverse effects have occurred that require rehabilitation,
- Technological developments relating to the rehabilitation of marine environments,
- Changes in what is accepted as best practice relating to the rehabilitation of marine environments,
- Submissions or recommendations made to the Applicant by interested parties, organisations and other bodies concerned with the rehabilitation of marine environments, and/or
- Any new relevant regulatory requirements.

4.18.3 The Decommissioning and Restoration Plan outlines the process for decommissioning of the WTG, foundations, scour protection, OSP, inter array cables and Offshore ECC. The plan outlines the assumption that the most practicable environmental option is to leave certain structures in situ (e.g. inter array cables, scour protection), however the general principle for decommissioning for all surface structures to be removed with wind turbine generators (WTG's) dismantled and completely removed to shore. Piled foundations will be cut at a level below the seabed and buried cables and scour and cable protection left in situ.

4.18.4 A description of the significance of effect upon fish and shellfish receptors VERs caused by each identified impact is provided below. An assessment of impacts on any qualifying interests of Natura 2000 sites is undertaken within the Report to Inform Appropriate Assessment Screening and the NIS (Part 4: Habitats Directive Assessments, Volume 4: NIS).

Impact 12: Temporary increases in SSC and sediment deposition arising during decommissioning activities

4.18.5 During the decommissioning phase, the removal (or partial removal) of any surface and subsurface infrastructure and associated protection measures is expected to lead to localised seabed disturbances, which is likely to result in short-term periods of increased SSCs and sediment deposition. The volumes of sediments to be released will be less the volumes predicted for the construction phase (Section 4.16, Impact 1) given the absence of sandwave clearance and other seabed preparation activities (Table 10). Consequently, any effects on fish and shellfish receptors are expected to be no greater in magnitude than those encountered during the construction phase (Impact 1, Table 14, maximum magnitude: **Low adverse**). The sensitivities of the fish and shellfish VERs to the impact would remain as described for the construction phase (Table 12, maximum sensitivity: **Medium**).

Significance of effects

4.18.6 The significance of effects resulting from temporary increases in SSC and deposition during decommissioning activities associated with the Dublin Array are expected to be less than those of the construction phase (Impact 1), which were not significant in EIA terms.

4.18.7 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

In relation to both the MDO and the ADOs, the significance of potential effects on fish, shellfish and marine turtle receptors from temporary increases in SSC and sediment deposition during decommissioning activities of the Dublin Array has been assessed as not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 13: Temporary damage and disturbance of the seabed during decommissioning activities

4.18.8 The decommissioning of infrastructure has the potential to cause temporary damage or disturbance to the seabed in the Dublin Array windfarm array area and Offshore ECC. It is proposed that that structures above the seabed would be decommissioned in reverse of the construction process.

4.18.9 It is anticipated that the maximum area of seabed to be affected during decommissioning will be less than that assessed for the construction phase given the absence of sandwave clearance and other seabed preparation activities (Section 4.16, Impact 2). In addition, as proposed in the Decommissioning and Restoration Plan (Volume 7, Appendix 2), the IAC and export cables will be left *in situ* where considered appropriate. Based on the above, it is concluded that any effects on fish and shellfish receptors from temporary disturbances or damages to the seabed during decommissioning will be no greater in magnitude than those encountered during the construction phase (Impact 2, Table 16, maximum magnitude: **Low adverse**). The sensitivities of the fish and shellfish VERs to the impact would remain as described for the construction phase (Table 15, maximum sensitivity: **Medium**).

Significance of effects

4.18.10 The significance of effects associated with temporary habitat loss and disturbance during decommissioning activities of the Dublin Array are expected to be less than those of the construction phase (Impact 2), which were not significant in EIA terms.

4.18.11 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

In relation to both the MDO and the ADOs, the significance of potential effects on fish, shellfish and marine turtle receptors from the temporary damage and disturbance of the seabed during decommissioning has been assessed as not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary. ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 14: Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination

4.18.12 As described for Impact 12, decommissioning activities will lead to localised seabed disturbances, which is likely to result in short-term periods of increased SSC and sediment deposition. This has the potential for sediment bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and lead to effects on fish and shellfish receptors.

4.18.13 As for construction and O&M, with respect to accidental pollution, good construction practice standards will be adhered to and control measures will be adopted to ensure necessary levels of environmental performance are being met and environmental risks are appropriately managed. Protocols will be put in place to ensure that there is a timely, measured, and effective response to all marine pollution incidents in the marine environment arising from any activities associated with construction and operation. Those protocols and standards will be compliant with relevant legislation including MARPOL and the Sea Pollution Act.

4.18.14 Whilst substances such as grease, oil, fuel, anti-fouling paints and grouting materials may be accidentally released or spilt into the marine environment, no discharges (continuous or intermittent) of chemicals or materials, which may be toxic or persistent within the marine environment, will be used during any phase of Dublin Array (see Project Description Chapter).

4.18.15 As discussed for Impact 12, the volumes of suspended sediments generated during decommissioning activities, and any associated releases of sediment-bound contaminants, will be less than those released during the construction phase (Section 4.16, Impact 1 and Table 10) given the absence of seabed preparation activities (Table 10). In addition, any decommissioning activities will be temporary. Consequently, any effects on fish and shellfish receptors will be no greater in magnitude than those encountered during the construction phase (Impact 3, Table 17, maximum magnitude: **Negligible**). The sensitivities of the fish and shellfish VERs to the impact would remain as described for the construction phase (maximum sensitivity: **Medium**).

Significance of effects

4.18.16 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the receptors being **High**. Therefore, the significance of effects associated with the release of contaminated sediments during the decommissioning phase is a **Neutral Effect (Not significant)**, which is not significant in EIA terms.

4.18.17 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

In relation to both the MDO and the ADOs, the significance of potential effects on fish shellfish and marine turtle receptors resulting from the release of sediment bound contaminants has been assessed as ***Neutral (Not significant)****, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary.* ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

Impact 15: Introduction of underwater noise and vibration leading to mortality, injury, TTS, behavioural changes, or auditory masking

4.18.18 As detailed in Impact 4 of the construction phase (Section 4.16), there is the potential for underwater noise from anthropogenic activities to lead to effects on fish, shellfish and marine turtles.

4.18.19 There is likely to be underwater noise generated during the decommissioning of Dublin Array. However, percussive piling or clearance of UXO would not be necessary, and therefore, any effects on sensitive fish and shellfish receptors will be reduced. Accordingly, any effects would be no greater in magnitude than those encountered during the construction phase (Impact 4).

Significance of effects

4.18.20 The significance of effects resulting from increases in underwater noise during decommissioning activities associated with Dublin Array are expected to be less than those of the construction phase (Impact 4), which were not significant in EIA terms.

4.18.21 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual Effect assessment

In relation to both the MDO and the ADOs, the maximum significance of potential effects on fish, shellfish and marine turtle receptors from underwater noise generated during decommissioning activities has been assessed as ***Slight adverse****, which is not significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary.* ***No significant adverse residual effects*** *on fish, shellfish and marine turtle receptors have therefore been predicted as a result of the impact.*

4.19 Environmental assessment: cumulative effects

Methodology

4.19.1 This section outlines the Cumulative Effects Assessment on fish and shellfish ecology and takes account of the impacts of the proposed development alone together with other plans and projects. As outlined in the Cumulative Effect Assessment Methodology chapter (Volume 2, Chapter 4), the screening process to select a long-list of plans and projects involved determination of appropriate search areas for projects, plans and activities and ZoIs for potential cumulative effects. These were then screened according to the level of detail publicly available and the potential for interactions with regard to the presence of an impact pathway as well as spatial and temporal overlap.

4.19.2 The Cumulative Effects Assessment (CEA) long list of projects (Volume 2, Chapter 4, Annex A: Offshore long-list), plans and activities with which Dublin Array's offshore infrastructure has the potential to interact with to produce a cumulative effect is presented within the Cumulative Effect Assessment Methodology chapter. Each plan and project has been considered on case by case basis with the maximum suite of projects identified from a long list within a search area defined as the ICES Ecoregion subsection 7a. Division 7a of the Celtic Sea ICES Ecoregion[21] is considered appropriate for this exercise in relation to fish and shellfish receptors as it will fully encompass all projects and plans with the potential to have spatial overlap with the effects of the offshore works associated with Dublin Array.

[21] Ecoregions are used to provide regional advice, steer regional integrated approaches and are the primary geographical units for ICES to develop science, new techniques and monitoring programmes. They provide the broad-scale spatial framework for the knowledge base to address management challenges and monitor the changing ecology of the North-East Atlantic. Division 7a is part of the Celtic Sea Ecoregion and broadly covers the Irish Sea

4.19.3 For the purpose of this assessment, the zone of influence has been defined as 100 km buffering the array area to encapsulate potential cumulative effects from underwater noise. Based on the noise modelling for Dublin Array, the greatest impact range for TTS (186 dB SEL_{cum}) for stationary fish during piling of foundations is 29 km during the sequential piling of four 5.75 m diameter pin piles (maximum hammer energy of 4,695 kJ), reducing to 19 km during the piling of one 13 m diameter monopile (maximum hammer energy 6,372 kJ (Table 21). To inform the cumulative assessment, it is assumed that maximum impact ranges for underwater noise effects resulting from other consented and proposed OWFs within the Irish Sea would be similar or greater than those predicted for Dublin Array. For example, underwater noise modelling conducted for the proposed Codling Wind Park predicted maximum impact ranges for the onset of TTS of 34 km for stationary receptors and 24 km for fleeing species (Codling Wind Park Limited, 2024). Modelling for the proposed North Irish Sea Array (NISA) showed maximum TTS onset ranges of up to 69 km for stationary receptors and 51 km for fleeing receptors (NISA, 2024), while the modelled maximum impact range for the onset of TTS during piling at the Awel Y Môr (AyM) OWF (located in Welsh waters) was 36 km for stationary receptors and 17 km for fleeing receptors (RWE, 2023). Therefore, a screening range of 100 km is considered to be precautionary and likely to encapsulate the area within which potential significant cumulative effects on fish and shellfish receptors from underwater noise might occur.

4.19.4 The ZoI of 100 km has also been applied to encompass potential cumulative effects relating to seabed disturbance events including increases in SSC and sediment deposition. It is acknowledged that sediment plumes with SSC above background levels created during the construction, O&M and decommissioning phases of Dublin Array are predicted to disperse over a maximum distance of 10 km (see Physical Processes chapter), and consequently cumulative effects as a result of overlapping plumes and sediment deposition events with other projects would be confined to a much smaller area than the selected screening range of 100 km. However, there is potential for non-overlapping sediment plumes or sediment deposition to simultaneously disturb spawning or nursery grounds, which may lead to cumulative effects on the reproductive or recruitment success of sensitive receptors. For this reason, a wider screening range of 100 km has been applied, which encapsulates the extent of mapped fish spawning grounds within the western Irish Sea. As described in the Fish and Shellfish technical baseline and summarised in Section 4.6, several VERs (e.g., plaice and cod) favour shallower inshore areas for spawning, with many spawning grounds showing a predominantly north-south orientation along the Irish east coast.

4.19.5 Plans and projects screened in, together with their allocated tier as defined in the Cumulative Effects Assessment Methodology chapter that reflects their current stage within the planning and development process, are presented in Table 40. For the purposes of the Cumulative Effects Assessment, a precautionary construction period has been assumed between the years 2029 to 2032, with offshore construction (excluding preparation works) lasting up 30 months as a continuous phase within this period (refer to the Project Description Chapter).

Project screened out

4.19.6 The following types of developments have been scoped out from this cumulative assessment for fish and shellfish receptors based on a lack of a spatial overlap:

- Aggregate production;
- Oil and gas infrastructure;
- Other Offshore Energy; and
- Carbon Capture storage.

4.19.7 Based on the criteria outlined within the Cumulative Effect Assessment Methodology chapter, shipping associated with existing traffic lanes and ports, Aquaculture, and designated disposal sites were considered part of the baseline environment and were consequently not included in the Cumulative Effects Assessment.

Projects for cumulative assessment

4.19.8 The specific projects and plans for projects scoped into this Cumulative Effects Assessment, and the tiers into which they have been allocated are presented in Table 40 below. Survey projects associated with offshore energy projects were included in the long-list but are not listed in Table 40 because these projects are already screened in under offshore wind where the highest level of noise disturbance during construction is assumed.

Table 40 Projects included within the Cumulative Effects Assessment

Development type	Project name	Current status of development	Data confidence assessment / phase	Planned programme
Tier 1				
Dumping at Sea and Coastal Assets	Dublin Port Company MP2 Project	Consented	High - Under construction Licence FS006893 Permit S0024-02 (2022-2032) Permit S0024-03 (2022-2029)	Construction activities in Dublin Harbour scheduled to take place 2022-2032; works include dredging within Dublin Harbour and the release of dredged material from vessels west of Burford Bank in outer Dublin Bay. Various activities in Dublin Port including construction of passenger building and new jetty.
Dredging	Dublin Port Company Maintenance Dredging	Consented	High Licence FS007132	Maintenance dredging at various locations in Dublin Port for the years 2022-2029 (four to six weeks each year).
Dumping at Sea and Coastal Assets	Drogheda Port Company	Consented	High Permit S0015-03 Licence FS007028	Maintenance dredging between the period 2021 and 2029 within the commercial estuary of the river Boyne and associated release of dredged material from vessels at predefined dumping sites approximately 4 km northeast (site A1) and 4 km north (site A2) from the Drogheda port entrance.
Coastal Assets	Arklow Waste Water Treatment Plant	Consented Licence FS006862	High	Works include the construction of a sea outfall pipe (approximately 955 m in length) to discharge treated effluent into the Irish Sea. Construction estimated at between 3.5 and 4 years but construction dates are unknown.

Development type	Project name	Current status of development	Data confidence assessment / phase	Planned programme
Coastal Assets	Development to the south of South Quay Arklow-ABWP2 OMF	Conditionally approved Planning application 211316	High - Under construction	Construction of the Arklow Bank Phase 2 onshore Operations and Maintenance Base, which will include the construction of a new pontoon and the dredging of nearshore areas to provide for navigational depth for vessels. Construction activities scheduled to take place 2029-2035.
Subsea Cables	EXA Atlantic	Consented	High - Operational	Active telecommunication cable. Unknown O&M activities as required.
Subsea Cables	Aqua Comms CeltixConnect 1 (CC-1)	Consented	High - Operational	Active telecommunication cable. Unknown O&M activities as required.
Subsea Cables	Hibernia Atlantic - Hibernia 'C'	Consented	High - Operational	Active telecommunication cable. Unknown O&M activities as required.
Subsea Cables	ESB, ZAYO Emerald Bridge Fibres	Consented	High - Operational	Active telecommunication cable. Unknown O&M activities as required.
Subsea Cables	Virgin Media Business - SIRIUS SOUTH	Consented	High - Operational	Active telecommunication cable. Unknown O&M activities as required.
Subsea Cables	euNetworks - Rockabill Telecoms Cable	Consented	High - Operational	Active telecommunication cable. Unknown O&M activities as required.
Subsea Cables	Eirgrid Interconnector Ltd. - East West Interconnector (EWIC)	Consented	High - Operational	Active power cable. Unknown O&M activities as required.
Subsea Cables	SSE - Arklow Phase 1 Power Cable	Consented	High - Operational	Active power cable. Unknown O&M activities as required.

Development type	Project name	Current status of development	Data confidence assessment / phase	Planned programme
Subsea Cables	National Grid and Scottish Power - Western HVDC Link	Consented	High - Operational	Active power cable. Unknown O&M activities as required.
Subsea Cables	Colt - Pan-European Crossing (UK-Ireland Crossing 2)	Consented	High - Operational	Active telecommunication cable. Unknown O&M activities as required.
O&G Pipelines	Interconnector 1 Scotland to Ireland IC1	Consented	High - Operational PL938	Active pipeline. Unknown O&M activities as required.
O&G Pipelines	Interconnector 2 Scotland to Ireland IC2	Consented	High - Operational PL1890	Active pipeline. Unknown O&M activities as required.
Tier 2				
No screened projects classed at Tier 2.				
Tier 3				
Subsea cables	Foresight Group and Etchea Energy - Mares Connect	Pre-application	Low - Proposed Environmental assessments ongoing; Foreshore licence (2023) in consultation	Subsea HVED electricity cable between Wales and Ireland. Construction period may overlap with offshore construction at Dublin Array (construction is scheduled for 2026 to 2029).

Development type	Project name	Current status of development	Data confidence assessment / phase	Planned programme
Offshore Wind Farm	Fred. Olsen Seawind, EDF Energies - Codling Wind Park	Pre-consent	High – Phase 1 (MAC awarded). Scoping report and EIA available (EIA submitted Q2 2024). Initial foreshore licence granted in 2005, more recently in 2021.	Installation of up to 75 WTGs, three export cables and three OSPs. Commencement in 2027 with offshore construction lasting 2-3 years.
Offshore Wind Farm	Statkraft - North Irish Sea Array (NISA)	Pre-consent	Medium - Phase 1 (MAC awarded). Scoping report and EIA available (EIA submitted Q2 2024). Initial foreshore licence granted 2021. Site investigations have been undertaken.	Installation of up to 49 WTGs, one OSP and two export cables. Offshore construction 2027-2029 with piling anticipated in 2028.

Development type	Project name	Current status of development	Data confidence assessment / phase	Planned programme
Offshore Wind Farm	SSE Renewables Arklow Bank Phase 2	Pre-consent	Medium – Phase 1 (MAC awarded) Scoping report and EIA available (EIA submitted Q2 2024). Foreshore licence (reference FS007339) granted for site investigations (2022-2027). Site investigations have been undertaken.	Installation of up to 56 WTGs, two OSPs and two export cables. Construction 2026-2030.
Offshore Wind Farm	Parkwind NV and ESB - Oriel Offshore Wind Farm	Pre-consent	Medium – Phase 1 (MAC awarded). Scoping report available . Foreshore license (Reference FS007383) granted for site investigations (2022-2027).	Installation of 25 WTGs, one OSP and one export cable. Construction 2026-2028.
Dredging and Dumping at Sea	Dublin Port Company 3FM Project	Pre-consent	Medium – EIA available (submitted July 2024)	Construction activities in Dublin Harbour scheduled to take place 2026-2040; works include capital dredging within Dublin Harbour and the release of dredged material from vessels at a designated disposal site at the Burford Bank in outer Dublin Bay.

4.19.9 The impacts that have been considered in the CEA are as follows:

- Construction phase:
  - Effect 16: Cumulative increases in SSC and associated sediment deposition during construction activities.
  - Effect 17: Cumulative damage and disturbance of the seabed during construction activities.
  - Effect 18: Cumulative underwater noise and vibration during construction activities.
- O&M phase:
  - Effect 19: Cumulative long-term habitat loss / alteration from the presence of foundations, scour protection and cable protection due to placement of subsea infrastructure.
  - Effect 20: Cumulative barriers to movement through the presence of EMF from cables.
  - Effect 21: Cumulative changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes.

4.19.10 Certain impacts assessed for Dublin Array alone are not considered in the Cumulative Effects Assessment due to:

- the highly localised nature of the impacts;
- management and mitigation measures in place for Dublin Array and other projects will reduce the risk of the impact occurring; and
- where the potential significance of effects from Dublin Array alone has been assessed as Imperceptible or Not significant (as defined in Table 6).

4.19.11 The Decommissioning and Restoration Plan (Volume 7, Appendix 2) is based on the best scientific and technical knowledge available at the time of submission of this Planning Application. As for the project alone assessment, in line with the process for decommissioning set out in the Decommissioning and Restoration Plan, it is concluded that potential impacts associated with the decommissioning phase would be no greater than that assessed during construction. It is likely that the types of plans or projects requiring assessment in the future would be similar in type and nature to those being progressed during the construction and operational phases, therefore it is reasonable to assume that the impacts associated with decommissioning would also be no greater than construction from a cumulative perspective.

4.19.12 The impacts excluded from the fish and shellfish Cumulative Effects Assessment for these reasons are:

- Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination during construction, O&M and decommissioning (Impacts 3, 8 and 14): Potential effects on fish and shellfish receptors through the release of contaminated sediments have been assessed as 'Not significant'. Furthermore, it is expected that all offshore projects will employ a vessel management plan or follow best practice guidelines such as IMO MARPOL[22] and/or OSPAR[23] to reduce the risk of accidental contamination.

- Temporary increases in SSC and sediment deposition during O&M and decommissioning activities (Impacts 5 and 12), temporary damage and disturbance of the seabed during O&M and decommissioning activities (Impacts 6 and 13) and introduction of underwater noise during decommissioning activities (Impact 15): Effects on fish and shellfish receptors arising from the impacts are likely to be less in magnitude than the effects from construction activities

4.19.13 The cumulative maximum design scenario for each assessed impact is described in Table 41 below.

[22] https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx
[23] https://www.ospar.org/documents?v=33037

Table 41 Cumulative Maximum Design Option for fish and shellfish ecology

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
Effect 16: Cumulative increases in SSC and associated sediment deposition during construction activities	**Tier 1** ▪ Dublin Port Company MP2 Project ▪ Dublin Port Company Maintenance Dredging ▪ Drogheda Port Company Maintenance Dredging ▪ Arklow Waste Water Treatment Plant ▪ South Quay Arklow ABWP2 OMF	Maximum design option for Dublin Array plus the release of sediments and sediment deposition associated with the identified Tier 1 and Tier 3 projects. **Dublin Port Company MP2 Project** ▪ Capital dredging and disposal will cause temporary localised sediment plumes both at the loading and licensed disposal sites. ▪ Total volume to be dredged: 424,644 m^3. **Dublin Port Company** (Licence: FS007132) ▪ 300,000 m^3 of material to be dredged per annum using TSHD. ▪ Disposal of material into a licenced Dumping at Sea (DAS) site (west of Burford Bank). ▪ Dredged sediment consists mostly of silt and sand with elements of clay, gravel, and cobbles. **Dublin Port Company** (DAS permit: S0004-03) ▪ The activities involve the loading and dumping of a maximum of 3,960,000 tonnes (wet weight) of dredged material during the months of April to September from 2022-2029. ▪ A maximum quantity of 495,000 tonnes (wet weight) per annum. ▪ Disposal of material into a licenced DAS site (west of Burford Bank). **Dublin Port Company** (DAS permit: S0024-02)	If these intermittent activities overlap temporally with either the construction or maintenance of Dublin Array, there is potential for cumulative effects on fish and shellfish receptors including early life stages and spawning and nursery grounds.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
		▪ Material arising from the MP2 project, which involves the loading and dumping of a maximum of 1,102,723 tonnes (wet weight) of dredged material. ▪ Disposal of material into a licensed DAS site (west of Burford Bank). **Drogheda Port Company Maintenance Dredging** (DAS permit: S0015-03; Licence: FS007028) ▪ An estimated 120,000 m^3 of material (plus 100,000 m^3 contingency) to be dredged per annum from the commercial estuary of the River Boyne. ▪ Disposal of material at two licenced DAS sites (site 'A1' located about 2.5 km from the shore and about 4 km to the north-east of the Drogheda port entrance, and site 'A2' about 4 km to the north of the port entrance close to shore). **Arklow Waste Water Treatment Plant** (Licence: FS006862) ▪ Construction of a marine outfall pipe (approximately 955 m in length) from the new Arklow Waste Water Treatment Plant into the Irish Sea. ▪ Potential installation methods: HDD, flood and float method, and bottom-pull method. ▪ Potential placement of concrete mattresses to protect against scour. **South Quay Arklow ABWP2 OMF** ▪ Dredging of up to 6,000 m^3 of sediment from the South Dock area.	

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
	Tier 1 ▪ All active power and telecommunications cables ▪ Interconnector 1 and 2 Scotland to Ireland IC 1 and IC2	Routine planned and unplanned maintenance works over the lifetime of the cables and pipelines. Exact details and maintenance schedules are unknown and so there is a high uncertainty.	SSC plumes are likely to be generated during cable re-burial and repair operations, which has the potential to result in cumulative effects on fish and shellfish receptors including early life stages.

	Tier 3
	▪ Mares Connect
	▪ Dublin Port Company 3FM Project
		Mares Connect
		▪ Two HVDC subsea cables with construction anticipated between 2026 to 2029.
		▪ Installation methodologies and the exact cable route are unknown at the time of writing.
		▪ Landfall in the Greater Dublin area.
		▪ Routine planned and unplanned cable maintenance over the lifetime of the cables.
		Dublin Port Company 3FM Project
		▪ Capital dredging and disposal will cause temporary localised sediment plumes both at the loading and licensed disposal sites.
		▪ Total volume to be dredged: 1,259,000 m^3 (70,000 m^3 of which are not suitable for disposal at sea)
		▪ Dredging will consist of:
		  ▪ Maritime Village - Capital Dredging, 3 m Chart Datum (CD), 197,000 m^3
		  ▪ Area K - Ro-Ro Terminal Scour Protection, 12.5 m CD, 13,000 m^3
		  ▪ Turning Circle - Capital Dredging, 10 m CD, 444,000 m^3
		  ▪ Area N - Lo-Lo Terminal - Capital Dredging, 13 m CD, 533,000 m^3
		  ▪ Area N - Lo-Lo Terminal - Capital Dredging, 3 m CD, 72,000 m^3
			Owing to the close proximity of the Mares Connect cable route to the Dublin Array and the potential for temporal overlap during construction and O&M activities there is potential for the effects of increases in SSC and sediment deposition to act cumulatively. These assumptions are considered to be precautionary and an appropriate estimation in the absence of further information.
			
			If the intermittent activities associated with the Dublin Port Company 3FM Project overlap temporally with either the construction or maintenance of Dublin Array, there is potential for cumulative effects on fish and shellfish receptors, including early life stages and spawning and nursery grounds.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
	Tier 3 ▪ Codling Wind Park ▪ NISA ▪ Arklow Bank Phase 2 ▪ Oriel	**Codling Wind Park** ▪ Three export cables with landfall at Poolbeg. ▪ Cable corridor crossing the Offshore ECC of Dublin Array. ▪ Sediments to be released during pre-construction surveys, seabed preparation works, foundation and cable installation, landfall works, and maintenance activities. **NISA** ▪ Up to approximately 900,000 m^3 of sediment to be released during foundation and cable seabed preparation, cable installation and landfall HDD exit pits. ▪ Sediments to be released during maintenance activities. **Arklow Phase Bank 2** ▪ Sediments to be released during pre-construction surveys, seabed preparation works, foundation and cable installation, landfall works, and maintenance activities. **Oriel** ▪ Sediments to be released during seabed preparation works, foundation and cable installation, landfall works, and maintenance activities.	If these intermittent activities overlap temporally with either the construction or maintenance of Dublin Array, there is potential for the effects of increases in SSC and sediment deposition to act cumulatively.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
Impact 17: Cumulative damage and disturbance of the seabed during construction activities	**Tier 1** ▪ Dublin Port Company MP2 Project ▪ Dublin Port Company Maintenance Dredging ▪ Drogheda Port Company Maintenance Dredging ▪ Arklow Waste Water Treatment Plant ▪ South Quay Arklow ABWP2 OMF	Maximum design option for Dublin Array plus the area of seabed potentially damaged and disturbed during the construction and/ or maintenance of the identified Tier 1 and Tier 3 projects.	Owing to the potential for temporal overlap of the identified projects and the Dublin Array construction period there is potential for the effects of temporary habitats damage and disturbance to act cumulatively. These assumptions are considered to be precautionary and an appropriate estimation in the absence of further information.
	Tier 1 ▪ All active power and telecommunications cables ▪ Interconnector 1 and 2 Scotland to Ireland IC 1 and IC2	Routine planned and unplanned maintenance over the lifetime of the cables and pipelines. Exact details and maintenance schedules are unknown and so there is a high uncertainty.	Temporary damage and disturbance to the seabed is likely to result during the maintenance of existing cables and oil and gas pipelines. Due to the potential for temporal overlap during O&M activities and Dublin Array construction there is potential for the effects of temporary habitat damage to act cumulatively. These assumptions are considered to be precautionary and an appropriate estimation in the absence of further information.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
	Tier 3 ▪ Mares Connect	Owing to the early stage of the project within the planning process, exact site-specific information relating to the location and total area of seabed likely to be physically impacted during the construction of the proposed Mares Connect power cables is currently unavailable.	Owing to the close proximity of the proposed cable route to the Dublin Array and the potential for temporal overlap during construction and O&M activities there is potential for the effects of temporary habitat damage to act cumulatively. These assumptions are considered to be precautionary and an appropriate estimation in the absence of further information.
	Tier 3 ▪ Dublin Port Company 3FM Project	Maximum design option for Dublin Array plus the area of seabed potentially damaged and disturbed during the construction of the identified Tier 3 project.	Owing to the potential for temporal overlap of the identified project and the Dublin Array construction period there is potential for the effects of temporary habitats damage and disturbance to act cumulatively. These assumptions are considered to be precautionary and an appropriate estimation in the absence of further information.
	Tier 3 ▪ Codling Wind Park ▪ NISA ▪ Arklow Bank Phase 2 ▪ Oriel	**Codling Wind Park** ▪ Up to 12.1 km^2 of seabed to be disturbed during offshore and landfall construction activities. **NISA** ▪ Up to 6.3 km^2 of seabed to be disturbed during construction activities. ▪ Up to 0.7 km^2 of seabed to be disturbed during maintenance activities. **Arklow Bank Phase 2** ▪ Up to 9.9 km^2 of seabed to be disturbed during construction activities. **Oriel** ▪ Up to 0.7 km^2 of seabed to be disturbed during construction activities. ▪ Up to 0.4 km^2 of seabed to be disturbed during maintenance activities.	Owing to the close proximity of Codling Wind Park, NISA, Arklow Bank Phase 2 and Oriel to the Dublin Array and the potential for temporal overlap of the projects, there is potential for effects associated with the temporary damage and disturbance of the seabed during construction activities to act cumulatively. These assumptions are considered to be precautionary and an appropriate estimation in the absence of further information.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
Impact 18: Cumulative underwater noise and vibration during construction activities	**Tier 1** ▪ All listed projects	Maximum design option for Dublin Array plus any underwater noise emitted during the construction or maintenance of the identified Tier 1 and Tier 3 projects.	Owing to the potential for temporal overlap of the identified projects and the Dublin Array construction period there is potential for the effects of underwater noise to act cumulatively. These assumptions are considered to be precautionary and an appropriate estimation in the absence of further information.
	Tier 3 ▪ Mares Connect ▪ Dublin Port Company 3FM Project ▪ Codling Wind Park ▪ NISA ▪ Arklow Bank Phase 2 ▪ Oriel	**Mares Connect** Underwater noise from construction and maintenance-related activities (e.g. seabed preparation, cable installation and maintenance, cable protection, vessel noise). **Codling Wind Park** ▪ Piling of 78 monopile foundations (75 WTGs and three OSPs). ▪ Modelled maximum impact ranges for the onset of TTS up to 34 km for stationary receptors and 24 km for fleeing receptors. ▪ Detonation of up to 10 UXO. ▪ Underwater noise from other construction and maintenance-related activities (e.g. seabed preparation, cable installation and maintenance, cable protection, vessel noise, geophysical surveys). **NISA** ▪ Piling of 51 monopiles on 51 days over 9 months or piling of 144 pin piles on 72 days over 9 months (indicative piling schedule). ▪ Modelled maximum impact ranges for the onset of TTS up to 69 km for stationary receptors and 51 km for fleeing receptors. ▪ Detonation of UXO. ▪ Underwater noise from other construction and maintenance-related activities (e.g. seabed	If piling and other construction and maintenance-related activities associated with the identified projects overlap temporally with either the construction or maintenance of Dublin Array, there is potential for cumulative effects on fish and shellfish populations. Furthermore, cumulative effects on fish and shellfish may arise due to the prolonged exposure to piling noise because of the sequential piling of foundations for the identified wind farm projects.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
		preparation, cable installation and maintenance, cable protection, vessel noise, pre-construction geophysical surveys). **Arklow Phase Bank 2** ▪ Piling of 58 monopile foundations (56 WTGs and two OSPs) over a total of 79 days during the construction period (indicative piling schedule). ▪ Modelled maximum impact ranges for the onset of TTS up to 50 km for stationary receptors and 36 km for fleeing receptors. ▪ Detonation of UXO. ▪ Underwater noise from other construction and maintenance-related activities (e.g. seabed preparation, cable installation and maintenance, cable protection, vessel noise, geophysical surveys). **Oriel** ▪ Piling of 26 monopile foundations (25 WTGs and one OSPs) over a total of 26 days during the construction period (indicative piling schedule). ▪ Modelled maximum impact ranges for the onset of TTS up to 1,750 m. Underwater noise from other construction and maintenance-related activities (e.g. seabed preparation, cable installation and maintenance, cable protection, vessel noise).	

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
Impact 19: Cumulative long-term loss of benthic habitats due to the placement of subsea infrastructure	**Tier 1** ▪ Arklow Waste Water Treatment Plant	Maximum design option for Dublin Array plus the area of seabed lost as a result of the placement of infrastructure and protection material associated with the identified Tier 1 and Tier 3 projects. **Arklow Waste Water Treatment Plant** ▪ The amount of scour protection associated with the sewage outfall pipe is unknown at the time of writing.	The cumulative long-term loss of sedimentary habitats will result from the presence of infrastructure and protection measures associated with the identified projects. This has the potential to result in cumulative adverse effects on essential fish and shellfish habitats, such as feeding and spawning grounds.
	Tier 3 ▪ Mares Connect ▪ Codling Wind Park ▪ NISA ▪ Arklow Bank Phase 2 ▪ Oriel	**Mares Connect** ▪ The amount of cable protection associated with the power cables is unknown at the time of writing. **Codling Wind Park** ▪ Up to 0.6 km^2 of seabed to be lost due to the placement of foundations, scour protection and cable protection. **NISA** ▪ Up to 0.3 km^2 of seabed to be lost due to the placement of foundations, scour protection and cable protection. **Arklow Bank Phase 2** ▪ Up to 0.7 km^2 of seabed be lost due to the placement of foundations, scour protection and cable protection. **Oriel** ▪ Up to 0.3 km^2 of seabed to be lost due to the placement of foundations, scour protection and cable protection.	

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
Impact 20: Cumulative barriers to movement through the presence EMF from cables	**Tier 1** ▪ All active power and telecommunications cables	Maximum design scenario for Dublin Array plus the potential EMFs emitted by the identified projects.	EMFs could be emitted during the operation of cables associated with the identified projects.
	Tier 3 ▪ Mares Connect	Owing to the early stage of the projects within the planning process, exact site-specific information relating to cable specifications, target burial depths and the predicted amounts of cable protection are unknown.	
	Tier 3 ▪ Codling Wind Park ▪ NISA ▪ Arklow Bank Phase 2 ▪ Oriel	Cables associated with the identified wind farm projects are expected to be buried where practicable, and the use of cable protection is expected to be required for all projects in areas where cable burial is not possible. **Codling Wind Park** ▪ 66 kV IAC and interconnector cables between 127.4-147.6 km in length. ▪ 220 kV export cables between 126-146 km in length. ▪ Minimum burial depth of interconnector cables and IAC cables = 1 m. ▪ Minimum burial depth of export cables = 1.4 m. **NISA** ▪ 66 kV or 132 kV IAC between 91-111 km in length. ▪ 220 kV export cables 36 km in length. ▪ Target burial depth of all cables = 1-3 m. **Arklow Bank Phase 2** ▪ 66 kV IAC between 110-122 km in length. ▪ 220 kV OSP interconnector cables between 25-28 km in length. ▪ 220 kV export cables between 35-40 km in length.	

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
		▪ Burial depth between 0-1.5 m for inter-array cables and 0-2.5 m for OSP interconnector and offshore export cables. **Oriel** ▪ 66 kV IAC 41 km in length. ▪ 220 kV export cables 16 km in length. ▪ Target burial depth of all cables = 0.5-3 m.	
Impact 21: Cumulative changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes	**Tier 1** ▪ All active power and telecommunications cables ▪ Interconnector 1 and 2 Scotland to Ireland IC 1 and IC2	Maximum design option for Dublin Array plus the potential changes to seabed habitats from effects on local hydrodynamic and sediment transport processes from the identified projects. **Existing cables and pipelines** ▪ Presence of cables and cable protection on the seabed.	Cumulative changes to seabed habitats arising from changes in physical processes could result from the presence of infrastructure and rock protection associated with the identified projects.
	Tier 3 ▪ Mares Connect ▪ Codling Wind Park ▪ NISA ▪ Arklow Bank Phase 2 ▪ Oriel	**Mares Connect** ▪ Presence of cables and cable protection on the seabed. **Offshore Wind Farms** ▪ Presence of WTG and OSP foundations and associated scour protection. ▪ Presence of remedial protection and cable crossings for inter-array, export and interconnector cables.	

Effect 16: Cumulative increases in SSC and associated sediment deposition during construction activities

4.19.14 Dredging and sediment disposal, seabed preparation works, and foundation and cable installation activities associated with the identified projects (Table 41) will cause temporary increases in SSC and associated sediment deposition, which if temporally overlapping with works at Dublin Array may give rise to additive effects on fish and shellfish receptors. The potential for significant cumulative effects as a result of simultaneous increases in SSC and sediment deposition is assessed in Table 42 to Table 45.

4.19.15 Particular regard has been given to the possibility of cumulative effects from works associated with the Dublin Port Company MP2 and 3FM Projects and the Codling Wind Park given the close proximity between these projects and Dublin Array. However, given the project timelines, it is highly unlikely that the proposed construction programmes for Codling Wind Park and Dublin Array would overlap. Furthermore, constraints due to equipment availability and space for the works to be safely undertaken also exist. Considering these constraints, it is not considered feasible for Dublin Array and Codling Wind Park to install cables or make landfall at the same time. However, the projects could undertake these activities sequentially to one another. Therefore, this assessment has not considered the possibility of the MP2 and 3FM Projects, Dublin Array and Codling Wind Park undertaking activities at the same time in close proximity. Instead, Dublin Array has been assessed cumulatively with each project individually.

Table 42 Consideration of potential for cumulative increases in SSC and sediment deposition within Dublin Bay

Step	Justification
Step 1: Drivers	Capital and maintenance dredging in Dublin harbour and associated sediment disposal (Dublin Port Company MP2 and 3FM Projects and Dublin Port Company Maintenance Dredging).
Step 2: Pressures	Temporary increases in SSC and sediment deposition and associated effects on fish and shellfish and their supporting habitats (i.e., spawning, nursery and feeding grounds).
Step 3: States	Fish and shellfish ecological receptors and their supporting habitats.

Step	Justification
Step 4: Impacts	Capital and maintenance dredging in Dublin harbour and associated sediment disposal will cause temporary localised sediment plumes both at the loading location and the licensed disposal sites. Plume modelling undertaken on behalf of the Dublin Port Company showed that plumes generated during capital dredging associated with the MP2 Project are typically less than 10 mg/l within 750 m of the dredging activities and within the background range of sediment concentrations during normal Port operations (RPS, 2020). The deposition of sediments was generally confined to the area being dredged and was generally less than 40 g/m^2 beyond the immediate area of the dredging operation. The plumes associated with the disposal of dredged material in the greater Dublin Bay area are confined to 750 m from the location of the designated disposal area, with sediment plumes outside the dump site predicted to contain less than 200 mg/l of suspended sediments (Dublin Port Company, 2024; RPS, 2020). Suspended sediments in plumes generated during maintenance dredging in Dublin harbour are anticipated to be between 25-35 mg/l above background levels beyond the immediate dredge area, with larger concentrations restricted to the areas being dredged (RPS, 2021). The volume of material deposited outside of the dredge area is predicted to be generally less than $30g/m^2$, with the deposition of sediment generally being confined to within the immediate area of the dredging operation. As demonstrated by the plume modelling results (RPS, 2020, 2021), maxima of suspended sediments and sediment deposition resulting from dredging and disposal activities remain local to the works with background levels occurring beyond the immediate area of operations. Further, activities will be intermittent and any increased SSC levels will dissipate quickly following the cessation of activities, thereby reducing the likelihood for additive effects on fish and shellfish receptors. Therefore, the magnitude of any potential effects on fish and shellfish receptors resulting from the simultaneous increase in SSC and sediment deposition at Dublin Array in-combination with dredging and disposal activities within Dublin harbour and Dublin Bay is considered to be comparable to the magnitude predicted for the project alone (Table 14). Consequently, the maximum magnitude of the impact for these receptors is assessed as being **Low adverse**. The sensitivity of fish and shellfish receptors to an increase in SSC and sediment deposition has been documented in Impact 1 (Table 12), with the maximum sensitivity assessed to be **Medium.**
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.

Step	Justification
Conclusion	*The magnitude of the potential cumulative increases in SSC and sediment deposition from simultaneous operations is concluded to be* ***Low adverse****. The maximum sensitivity of the receptors in the area is assessed as* ***Medium****. The potential significance of effect of cumulative increases in SSC and deposition from simultaneous operations on fish, marine turtle and shellfish ecological receptors is, at most,* ***Slight adverse*** *(i.e. the same as the project alone), which is not significant in EIA terms.*

Table 43 Consideration of potential for cumulative increases in SSC and deposition with the Codling Wind Park project

Step	Justification
Step 1: Drivers	Simultaneous construction activities including cable laying in Dublin Bay.
Step 2: Pressures	Temporary increases in SSC and sediment deposition and associated effects on fish and shellfish and their supporting habitats (i.e., spawning, nursery and feeding grounds).
Step 3: States	Fish and shellfish ecological receptors and their supporting habitats.
Step 4: Impacts	Construction of Codling Wind Park is anticipated to commence in 2027 with offshore construction anticipated to last between two to three years. This suggests that construction activities at Codling would be mostly completed before the construction of Dublin Array commences. Further, as described previously, it is not considered feasible for Dublin Array and Codling Wind Park to install cables or make landfall at the same time. Should the construction programmes of the two projects change such that they are scheduled for the same period , the greatest likelihood is for the two projects' installation periods to be sequenced to allow for the availability of installation equipment. As predicted by the Dublin Array plume modelling, sediment plumes are likely to rapidly dissipate following the cessation of activities, and so it is not expected for there to be any measurable plume coalescence. Therefore, the magnitude of any effects on fish and shellfish receptors resulting from increases in SSC and sediment deposition at Dublin Array in-combination with construction activities at Codling Wind Park is considered to be no greater than that assessed for the project alone (Table 14). Consequently, the maximum magnitude of the impact for these receptors is assessed as being **Low adverse**. The sensitivity of fish and shellfish receptors to increased SSC and sediment deposition have been documented in Impact 1 (Table 12), with the maximum sensitivity assessed to be **Medium**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.

Step	Justification
Conclusion	*The magnitude of the potential cumulative increases in SSC and sediment deposition from simultaneous construction is concluded to be **Low adverse**. The maximum sensitivity of the receptors in the area is assessed as **Medium**. The potential significance of effect of cumulative increases in SSC and deposition from simultaneous operations on fish, marine turtle and shellfish ecological receptors is, at most, **Slight adverse** (i.e. the same as the project alone), which is not significant in EIA terms.*

Table 44: Consideration of potential for cumulative increases in SSC and deposition with the Mares Connect project

Step	Justification
Step 1: Drivers	Installation of the Mares Connect power cables and associated landfall activities.
Step 2: Pressures	Temporary increases in SSC and sediment deposition and associated effects on fish and shellfish and their supporting habitats (i.e., spawning, nursery and feeding grounds).
Step 3: States	Fish and shellfish ecological receptors and their supporting habitats.
Step 4: Impacts	Installation methodologies, location and construction period for the Mares Connect power cables are unknown at the time of writing. However, if Mares Connect is installed in close proximity to Dublin Array, then there will be construction constraints due to space for the works to be safely undertaken in practice. Therefore, it is not considered feasible for Dublin Array and Mares Connect to install cables or make landfall at the same time. However, the projects could undertake these activities sequentially to one another. As predicted by the Dublin Array plume modelling, sediment plumes are anticipated to rapidly dissipate following the cessation of activities, and so it is not expected for there to be any measurable plume coalescence. Therefore, the magnitude of any effects on fish and shellfish receptors resulting from increases in SSC and sediment deposition at Dublin Array in-combination with the installation of Mares Connect is considered to be no greater than that assessed for the project alone (Table 14). Consequently, the maximum magnitude of the impact for these receptors is assessed as being Low adverse. The sensitivity of fish and shellfish receptors to increased SSC and sediment deposition have been documented in Impact 1 (Table 12), with the maximum sensitivity assessed to be Medium.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.
Conclusion	*The magnitude of the potential cumulative increases in SSC and sediment deposition from simultaneous construction is concluded to be Low adverse. The maximum sensitivity of the receptors in the area is assessed as Medium. The potential significance of effect of cumulative increases in SSC and deposition from simultaneous operations on fish, marine turtle and shellfish ecological receptors is, at most, Slight adverse (i.e. the same as the project alone), which is not significant in EIA terms.*

Table 45 Consideration of potential for cumulative increases in SSC and deposition with the remaining projects

Step	Justification
Step 1: Drivers	Construction and maintenance activities related to the NISA, Oriel and Arklow Bank Phase 2 wind farm projects; maintenance work of existing subsea cables and pipelines; dredging and disposal of sediment associated with the Drogheda Port maintenance dredging project; construction and maintenance activities associated with the Arklow Waste Water Treatment Plant and the Arklow ABWP2 OMF
Step 2: Pressures	Temporary increases in SSC and sediment deposition and associated effects on fish and shellfish and their supporting habitats (i.e., spawning, nursery and feeding grounds).
Step 3: States	Fish and shellfish ecological receptors and their supporting habitats.
Step 4: Impacts	Of the Tier 1 projects screened into the cumulative assessment, ongoing maintenance dredging associated with the Drogheda Port project and activities associated with the Arklow Waste Water Treatment Plant and the Arklow ABWP2 OMF may contribute to cumulative effects with the proposed offshore construction works through sediment plumes or deposition effects. In addition, cumulative effects may arise during simultaneous offshore construction activities associated with the NISA, Oriel and Arklow Phase 2 wind farm projects. However, given the distance between the projects and the Dublin Array (the nearest project, the proposed NISA OWF, is located > 21 km from the array area), the potential for sediment plumes and deposition to interact is considered to be low, with SSC across overlapping plumes likely to be close to natural background levels. Further, potential concurrent increases in SSC within the cumulative assessment area during simultaneous are anticipated to be temporary and intermittent. Cumulative effects may also arise during the installation of the offshore components of Dublin Array and planned and unplanned maintenance of operational subsea cables and pipeline. It is not known what volumes of sediment would be disturbed and/or released at any one time; however, it is anticipated that the lengths of cable and/ or pipelines to be replaced or reburied would be shorter, and the potential impacts would be more localised and occur over a shorter duration than those considered for the installation of the Dublin Array. Overall, any potential disturbance effects on sensitive fish and shellfish receptors within the cumulative assessment area due to concurrent activities are expected to be localised, temporary and intermittent as sediment plumes are expected to quickly dissipate following cessation of activities. Similarly, any areas likely to be exposed to heavy sediment deposition will be localised and as such are expected to be small in the context of available suitable habitats for fish and shellfish receptors in the study area and wider region. Therefore, any potential cumulative effects on fish and shellfish receptors resulting from the increase in SSC and sediment deposition at the proposed development in-combination with remaining Tier 1 and Tier 3 projects are anticipated to be at most barely discernible from baseline conditions, i.e. the same as the project alone. Consequently, the maximum magnitude of the cumulative effect with respect to Tier 3 projects is assessed as being **Low adverse**.

Step	Justification
	The sensitivity of fish and shellfish receptors to increased SSC and sediment deposition have been documented in Impact 1 (Table 12), with the maximum sensitivity assessed to be **Medium**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.
Conclusion	*The magnitude of the potential cumulative increases in SSC and sediment deposition from simultaneous construction is concluded to be* ***Low adverse****. The maximum sensitivity of the receptors in the area is assessed as* ***Medium****. The potential significance of effect of cumulative increases in SSC and deposition from simultaneous operations on fish, marine turtle and shellfish ecological receptors is, at most,* ***Slight adverse*** *(i.e. the same as the project alone), which is not significant in EIA terms.*

In summary, sediment plumes and deposition generated by the identified projects are anticipated to behave in a similar pattern as the sediments being disturbed by the proposed development due to expected similarities in activities combined with a similar environmental setting and sediment characteristics. Any plumes associated with these projects will be intermittent and disperse rapidly, while any heavy sediment deposition will be localised and small in the context of available suitable habitats for fish and shellfish receptors that depend on the seabed. Therefore, it is concluded that the maximum magnitude of potential cumulative effects on fish and shellfish receptors from the proposed development in-combination with the identified projects will be comparable to the project alone, i.e. ***Low adverse****. As per the project alone assessment, the maximum sensitivity of the receptors to the impact is deemed to be* ***Medium****. This could result in a* ***Slight adverse*** *cumulative effect, which is not considered significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary, and no significant adverse residual cumulative effects on fish, shellfish and marine turtle receptors have been predicted in respect to this impact.*

Effect 17: Cumulative damage and disturbance of the seabed during construction activities

4.19.16 Dredging and disposal, seabed preparation works, and foundation and cable installation activities associated with other projects can temporarily damage and disturb the seabed, which may give rise to additive effects on fish and shellfish receptors. The potential for significant cumulative effects as a result of seabed disturbance during construction activities is assessed in Table 46.

Table 46 Consideration of potential for cumulative damage and disturbance of the seabed

Step	Justification
Step 1: Drivers	Construction and maintenance activities related to Mares Connect and the Codling, NISA, Oriel and Arklow Bank Phase 2 wind farm projects; maintenance work of existing subsea cables and pipelines; capital and maintenance dredging associated with the Dublin Port Company MP2 and 3FM Projects and the Drogheda Port dredging project; construction and maintenance activities associated with the Arklow Waste Water Treatment Plant and the Arklow ABWP2 OMF.

Step	Justification
Step 2: Pressures	Direct damage (e.g. crushing) and disturbance of fish and shellfish receptors and/ or their supporting benthic habitats.
Step 3: States	Fish and shellfish ecological receptors and their supporting habitats.
Step 4: Impacts	Temporary disturbance and damage of the seabed associated with the Tier 3 OWF projects are anticipated to be similar in scale as the changes resulting from the proposed development due to expected similarities in project designs and offshore activities (Table 41). Specifically, any changes to the seabed and effects on sensitive fish and shellfish receptors resulting from these projects are expected to be restricted to discrete areas within the array areas and export cable corridors of these projects, and as such these would be restricted to the near-field. Further, with the exception of the location of Codling export cable corridor potentially encroaching on that for Dublin Array, there will be no overlap between seabed disturbance footprints of these projects. It should also be noted that construction plans indicate that the majority of offshore construction activities associated with the Tier 3 wind farm projects will be prior to work commencing on Dublin Array. Any cumulative disturbances to the seabed due to sequential and/ or simultaneous activities would be of short-term duration, intermittent and reversible. Physical impacts to the seabed associated with remaining projects are also expected to be of local extent, temporary and reversible, with the cumulative duration of activities expected to be at most short-term. Broadscale habitat maps (INFOMAR, 2023) indicate that the subtidal benthic substrates that would be affected are common and widespread within the wider region. Furthermore, the fish and shellfish receptors, including their spawning and nursery grounds are widely distributed within the cumulative assessment area. Therefore, any effects on fish and shellfish receptors when considered cumulatively, are still anticipated to be at most barely discernible from baseline conditions. Consequently, the maximum magnitude of the cumulative effect with respect to Tier 2 projects is assessed as being Low adverse. The sensitivity of fish and shellfish receptors to the damage and disturbance of the seabed during the construction of Dublin Array has been documented in Impact 2 (Table 15), with the maximum sensitivity assessed as being Medium.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.
Conclusion	*The magnitude of the potential cumulative direct damage from simultaneous and sequential operations is concluded to be Low adverse. The maximum sensitivity of the receptors in the area is assessed as Medium. The potential significance of effect of cumulative direct damage and disturbance on fish, marine turtle and shellfish receptors is, at most, Slight adverse (i.e. the same as the project alone), which is not significant in EIA terms.*

Effect 18: Cumulative underwater noise and vibration during construction activities

4.19.17 As for the project alone, potential cumulative underwater noise effects on fish and shellfish receptors include mortality and potential mortal injury, recoverable injury, TTS and behavioural changes. Activities that may cause these changes include geophysical surveys, the detonation of UXO and construction- and maintenance-related activities associated with the identified projects such as the piling of foundations, dredging, rock placement, cable installation and maintenance, and vessel noise. The potential for significant cumulative effects as a result of underwater noise and vibration generated by these activities is assessed in Table 47 to Table 49.

4.19.18 The greatest risk of cumulative effects of underwater noise on fish and shellfish species has been identified as being that produced by impact piling during the construction phase of other offshore energy sites within 100 km of Dublin Array. As such, likely significant cumulative effects related to impact piling have been the primary focus of the assessment. Each of the five OWF projects included in the assessment provided indicative piling schedules, indicating that piling at Oriel, Codling, NISA and Arklow Bank Phase 2 would be mostly completed before the piling of foundations at Dublin Array commences in 2029.

Table 47 Determination of potential for cumulative effects from underwater noise and vibration as a result of piling during the construction of Phase 1 OWF projects

Step	Justification
Step 1: Drivers	Underwater noise generated during piling of foundations associated with the construction of the identified Tier 3 OWF projects.
Step 2: Pressures	Cumulative mortality, recoverable injury, TTS and behavioural changes from noise and vibration as a result of piling activities. Effects on sensitive receptors may result from concurrent piling at different wind farm sites or the long-term exposure of sensitive receptors due to sequential piling operations over prolonged periods of time.
Step 3: States	Noise-sensitive fish, shellfish and marine turtle VERs, including eggs and larvae.
Step 4: Impacts	Piling operations will represent intermittent occurrences at these offshore wind farm sites with each individual piling event likely to be similar in duration to that at Dublin Array. For Dublin Array, the temporal and spatial MDOs are presented in Table 10. The indicative construction programmes of the east coast Phase 1 OWF projects (Table 40) suggest that the total duration of piling for these projects would be short-term (i.e., lasting one to seven years, as defined by the EPA guidance, 2022). **Mortality and Potential Mortal Injury and Recoverable Injury** Mortality, potential mortal injury and recoverable injury to fleeing fish and marine turtles from piling noise during the construction of Dublin Array are predicted to occur within a 100 m of piling activity (Table 21). Based on a stationary receptor model, lethal effects on sandeel and egg and larvae may occur up to 350 m and 1.4 km from the noise source, respectively, while recoverable injuries in sandeel were predicted to occur up to 550 m from the piling location (Table 21).

Step	Justification
	Comparable impact ranges have been predicted for the other Phase 1 OWF projects. For example, underwater noise modelling for NISA and Codling predicted mortal and recoverable injuries to fleeing receptors within < 100 m from the piling locations (Codling Wind Park, 2024; NISA, 2024), while for Arklow Phase Bank 2, mortality and recoverable injuries were predicted to occur up to 130 m away from the noise source (SSE Renewables, 2024). Based on these predictions and given the distance between the projects (Table 40), the maximum impact ranges for the onset of mortality, potential mortal injury and recoverable injuries in fleeing receptors for each individual project are unlikely to overlap. Furthermore, the potential for mortality and potential mortal injury or recoverable injuries to occur is likely to be reduced due to the implementation of soft-start procedures, which will allow mobile receptors to leave the area before injurious effects can occur. In addition, the mobile receptors and their spawning and nursery grounds are widely distributed within the region and as such the receptors would be able to re-locate to nearby unimpacted areas. Therefore, while piling of foundations at the identified Tier 3 OWF projects has the potential to result in additive mortality and/ or recoverable injury over time, the adaptability of the receptors together with the implementation of best practice mitigation measures (e.g. soft-start procedures) is considered to reduce the risk of these effects occurring. Based on this and considering the small area potentially affected together with the intermittent nature of the impact, the maximum magnitude of potential cumulative mortality and recoverable injury from impact piling on mobile VERs (i.e., pelagic and demersal fish, elasmobranchs, marine turtles, and diadromous fish VERs) is assessed as **Low adverse**. Similarly, the proportions of eggs and larvae of pelagic spawning species predicted to be affected by underwater noise from piling operations are expected to be small in the context of the distribution of spawning habitats within the cumulative assessment area. Therefore, the magnitude of potential cumulative mortality and recoverable injury from impact piling on pelagic eggs and is also assessed as **Low adverse**. The magnitude of any potential cumulative mortality and/ or recoverable injuries to sandeel is assessed as **Low adverse**, the same as the project alone. As discussed previously, analysis of PSA data indicate the wide distribution of suitable sandeel habitats within the Dublin Array study area (Figure 6), with any potential mortality and/ or recoverable injuries during pilling at Dublin Array anticipated to be small in the context of the sandeel population in the study area and wider environment (Table 23). Sediments across the proposed Codling array area and along the export cable corridors are mostly unsuitable for sandeel, as the percentage of sand is low, with the majority of sediments characterised as coarse sediments (Codling Wind Park, 2024). Likewise, PSA data collected across the NISA development area indicate that substrates in the NISA array area are unlikely to support sandeel (NISA, 2024), further reducing the likelihood of cumulative mortal and sublethal injury effects on sandeels due to piling within the cumulative assessment area.

	Similarly, given that there is no overlap between the predicted impact ranges for the onset of mortality, mortal injury and recoverable injury and the Mourne herring spawning ground, the potential for the proposed development to contribute to any cumulative mortality or recoverable injuries to spawning herring is assessed as **Negligible**. In the case of shellfish species, current evidence suggests that piling noise is unlikely to cause mortality, potential mortal injury or recoverable injuries (Table 32), and as such, the magnitude of potential cumulative lethal or sublethal injuries for shellfish species is, as for the project alone assessment, deemed to be **Negligible**. **TTS and Behavioural Changes** Based on the noise modelling for Dublin Array, TTS (186 dB SELcum) in fish may occur up to 29 km from the piling location for stationary receptors and 9.3 km for fleeing receptors. Behavioural changes are likely to occur within these ranges, with the relative risk of behavioural responses at far distances (1000s of metres) considered to be low for all receptor groups (Table 20; Popper *et al.*, 2014). Based on the noise propagation ranges predicted for the other OWF projects (Table 40), noise emitted during piling at Codling Wind Park (located approximately 2.5 km to the south-east of the Dublin Array array area), NISA (located approximately 22 km to the north of Dublin Array), and Arklow Bank Phase 2 (located approximately 26 km to the south of Dublin Array) may be sufficient to result in cumulative TTS and/or behavioural reactions in fish, which may result in the temporary re-distribution of individuals between the affected areas. However, the piling of foundations for the Codling Wind Park is anticipated to take place in 2027, while piling at NISA and Arklow Bank Phase 2 is scheduled to take place in 2028, suggesting that piling for these projects would be completed before the installation of foundations at Dublin Array commences (earliest construction start Q2 2028 with piling anticipated to take place 2029-2031). However, there still remains the potential for cumulative disturbances of sensitive receptors due to sequential piling activities. TTS and behavioural effects on fish species as a result of piling noise are predicted to be dependent on the receptors, with larger impact ranges predicted for Group 3 and Group 4 species (e.g., herring, sprat, twaite shad) compared to Group 1 (e.g., flatfish, sandeel) and Group 2 (sea trout, Atlantic salmon) species (Popper *et al.*, 2014). The noise emitted during piling may be sufficient to result in temporary avoidance by some species, with some temporary redistribution of fish in the wider area between affected areas. It is anticipated that the duration of the impact at each construction site will be temporary (i.e., less than one year) to short-term (i.e., one to seven years) and that any TTS and/ or behavioural effects would be intermittent, and reversible. The overall duration of cumulative effects would also be short-term. Whilst the Popper *et al.* (2014) criteria suggest a moderate (Group 1 and Group 2 species) to high (Group 3 and Group 4) risk of behavioural changes at intermediate distances from the sound source (100s of metres) and a moderate (Group 1 and Group 2) to high (Group 3 and Group 4) risk in the far field (1000s of metres), the risk assessment is likely to predicated on the individuals not being involved in activities with a strong biological driver (i.e., spawning, feeding or migrating).

Step	Justification
	As such, any behavioural reactions to fish may be reduced when spawning, with consequently limited impact on spawning potential for the relevant species. Effects on shellfish species are also predicted to be limited as these species are less sensitive to noise than fish species or would only be affected at ranges much less than those predicted for fish. The magnitude of potential cumulative TSS from piling is therefore assessed as Low adverse. Based on the above combined with the intermittent and short-term nature of the impact and the temporary nature of the effects, any cumulative TTS and behavioural changes in fish and shellfish receptors during piling are assessed to be barely discernible from baseline conditions. Consequently, the magnitude of the cumulative effect is rated as **Low adverse**. The sensitivity of fish and shellfish receptors to impulse sounds generated during piling has been documented in Impact 4, with the maximum sensitivity assessed as being **Medium**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.
Conclusion	*The maximum magnitude of potential cumulative underwater noise effects from simultaneous and sequential piling operations during construction of the east coast Phase 1 projects is concluded to be **Low adverse**. The maximum sensitivity of the receptors is assessed as **Medium**. Therefore, the potential maximum significance of cumulative underwater noise effects on fish, shellfish and marine turtle receptors as a result of piling is **Slight adverse** (i.e., the same as the project alone), which is not significant in EIA terms.*

Table 48 Determination of potential for cumulative effects from underwater noise and vibration as a result of UXO clearance during the construction of Phase 1 Projects

Step	Justification
Step 1: Drivers	Underwater noise from UXO clearance operations associated with the construction of the identified Tier 3 OWF projects.
Step 2: Pressures	High order and low order UXO detonation has the potential to result in mortality and potential mortal injury, recoverable injury, TTS and disturbance to fish and shellfish species, depending on the proximity of the individuals to the UXO location and the size of the UXO.
Step 3: States	Noise-sensitive fish, shellfish, and marine turtle VERs, including eggs and larvae.
Step 4: Impacts	Small-scale mortality and physical injuries in fish as a result of underwater explosions have been reported by several authors, with physical injuries including rupture of the swim bladder and haemorrhage caused by the rupture of blood vessels (Dahl *et al.*, 2020; Popper *et al.*, 2014). Any potential mortality and recoverable injury resulting from high-order UXO clearance are anticipated to be restricted to the vicinity of the detonation (100s of metres), and as such this is expected to be a small-scale impact, with the maximum impact ranges for the onset of mortality and recoverable injuries for each individual project unlikely to overlap.

Step	Justification
	Moreover, UXO clearance operations at each OWF sites will likely follow a UXO mitigation hierarchy similar to that adopted for Dublin Array, with high order UXO detonation only used when other clearance options (e.g., avoidance, removal and low order deflagration) are not possible. Changes in hearing (TTS) and disturbance effects are likely to occur over larger areas, potentially reaching 10's of kilometres from the UXO location. However, as discussed previously, these effects would be reversible, and sensitive receptors are anticipated to resume normal behaviour and distribution shortly after the clearance event. Each UXO clearance is a discrete event with impulse sounds anticipated to be momentary (i.e., seconds to minutes). Therefore, the likelihood of concurrent clearance events between projects is considered to be low, thereby reducing the likelihood of cumulative effects. Moreover, while these events may result in some temporary disturbance and re-distribution in fish and shellfish receptors, given their discrete nature, they are unlikely to result in widespread and long-term displacement of receptors from migration routes or spawning, nursery and feeding grounds, compared to longer-term activities such as piling. Based on the above, it is concluded that any cumulative effects upon fish and shellfish receptors from UXO clearance would at most result in barely discernible changes from baseline conditions. Consequently, the magnitude of the cumulative effect is concluded to be **Low adverse**. The sensitivity of fish and shellfish receptors to impulse sounds generated during high order UXO detonation has been documented in Impact 4, with the maximum sensitivity assessed as being **Medium**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.
Conclusion	*The maximum magnitude of potential cumulative underwater noise effects from UXO clearance is concluded to be* ***Low adverse****. The maximum sensitivity of the receptors is assessed as* ***Medium****. The potential maximum significance of cumulative underwater noise effects on fish, marine turtle and shellfish receptors as a result of UXO clearance is* ***Slight Adverse*** *(i.e., the same as the project alone), which is not significant in EIA terms.*

Table 49 Determination of potential for cumulative effects from underwater noise and vibration as a result of non-impulsive sounds

Step	Justification
Step 1: Drivers	Construction and maintenance activities associated with the identified Tier 1 and Tier 3 projects.
Step 2: Pressures	Recoverable injury, TTS and/ or behavioural changes as a result of impulse sounds generated by the identified projects.
Step 3: States	Noise-sensitive fish, shellfish, and marine turtle VERs, including eggs and larvae.
Step 4: Impacts	As assessed in paragraph 4.16.113 *et seq.*, non-impulsive sounds such as those emitted during dredging, cable installation, the drilling of foundations, geophysical surveys and vessel traffic, do not represent a risk of mortality and potential mortal injury to fish and shellfish species.

Step	Justification
	However, there is potential for auditory tissue injuries and TTS, particularly in species with enhanced sensitivities to sound pressure, but current evidence suggests that these effects are temporary and reversible (Popper *et al.*, 2014). Similarly, any potential behavioural reactions would be temporary. Therefore, these activities are considered to have a much lower likelihood to result in significant adverse effects in fish and shellfish receptors compared to piling and high order UXO clearance, both alone and cumulatively with other projects. **Tier 3 OWF Projects** It is anticipated that, following standard practices, vessels moving to and from offshore windfarm sites will, for the majority, use existing vessel routes for pre-existing vessel traffic (Table 11), which fish and shellfish will be accustomed to. Therefore, it is considered that potential cumulative effects may predominantly result at the construction sites. Assuming similar construction activities at the OWF sites, any potential recoverable injuries or TSS in Group 3 and Group 4 species as a result of non-impulse sounds are anticipated to be highly localised (i.e., within 10s of metres, see paragraph 4.16.121 *et seq.*), and therefore the potential for cumulative effects is limited. Similarly, the risk of adverse cumulative behavioural reactions from overlapping noise contours or as a result of sequential disturbances across the cumulative assessment area is considered to be low, given the reversibility of the effects and the intermittent and temporary to short-term nature of the activities. Therefore, as for the project alone assessment, the magnitude of cumulative effects to Group 3 and Group 4 VERs is deemed at most **Low adverse**. Given their lower hearing capabilities and the lower risk of recoverable injuries and TTS, the magnitude of cumulative effects to the remaining receptors is deemed to be **Negligible**. **Tier 1 Projects, Mares Connect and Dublin Port Company 3FM Project** The remaining projects screened into the cumulative assessment for underwater noise (Table 41) will generate non-impulsive sounds similar to those generated during the construction of the proposed development (e.g., dredging and vessel noise, noise generated during geophysical surveys). As for the construction activities associated with the Tier 3 OWF projects including Dublin Array, the noise levels emitted during these activities may potentially cause temporary TTS in the most sensitive VERs (i.e., Group 3 and Group 4 species) as well as behavioural reactions but are not thought to cause mortal injuries. Any TTS are predicted to be restricted to the near-field (10s of metres), while behavioural reactions may occur over larger areas (1000s of metres). It is anticipated that, following standard practices, any vessel moving to and from offshore construction and sediment disposal sites will, for the majority, use existing vessel routes for pre-existing vessel traffic, which fish and shellfish will be accustomed to. They may also have become habituated to the noise generated by regular vessel movements, and therefore it is considered that potential cumulative effects from the projects may predominantly result from activities at construction and survey sites (e.g., along the Mares Connect cable corridor and within the areas covered by geophysical surveys).

Step	Justification
	Activities associated with the projects are anticipated to be temporary (i.e., lasting less than one year), with most activities such as geophysical surveys and maintenance dredging operations expected to be of shorter duration (days to weeks). Any potential TTS and disturbance effects will be temporary, with affected individuals expected to resume to normal behaviours shortly after the activities have ceased (i.e., within days to one to two weeks) (Popper *et al.,* 2014). Therefore, as for the project alone assessment, the magnitude of cumulative effects to Group 3 and Group 4 VERs is deemed at most **Low adverse**. Given their lower hearing capabilities and the associated lower risk of recoverable injuries and TTS, the magnitude of cumulative effects to the remaining receptors is deemed to be **Negligible**. The sensitivity of fish and shellfish receptors to non-impulse sounds has been documented in Impact 4, with the maximum sensitivity assessed as being **Low**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.
Conclusion	*The maximum magnitude of potential cumulative underwater noise from non-impulse sounds is concluded to be **Low adverse**. The maximum sensitivity of the receptors is assessed as **Low**. The potential maximum significance of cumulative effects on fish, marine turtle and shellfish receptors as a result of non-impulse sounds is **Slight Adverse** (i.e., the same as the project along), which is not significant in EIA terms.*

4.19.19 Based on the information presented above, it is concluded that any simultaneous and/ or sequential effects on fish and shellfish resulting from the identified Tier 1 and Tier 3 projects in-combination with any underwater noise generated during the construction phase of the proposed development (i.e., piling of foundations, UXO clearance, other construction activities and pre-construction surveys) would be no greater in magnitude than those predicted for the project alone (i.e., **Low adverse**, Impact 4). As per the project alone assessment, the maximum sensitivity of the receptors to the impact is deemed to be **Medium**. At most, this would result in a Slight (adverse) cumulative effect, which is not considered significant in EIA terms. Therefore, no mitigation in addition to that already identified in Table 11 is considered necessary, and no significant adverse residual cumulative effects on fish, shellfish and marine turtle receptors have been predicted in respect to this impact.

Effect 19: Cumulative long- term loss of benthic habitat due to placement of subsea infrastructure

4.19.20 The presence of infrastructure in the marine environment, including turbine foundations, scour protection and cable protection, will cause long-term changes in the extent and distribution of sedimentary habitats. This may affect the distribution and abundance of fish and shellfish receptors that depend on the seabed for all or part of their life cycle. In addition, any infrastructure left in situ (excluding buried cables) following decommissioning will represent a permanent loss of sedimentary habitat. The potential for significant effects on fish and shellfish receptors as a result of cumulative long-term habitat loss is assessed in Table 50.

Table 50 Determination of potential for cumulative effects due to long-term habitat loss from the presence of foundations and scour and cable protection

Steps	Justification
Step 1: Drivers	Presence of OWF infrastructure in the marine environment, including foundations, scour protection and cable protection; presence of cable protection.
Step 2: Pressures	Long-term loss of essential sedimentary fish and shellfish habitats through the presence of infrastructure and associated protection material on the seabed.
Step 3: States	Fish and shellfish receptors and their supporting benthic habitats.
Step 4: Impacts	It is predicted that under the maximum design option approximately 1.02 km^2 of seabed would be permanently lost due to the installation of Dublin Array. The loss of sedimentary habitats resulting from the Codling, NISA, Oriel and Arklow Bank Phase 2 projects are predicted to be slightly smaller compared to that assessed for the proposed development (see Table 41) based on similar technology and analogous project designs. Specifically, any long-term or permanent loss of seabed habitats associated with the Tier 3 Phase 1 OWF projects is expected to be highly localised (between up to 0.3 km^2 and 0.7 km^2) and restricted to discrete areas within the array areas and ECCs of these projects, resulting in a cumulative loss together with Dublin Array of approximately 3 km^2. Broadscale habitat maps (INFOMAR, 2023) suggest that the subtidal benthic substrates that would be affected are common and widespread within the cumulative assessment area. Furthermore, the fish and shellfish receptors that relay on these habitats are widely distributed within the western Irish Sea and also use comparatively large areas for spawning in the context of the localised loss of sedimentary habitats. Therefore, any effects on fish and shellfish receptors due to the cumulative loss of benthic habitats from the proposed development in-combination with the assessed OWF projects are anticipated to be at most barely discernible from baseline conditions. Consequently, the maximum magnitude of the cumulative effect with respect to these projects is assessed as being **Low adverse**. Of the Tier 3 projects screened into the cumulative assessment, the proposed Mares Connect power cable and marine works associated with the Arklow Waste Water Treatment Plan may contribute to the cumulative long-term loss of benthic fish and shellfish habitats through the placement of cable and scour protection measures. No information relating to the volumes of protection material needed by these projects is currently available. However, any loss of seabed habitats from the use of protection material by these projects would be highly localised, and as such no discernible loss of resource for fish and shellfish receptors in the context of the western Irish Sea populations are anticipated from these projects alone. Cumulatively with the proposed development and the assessed OWF projects, at most, barely discernible changes to fish and shellfish receptors are expected. Consequently, the maximum magnitude of cumulative losses of the seabed with respect to all considered projects is assessed as being **Low adverse**. The sensitivity of fish and shellfish receptors to the long-term habitat loss of sedimentary habitats has been documented in Impact 7 (Table 34), with the maximum sensitivity assessed to be **Medium**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.

Steps	Justification
Conclusion	*The maximum magnitude of the potential cumulative long-term loss of supporting benthic habitats following the construction of the Phase 1 Irish Projects and the Mares Connect power cable is concluded to be* ***Low adverse****. The maximum sensitivity of the receptors in the area is assessed as* ***Medium****. Therefore, the potential significance of effects of long-term cumulative habitat loss on fish, marine turtle and shellfish receptors is* ***Slight adverse*** *(i.e., the same as the project alone), which is not significant in EIA terms.*

Effect 20: Cumulative barriers to movement through the presence of seabed infrastructure and EMF from cables

4.19.21 The potential for significant cumulative barriers to movement through the presence of EMF from cables is presented in Table 51.

Table 51 Determination of potential for cumulative effects through the presence of EMFs from submarine power cables

Steps	Justification
Step 1: Drivers	Presence of active submarine power and telecommunication cables.
Step 2: Pressures	Emission of artificial EMFs into the sediment and water column through the transmission of electricity through subsea cables.
Step 3: States	Electro- and magneto-sensitive fish and shellfish receptors.
Step 4: Impacts	The potential maximum magnitude of effects arising from EMFs during the operation of Dublin Array has been assessed as Low adverse, based on the rapid attenuation of EMFs within the water column and the localised nature of behavioural changes of sensitive receptors (Table 37, Figure 14 and Figure 15). Given the similarity in project designs, the extent of EMF emissions from the other identified OWF projects is also expected to be highly localised and restricted to discrete areas within the immediate proximity of the cable lines. The receptors are widely distributed within the study area and wider western Irish Sea and use comparatively large feeding, spawning and nursery grounds. Therefore, cumulative increases in the spatial extent of areas affected by artificial EMFs emitted from cables of the proposed OWF projects are likely to be small in relation to the wider environment. As per the project alone assessment, any cumulative behavioural responses of sensitive fish and shellfish receptors are therefore assessed as being at most barely discernible from baseline conditions, and consequently, the maximum magnitude of cumulative emissions of EMF with respect to the assessed Phase 1 projects is assessed as being **Low adverse**.

Steps	Justification
	Of the other projects screened into the cumulative assessment, the proposed Mares Connect power cables would together with existing active power and telecommunications cables contribute to ongoing EMF emission within the cumulative assessment area. Based on the same rationale as presented above for EMF generated by the Phase 1 OWF projects, any cumulative behavioural responses in sensitive fish and shellfish receptors are expected to be restricted to the immediate proximity of the cable lines and would at most be barely discernible from baseline conditions. Consequently, the maximum magnitude of cumulative emissions of EMF with respect to these projects is assessed as being Low adverse. In summary, EMFs emitted at Dublin Array and from projects screened into the assessment are predicted to result in highly localised behavioural responses in electro- and magneto-sensitive receptors. Given the wide distribution of the receptors within the cumulative assessment area and the distances between the assessed projects (1000s of metres), any potential cumulative changes in the distribution of individuals are assessed to result in at most barely discernible changes to baseline conditions, and as such the overall magnitude of the cumulative effect when assessed across all tiers is deemed to be **Low adverse**. The sensitivity of fish and shellfish receptors to directly (B-fields) or indirectly (iE-fields) produced EMFs from power cables has been documented in Impact 10 (Table 38), with the maximum sensitivity assessed as being **Low**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 is considered necessary to prevent significant effects.
Conclusion	*The maximum magnitude of potential cumulative effects of EMF is concluded to be **Low adverse**. The maximum sensitivity of the receptors in the area is assessed as Low. Therefore, the potential maximum significance of cumulative effects from EMF on fish, marine turtle and shellfish receptors is a **Slight adverse** (i.e. the same as the project alone), which is not significant in EIA terms.*

Effect 21: Cumulative changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes

4.19.22 The potential for significant cumulative changes to supporting seabed habitats as a result of the presence of structures on the seabed is presented in Table 52.

Table 52 Determination of potential for cumulative changes to seabed habitats as a result of the changes to local hydrodynamic and sediment transport processes

Steps	Justification
Step 1: Drivers	Changes to hydrodynamic, wave and sediment transport processes through the presence of structures on the seabed.
Step 2: Pressures	Alterations to benthic habitats as a result of scour effects, changes to the local wave regime and changes to seabed topography.
Step 3: States	Fish and shellfish species that are directly reliant on the benthos for either all, or part of their life cycle, such as demersal spawners.

Steps	Justification
Step 4: Impacts	Changes to the tidal and wave regimes from the Dublin Array alone were deemed to be of **Negligible** magnitude (see Physical Processes Chapter), with any potential changes predicted to be highly localised. Therefore, no significant pathway of effect on fish, marine turtles and shellfish receptors were predicted for these aspects (Impact 11). Given the similar technologies, scales of development and similar seabed environments of the other assessed projects, it is anticipated that similar magnitudes of effects would occur for these projects alone, i.e. localised and not significant in EIA terms. Therefore, despite being potentially additive, it is not anticipated that the cumulative changes in wave and tidal regimes arising from the developments would be discernible from baseline conditions. As such, it is expected that there would be no changes to the supporting habitats of fish, shellfish and marine turtles and the magnitude of the cumulative effect is consequently assessed as **Negligible**. Changes in seabed topography and flow patterns around the foundations of Dublin Array resulting from scour were predicted to be of Low magnitude given their highly localised nature (see Physical Process Chapter). Any effects on fish and shellfish receptors resulting from these changes were deemed to be Negligible based on the localised nature of the impact and given that the supporting benthic habitats are common and widespread throughout the study area and wider region. Given the similar technologies, scales of development and similar seabed environments of the other assessed projects, it is anticipated that similar magnitudes of effects would occur for these projects alone, i.e. localised and not significant in EIA terms. Therefore, despite being potentially additive, it is not anticipated that the cumulative changes in seabed conditions due to scour development would result in discernible changes in the distribution of sensitive fish and shellfish receptors, and the magnitude of the cumulative effect is consequently assessed as **Negligible**.
Step 5: Responses	No mitigation in addition to that already identified in Table 11 Project design features/other avoidance and preventative measures relating to fish and shellfish is considered necessary to prevent significant effects.
Conclusion	*Despite being potentially additive, it is not anticipated that the cumulative changes in physical processes arising from the developments would be measurable and therefore the magnitude is concluded to be* ***Negligible****. The maximum sensitivity of receptors in the area is assessed as* ***Medium.*** *This would result in a* ***Neutral Effect (Not significant)*** *(i.e. the same as project alone), which is not significant in EIA terms.*

4.20 Interactions of environmental factors

4.20.0 A matrix illustrating the likely interactions of the environmental factors arising from Dublin Array on fish and shellfish is provided in Volume 8, Chapter 1: Interactions of the Environmental Factors.

4.20.1 Interactions of environmental factors are considered to be the effects and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, O&M and decommissioning) to interact and potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project phases; and

- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, jack up vessel use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects.

4.20.2 As indicated in the interactions matrix (there are linkages between the topic-specific chapters presented within this EIAR, whereby the effects assessed in one chapter have either the potential to result in secondary effects on another receptor (e.g. effects on fish and shellfish ecology have the potential to result in secondary effects on marine mammals' prey resources).

4.20.3 The potential effects on fish and shellfish during construction, operational and maintenance and decommissioning phases of the Project have been assessed in sections 4.16, 4.17 and 4.18 above.

4.20.4 As effects on fish and shellfish (i.e. displacement effects) also have the potential to have secondary effects on other receptors which have been fully assessed in the topic-specific chapters. These receptors are:

- Chapter 6: Marine Mammals and Reptiles;

- Chapter 7: Offshore and Intertidal Ornithology; and

- Chapter 10: Commercial Fisheries.

4.20.5 For Fish and Shellfish receptors, the following potential impacts have been considered within the interactions assessment:

- Temporary or long-term habitat disturbance/loss resulting in indirect effects on fish, marine turtles, and shellfish receptors.

- Increased SSC and sediment deposition resulting in indirect effects fish, marine turtles and shellfish receptors (i.e. through avoidance behaviour, physiological effects, effects on eggs and larvae, smothering effects).

Project lifetime effects

4.20.6 Project lifetime effects consider impacts from the construction, operation or decommissioning of Dublin Array on the same receptor (or group). The potential inter-related effects that could arise in relation to fish and shellfish ecology are presented in Table 53.

Table 53 Project lifetime effects assessment for potential inter-related effects on fish and shellfish ecology

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
Temporary or long-term habitat disturbance/loss resulting in indirect effects on fish, marine turtles, and shellfish receptors	Slight Adverse (temporary loss)	Imperceptible to Slight adverse (temporary loss) Slight Adverse (long-term loss)	Imperceptible to Slight adverse (temporary loss)	Temporary or long-term habitat disturbance/loss will represent a long-term and continuous impact throughout the lifetime of the project. However, only a relatively small proportion of the fish and shellfish habitats will be affected in the context of wider habitats in the area. The inter-related impacts are therefore predicted to be Slight Adverse, which are not significant in EIA terms.
Increased SSC and sediment deposition resulting in indirect effects fish, marine turtles and shellfish receptors (i.e. through avoidance behaviour, physiological effects, effects on eggs and larvae, smothering effects)	Slight Adverse	Imperceptible to Slight adverse	Imperceptible to Slight adverse	The majority of seabed disturbance resulting in increased suspended sediment and deposition will be within the construction and decommissioning phases. There is potential for some disturbance within the operational phase however, these activities will be localised and temporally discrete. It is therefore considered that impacts in the operation phase will not materially contribute to inter-related effects. The construction and decommissioning phases are significantly temporally separate such that there will be no interaction between the two.

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
				There will therefore be no inter-related effects of greater significance compared to the impacts considered alone.

Receptor led effects

4.20.7 There is the potential for spatial and temporal interactions between the effects arising from supporting habitat loss/ disturbance and increases in SSC and sediment deposition during the project lifetime. The greatest potential for interactions of environmental factors is predicted to occur through the interaction of both temporary and permanent habitat loss/ disturbance from foundation installation/ jack-up vessels/ anchor placement/ scour, indirect habitat disturbance due to sediment deposition and indirect effects of changes in physical processes due the presence of infrastructure in the operational wind farm.

4.20.8 With respect to this interaction, these individual impacts were assigned a significance of negligible to moderate significance as standalone impacts and although potential combined impacts may arise (i.e. spatial and temporal overlap of direct habitat disturbance), it is predicted that this will not be any more significant than the individual impacts in isolation. This is because the combined amount of habitat potentially affected would remain very limited, the supporting habitat types affected are widespread across the Irish Sea, and full recovery is predicted where temporary damage/disturbance occurs. In addition, any effects due to changes in the physical processes are likely to be limited, both in extent and in magnitude, with receptors having low sensitivity to the scale of changes predicted. As such, these interactions are predicted to be no greater in significance than that for the individual effects assessed in isolation.

4.20.9 Overall, the interactions of environmental factors do not identify any significant effects that were not already covered by the assessments set out in the preceding sections. Although certain individual effects have been identified that are predicted to interact with each other, these will not lead to any greater significance of effect.

4.21 Transboundary statement

4.21.1 No transboundary effects have been identified. Whilst underwater noise effects may travel into other states waters, due to the distance of Dublin Array to relevant nations (Wales), combined with the lack of any designated areas for fish, marine turtles and shellfish receptors within the range of potential noise effects from Dublin Array, and the project alone conclusions of no adverse effects, it can be concluded that there will be no adverse transboundary effects from the construction, operation or decommissioning of Dublin Array.

4.22 Summary of effects

4.22.1 A summary of the effects presented within this EIAR chapter are presented in Table 54.

Table 54 Summary of effects assessed for fish and shellfish ecology

Impact no	Impact	Additional mitigation measures	Residual impact
Construction			
Impact 1	Temporary increase in SSC and sediment deposition as a result of construction activities.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 2	Damage and disturbance of the seabed during construction activities.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 3	Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 4	Introduction of underwater noise and vibration leading to mortality, injury, behavioural changes or auditory masking.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Operation and maintenance			
Impact 5	Temporary increase in SSC and sediment deposition during O&M activities.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 6	Damage and disturbance of the seabed during O&M activities.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 7	Long-term loss of habitat due to placement of subsea infrastructure.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 8	Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 9	Increased hard substrate and structural complexity due to the placement of subsea infrastructure.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 10	Potential barriers to movement through the presence of seabed infrastructure and EMFs from cables.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 11	Changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes.	Not Applicable – no additional mitigation identified	No significant adverse residual effects

Impact no	Impact	Additional mitigation measures	Residual impact
Decommissioning			
Impact 12	Temporary increases in SSC and sediment deposition as a result of decommissioning activities.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 13	Damage and disturbance of the seabed during decommissioning activities.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 14	Reduction in water and sediment quality through the release of contaminated sediments and/or accidental contamination	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 15	Introduction of underwater noise and vibration leading to mortality, injury, behavioural changes, or auditory masking.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Cumulative			
Impact 16	Cumulative increases in SSC and associated sediment deposition during construction activities	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 17	Cumulative damage and disturbance of the seabed during construction activities.	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 18	Cumulative underwater noise and vibration during construction activities	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 19	Cumulative long-term loss of benthic habitat due to placement of subsea infrastructure	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 20	Cumulative barriers to movement through the presence of seabed infrastructure and EMF from cables	Not Applicable - no additional mitigation identified	No significant adverse residual effects
Impact 21	Cumulative changes to seabed habitats resulting from effects on local hydrodynamic and sediment transport processes	Not Applicable – no additional mitigation identified	No significant adverse residual effects

4.23 References

Alves, L. M., Lemos, M. F., Cabral, H. and Novais, S. C. (2022), 'Elasmobranchs as bioindicators of pollution in the marine environment', Marine Pollution Bulletin, 176: 13418.

Aquafact International Services Ltd. (2018), 'Marine Ecological Assessment Dublin Array Wind Farm. On behalf of Saorgus Ltd'.

Aquafact International Services Ltd. (2019), 'A Fisheries survey of the Kish and Bray Banks. On behalf of Innogy'.

Aquatic Services Unit (2019), 'Dublin Port Company Maintenance Dredging (2020-2021). Assessment of Potential Benthic and Fisheries Impacts'. https://www.gov.ie/en/foreshore-notice/7a2de-maintenance-dredging-in-dublin-port/ [Accessed: January 2025].

Aquatic Services Unit (2020), 'Dublin Port Company Maintenance Dredging 2022-2029. Benthic and Fisheries Assessment'. https://www.gov.ie/en/foreshore-notice/60147-dublin-port-maintenance-dredging/ [Accessed: April 2024].

Atalah J., Fitch, J., Coughlan, J., Chopelet, J., Coscia, I. and Farrell, E. (2013), 'Diversity of demersal and megafaunal assemblages inhabiting sandbanks of the Irish Sea', Marine Biodiversity, 43: 121-132.

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.

Béguer-Pon, M., Castonguay, M., Shan, S., Benchetrit, J. and Dodson, J. J. (2015), 'Direct observations of American eels migrating across the continental shelf to the Sargasso Sea', Nature Communications, 6/1: 8705.

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

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: 1991-1995.

Bergstedt, R. A. and Seelye, J. G. (1995), 'Evidence for lack of homing by sea lampreys', Transactions of the American Fisheries Society, 124(2): 235-239.

BERR (2008) 'Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind – Technical Report'. https://tethys.pnnl.gov/sites/default/files/publications/Cabling_Techniques_and_Environmental_Effects.pdf [Accessed: October 2023].

BioConsult (2006), 'Benthic communities at Horns Rev, before, during and after construction of Horns Rev offshore wind farm', Final annual report 2005.

Bochert, R. and Zettler, M. L. (2004), 'Long-term exposure of several marine benthic animals to static magnetic fields', BioElectroMagnetics, 25(7): 498-502.

Bodznick, D. and Northcutt, R. G. (1981), 'Electroreception in lampreys: Evidence that the earliest vertebrates were electroreceptive', Science, 212(4493): 465-467.

Bodznick D. and Preston, D. G. (1983), 'Physiological characterization of electroreceptors in the lampreys Ichthyomyzon unicuspis and Petromyzon marinus', Journal of Comparative Physiology, 152: 209-217.

Bolger, E. (2014), 'The abundance, movement and population characteristics of common whelk, Buccinum undatum (L.), in an area under consideration for an offshore windfarm development in the territorial waters of the Isle of Man', MSc thesis, Bangor University. http://sustainable-fisheries-iom.bangor.ac.uk/documents/theses/2016_Bolger.pdf [Accessed: October 2024].

BOWL (2016), 'Beatrice Offshore Wind Farm Consent Plan: Cable Plan (OfTW). https://marine.gov.scot/sites/default/files/00516308.pdf [Accessed: December 2024].

Carlson, T. J., Ploskey, G., Johnson, R. L., Mueller, R. P., Weiland, M. A. and Johnson, P. N. (2001), 'Observations of the Behavior and Distribution of Fish in

Relation to the Columbia River Navigation Channel and Channel Maintenance Activities', Pacific Northwest National Laboratory, Richland, 35 pp.

Casper B. M., Halvorsen M. B. and Popper A. N. (2012), 'Are sharks even bothered by a noisy environment? In The Effects of Noise on Aquatic Life', pp. 93-97. Ed. by A., Hawkins, A. N., Popper Springer, New York.

Causon, P. D. and Gill, A. B. (2018), 'Linking ecosystem services with epibenthic biodiversity change following installation of offshore wind farms', Environmental Science and Policy, 89: 340-347.

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

Ceraulo M., Bruintjes R., Benson T., Rossington K., Farina A. and Buscaino G. (2016), 'Relationships of underwater sound pressure and particle velocity in a shipbuilding dock', In: 4th International Conference on the Effects of Noise on Aquatic Life, 10-16 July 2016, Dublin, Ireland.

Chartered Institute of Ecology and Environment Management (CIEEM) (2018), 'Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater and Coastal', September 2018, Version 1.2 - Updated April 2022. Chartered Institute of Ecology and Environmental Management, Winchester. https://cieem.net/resource/guidelines-for-ecological-impact-assessment-ecia/

Christian, J. R., Mathieu, A., Thompson, D. H., White, D., Buchanan, R. A. (2003), 'Effect of Seismic Energy on Snow Crab (Chionoecetes opilio)', Environmental Funds Project No. 144. Fisheries and Oceans Canada, Calgary, File No.: CAL-1-00364.

Chung-Davidson, Y. -W., Yun, S. -S., Teeter, J. and Li, W. (2004), 'Brain Pathways and Behavioral Responses to Weak Electric Fields in Parasitic Sea Lampreys (Petromyzon marinus)', Behavioral Neuroscience, 118(3): 611-619.

Chung-Davidson Y. W., Bryan, M. B., Teeter, J., Bedore, C. N. and Li, W. (2008), 'Neuroendocrine and behavioral responses to weak electric fields in adult sea lampreys (Petromyzon marinus)', Hormones and Behavior, 54(1): 34-40.

Claisse, J. T., Pondella, D. J., Love, M., Zahn, L. A., Williams, C. M., Williams, J. P. and Bull, A. S. (2014), 'Oil platforms off California are among the most productive marine fish habitats globally', Proceedings of the National Academy of Sciences 111/43: 15462-15467.

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.

CMACS (2003), 'A baseline assessment of electromagnetic fields generated by offshore windfarm cables', COWRIE Report EMF-01-2002 66.

CMACS (2012), 'East Anglia One Offshore Wind Farm: Electromagnetic Field Environmental Appraisal. Assessment of EMF on sub tidal marine ecology. APPENDIX 9.2 Electromagnetic Field Environmental Appraisal of East Anglia Three ES'.

Codling Wind Park Limited (2024), 'Environmental Impact Assessment Report, Volume 3, Chapter 9 Fish, Shellfish, and Turtle Ecology'. https://codlingwindparkplanningapplication.ie/environmental-impact-assessment-report-eiar/ [Accessed: September 2024].

Compagno, L. J. (2001), 'Sharks of the world: an annotated and illustrated catalogue of shark species known to date. Volume 2. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes)', FAO Species Catalogue for Fishery Purposes, No. 1, Vol. 2. Rome, FAO, 2001, 269 pp.

Corcoran, W., Matson, R., McLoone, P., Bateman, A., Cierpial, D., Donovan, R., Duffy, P., Gavin, A., Gordon, P., McCarthy, E., Robson, S., Wightman, G., Roche, W. and Kelly, F. L. (2022), 'Sampling Fish for the Water Framework Directive - Summary Report 2021', National Research Survey Programme, Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24.

Cohen, S. C. and Strathmann, R. R. (1996), 'Embryos at the edge of tolerance: Effects of environment and structure of egg masses on supply of oxygen to embryos', The Biological Bulletin, 190/1: 8-15.
Corell, H., Bradshaw, C. and Sköld, M. (2023), 'Sediment suspended by bottom trawling can reduce reproductive success in a broadcast spawning fish', Estuarine, Coastal and Shelf Science, 282: 108232.
Coull, K. A., Johnstone, R., and Rogers, S. I. (1998), 'Fisheries Sensitivity Maps in British Waters', UKOOA Ltd.' https://www.cefas.co.uk/media/o0fgfobd/sensi_maps.pdf [Accessed: October 2023]
Crocker, S. E., and Fratantonio, F. D. (2016), 'Characteristics of sounds emitted during high-resolution marine geophysical surveys', OCS Study, BOEM 2016-44, NUWC-NPT Technical Report 12.
Crocker, S. E., Fratantonio, F.D., Hart, P. E., Foster, D. S., O'Brien, T. F. and Labak, S. (2019), 'Measurement of Sounds Emitted by Certain High-Resolution Geophysical Survey Systems', Journal of Oceanic Engineering, 44: 796-813.
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. http://celticseatrout.com/downloads/technical-report/ [Accessed: November 2023]
Dahl, P. H., Keith Jenkins, A., Casper, B., Kotecki, S. E., Bowman, V., Boerger, C., Dall'Osto, D. R., Babina, M. A. and Popper, A. N. (2020), 'Physical effects of sound exposure from underwater explosions on Pacific sardines (Sardinops sagax)', The Journal of the Acoustical Society of America, 147(4): 2383-2395.
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'. https://www.gov.ie/en/publication/3d6efb-guidance-documents-for-offshore-renewable-energy-developers/ [Accessed: November 2023].
DCCAE (2018), 'Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects, Part 1 and Part 2'. https://www.gov.ie/en/publication/3d6efb-guidance-documents-for-offshore-renewable-energy-developers/#:~:text=Part%201%20of%20the%20Guidance%20on%20Marine%20Baseline,offshore%20renewable%20energy%20projects%20on%20the%20marine%20environment [Accessed: November 2023].
de Groot, S. J. (1980). 'The consequences of marine gravel extraction on the spawning of herring, Clupea harengus Linné', Journal of Fish Biology, 16/6: 605-611.
Department of Housing, Planning and Local Government, (2018), 'Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment'. https://www.gov.ie/en/publication/53aee9-guidelines-for-planning-authorities-and-an-bord-pleanala-on-carrying/ [Accessed: December 2023].
de Vooys, C. G. N. (1987), 'Elimination of sand in the blue mussel, Mytilus edulis. Netherlands Journal of Sea Research', 21(1): 75-78.
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.
Doksæter, L., Rune Godø, O., Olav Handegard, N., Kvadsheim, P. H., Lam, F. P. A., Donovan, C. and Miller, P. J. (2009), 'Behavioral responses of herring (Clupea harengus) to 1-2 and 6-7kHz sonar signals and killer whale feeding sounds', The Journal of the Acoustical Society of America, 125(1): 554-564.

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.

Dublin Array (2020), 'Dublin Array Offshore Wind Farm. Environmental Impact Assessment Scoping Report', September 2020, Revision 1, prepared by SLR/GoBe/RWE. https://dublinarray.com/wp-content/uploads/2020/10/Dublin-Array-EIAR-Scoping-Report-Part-1-of-2.pdf

Dublin Port Company (2024), '3FM Project Environmental Impact Assessment Report – Chapter 20: Cumulative Effects & Environmental Interactions (Volume 2, Part 5)', https://dublinport3fm.ie/wp-content/uploads/2024/07/Chapter-20-Cumulative-Effects-Environmental-Interactions-Volume-2-Part-5.pdf [Accessed: January 2025].

Durkin, O. C. and Tyler-Walters, H. (2022), 'Burrowing megafauna and Maxmuelleria lankesteri in circalittoral mud', in Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]', Plymouth: Marine Biological Association of the United Kingdom. https://www.marlin.ac.uk/ [Accessed: September 2023].

EcoServe (2008), 'A marine ecological study of the Kish and Bray banks for a proposed offshore wind farm development: Re-characterisation survey', Ecological Consultancy Services Limited. Issued report.

Ellis, J. R., Milligan, S. P., Readdy, L., South, A., Taylor, N. and Brown, M. (2010), 'Spawning and Nursery Grounds Layers for Selected Fish in UK Waters in 2010'. https://data.cefas.co.uk/view/153 [Accessed: September 2023]

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', Science Series Technical Report, 147: 56 pp. Cefas, Lowestoft.

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

EPA (2022), 'Guidelines on the information to be contained in Environmental Impact Assessment reports (EIAR)', ISBN 978-1-80009-005-7. https://www.epa.ie/publications/monitoring--assessment/assessment/guidelines-on-the-information-to-be-contained-in-environmental-impact-assessment.php [Accessed: August 2023].

EPA (2024a), 'EPAMaps'. https://gis.epa.ie/EPAMaps/default [Accessed: January 2025].

EPA (2024b), 'Ireland's State of the Environment Report 2024'. https://www.epa.ie/our-services/monitoring--assessment/assessment/state-of-environment-report-/ [Accessed: December 2024].

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

Everitt, N. (2008), 'Behavioural responses of the shore crab, Carcinus maenas, to magnetic fields', MSc Thesis, University of Newcastle-upon-Tyne: 94 pp.

Fahy, E., Masterson, E., Swords, D. and Forrest, N. (2000), 'A second assessment of the whelk fishery *Buccinum undatum* in the southwest Irish Sea with particular reference to its history of management by size limit', A Report for the Marine Fisheries Services Division, Marine Institute.

Fahy, E., O'Toole, M., Stokes, D. and Gallagher, M. (2002), 'Appraisal of the whelk (*Buccinum undatum*) fishery on a part of the Codling Bank following aggregate extraction for beach restoration at Bray, Co Wicklow', Marine Institute Fisheries Leaflet 182.

Farkas, J., Nordtug, T., Svendheim, L. H., Amico, E. D., Davies, E. J., Ciesielski, T., Jenssen, B. M., Kristensen, T., Olsvik, P. A. and Hansen, B. H. (2021), 'Effects of mine tailing exposure on early life stages of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*)', Environmental Research, 200: 111447.

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.

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(6): 1259-1268.

Froese, R. and Pauly, D. (eds.) (2023), 'FishBase. World Wide Web electronic publication', www.fishbase.org [Accessed: September 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.

Fugro (2021). 'WPM1, WPM2 & WMP3 - Main Array & ECR - Benthic Ecology Monitoring Report', Dublin Array Offshore Site Investigation, Ireland, Irish Sea.

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.

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 Bartlett, M. (2010), 'Literature review on the potential effects of electromagnetic fields and subsea noise from marine renewable energy developments on Atlantic salmon, sea trout and European eel', Scottish Natural Heritage Commissioned Report No.401.

Gill, A. B. and Taylor, H. (2001), 'The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon elasmobranch fishes', Countryside Council for Wales, Contract Science Report 488.

Gill, A. B., Gloyne-Phillips, I., Neal, K. J. and Kimber, J. A. (2005), 'The Potential Effects of Electromagnetic Fields Generated by Sub-Sea Power Cables Associated with Offshore Wind Farm Developments on Electrically and Magnetically Sensitive Marine Organisms - A Review', COWRIE 1.5 Electromagnetic Fields Review.

Gill, A. B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V. (2009), 'COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry', Commissioned by COWRIE Ltd (project reference COWRIE-EMF-1-06).

Gill, A. B., Hutchison, Z. L. and Desender, M. (2023), 'Electromagnetic Fields (EMFs) from subsea power cables in the natural marine environment', Cefas Project Report for Crown Estate Offshore Wind Evidence and Change Programme, 66 pp.

Gillson, J. P., Bašić, T., Davison, P. I., Riley, W. D., Talks, L., Walker, A. M. and Russell, I. C. (2022), 'A review of marine stressors impacting Atlantic salmon *Salmo salar*, with an assessment of the major threats to English stocks', Reviews in Fish Biology and Fisheries, 32(3): 879-919.

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.

Green, E. (2017), 'A literature review of the lesser (Raitt's) sandeel *Ammodytes marinus* in European waters', Technical Report by the Royal Society for the Protection of Birds (RSPB), Project Number: LIFE14 NAT/UK00394 Roseate Tern.

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

Hansen, M. J., Madenjian, C. P., Slade, J. W., Steeves, T. B., Almeida, P. R. and Quintella, B. R. (2016), 'Population ecology of the sea lamprey (*Petromyzon marinus*) as an invasive species in the

Laurentian Great Lakes and an imperiled species in Europe', Reviews in Fish Biology and Fisheries, 26(3): 509-535.
Hartley Anderson Ltd. (2020), 'Underwater acoustic surveys: review of source characteristics, impacts on marine species, current regulatory framework and recommendations for potential management options', NRW Evidence Report No: 448, 119pp, NRW, Bangor, UK.
Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O. A., Østensen, Ø., Fonn, M. and Haugland, E. K. (2004), 'Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*)', ICES Journal of Marine Science, 61/7: 1165-1173.
Hastings, M. C. and Popper, A. N. (2007), 'Update on exposure metrics for evaluation of effects of sound on fish', The Journal of the Acoustical Society of America, 122(5 Supplement): 3059-3059.
Hawkins, A. (2009) The impact of pile driving upon fish. Proceedings of the Institute of Acoustics Fifth International Conference on Bio-Acoustics, Loughborough, pp. 69-76.
Hawkins, A. D., Roberts, L. and Cheesman, S. (2014), 'Responses of free-living coastal pelagic fish to impulsive sounds', Acoustical Society of America, 135/5: 3101-3116.
Hawkins, A. D. and Popper, A. N. (2014), 'Assessing the impacts of underwater sounds on fishes and other forms of marine life', Acoustics Today, 10: 30-41.
Hawkins, A. D. and Popper, A. N. (2016), 'A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates', ICES Journal of Marine Science, 74/3: 635-651.
Hazelwood, R. A. and Macey, P. C. (2016), 'Modeling water motion near seismic waves propagating across a graded seabed, as generated by man-made impacts', Journal of Marine Science and Engineering, 4/3: 47. https://doi.org/10.3390/jmse4030047
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, 22/3: 337-367. doi:10.1002/aqc.2244
Hendrick, V. J., Hutchison, Z. L. and Last, K. S. (2016), 'Sediment burial intolerance of marine macroinvertebrates', PloS one, 11(2): e0149114.
Hermans, A., Bos, O. and Prusina, I. (2020), 'Nature-Inclusive Design: A Catalogue for Offshore Wind Infrastructure (Report No. 114266/20-004.274)', Report by Witteveen+Bos. Report for Wageningen University and Research Centre.
Higgs, D. M., Plachta, D. T. T., Rollo, A. K., Singheiser, M., Hastings, M. C. and Popper, A. N. (2004), 'Development of ultrasound detection in American shad (*Alosa sapidissima*)', Journal of Experimental Biology, 207(1): 155-163.
Higgs, D. M. and Radford, C. A. (2013), 'The contribution of the lateral line to 'hearing' in fish', Journal of Experimental Biology, 216(8): 1484-1490.
Hill, J. M. (2024), '*Ensis ensis* Common razor shell. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]', Plymouth: Marine Biological Association of the United Kingdom. https://www.marlin.ac.uk/species/detail/1419 [Accessed: April 2024].
Himmelman, J. H. and Hamel, J. R. (1993), 'Diet, behaviour and reproduction of the whelk Buccinum undatum in the northern Gulf of St. Lawrence, eastern Canada', Marine Biology, 116: 423-430.
Holling, C. S. (1973), 'Resilience and stability of ecological systems', Annual Review of Ecology and Systematics, 4/1: 1-23.
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.
Hutchison, Z. L., Secor, D. H., and Gill, A. B. (2020a), 'The interaction between resource species and electromagnetic fields associated with electricity production by offshore wind farms', Oceanography, 33(4): 96-107.

Hutchison, Z. L., Gill, A. B., Sigray, P., He, H. and King, J. W. (2020b), ‘Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom dwelling marine species’, Scientific Reports, 10: 4219.
Hutchison, Z. L., Gill, A. B., Sigray, P., He, H. and King, J. W. (2021), ‘A modelling evaluation of electromagnetic fields emitted by buried subsea power cables and encountered by marine animals: considerations for marine renewable energy development’, Renewable Energy, 177: 72-81.
Hvidt, C. B., Bech, M. and Klaustrup, M. (2004), ‘Monitoring programme-status report 2003. Fish at the cable trace. Nysted offshore wind farm at Rødsand’, Bioconsult.
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 (2003), ‘Report of the Benthos Ecology Working Group’, Fort Pierce, Florida, USA, 28th April - 1st May 2003, 58pp.
ICES (2022), ‘ICES Ecosystem Overviews. Celtic Seas ecoregion - Ecosystem Overview’. https://doi.org/10.17895/ices.advice.21731615
ICES (2023a), ‘Fish trawl survey: Northern Irish Groundfish Survey (2018-2022). ICES Database on Trawl Surveys (DATRAS)’, The International Council for the Exploration of the Sea, Copenhagen. https://datras.ices.dk [Accessed: October 2023].
ICES (2023b), ‘Fish trawl survey: Offshore Beam Trawl Survey (2018-2022). ICES Database on Trawl Surveys (DATRAS)’, The International Council for the Exploration of the Sea, Copenhagen. https://datras.ices.dk [Accessed: October 2023].
IFI (2008a), ‘Sampling Fish for the Water Framework Directive - Transitional Waters 2008 (Liffey Estuary)’. www.wfdfish.ie [Accessed: June 2024].
IFI (2008b), ‘Sampling Fish for the Water Framework Directive - Transitional Waters 2008 (Tolka Estuary)’. www.wfdfish.ie [Accessed: June 2024].
IFI (2010a), ‘Sampling Fish for the Water Framework Directive - Transitional Waters 2010 (Liffey Estuary)’. www.wfdfish.ie [Accessed: June 2024].
IFI (2010b), ‘Sampling Fish for the Water Framework Directive - Transitional Waters 2010 (Tolka Estuary)’. www.wfdfish.ie [Accessed: June 2024].
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/20221-4590.
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’. https://www.marine.ie [Accessed: 2023].
Irish Whale and Dolphin Group (2023). https://iwdg.ie [Accessed: February 2024].
Kajiura, S. M. and Fitzgerald, T. P. (2009), ‘Response of juvenile scalloped hammerhead sharks to electric stimuli’, Zoology, 112: 241-250.
Kajiura, S. M. and Holland, K. N. (2002), ‘Electroreception in juvenile scalloped hammerhead and sandbar sharks’, Journal of Experimental Biology, 205: 3609-3621.
Kalmijn, A. J. (1966), ‘Electro-perception in sharks and rays’, Nature, 212: 1232-1233.
Kalmijn, A. J. (1971), ‘The electric sense of sharks and rays’, Journal of Experimental Biology, 55(2): 371-383.
Kasumyan, A. O. (2001), ‘Effects of chemical pollutants on foraging behavior and sensitivity of fish to food stimuli’, Journal of Ichthyology, 41(1): 76-87.

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.

Khoshnood, Z. (2017), 'Effects of environmental pollution on fish: a short review. Transylvanian Review of Systematical and Ecological Research', 19(1): 49-60.

Kimber, J. A., Sims, D. W., Bellamy, P. H. and Gill, A. B. (2011), 'The ability of a benthic elasmobranch to discriminate between biological and artificial electric fields', Marine Biology, 158: 1-8.

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.

Kosheleva, V. (1992), 'The impact of airguns used in marine seismic exploration on organisms living in the Barents Sea', Fisheries and Offshore Petroleum Exploration, 2nd International Conference, Bergen, Norway, 6-8 April.

Krone, R., Dederer, G., Kanstinger, P., Krämer, P., Schneider, C. and Schmalenbach, I. (2017), 'Mobile demersal megafauna at common offshore wind turbine foundations in the German Bight (North Sea) two years after deployment-increased production rate of Cancer pagurus', Marine Environmental Research, 123: 53-61.

Langhamer, O. and Wilhelmsson, D. (2009), 'Colonisation of fish and crabs of wave energy foundations and the effects of manufactured holes - A field experiment', Marine Environmental Research 68/4: 151-157.

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'.

Lenhardt, M. L., Klinger, R. C. and Musick, J. A. (1985), 'Marine turtle middle-ear anatomy', The Journal of auditory research, 25/1: 66-72.

Lepper, P. A., Cheong, S. H., Robinson, S. P., Wang, L., Tougaard, J., Griffiths, E. T. and Hartley, J. P. (2024), 'In-situ comparison of high-order detonations and low-order deflagration methodologies for underwater unexploded ordnance (UXO) disposal', Marine Pollution Bulletin, 199: 115965.

Lewandowski, J., Luczkovich, J., Cato, D. and Dunlop, R. (2016), 'Summary Report Panel 3: Gap Analysis from the Perspective of Animal Biology: Results of the Panel Discussion from the Third International Conference on the Effects of Noise on Aquatic Life', In Popper A.N. and Hawkins A.D. The effects of noise on aquatic life, II. (pp. 1277-1282). Springer Science+Business Media, New York.

Lindeboom, H. J., Kouwenhoven, H. J., Bergman, M. J. N., Bouma, S., Brasseur, S. M. J. M., Daan, R., Fijn, R. C., de Haan, D., Dirksen, S., van Hal, R. and Lambers, R.H.R. (2011), 'Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation', Environmental Research Letters, 6/3: 035101.

Lindegren M., Möllmann C., Nielsen A., Brander K., MacKenzie B. R. and Stenseth N. C. (2010), 'Ecological forecasting under climate change: The case of Baltic cod', Proceedings of the Royal Society London B., 277 :2121–2130. doi: 10.1098/rspb.2010.0353

Lohmann, K. J., Putman, N. F. and Lohmann, C. M. (2008), 'Geomagnetic imprinting: A unifying hypothesis of long-distance natal homing in salmon and sea turtles', Proceedings of the National Academy of Sciences, 105(49): 19096-19101.

Love, M. S., Nishimoto, M. M., Snook, L., Schroeder, D. M. and Bull, A. S. (2017), 'Research Article A Comparison of Fishes and Invertebrates Living in the Vicinity of Energized and Unenergized Submarine Power Cables and Natural Sea Floor off Southern California, USA'.

Lurton, X. and Deruiter, S. (2011), 'Sound Radiation Of Seafloor-Mapping Echosounders', In The Water Column, In Relation To The Risks Posed To Marine Mammals.

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.

Mann, D. A., Popper, A. N. and Wilson, B. (2005), 'Pacific herring hearing does not include ultrasound', Biological Letters, 1: 158-161.

Marine Institute (2006), 'Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters'. https://oar.marine.ie/handle/10793/251 [Accessed: April 2021].

Marine Institute (2016), 'Ireland's Marine Atlas'. https://atlas.marine.ie/ [Accessed: July to December 2023].

Marine Institute (2019), 'Addendum to 2006 Guidelines for the Assessment of Dredged material in Irish Waters'. https://www.epa.ie/pubs/forms/lic/das/Addendum%20to%202006%20Guidelines%20%28Marine%20Insitute%202019%29.pdf [Accessed: January 2021].

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

Marine Institute and Bord Iascaigh Mhara (2023), 'Shellfish Stocks and Fisheries Review 2023: An assessment of selected stocks', Marine Institute, Galway, Ireland. 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. https://www.gov.ie/en/publication/e00ec-marine-protected-areas/#ecological-sensitivity-analysis-of-the-western-irish-sea [Accessed: November 2023].

Marshall, C. E. and Wilson, E. (2008), 'Pecten maximus Great scallop. 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. https://www.marlin.ac.uk/species/detail/1398 [Accessed: October 2023].

Mickle, M. F., Miehls, S. M., Johnson, N. S. and Higgs, D. M. (2019), 'Hearing capabilities and behavioural response of sea lamprey (Petromyzon marinus) to low-frequency sounds', Canadian Journal of Fisheries and Aquatic Sciences, 76(9): 1541-1548.

Millane, M., Fitzgerald, C., Kennedy, R., Maxwell, H., McLean, S., Barry J. and 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.

Mitson, R. B. (1993), 'Underwater noise radiated by research vessels', ICES Marine Science Symposium, 196: 147-152.

MMO (2014), 'Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms'.

Mueller-Blenkle, C., McGregor, P. K., Gill, A. B., Andersson, M. H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D. and Thomsen, F. (2010), 'Effects of Pile-driving Noise on the Behaviour of Marine Fish', COWRIE Ref: Fish 06-08, Technical Report 31st March 2010.

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. https://www.marlin.ac.uk/species/detail/1179 [Accessed: August 2023].
Nedwell, J.R. and Howell, D. (2004),' 'A review of offshore wind farm related underwater noise sources', Report No. 544 R 0308 by Subacoustech, commissioned by COWRIE on behalf of the Crown Estate. https://tethys.pnnl.gov/sites/default/files/publications/Nedwell-Howell-2004.pdf [Accessed: August 2024].
Nedwell, J. R., Parvin, S. J., Edwards, B., Workman, R., Brooker, A. G. and Kynoch, J. E. (2007), 'Measurement and interpretation of underwater noise during construction and operation of offshore windfarms in UK waters', Subacoustech Report No. 544R0738 to COWRIE Ltd., ISBN: 978-0-9554279-5-4.
Nelms, S. E., Piniak, W. E., Weir, C. R. and Godley, B. J. (2016), 'Seismic surveys and marine turtles: An underestimated global threat?', Biological conservation, 193: 49-65.
NISA (2024), 'Environmental Impact Assessment Report, Volume 3: Offshore Chapters, Chapter 13 Fish and Shellfish Ecology'. https://www.pleanala.ie/en-ie/case/319866 [Accessed: September 2024].
NOAA (2020), 'US/UK World Magnetic Model - Epoch 2020.0 Main Field Total Intensity (F). Map developed by NOAA/NCEI and CIRES', https://www.ngdc.noaa.gov/geomag/WMM/data/WMM2020/WMM2020_F_BoZ_MILL.pdf [Accessed: May 2021].
Normandeau, Exponent, Tricas, T. and Gill, A. (2011), 'Effects of EMFs from Undersea Power Cables on Elasmobranchs and other marine species', US Deptartment of the Interior. Bureau of Ocean Energy Management, Regulation and Enforcement, Pacific OCS Region, California. OCS Study. BOEMRE 2011-09: 426pp.
NPWS (2013a), 'Rockabill to Dalkey Island SAC (site code: 3000). Conservation objectives supporting document - Marine Habitats and Species'. https://www.npws.ie/protected-sites/sac/003000 [Accessed: November 2023].
NPWS (2013b), 'Lambay Island SAC (site code: 0204). Conservation objectives supporting document - Marine Habitats and Species'. https://www.npws.ie/protected-sites/sac/000204 [Accessed: June 2024].
NPWS (2013c), 'Conservation Objectives: Rockabill SPA 004014. Version 1', National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. https://www.npws.ie/protected-sites/spa/004014 [Accessed: April 2024].
NPWS (2015), 'Conservation Objectives: South Dublin Bay and River Tolka Estuary SPA 004024. Version 1', National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. https://www.npws.ie/protected-sites/spa/004024 [Accessed: June 2024].
NPWS (2023), 'Conservation Objectives: North-west Irish Sea SPA 004236. Version 1', National Parks and Wildlife Service, Department of Housing, Local Government and Heritage. 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.
Öhman, M. C., Sigray, P. and Westerberg, H. (2007), 'Offshore Windmills and the Effects of Electromagnetic Fields on Fish', AMBIO: A Journal of the Human Environment, 36(8): 630-633.
Orpwood, J. E., Fryer, R. J., Rycroft, P. and Armstrong, J. D. (2015), 'Effects of AC Magnetic Fields (MFs) on Swimming Activity in European Eels *Anguilla anguilla*', Scottish Marine and Freshwater Science, 6(8).
OSPAR (2008), 'OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development (Reference number: 2008-3)'. https://www.ospar.org/work-areas/eiha/offshore-renewables [Accessed: November 2023].

O'Sullivan, D., O'Keefe, E., Berry, A., Tully, O. and Clarke, M. (2013), 'An Inventory of Irish Herring Spawning Grounds', Irish Fisheries Bulletin, 42. Marine Institute, ISSN: 1649 5055.
Patullo, B. W. and Macmillan, D. L. (2007), 'Crayfish respond to electrical fields', Current Biology, 17: 83-84.
Pawson, M. G. (1995), 'Biogeographical identification of English Channel fish and shellfish stocks', Fisheries Research technical report No 99. Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research.
Payne, J. F., Andrews, C. A., Fancey, L. L., Cook, A. L. and Christian, J. R. (2007), 'Pilot Study on the Effect of Seismic Air Gun Noise on Lobster (Homarus Americanus)', Environmental Studies Research Funds Report No. 171. St. John's, NL. pp.1-40.
Pena, H. Handegard, N. O. and Ona, E. (2013), 'Feeding herring schools do not react to seismic air gun surveys', ICES Journal of Marine Science, 70(6): 1174-1180.
Penrose, R. S., Westfield, M. J. B. and Gander, L. R. (2022), 'British & Irish Marine Turtle Strandings & Sightings Annual Report 2021'. Marine Environmental Monitoring, Cardigan, Wales, UK.
Popper, A. N., Salmon, M. and Horch, K. W. (2001), 'Acoustic detection and communication by decapod crustaceans', Journal of Comparative Physiology A, 187(2): 83-89.
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.
Popper, A. N. and Hawkins, A. D. (2018), 'The importance of particle motion to fishes and invertebrates', The Journal of the Acoustical Society of America, 143: 470-486.
Popper, A. N. and Hawkins, A. D. (2019), 'An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes', Journal of Fish Biology, 94: 692-713.
Putland, R. L., Montgomery, J. C. and Radford, C. A. (2019), 'Ecology of fish hearing', Journal of Fish Biology, 95(1): 39-52.
Radford, C. A., Montgomery, J. C., Caiger, P. and Higgs, D. M. (2012), 'Pressure and particle motion detection thresholds in fish: a re-examination of salient auditory cues in teleosts', Journal of Experimental Biology, 215(19): 3429-3435.
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'.
Régnier, T., Gibb, F. M. and Wright, P. J. (2019), 'Understanding temperature effects on recruitment in the context of trophic mismatch', Scientific Reports, 9: 15179.
Reubens, J. T., Braeckman, U., Vanaverbeke, J., van Colen, C., Degraer, S. and Vincx, M. (2013), 'Aggregation at windmill artificial reefs: CPUE of Atlantic cod (Gadus morhua) and pouting (Trisopterus luscus) at different habitats in the Belgian part of the North Sea', Fisheries Research, 139: 28-34.
Ridgway, S. H., Wever, E. G., McCormick, J. G., Palin, J. and Anderson, J. H. (1969), 'Hearing in the giant sea turtle, Chelonia mydas', Proceedings of the National Academy of Sciences, 64/3: 884-890.
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.
Risch, D., Wilson, B. and Lepper, P. (2017), 'Acoustic Assessment of SIMRAD EK60 High Frequency Echo Sounder Signals (120 & 200 kHz) in the Context of Marine Mammal Monitoring'.
Rivera-Vicente, A. C., Sewell, J. and Tricas, T. C. (2011), 'Electrosensitive spatial vectors in elasmobranch fishes: implications for source localization', PLoS One, 6/1: e16008.

Roach, M., Cohen, M., Forster, R., Revill, A. S. and Johnson, M. (2018), 'The effects of temporary exclusion of activity due to wind farm construction on a lobster (Homarus gammarus) fishery suggests a potential management approach', ICES Journal of Marine Science, 75/4: 1416-1426.

Roberts, L. (2015), 'Behavioural responses by marine fishes and macroinvertebrates to underwater noise', Doctoral dissertation, University of Hull.

Roberts, L. and Breithaupt, T. (2016), 'Sensitivity of Crustaceans to Substrate- Borne Vibration', In Popper A.N., and Hawkins A.D. The effects of noise on aquatic life, II. (pp. 925 - 932). Springer Science+Business Media, New York.

Roberts, L., Harding, H. R., Voellmy, I., Bruintjes, R., Simpson, S. D., Radford, A. N., Breithaupt, T. and Elliott, M. (2016), 'Exposure of benthic invertebrates to sediment vibration: From laboratory experiments to outdoor simulated pile-driving', Proceedings of Meetings on Acoustics, Vol. 27, No. 1. AIP Publishing.

Roegner, G. C., Fields, S. A. and Henkel, S. K. (2021), 'Benthic video landers reveal impacts of dredged sediment deposition events on mobile epifauna are acute but transitory', Journal of Experimental Marine Biology and Ecology, 538: 151526.

Rowley, S. J. (2005), 'Caretta caretta Loggerhead turtle', 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. https://www.marlin.ac.uk/species/detail/2094 [Accessed: October 2023].

RPS (2014), 'Alexandra Basin Redevelopment Project Environmental Impact Statement'. https://www.gov.ie/en/foreshore-notice/d0b8b-dublin-port-company-alexandra-basin-re-development/ [Accessed: April 2024]

RPS (2020), 'MP2 Project Environmental Impact Assessment Report, Volume 2, Main Document (Part 2)', prepared by RPS on behalf of Dublin Port Company. https://www.gov.ie/en/foreshore-notice/c4b86-dublin-port-company-mp2-project/ [Accessed: September 2024].

RPS (2021), 'Dublin Port Company Maintenance Dredging Programme 2022-2029, Application for Foreshore Licence, Coastal Processes Risk Assessment', prepared by RPS on behalf of Dublin Port Company. https://www.gov.ie/en/foreshore-notice/60147-dublin-port-maintenance-dredging/ [Accessed: September 2024].

RWE (2023), 'Awel y Môr Offshore Wind Farm. Category 6: Environmental Statement. Volume 2, Chapter 6: Fish and Shellfish Ecology. Deadline 8, Revision C. Document Reference: 8.42'. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010112/EN010112-001536-8.42_D8_AyM_ES_Volume_2_Chapter_6_Fish_and_Shellfish_Ecology_RevC.pdf [Accessed: April 2024].

Saluta, G.G., Ralph, G.M., Knick, K.E., Seebo, M.S. and Lipcius, R.N. (2023), 'Lethal and sublethal effects of simulated dredged sediment deposition on overwintering blue crabs Callinectes sapidus', Marine Ecology Progress Series, 719: 65-75.

Samson, J. E., Mooney, T. A., Gussekloo, S. W. S. and Hanlon, R. T. (2014), 'Graded behavioral responses and habituation to sound in the common cuttlefish Sepia officinalis', Journal of Experimental Biology, 217: 4347-4355.

Saorgus Energy Limited (2013), 'Dublin Array An Offshore Wind Farm on the Kish and Bray Banks. Environmental Impact Statement. Volume 2'. https://www.gov.ie/en/foreshore-notice/60c81-bray-offshore-wind-ltd/ [Accessed: January 2024].

Scott, K., Harsanyi, P. and Lyndon, A. R. (2018), 'Understanding the effects of electromagnetic field emissions from marine renewable energy devices (MREDs) on the commercially important edible crab, Cancer pagurus (L.)', Marine Pollution Bulletin, 131: 580-588.

Scott, K., Harsanyi, P., Easton, B. A. A., Piper, A. J. R., Rochas, C. M. V. and Lyndon, A. R. (2021), 'Exposure to Electromagnetic Fields (EMF) from Submarine Power Cables Can Trigger

Strength-Dependent Behavioural and Physiological Responses in Edible Crab, Cancer pagurus (L.)'. Journal of Marine Science and Engineering, 9: 776.
ScottishPower Renewables (2019), 'East Anglia TWO Offshore Windfarm Environmental Statement Volume 1, Chapter 10, Fish and Shellfish Ecology'. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010078/EN010078-001081-6.1.10%20EA2%20Environmental%20Statement%20Chapter%2010%20Fish%20and%20Shellfish%20Ecology.pdf [Accessed: January 2025].
Silva, T. (2016), 'Monthly average non-algal Suspended Particulate Matter concentrations. Cefas, UK. V1. https://doi.org/10.14466/CefasDataHub.31
Simpson, S., Blanchard, J. and Genner, M. (2013), 'Impacts of climate change on fish', Marine Climate Change Impacts Partnership (MCCIP), Science Review: 113-124.
Skaret, G., Axelsen, B. E., Nøttestad, L., Fernö, A., and Johannessen, A. (2005), 'The behaviour of spawning herring in relation to a survey vessel', ICES Journal of Marine Science, 62/6: 1061-1064.
Smith, I. P., Collins, K. J. and 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 R. S., Johnston E. L. and Clark, G.F. (2014), 'The Role of Habitat Complexity in Community Development Is Mediated by Resource Availability', PLoS ONE 9/7: e102920. https://doi.org/10.1371/journal.pone.0102920
Spiga, I., Caldwell, G. S. and Bruintjes, R. (2016), 'Influence of Pile Driving on the Clearance Rate of the Blue Mussel, Mytilus edulis (L.)', Proceedings of Meetings on Acoustics, 27/1: 040005. 10.1121/2.0000277.
SSE Renewables (2024), 'Arklow Bank Wind Park 2, Environmental Impact Assessment Report, Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology'. https://www.arklowbank2offshoreplanning.ie/eiar/ [Accessed: September 2024].
Szostek, C. L., Davies, A. J. and Hinz, H. (2013), 'Effects of elevated levels of suspended particulate matter and burial on juvenile king scallops *Pecten maximus*', Marine Ecology Progress Series, 474: 155-165.
Steullet, P., Edwards, D. H. and Derby, C. D. (2007), 'An electric sense in crayfish?', Biological Bulletin, 213: 16-20.
Taormina B., Laurans M., Marzloff M., Dufournaud N., Lejart M., Desroy N., Leroy D., Martin S., Carlier A. (2020a), 'Renewable energy homes for marine life: habitat potential of a tidal energy project for benthic megafauna', Marine Environmental Research 161: 105131.
Taormina B., Quillien N., Lejart M., Carlier A., Desroy N., Laurans M., D'Eu J.-F., Reynaud M., Perignon Y., Erussard H., Derrien-Courtel S., Le Gal A., Derrien R., Jolivet A., Chauvaud S., Degret V., Saffroy D., Pagot J.-P. and Barillier A. (2020b), 'Characterisation of the potential impacts of subsea power cables associated with offshore renewable energy projects', Plouzané: France Energies Marines Editions, 2020, 74 pages.
Technical Expert Group on Eel (2021), 'Activity Report of the Technical Expert Group on Eel 2020. Report of the Technical Expert Group on Eel to the North-South Standing Scientific Committee on Inland Fisheries (NSSSCIF)'.
Tillin, H. M., Mainwaring, K., Tyler-Walters, H. and Williams, E. (2023). Mytilus edulis beds on sublittoral sediment. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. https://www.marlin.ac.uk/habitat/detail/36 [Accessed: February 2024].
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.

Tricas, T. C. and Gill, A. B. (2011), 'Effects of EMFs from Undersea Power Cables on Elasmobranchs and other marine species. US Department of the Interior', Bureau of Ocean Energy Management, Reguation and Enforcement, Pacific OCS Region, California. OCS Study. BOEMRE 2011-09: 426pp.

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

Tyler-Walters, H., Tillin, H. M., d'Avack, E. A. S., Perry, F. and Stamp, T. (2023), 'Marine Evidence-based Sensitivity Assessment (MarESA) - Guidance Manual', Marine Life Information Network (MarLIN). Marine Biological Association of the UK, Plymouth, pp. 170. https://www.marlin.ac.uk/publications

Vavrinec, J., Pearson, W.H., Kohn, N.P., Skalski, J.R., Lee, C., Hall, K.D., Romano, B.A., Miller, M.C. and Khangaonkar, T.P. (2007), 'Laboratory assessment of potential impacts to Dungeness Crabs from disposal of dredged material from the Columbia River', No. PNNL-16482, Pacific Northwest National Lab (PNNL), Richland, WA (United States).

Vabø, R., Olsen, K. and Huse, I. (2002), 'The effect of vessel avoidance of wintering Norwegian spring spawning herring', Fisheries Research, 58(1): 59-77.

van der Oost, R., Beyer J., and Vermeulen, N. P. E. (2003), 'Fish bioaccumulation and biomarkers in environmental risk assessment: a review', Environmental toxicology and pharmacology, 13(2): 57-149.

von Nordheim, L., Kotterba, P., Moll, D. and Polte, P. (2018), 'Impact of spawning substrate complexity on egg survival of Atlantic herring (Clupea harengus, L.) in the Baltic Sea', Estuaries and Coasts, 41(2): 549-559.

Wang, H., Liang, Y., Li, S. and Chang, J. (2013), 'Acute toxicity, respiratory reaction, and sensitivity of three cyprinid fish species caused by exposure to four heavy metals', Plos one, 8(6): e65282.

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.

Wardle C. S., Carter, T. J., Urquhart, G. G., Johnstone, A. D. F., Ziolkowski, A. M., Hampson, G., Mackie, D. (2001), 'Effects of seismic air guns on marine fish', Continental Shelf Research, 21: 1005-1027.

Westerberg, H. (2000), 'Effect of HVDC cables in eel orientation', In Technische Eingriffe in Marine Lebensraume (ed. T. Merk & H. Von Nordheim), Bundesamt fur Naturschultz: 70-76.

Westerberg H., Rönnbäck, P. and Frimansson, H. (1996), 'Effects of suspended sediment on cod egg and larvae and the behaviour of adult herring and cod', ICES Marine Environmental Quality Committee, CM 1996/E:26.

Wever, E. G. (1978), 'The reptile ear: Its structure and function', Princeton University Press. Princeton, NJ.

Wilber, D. H. and Clarke, D. G. (2001), 'Biological effects of suspended sediments: a review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries', North American journal of fisheries management, 21(4): 855-875.

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

Winslade, P. (1971), 'Behavioural and embryological studies on the lesser sandeel *Ammodytes marinus* (Raitt)', PhD thesis, University of East Anglia, 174 pp.

Winter, A. G. and Hosoi, A. E. (2011), 'Identification and evaluation of the Atlantic razor clam (*Ensis directus*) for biologically inspired subsea burrowing systems', Integrative and Comparative Biology, 51/1: 151-157.

Woodruff, D. L., Schultz, I. R., Marshall, K. E., Ward, J. A. and Cullinan, V. (2012), 'Effects of electromagnetic fields on fish and invertebrates', US Department of Energy.

Wyman, M. T., Peter Klimley, A., Battleson, R. D., Agosta, T. V., Chapman, E. D., Haverkamp, P. J., Pagel, M. D. and Kavet, R. (2018), 'Behavioral responses by migrating juvenile salmonids to a subsea high-voltage DC power cable', Marine Biology, 165(8): 1-15.

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Annex A: Fish and Shellfish Ecology Policy

Legislation, Policy and Guidance

Policy/ Legislation	Key provisions	Section where provision is addressed
Legislation		
Marine Strategy Framework Directive Directive 2008/56/EC, as amended European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011), as amended MSFD high level descriptor of Good Environmental Status (GES) relevant to fish and shellfish ecology: Descriptor 1.	Biological diversity. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	See Consents, Legislation, Policy & Guidance (Volume 2, Chapter 2) and the Regulatory section of this Chapter The effects upon all fish and shellfish ecological receptors (and their supporting habitats) which are predicted to be impacted by the proposed development have been considered in Sections 4.16 to 4.19.
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011), as amended MSFD high level descriptor of Good Environmental Status (GES) relevant to fish and shellfish ecology: Descriptor 2.	Non-indigenous species. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	An offshore PEMP with a detailed biosecurity plan will be implemented to ensure that the risk of potential introduction and spread of IAS will be minimised (see Table 11).
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011), as amended MSFD high level descriptor of Good Environmental Status (GES) relevant to fish and shellfish ecology: Descriptor 4.	Elements of marine food webs. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	The effects upon all fish and shellfish ecological receptors (and their supporting habitats) which are predicted to be impacted by the proposed development have been considered in Sections 4.16 to 4.19.

Policy/ Legislation	Key provisions	Section where provision is addressed
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011), as amended MSFD high level descriptor of Good Environmental Status (GES) relevant to fish and shellfish ecology: Descriptor 6.	Sea floor integrity. Seafloor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	The effects upon all fish and shellfish ecological receptors (and their supporting habitats) which are predicted to be impacted by the proposed development have been considered in Sections 4.16 to 4.19. Temporary and long-term benthic habitat loss has been addressed specifically within these sections.
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011), as amended MSFD high level descriptor of Good Environmental Status (GES) relevant to fish and shellfish ecology: Descriptor 8.	Contaminants. Concentrations of contaminants are at levels not giving rise to pollution effects.	The effects of contaminants upon all fish and shellfish ecological receptors have been considered in Sections 4.16 to 4.19.
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011), as amended MSFD high level descriptor of Good Environmental Status (GES) relevant to fish and shellfish ecology: Descriptor 10.	Marine litter. Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	Section 4.15 outlines mitigation measures which include the development of a Construction Project Environmental Management and Monitoring Plan (CPEMMP) that will include details of waste management and disposal arrangements.
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011), as amended MSFD high level descriptor of Good Environmental Status (GES) relevant to fish and shellfish ecology: Descriptor 11.	Energy incl. Underwater Noise. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	The effects of noise and vibration upon all fish and shellfish ecological receptors have been considered in Sections 4.16 to 4.19.

Policy/ Legislation	Key provisions	Section where provision is addressed
Shellfish Waters Directive (2006/113/EC) was superceded / repealed by the Water Framework Directive with effect from 2013. 64 Shellfish Waters are designated pursuant to S.I. No 464 of 2009 European Communities (Quality of Shellfish Waters (Amendment)(No 2) Regulations 2009; S.I. No 55 of 2009 European Communities (Quality of Shellfish Waters) (Amendment) Regulations 2009; S.I. No. 268 of 2006 European Communities (Quality of Shellfish Waters) Regulations 2006	The aim of the Shellfish Waters Directive is to protect or improve shellfish waters in order to support shellfish life and growth. It is designed to protect the aquatic habitat of bivalve and gastropod molluscs, which include oysters, mussels, cockles, scallops and clams. The Directive requires Member States to designate waters which need protection in order to support shellfish life and growth.	The study area overlaps with the Balbriggan/Skerries and Malahide shellfish waters. The effects of the proposed development upon shellfish ecological receptors have been considered in Sections 4.16 to 4.19.
Water Framework Directive (WFD) (2000/60/EC)	The WFD requires good ecological and good chemical status in inland and coastal waters by 2015. The WFD relates to water bodies up to 1nm from the baseline; with the exception of chemical status which also includes territorial waters i.e. to 12nm. The WFD requires that a River Basin Management Plan (RMBP) is prepared and adopted in six-year cycles, setting out the programme of measures to achieve the necessary water quality objectives within that cycle. Ireland's current RBMP is the 'Water Action Plan 2024 - A River Basin Management Plan for Ireland'	A full assessment of the proposed development on the chemical and ecological status of relevant WFD water bodies is provided in Volume 4, Appendix 4.3.2-1: Water Framework Directive and Marine Strategy Framework Directive Summary (referred to as the WFD Assessment)

Habitats Directive (1992/43/EEC) S.I. No. 477/2011 - EC (Birds and Natural Habitats) Regulations 2011, as amended European Union (Birds and Natural Habitats) (Sea-fisheries) Regulations 2013 (S.I. 290 of 2013), as amended	Regulation 27 of SI 477/2011 provides that primary responsibility for the conservation of species of finfish listed in Annex II and V of the Habitats Directive and listed in the Fourth Schedule of the Habitats Regulations, is vested in the Minister with responsibility for Fisheries (currently the Minister for Agriculture, Food and the Marine), and that Minister and their Department and any agencies or bodies under the aegis of that Minister shall exercise their powers and functions so as to comply with and meet the requirements of the Habitats and Birds Directives and of the Habitats Regulations. Under SI 290/2013, the Minister for Agriculture Food and the Marine may invite any person who is carrying out or proposing to carry out a sea fishing activity that has the potential to have an impact on the conservation objectives of one or more European sites to invite that person to submit a 'Fisheries Natura Plan' that relates to such activity and such sites. The Minister may then carry out an appropriate assessment in accordance with Article 6(3) of the Habitats Directive of such Fisheries Natura Plan and reject or approve it, with or without conditions or modifications. Where necessary to protect and conserve the interests of the European site concerned, the Minister may issue a Fisheries Natura Declaration which has the effect of restricting or prohibiting certain sea-fishing activities within the area for a prescribed period without a permit. The Minister may grant Natura Permits for sea-fishing activities within the area the subject of the Declaration on a case-by-case basis, where consistent with the criteria as specified in the Regulations.	Section 4.7.40 and Figure 9

Policy/ Legislation	Key provisions	Section where provision is addressed
	For example, the Irish Sea seed mussel fishery occurs within European sites and is the subject of a Fisheries Natura 2000 Plan setting out the conditions and requirements under which such fishery may be operated.	
Planning Policy and Development Control		
See Consents, Legislation, Policy & Guidance (Volume 2, Chapter 2) and detailed description of the development consent framework in the Planning and Development Act 2000, as amended, and the Planning and Development Regulations 2001, as amended, including the detailed requirements for EIA as specified in Part X of the Act and Schedule 6 of the Regulations.	Article 94 of the Planning Regulations and Schedule 6 specify the requirements for an EIAR, including a description of the aspects of the environment likely to be significantly affected by the proposed development, including in particular: 1(b): biodiversity (for example fauna and flora), with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC	This assessment provides a description of the likely significant effects on the marine fish and shellfish ecology in conjunction with Volume 3, Chapter 1.
Guidelines and technical standards		
Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (Department of Housing, Planning and Local Government, 2018) (hereafter referred to as the EIA Guidelines) Para 4.31.	The starting point for EIA is an assessment of the current state of the environment and how this is likely to evolve without the proposed project but having regard to existing and approved projects and likely significant cumulative effects - in other words the 'do nothing' scenario.	A full characterisation of the receiving environment is presented in the Fish and Shellfish technical baseline. The findings of this characterisation have been summarised in this chapter for the ease of the reader.

Policy/ Legislation	Key provisions	Section where provision is addressed
Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (Department of Housing, Planning and Local Government, 2018) Para 6.12.	The EIA Directive requires that the EIAR describes the cumulation of effects[24]. Cumulative effects may arise from: ▪ The interaction between the various impacts within a single project; and ▪ The interaction between all of the different existing and/or approved projects in the same area as the proposed project.	The interactions between various environmental aspects within the proposed developments are presented in Volume 4 of this EIAR. A summary is provided in Section 4.20 of this chapter. The interactions between Dublin Array and other plans and projects, for fish and shellfish receptors are presented in Section 4.19 of this EIAR chapter.
Guidance on Environmental Impact Statement (EIS) and Natura Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects (Environmental Working Group of the Offshore Renewable Energy Steering Group and the Department of Communications, Climate Action and Environment, 2017) (hereafter referred to as the DCCAE Guidance)	"Cumulative Effects Assessments only need to take account of existing and/or approved projects and not other projects within the planning process."	A precautionary approach was undertaken to consider any plans or projects that could result in a cumulative effect. The cumulative assessment is presented in Section 4.19. To account for the uncertainty associated with projects and plans which have not yet been consented a tiering system was adopted. Further details of the approach are available in Volume 2, Chapter 4: Cumulative Effects Assessment Methodology.
DCCAE Guidance, 2017 Table 3	"Environmental protection by assessment of likely significant effects of projects to promote sustainable development".	The scope of the impact assessment is presented in Section 4.13. All included impacts were identified in the Dublin Array Scoping Report (Dublin Array, 2020) and assessed with regards to their potential to result in significant effects (in EIA terms) on fish and shellfish receptors.
DCCAE Guidance, 2017 Table 4	"Developers and competent authorities should have regard to when planning/assessing a project - • Protected sites and species • Fish and shellfish	An assessment of the potential effects on designated fish and shellfish receptors are presented Sections 4.16 to 4.19.

24 Annex IV, point 5(e) of the Directive. See also Schedule 6(2)(e)(i)(V) to the Regulations.

Policy/ Legislation	Key provisions	Section where provision is addressed
	• Marine mammals and reptiles • Birds • Benthic and pelagic ecology • Energy (noise and EMF)".	
DCCAE Guidance, 2017 Section 3.2	"All phases of the development should be considered in the assessment process. Each of these phases will have its own specific effects on the environment and will differ in duration. Considering all phases of the development will address full lifecycle effects of a proposed development."	All phases of the development have been considered within this fish and shellfish ecology assessment. The assessment of effects in the construction phase are presented in Section 4.16. The assessment of effects in the operational phase (including maintenance) are presented in Section 4.17. The assessment of effects in the decommissioning phase are presented in Section 4.18.
DCCAE Guidance, 2017 Section 4.5.3	"The zones of influence may differ depending upon the topic under consideration (e.g. the visual zone will differ from the biodiversity zone). In establishing the zones of influence, the following should be identified: • the physical footprint of the project; • the measures required to determine the overall zones of influence of a project (i.e. the area impacted by the development with reference to the of likely significant effects); and • the study area (i.e. that selected for the review). Specific modelling techniques, typically simulating water mixing processes to predict temporal and spatial variations, can be used to assist in the exercise. The zones of influence relate primarily to ecological and visual impacts of the development."	The ZoIs for Dublin Array on the fish and shellfish receptors was developed through use of project specific sediment and underwater noise modelling. The extent of each ZOI is detailed in Section 4.1.

Policy/ Legislation	Key provisions	Section where provision is addressed
DCCAE Guidance, 2017 Section 4.5.3	"A source - pathway - target risk assessment methodology may be of benefit in establishing the potential zones of influence."	A source-pathway-receptor assessment methodology was used to scope the receptors within the ZoIs for the impact assessment. The receptors scoped in for assessment are listed in Section 4.8.
DCCAE Guidance, 2017 Section 4.6.3	"A description of the existing environment is required to allow for a prediction of significant likely effects of a development. "	A full characterisation of the receiving environment is presented in the Fish and Shellfish Ecology technical baseline. The findings of this characterisation have been summarised in this chapter for the ease of the reader.
DCCAE Guidance, 2017 Section 4.6.3	"The condition of the receiving environment should be used to inform whether or not an effect is significant and to understand its vulnerability and sensitivity."	The assessment criteria for assessing the sensitivity of receptor to a potential effect is detailed in Section 4.5.
DCCAE Guidance, 2017 Table 8	Indicative list of impacts – • Disturbance • Displacement • Reefing and creation of refuge • Smothering • Noise • Collision risk • Entrapment • Suspended sediments and increased turbidity • Habitat exclusion areas • Barriers to movement • Disturbance of contaminated sediments • Accidental contamination • Substratum loss • Changes in wave and tidal regime • EMF	The potential impacts assessed within this chapter, as identified through the Dublin Array Scoping Report (Dublin Array, 2020) as being of relevance to Dublin Array, are presented within Section 4.13 of this chapter.

Policy/ Legislation	Key provisions	Section where provision is addressed
DCCAE Guidance, 2017 Section 4.6.5	Mitigation measures are usually required where likely significant effects on the environment are identified. Mitigation measures may be proposed in order to avoid, prevent, reduce, rectify, or sometimes compensate any major adverse effects. The impact of residual effects should then be assessed.	The avoidance and preventative measures relevant to the fish and shellfish ecology assessment are presented in Section 4.15.
Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects Parts 1 and 2 (DCCAE, 2018)	The need for fisheries surveys should be determined through a desk-based review. Fisheries surveys should be timed with consideration of the seasonality of fish populations. Where project specific fisheries surveys are undertaken, these should comprise of trawl/acoustic surveys for pre-construction baseline surveys.	A detailed description of the base data (inclusive of site-specific surveys) is provided in Section 4.6 of this chapter and within the Fish and Shellfish Ecology technical baseline.
Guidelines on the Information to be contained in Environmental Impact Assessment reports (Environmental Protection Agency, 2022) (referred to as the Guidelines)	"The Guidelines have been drafted with the primary objective of improving the quality of EIARs with a view to facilitating compliance (with the [EIA] Directive). By doing so they contribute to a high level of protection for the environment through better informed decision-making processes. They are written with a focus on the obligations of developers who are preparing EIARs." "The Guidelines emphasise the importance of the methods used in the preparation of an EIAR to ensure that that the information presented is adequate and relevant."	The methodology presented within the draft Guidelines was utilised in the development of the EIA methodology applied within this EIAR. Further details are provided in Volume 2, Chapter 3: EIA Methodology (referred to as the EIA Methodology chapter).

Policy/ Legislation	Key provisions	Section where provision is addressed
Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018)	The construction of a wind farm may have a variety of local effects, but defining the zones of influence of the project also needs to take account of the potential for more widespread impacts, such as: • changes to sediment movement and potentially to coastal morphology depending upon proximity to the shore and the method of protecting transmission cables; • direct construction impacts; • provision of substrate for colonisation by native or non-native species.	The sedimentary ZoI (as informed by the Physical Processes Chapter) incorporates the extent of any potential direct and indirect effects on fish and shellfish receptors as a result of the proposed development. The sedimentary ZoI is defined in full in Section 4.1.
Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008) Table 3	Potential impacts associated with the development of offshore wind-farms (not exhaustive): • temporary and permanent habitat loss; • alteration in the benthic community composition; • indirect habitat loss through small-scale changes in sediment structure around the turbine and changes of large-scale sediment dynamics; • alteration in the endobenthic community including colonisation by alien species; • increased degradation of the organic content resulting in a release of heavy metals (depending on the total organic matter content and metal content of the sediment).	The potential impacts outlined in Table 3 of the OSPAR guidance were considered in the development of the scope of this assessment. A list of all the impacts assessed is provided in Section 4.13 of this chapter. A comprehensive assessment of the potential impacts on fish and shellfish receptors is provided in Sections 4.16 to 4.18 of this chapter.

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