Liverpool Bay CCS Ltd

HYNET CARBON DIOXIDE TRANSPORTATION AND STORAGE PROJECT - OFFSHORE

Environmental Statement
Volume 2, Chapter 7: Marine Biodiversity

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Liverpool Bay CCS Ltd
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Marine Biodiversity

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Glossary

Term	Meaning
Annelida	A large phylum that comprises the segmented worms, which include earthworms, lugworms, ragworms, and leeches.
The Applicant	Liverpool Bay Carbon Capture and Storage (CCS) Limited (Ltd.)
Arthropoda	Phylum with a wide diversity of animals with hard exoskeletons and jointed appendages.
Bathymetry	The measurement of water depth in oceans, seas, and lakes.
Benthic Ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment.
Biotope	The combination of physical environment (habitat) and its distinctive assemblage of conspicuous species.
Circalittoral	The region of the sublittoral zone which extends from the lower limit of the infralittoral to the maximum depth at which photosynthesis is still possible.
Cumulative Effects	Changes to the environment caused by a combination of present and future projects, plans or activities.
Demersal	Species that live and feed on or near the seabed (typically used to describe fish).
Demersal Spawners	Species which deposit eggs onto the seabed during spawning.
"Do Nothing" Scenario	The environment as it would be in the future should the Proposed Development not be developed.
Drop Down Video (DDV)	Survey method in which imagery of habitat is collected, used predominantly to survey marine environments.
Echinodermata	Phylum of marine invertebrates, such as a starfish, sea urchin, or sea cucumber.
Elasmobranchs	Cartilaginous fishes which include sharks, rays, and skates.
Ensonified	Filled with sound.
Environmental Impact Assessment	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Environmental Impact Assessment (EIA) Directive and EIA Regulations, including the publication of an EIA Report.
Epifauna	Organisms living on the surface of the seabed.
Epibenthic	Benthic invertebrates living on the surface of the seabed.
Eulittoral	Applied to the habitat formed on the lower shore of an aquatic ecosystem, below the littoral zone.
Filter Feeder	Suspension feeding animals that feed by straining suspended matter and food particles from water, typically by passing the water over a specialized filtering structure.
Habitat	The environment that a plant or animal lives in.
Important Ecological Features (IEFs)	Habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Proposed Development.
Infauna	The animals living in the sediments of the seabed.
Infralittoral	A subzone of the sublittoral in which upward-facing rocks are dominated by erect algae.
Intertidal Area	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS).
Invasive Non-Native Species	An introduced organism that becomes overpopulated and adversely alters its new environment.
Littoral	Residing within the littoral zone which extends from the high water mark, which is rarely inundated, to shoreline areas that are permanently submerged.
Magnitude	Size, extent and duration of an impact.
Marine Licence	A Marine Licence is a regulatory instrument awarded to developers that permits development/construction within the marine environment. See chapter 2: Policy and Legislation for further information.
Masking	Masking occurs when noise emissions interfere with a marine animal's ability to hear a sound of interest.

Term	Meaning
Mitigation Measure	Measure which would avoid, reduce, or remediate an impact.
Mollusca	Phylum of invertebrates which have a soft unsegmented body, commonly protected by a calcareous shell.
Non-statutory stakeholder	Organisations with whom the regulatory authorities may choose to engage who are not designated in law but are likely to have an interest in a proposed development.
Nursery	A habitat where juveniles of a species regularly occur as a population.
Particle Motion	The vibration of the water molecules which results in a pressure wave,
Pelagic	Species which live and feed within the water column (typically used to describe fish),
Pelagic Spawners	Species which release eggs into the water column during spawning,
Polychaete	A class of segmented worms often known as bristleworms.
Project	The Project refers to the overall HyNet Carbon Dioxide Transportation and Storage Project.
Project Design Envelope (PDE)	Also known as the Rochdale Envelope, the PDE concept is routinely utilised in both onshore and offshore planning applications to allow for some flexibility in design options, particularly offshore, and more particularly for foundations and turbine type, where the full details of the project are not known at application submission but where sufficient detail is available to enable all environmental impacts to be appropriately considered during the EIA.
Proposed Development	The Proposed Development refers to the offshore components of the Project.
Residual Impact	Residual impacts are the final impacts that occur after the proposed mitigation measures have been put into place, as planned.
Shellfish	For the purposes of this assessment, shellfish is considered a generic term to define molluscs and crustaceans.
Spawning Ground	Spawning grounds are the areas of water or seabed where fish spawn or produce their eggs.
Species	A group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.
Sublittoral	Area extending seaward of low tide to the edge of the continental shelf.
Subtidal	Area extending from below low tide to the edge of the continental shelf.
Tidal Excursion	The horizontal distance over which a water particle may move during one cycle of flood and ebb.

Acronyms and Initialisations

Acronyms and Initialisations	Description
2D	Two-dimensional
3D	Three-dimensional
ADD	Acoustic Deterrent Devices
Ag	Silver
AL	Action Level
ANSI	American National Standards Institute
As	Arsenic
ASA	Acoustical Society of America
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BAC	Background Assessment Concentration
BEIS	Department for Business, Energy, and Industrial Strategy
BERR	Business Enterprise and Regulatory Reform
BOWL	Beatrice Offshore Wind Farm Limited
BP	British Petroleum

Acronyms and Initialisations	Description
CBRA	Cable Burial Risk Assessment
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Usage, and Storage
CCW	Countryside Council for Wales
Cd	Cadmium
CD	Chart Datum
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries, and Aquaculture Science
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Management
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMACS	Centre for Marine and Coastal Studies
CMS	Construction Method Statement
CO_2	Carbon Dioxide
Co	Cobalt
CPT	Cone Penetration Test
Cr	Chromium
CSIP	Cable Specification and Installation Plan
Cu	Copper
DAERA	Department of Agriculture, Environment and Rural Affairs
DCO	Development Consent Order
DDCs	Drop Down Cameras
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food, and Rural Affairs
DFO	Department of Fisheries and Oceans (Canada)
EcIA	Ecological Impact Assessment
ECoW	Ecological Clerk of Works
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EMP	Environmental Management Plan
EN-1	National Policy Statement (NPS) for Energy
EnBW	Energie Baden-Württemberg
EDR	Effective Deterrence Ranges
EPA	Environmental Protection Agency
EPS	European Protected Species
ES	Environmental Statement
EUNIS	European Nature Information Systems
FCC	Flintshire County Council
GIS	Geographical Information System
HDD	Horizontal Directional Drilling
HF	High Frequency
Hg	Mercury
HLCP	The Humber Low Carbon Pipelines

Acronyms and Initialisations	Description
HPI	Habitat of Principal Importance
IAMMWG	Inter-Agency Marine Mammal Working Group
ICES	International Council for the Exploration of the Sea
IEF	Important Ecological Feature
IEMA	Institute of Environmental Management and Assessment
IMO	International Maritime Organisation
INNS	Invasive Non-Native Species
INNSMP	Invasive Non-Native Species Management Plan
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
LSE	Likely Significant Effects
Ltd.	Limited
MarESA	Marine Evidence Based Sensitivity Assessment
MarLIN	Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MBA	Marine Biological Association
MBES	Multi-Beam Echo-Sounder
MCA	Maritime and Coastguard Agency
MCCIP	Marine Climate Change Impacts Partnership
MCZ	Marine Conservation Zone
MDS	Maximum Design Scenario
MF	Mid Frequency
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMMP	Marine Mammal Mitigation Plan
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MSFD	Marine Strategy Framework Directive
MU	Management Unit
MV	Marine Vibroseis
NEQ	Net Explosive Quantity
NERC	Natural Environment Research Council
Ni	Nickel
NIOSH	National Institute for Occupational Safety and Health
NISA	North Irish Sea Array
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Policy Statement
NPWS	National Park and Wildlife Service
NRW	Natural Resources Wales

Acronyms and Initialisations	Description
NSIP	Nationally Significant Infrastructure Project
OCEMP	Outline Construction Environment Management Plan
OCW	Other Marine Carnivores in Water
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	Oslo/Paris Convention
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
PAM	Passive Acoustic Monitoring
Pb	Lead
PCB	Polychlorinated Biphenyl
PCW	Phocid Carnivores in Waters
PEIR	Preliminary Environmental Information Report
PoA	Point of Ayr
p-p	Peak-peak
PPG	Pollution Prevention Guidelines
ppm	Parts per Million
PTS	Permanent Threshold Shift
PSA	Particle Size Analysis
REAC	Register of Environmental Actions and Commitments
RIAA	Report to Inform Appropriate Assessment
RIB	Rigid Inflatable Boat
rms	Root Mean Square
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SBES	Single-Beam Echosounder
SBP	Sub Bottom Profiler
SCOS	Special Committee on Seals
SEAMARCO	Sea Mammal Research Company
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SEL_{ss}	Single-strike Sound Exposure Levels
SI	Sirenian
SPI	Species of Principal Importance
SPL	Sound Pressure Level
SPL_{pk}	Peak Sound Pressure Level
SPM	Suspended Particulate Matter
SSC	Suspended Sediment Concentration
SSS	Sidescan Sonar
SSSI	Sites of Special Scientific Interest
SWF	Sea Watch Foundation
TBT	Tributyltin
TCPA	Town and Country Planning Act
THC	Total Hydrocarbon Content
TTS	Temporary Threshold Shift

Acronyms and Initialisations	Description
UHRS	Ultra High Resolution Seismic
UK	United Kingdom
UK BAP	United Kingdom Biodiversity Action Plan
US	United States
UXO	Unexploded Ordnance
VHF	Very High Frequency
VSP	Vertical Seismic Profiler
WFD	Water Framework Directive
Zn	Zinc
ZoI	Zone of Influence

Units

Unit	Description
bara	Absolute pressure
cm	Centimetre
cu in	Cubic inch
dB	Decibel
GW	Gigawatt
Hz	Hertz
kHz	Kilohertz
kJ	Kilojoule
km	Kilometre
km^2	Kilometres squared
kV	Kilovolt
kW	Kilowatt
g	Gram
g/l	Grams per litre
h	Hour
Hz	Hertz
m	Metre
mm	Millimetres
m/s	Metres per second
m^2	Metres squared
mg/kg	Milligrams per kilogram
mg/l	Milligrams per litre
MW	Megawatt
nm	Nautical Mile (distance; equal to 1.852 km)
psi	Pound per square inch
s	Second
µg/kg	Micrograms per kilogram
$\mu mol/m^2$	Micromoles per metre squared
µPa	Micro Pascal (10^{-6})

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7 MARINE BIODIVERSITY

7.1 Introduction

This chapter of the offshore Environmental Statement (ES) assesses the potential impacts of the HyNet Carbon Dioxide Transportation and Storage System (hereafter referred to as the 'Project') on Marine Biodiversity. Specifically, this chapter considers the potential impact of the offshore components of the Project that are seaward of Mean High Water Springs (MHWS) (hereafter referred to as the 'Proposed Development') during the construction, operational and maintenance, and decommissioning phases.

Article 3 of Directive 2011/92/EU (as amended) by Directive 2014/52/EU requires that the ES identifies, describes and assesses the direct and indirect significant effects of a project on biodiversity. This Marine Biodiversity chapter encompasses Benthic Subtidal and Intertidal Ecology, Fish and Shellfish Ecology, and Marine Mammals and Marine Turtles.

This chapter specifically addresses three topics:

- Benthic Subtidal and Intertidal Ecology: which includes the organisms with the potential to be present on and/or buried within the subtidal seabed, and intertidal benthic organisms between the low and high water marks within the regional benthic ecology study area.
- Fish and Shellfish Ecology: which includes all fish and shellfish species with the potential to be present within the regional fish and shellfish ecology study area, including demersal, pelagic, bentho-pelagic, diadromous, elasmobranch, and shellfish species.
- Marine Mammals and Marine Turtles: which includes all marine mammal and marine turtle species with the potential to be present within the regional marine mammal study area seaward of MHWS (thus excluding the otter *Lutra lutra,* which will be assessed as a terrestrial species).

The assessment presented is informed by the technical information presented in volume 3, appendix I.

A detailed baseline that underpins the impact assessment for each marine biodiversity topic is included in sections 7.8.1, 7.8.2, and these provide characterisations of Benthic Subtidal and Intertidal Ecology, Fish and Shellfish Ecology, and Marine Mammal and Marine Turtles Ecology within their respective study areas. These characterisations are based on an extensive review of desktop literature and data sources and, where applicable, the results of the site-specific benthic surveys undertaken within the benthic ecology study area.

7.2 Purpose of this chapter

The primary purpose of this ES chapter is to assess likely impacts of the Proposed Development on marine biodiversity and to support the consent applications for the Project.

It is intended that this ES chapter will provide prescribed bodies and non-statutory stakeholders with sufficient information to determine the potential impacts of the Proposed Development on marine biodiversity. This ES chapter is intended to inform any consent conditions and any issues of appropriate consents and/or licences.

Overall, this chapter:

- summarises the existing environmental baselines described in volume 3, appendix I, and established from desk studies, site-specific surveys, and consultation (sections 7.4 and 7.8).
- identifies embedded mitigation measures which, if required, could prevent, minimise, reduce, or offset the possible environmental effects identified in the impact assessment (section 7.11).
- assesses the potential environmental impacts on benthic subtidal and intertidal ecology, fish and shellfish ecology, and marine mammals, arising from the Proposed Development (section 7.12); and

- assesses the potential cumulative, transboundary, and inter-related effects of the Proposed Development (sections 7.13, 7.14, and 7.15).

Furthermore, to supplement this ES chapter, volume 3, appendix I identifies any assumptions and limitations encountered in compiling the environmental baseline.

7.3 Policy and Legislative Context

Planning policy relevant to the Proposed Development is presented in volume 1, chapter 2. This section presents planning policy which specifically relates to the three Marine Biodiversity topics (Benthic Subtidal and Intertidal Ecology, Fish and Shellfish Ecology, and Marine Mammals and Marine Turtles).

7.3.1 National Policy Statements

Planning policy for CCS technology, specifically in relation to marine biodiversity receptors, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1) (Department for Business, Energy, and Industrial Strategy (BEIS), 2023). NPS EN-1 includes guidance on what matters are to be considered in the assessment (Table 7.1). NPS EN-1 also highlight a number of factors relating to the determination of an application and in relation to mitigation (Table 7.2).

Table 7.1: Summary Of The NPS EN-1 Provisions Relevant To Marine Biodiversity Receptors

Summary of EN-1 Provision	Where Considered in the EIA
To consider the potential effects, including benefits, of a proposal for a project, the applicant should set out information on the likely significant social and economic effects of the development, and show how any likely significant negative effects would be avoided, reduced, or mitigated. For the purposes of this NPS and the technology specific NPSs the ES should cover the environmental, social and economic effects arising from pre-construction, construction, operation and decommissioning of the project.[1] (BEIS, 2023; paragraph 4.2.4-4.2.5)	Using information set out for each receptor in the Maximum Design Scenario (MDS) (section 7.9.1), the potential impacts on benthic, fish and shellfish, marine mammals and marine turtles receptors during construction, operations and maintenance, and decommissioning phases have been considered in the assessment of impacts in sections 7.12 and 7.13. Embedded mitigation measures have been outlined in section 7.11, and where required, tertiary mitigation has been suggested throughout the assessment.
In cases where the EIA Regulations do not apply and an ES is not therefore required, the applicant should instead provide information proportionate to the scale of the project on the likely significant environmental, social, and economic effects. (BEIS, 2023; paragraph 4.2.13)	The scoping process enables the Proposed Development to deliver environmental information proportionate to the infrastructure. This is demonstrated in this chapter in regard to the justification of the topics scoped out (section 7.9.2) as this demonstrates a proportionate approach.
Many Sites of Special Scientific Interest (SSSIs) are also designated as sites of international importance and will be protected accordingly. Those that are not, or those features of SSSIs not covered by an international designation, should be given a high degree of protection. Most National Nature Reserves are notified as SSSIs. (BEIS, 2023; paragraph 5.4.7)	There are no SSSIs with marine biodiversity features overlapping with the Proposed Development, however further information has been provided on those within the regional study areas, where relevant, in Table 7.9.
Many individual wildlife species receive statutory protection under a range of legislative provisions. Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales, as well as for their continued benefit for climate mitigation and adaptation and thereby requiring conservation action.	Relevant policy and legislation for marine biodiversity Important Ecological Features (IEFs) is provided in section 7.7.

[1] In some instances, it may not be possible at the time of the application for development consent for all aspects of the proposal to have been settled in precise detail. Where this is the case, the applicant should explain in its application which elements of the proposal have yet to be finalised, and the reasons why this is the case. (BEIS, 2023; paragraph 4.2.11).

Summary of EN-1 Provision	Where Considered in the EIA
(BEIS, 2023; paragraph 5.4.16)	
Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats. (BEIS, 2023; paragraph 5.4.17)	Identification of the designated sites is considered in section 7.6 and those which have the potential to be impacted have been considered throughout the assessment in section 7.12. Likely Significant Effects (LSE) on designated sites have been screened and are presented in volume 4, appendix P.
The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests. (BEIS, 2023; paragraph 5.4.19)	The Proposed Development will aim to conserve habitats through a number of embedded mitigation measures (section 7.11).
Applicants should consult the Marine Management Organisation (MMO) (or Natural Resources Wales (NRW) in Wales) on energy Nationally Significant Infrastructure Projects (NSIPs) which would affect, or would be likely to affect, any relevant marine areas as defined in the Planning Act 2008 (as amended by section 23 of the Marine and Coastal Access Act 2009). Applicants are encouraged to consider the relevant marine plans in advance of consulting the MMO for England or the relevant policy teams at the Welsh government. (BEIS, 2023; paragraph 4.11.5)	Section 7.3.3 covers the consultation process, including any communications with the MMO and NRW. Relevant marine plans are considered in section 7.3.
Marine Conservation Zones (MCZs) (Marine Protected Areas (MPAs) in Scotland), introduced under the Marine and Coastal Access Act 2009, are areas that have been designated for the purpose of conserving marine flora or fauna, marine habitats or types of marine habitat or features of geological or geomorphological interest. The protected feature or features and the conservation objectives for the MCZ are stated in the designation order for the MCZ. The Secretary of State is bound by the duties in relation to MCZs imposed by sections 125 and 126 of the Marine and Coastal Access Act 2009. (BEIS, 2023; paragraph 5.4.9)	All relevant nearby MPAs and designated sites were identified through desktop review and stakeholder consultation (section 7.6). Those which have the potential to be impacted have been considered throughout the assessment in sections 7.12 and 7.13.
The applicant should demonstrate that: • During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works. • During construction and the operations and maintenance phase best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements. • Habitats will, where practicable, be restored after construction works have finished. • mitigation measures should consider existing habitats and should generally seek opportunities to enhance them, rather than replace them. Where practicable, mitigation measures should seek to create new habitats of value within the site landscaping proposals. (BEIS, 2023; paragraph 5.4.35)	The extent of works will be taking place within the Proposed Development and detailed in volume 1, chapter 3. Additionally, MDS has been set out for each receptor (section 7.9.1). Best practice during construction and maintenance will be set out in the Construction Method Statement (CMS) and the Environmental Management Plan (EMP) (see section 7.11). Following the completion of most activities habitats are expected to recover naturally (see section 7.12). The Proposed Development will aim to conserve habitats and species through a number of embedded mitigation measures (section 7.11).

Table 7.2: Summary Of The NPS EN-1 Policy On Decision Making Relevant To Marine Biodiversity Receptors

Summary of EN-1 Provision	Where Considered in the EIA
The government's policy for biodiversity in England is set out in the Environmental Improvement Plan, Biodiversity 2020, the National Pollinator Strategy and the UK Marine Strategy. The aim is to halt overall biodiversity loss, support healthy well-functioning ecosystems and establish coherent ecological networks, with more and better places for nature for the benefit of wildlife and people. This aim needs to be viewed in the context of the challenge presented by climate change. Healthy, naturally functioning ecosystems and coherent ecological networks will be more resilient and adaptable to climate change effects. Failure to address this challenge will result in significant adverse impact on biodiversity and the ecosystem services it provides. (BEIS, 2023; paragraph 5.4.2)	The conservation status of habitats and species is considered throughout this assessment and measures have been adopted to ensure impacts are reduced (section 7.11). The future impact of climate change on the marine ecology in the Irish Sea has been considered in section 7.8.1.9, 7.8.2.10, and 7.8.3.9.
As a general principle, and subject to the specific policies below, development should, in line with the mitigation hierarchy, aim to avoid significant harm to biodiversity and geological conservation interests, including through consideration of reasonable alternatives. Where significant harm cannot be avoided, impacts should be mitigated and as a last resort, appropriate compensation measures should be sought. (BEIS, 2023; paragraph 5.4.42)	Embedded mitigation measures have been outlined in section 7.11, and each impact has been comprehensively assessed in section 7.12 and where required, tertiary mitigation has been suggested.
In taking decisions, the Secretary of State should ensure that appropriate weight is attached to designated sites of international, national, and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment. (BEIS, 2023; paragraph 5.4.48)	Identification of the designated sites is considered in section 7.6 and those which have the potential to be impacted have been considered throughout the assessment in sections 7.12 and 7.13. Likely Significant Effects (LSE) on designated sites have been screened and are presented in volume 4, appendix P.

7.3.2 Welsh National Marine Plan

The Proposed Development sits within the Welsh waters and therefore Welsh plans such as the relevant 2019 Welsh National Marine Plan (Welsh Government, 2019) have been considered. Key provisions are set out in Table 7.3 along with details as to where these have been addressed within the assessment. Further information on the Welsh National Marine Plan is provided in volume 3, appendix D.

Table 7.3: Welsh National Marine Plan 2019 Policies Of Relevance To Marine Biodiversity Receptors

Policy	Key provisions	Where considered in the EIA
Benthic Receptors		
• ENV_01, 02, 03, 04, 05, 06, 07 • SOC_06, 09 • GOV_01	The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. Commitments to supporting an ecologically coherent network of MPAs.	The extent of each potential impact on the benthic receptors takes into account the abundance and distribution of species and habitats and is considered throughout the assessment and the cumulative assessment (sections 7.12 and 7.13). Identification of the designated sites is considered in section 7.6 and those which have the potential to be impacted have been considered throughout the assessment in sections 7.12 and 7.13. Likely Significant Effects (LSE) on designated sites have

Policy	Key provisions	Where considered in the EIA
		been screened and are presented in volume 4, appendix P..
• ENV_01; 03 • GOV_01	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	The potential impact of invasive species in regard to the Proposed Development is considered in sections 7.12 and 7.13.
• ENV_01, 02, 03, 04, 05, 06, 07 • GOV_01	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 extent of each potential impact on the benthic receptors take into account the abundance and distribution of species and habitats and is considered throughout the assessment and the cumulative assessment (sections 7.12 and 7.13).
• ENV_01, 02, 03, 07 • GOV_01 • FIS_01	Sea-floor 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.	Seabed integrity is considered within the temporary habitat disturbance/loss and long-term habitat loss impacts on benthic receptors (sections 7.12 and 7.13). These impacts consider pressures such as changes in substrate or seabed type and the sensitivity of the impacted habitats and species in relation to this pressure.
• ENV_06 • SOC_01 • GOV_01	Contaminants are at a level not giving rise to pollution effects.	The effects of contaminants are considered in the remobilisation of sediment-bound contaminants impacts on benthic ecology receptors (section 7.12.7).
Fish and shellfish		
• ENV_01 • ENV_05 • ENV_07 • GOV_01	Proposals should demonstrate how potential impacts on marine ecosystems have been taken into consideration and should, in order of preference: i. avoid adverse impacts; and/or ii. minimise impacts where they cannot be avoided; and/or iii. mitigate impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to the protection, restoration and/or enhancement of marine ecosystems are encouraged.	Potential impacts on fish and shellfish ecology receptors (including underwater noise and effects on important feeding, breeding (including spawning and nursery) and migration areas) from the Proposed Development have been identified in the key parameters for assessment in section 7.9 and further assessed in sections 7.12 and cumulatively with other projects in section 7.13. Embedded mitigation measures have been outlined in section 7.11, and each impact has been comprehensively assessed in section 7.12.
• ENV_02	Proposals should demonstrate how they: • avoid adverse impacts on individual MPAs and the coherence of the network as a whole; • have regard to the measures to manage MPAs; and • avoid adverse impacts on designated sites that are not part of the MPA network.	All relevant nearby MPAs and designated sites were identified through desktop review and stakeholder consultation (section 7.6). Those which have the potential to be impacted have been considered throughout the assessment in sections 7.12 and 7.13. Likely Significant Effects (LSE) on designated sites have been screened and are presented in volume 4, appendix P..
Marine mammals		
• ENV_01 • ENV_05 • ENV_07 • GOV_01	Proposals should demonstrate how potential impacts on marine ecosystems have been taken into consideration and should, in order of preference:	Potential impacts on marine mammal ecology (including effects associated with underwater noise) from Proposed Development alone and cumulatively with other projects have been addressed in sections 7.12 and 7.13, respectively.

Policy	Key provisions	Where considered in the EIA
	i. avoid adverse impacts; and/or ii. minimise impacts where they cannot be avoided; and/or iii. mitigate impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to the protection, restoration and/or enhancement of marine ecosystems are encouraged.	Embedded mitigation measures have been outlined in section 7.11, and each impact has been comprehensively assessed in section 7.12. The potential impacts on fish species and their habitats (including effects on important feeding, breeding (including spawning and nursery) and migration areas) have been assessed in full in sections 7.12. Section 7.12.19 assesses the potential effects on fish species and habitats in the context of how marine mammal prey species may be impacted.
• ENV_02:	Proposals should demonstrate how they: • avoid adverse impacts on individual MPAs and the coherence of the network as a whole; • have regard to the measures to manage MPAs; and • avoid adverse impacts on designated sites that are not part of the MPA network.	All relevant nearby MPAs and designated sites were identified through desktop review and stakeholder consultation (section 7.6). Those which have the potential to be impacted have been considered throughout the assessment in sections 7.12. Likely Significant Effects (LSE) on designated sites have been screened and are presented in volume 4, .

7.3.3 North West Inshore and North West Offshore Marine Plan

The assessment of potential impacts to Marine Biodiversity receptors has also been made with consideration to the specific policies set out in the North West Inshore and North West Offshore Marine Plans (MMO, 2021). Key provisions are set out in Table 7.4 along with details as to how these have been addressed within the assessment. Further information on the Welsh National Marine Plan is provided in volume 3, appendix D.

Table 7.4: North West Inshore And North West Offshore Marine Plan Policies Of Relevance To Marine Biodiversity Receptors

Policy	Key provisions	Where considered in the EIA
Benthic Receptors		
• NW-SCP-1 • NW-MPA-1	Proposals within or relatively close to nationally designated areas should have regard to the specific statutory purposes of the designated area. Great weight should be given to conserving and enhancing landscape and scenic beauty in National Parks and Areas of Outstanding Natural Beauty. Proposals that support the objectives of marine protected areas and the ecological coherence of the marine protected area network will be supported	Identification of the designated sites is considered in section 7.6 and those which have the potential to be impacted have been considered throughout the assessment in sections 7.12 and 7.13.
• NW-BIO-1	NW-BIO-1 encourages and supports proposals that enhance the distribution of priority habitats and priority species.	The Proposed Development will aim to conserve habitat through a number of embedded mitigation measures adopted to reduce the impacts of the Proposed Development (section 7.11).
• NW-BIO-2	NW-BIO-2 requires proposals to manage negative effects which may	Embedded mitigation measures have been outlined in section 7.11, and tertiary mitigation is considered

Policy	Key provisions	Where considered in the EIA
	significantly adversely impact the functioning of healthy, resilient and adaptable marine ecosystems.	where the significance of an impact is moderate or major to reduce the significance of the impact to negligible or minor (sections 7.12 and 7.13).
• NW-BIO-3	Proposals that conserve, restore or enhance coastal habitats, where important in their own right and/or for ecosystem functioning and provision of ecosystem services, will be supported.	Section 7.12 considers the magnitude, sensitivity and significance of the impacts associated with the Proposed Development on benthic habitats. Embedded mitigation measures have been outlined in section 7.11, and each impact has been comprehensively assessed in section 7.12 and where required, tertiary mitigation has been suggested. As a result, the Proposed Development seeks to conserve the function and services provided by coastal habitats.
• NW-INNS-1	NW-INNS-1 aims to avoid or minimise damage to the marine area from the introduction or transport of Invasive Non-Native Species (INNS).	The implementation of an EMP as part of the embedded measures adopted by the Proposed Development (section 7.11) will manage and reduce the risk of introduction or spread of INNS. The INNS Management Plan is presented in volume 4, appendix T.
Fish and Shellfish		
• NW-FISH-3	Proposals that enhance essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes, should be supported. Proposals that may have significant adverse impacts on essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes, must demonstrate that they will, in order of preference: i. avoid; ii. minimise; and iii. mitigate adverse impacts so they are no longer significant.	The areas of essential fish habitat potentially impacted have been identified in the volume 3, appendix I and summarised in the baseline (section 7.8.2). The impacts as a result of the Proposed Development are assessed in detail in sections 7.12 and 7.13.
• NW-MPA-1	Proposals that support the objectives of marine protected areas and the ecological coherence of the marine protected area network will be supported. Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of preference: i. avoid; ii. minimise; and iii. mitigate adverse impacts, with due regard given to statutory advice on an ecologically coherent network.	Designated sites have been identified in section 7.6 and those which have the potential to be impacted have been considered throughout the assessment in sections 7.12 and 7.13.
• NW-BIO-2	Proposals that enhance or facilitate native species or habitat adaptation or connectivity, or native species migration, will be supported. Proposals that may cause significant adverse impacts on native species or habitat adaptation or connectivity, or native species migration, must demonstrate that they will, in order of preference: i. avoid;	The areas of essential fish habitat potentially impacted have been identified in volume 3, appendix I and summarised in the baseline (section 7.8.2). The impacts as a result of Proposed Development are assessed in detail in sections 7.12 and 7.13. Embedded mitigation measures have been outlined in section 7.11, and tertiary mitigation is considered where the significance of an impact is moderate or major to

Policy	Key provisions	Where considered in the EIA
	ii. minimise; iii. mitigate adverse impacts so they are no longer significant; and iv. compensate for significant adverse impacts that cannot be mitigated.	reduce the significance of the impact to negligible or minor (sections 7.12 and 7.13).
• NW-INNS-1	Proposals that reduce the risk of introduction and/or spread of non-native invasive species should be supported. Proposals must put in place appropriate measures to avoid or minimise significant adverse impacts that would arise through the introduction and transport of invasive non-native species, particularly when: 1) moving equipment, boats or livestock (for example fish or shellfish) from one water body to another 2) introducing structures suitable for settlement of invasive non-native species, or the spread of invasive non-native species known to exist in the area.	The prevention of the spread of INNS has been highlighted and considered in section 7.12.6, alongside appropriate embedded measures (section 7.11). Tertiary mitigation is considered where the significance of an impact is moderate or major to reduce the significance of the impact to negligible or minor (sections 7.12 and 7.13). The INNS Management Plan is presented in volume 4, appendix T.
• NW-DIST-1 • NW-UWN-2 • NW-CE-1	Proposals that may have significant adverse impacts on highly mobile species through disturbance or displacement and/or result in the generation of impulsive or non-impulsive noise and/or have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will, in order of preference: i. avoid; ii. minimise; and iii. mitigate adverse impacts so they are no longer significant.	Potential impacts on fish and shellfish ecology receptors (including underwater noise) from Proposed Development have been identified in the key parameters for assessment in section 7.9 and further assessed in sections 7.12 and cumulatively with other projects in section 7.13. Embedded mitigation measures have been outlined in section 7.11, and each impact has been comprehensively assessed in section 7.12.
• NW-CBC-1	Proposals must consider cross-border impacts throughout the lifetime of the proposed activity. Proposals that impact upon one or more marine plan areas or terrestrial environments must show evidence of the relevant public authorities (including other countries) being consulted and responses considered.	Any potential cross-border impacts have been assessed in the transboundary effects (section 7.13.15) and inter-related effects (section 7.15) sections.
Marine mammals		
• NW-SCP-1 • NW-MPA-1	Proposals within or relatively close to nationally designated areas should have regard to the specific statutory purposes of the designated area. Proposals that support the objectives of marine protected areas and the ecological coherence of the marine protected area network will be supported. Proposals that may have adverse impacts on the objectives of marine protected areas must	The process of identifying designated sites has been undertaken for the regional marine mammal study area (section 7.6) and was done to ensure all habitats and features or species of conservation importance were considered in this assessment (sections 7.12 and 7.13).

Policy	Key provisions	Where considered in the EIA
	demonstrate that they will, in order of preference: i. avoid; ii. minimise; and iii. mitigate adverse impacts, with due regard given to statutory advice on an ecologically coherent network.	
• NW-BIO-2	NW-BIO-2 requires proposals to manage negative effects which may significantly adversely impact the functioning of healthy, resilient and adaptable marine ecosystems.	Embedded mitigation measures have been outlined in section 7.11, and tertiary mitigation is considered where the significance of an impact is moderate or major to reduce the significance of the impact to negligible or minor (sections 7.12 and 7.13).
• NW-CE-1	Proposals which may have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will avoid, minimise and mitigate.	Cumulative effects have been considered and their significance assessed in section 7.13. This section includes the consideration of tertiary mitigation where the significance of an impact is moderate or major.
• NW-UWN-2	Proposals that result in the generation of impulsive or non-impulsive noise must demonstrate that they will, in order of preference: i. avoid; ii. minimise; and iii. mitigate adverse impacts on highly mobile species so they are no longer significant.	The potential impacts of underwater noise resulting from the construction, operations and maintenance, and decommissioning phases have been considered in the assessment of impacts in sections 7.12 and 7.13. Embedded mitigation measures have been outlined in section 7.11, and where required, tertiary mitigation has been suggested.

7.4 Consultation

Consultation with relevant stakeholders has been undertaken throughout the consenting process of the Proposed Development. Table 7.5 summarises the issues raised relevant to Benthic Subtidal and Intertidal Ecology, Fish and Shellfish Ecology, and Marine Mammals and Marine Turtles, which have been identified during consultation activities undertaken to date. Table 7.5 also presents how and where these issues have been considered in the production of this Offshore ES.

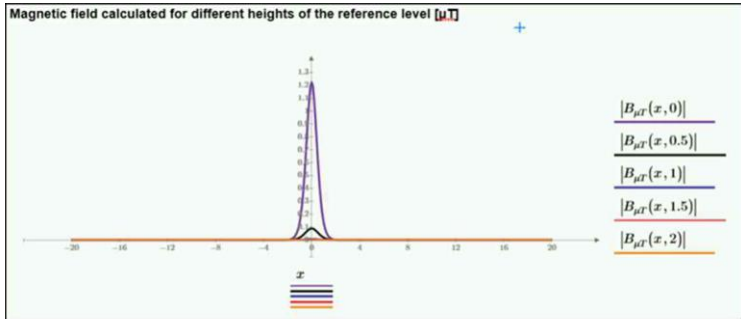
The installation of the Proposed Development within the intertidal area between MHWS and MLWS, also overlaps with an onshore planning application made to Flintshire County Council (FCC) for works at the Point of Ayr terminal (planning application FUL/000246/23). The onshore planning application and its supporting ES, therefore, duplicates the cable installation works within the intertidal area.

Following submission of the onshore planning application on 14 March 2023, a consultation response from NRW was received on 10 May 2023 and a response from FCC’s Ecology Officer was received on 31 May 2023. As a result of these responses, some clarifications on the information presented within the ES, HRA and Water Framework Directive (WFD) Assessment were provided. Details regarding the issues raised on the onshore application have therefore been included within Table 7.5, and commentary provided on how and where these issues have been considered in the production of this Offshore ES.

Table 7.5: Summary Of Key Consultation Issues Raised During Consultation Activities Undertaken For The Proposed Development Relevant To Marine Biodiversity

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
27 January 2023	Offshore Petroleum Regulator for Environment and Decommissioning (OPRED). Scoping Opinion response	"All relevant environmental data is expected to be sourced, analysed, and presented in relation to the Project. A non-exhaustive list of potential sources of environmental information is provided in Annex 2 but the Developer is expected to consult such other sources as it considers necessary." "Relevant local environmental data should also be sourced from the appropriate local bodies which may include local environmental records centre, the local wildlife trust, local geo-conservation groups or other recording societies."	All available relevant environmental data has been identified when characterising the baseline (see volume 3, appendix I and Table 7.8, Table 7.11, and Table 7.14).
		"The ES should assess the environmental effects of the Project upon features of nature conservation interest. It is recommended that the ES thoroughly assesses the potential for the Project to affect national or international sites of nature conservation importance. This should include a full assessment of the direct and indirect effects of the Project on the features of all important nature conservation sites including, but not limited to, Natural England's Impact Risk Zones, SSSIs, MCZs, and Designated Sites with Fish and Shellfish Qualifying Features. Further website information on these sites and how this may be accessed is provided in Annex 2. In particular, it is noted that the following Welsh sites have been omitted in Table 7-7 (Designated Sites with Fish and Shellfish Qualifying Features) of the ES scoping report: • Dee Estuary SAC, designated for river and sea lamprey; • River Dee and Bala lake SAC, designated for Atlantic salmon, river and sea lamprey; • Afon Gwyrfai a Llyn Cwellyn SAC, designated for Atlantic salmon; • Afon Eden SAC - Cors Goch Trawsfynydd, designated for Atlantic salmon and Freshwater peal mussel; and • River Teifi SAC, designated for Atlantic salmon, river and sea lamprey."	Potential environmental effects upon features of nature conservation interest have been identified following the methodology described in section 7.6 and assessed (where appropriate, see section 7.12) in their respective sections. The recommended Welsh SACs were included in the Fish and Shellfish section (see Table 7.12).

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
		"It is advised that records of protected species are sought from the appropriate local biological record centres, nature conservation organisations and National Biodiversity Network (NBN) Atlas (https://nbnatlas.org/.). It is also advised that consideration should be given to the wider context of the location of the Project, in terms of habitat linkages and protected species populations in the wider area to assist the impact assessment."	Records of protected species were sought from the mentioned resources (Table 7.8, Table 7.11, and Table 7.14; see volume 3, appendix I for detailed findings). Wider context has been researched through the use of regional study areas for the three marine biodiversity topics (see Figure 7.1, Figure 7.2, and Figure 7.3) and volume 3, appendix I for the full baseline descriptions of these wider study areas.
		"With respect to the impacts proposed to be scoped into the ES, the introduction of artificial habitat and colonisation of hard structures should not be considered beneficial." "It should also be noted that the introduction of hard substrates may act as a stepping-stone for the introduction of INNS, which is not currently scoped into the assessment. It is advised that the above points are scoped in and assessed."	This has been noted and this impact has been assessed proportionately, taking into consideration changes from the baseline substrate regime (see section 7.12.4). INNS are assessed separately under the impact 'Increased risk of introduction and spread of INNS', which has been assessed for project phases for benthic subtidal and intertidal ecology (see section 7.12.6).
		"Impacts resulting from the release of sediment bound benthic contaminants should be scoped in and assessed for the operational phase."	During the operational phase the potential for release of sediment-bound contaminants is considered lower than during installation and removal of significant infrastructure, with small areas of disturbance anticipated for cable repairs and maintenance. After review of the site-specific contaminants data and the physical processes modelling, it is proposed that this effect remains scoped out during the operational phase.
		"The footprint of area affected by cables and cable protection and potential impacts from scour and secondary scour from the use of cable protection and mattresses on benthic habitats during the operational phase should be scoped into the ES."	This impact is covered within the MDS for Temporary habitat loss and/or disturbance and Long-term subtidal habitat loss (Table 7.21 and Table 7.22) and is included in these assessments of significance, where relevant (see sections 7.12.1, 7.12.3, 7.12.9, and 7.12.10).
		"It is recommended that impacts to benthic ecology [and fish and shellfish] due to Electromagnetic Fields (EMF) is scoped into the ES and that an estimation of EMFs potentially arising from cables (both at exterior and at surface of seabed above buried cables) is scoped in at this stage."	Mitigation of this impact and associated effects through cable burial (at a target depth of between 2 and 3 m depth) and/or rock deposit protection (where burial is not possible) is considered embedded mitigation (see Table 7.32). Therefore, it is proposed that this impact remains scoped out for benthic subtidal and intertidal ecology and fish and shellfish, as with the planned embedded mitigation, it is anticipated that the significance of this effect will be negligible (Table 7.24 and Table 7.25). The graph below shows an order of magnitude calculation for I a 33kV, three core x 630sqmm cable with a current rating of 750A (although the Applicant's will be less than this), along with grounded metallic sheath and buried to a 1m depth below the surface (the

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
			Applicant's cable has a target burial depth of 3m across the intertidal zone). Unlike the 400kV AC export cables from offshore wind farms, the Applicant's cables for the Proposed Development are 33kV DC, so there will be **no detectible electric fields** external to the metallic sheath. However, the cable will generate static magnetic fields, which will not be screened by the metallic sheath. The curves in the graph below represent the anticipated magnetic field at 0m (purple), and 0.5m (black) distance from the top of the cable. Values are in microtesla (µT). The graph shows, at the seabed (i.e. 1.0m above the cable), the magnetic field will be ~0.1uT, and at 0.5 m above the cable (i.e. 0.5m below the seabed) ~1.2uT. The Applicant's cabler will be buried between 2-3 m below the seabed. These are extremely low values, and these values are much lower than any of those cited from the published literature on the matter where effects may occur on marine life, for example CMACS (2003) and Gill et. al (2009). As previously stated, it is anticipated that the significance of this effect will be negligible. 
		"Details of the footprint area affected by any installation vessels should be included."	This has been noted and is included within the MDS for Temporary habitat loss (Table 7.21 and Table 7.22) and is included in these assessments of significance, where relevant (see sections 7.12.1 and 7.12.9).

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
		"Long-term subtidal habitat loss – Currently long-term subtidal habitat loss is only predicted to occur directly under the newly installed cable route with rock armour/protection in place. Confirmation that no additional long-term habitat loss is expected from the other activities highlighted is requested."	All relevant project design parameters have been built into the MDS associated with long term subtidal habitat loss, including any structures associated with the new Douglas platform (see Table 7.21 and Table 7.22).
10 May 2023	NRW – comments received in relation to planning application to FCC, application reference FUL/000246/23: Detailed Planning Application For The Retention And Reuse Of The Point Of Ayr Gas Terminal And Associated Gas Pipeline To The Mean Low Water Spring Mark For The Management And Processing Of CO_2; The Construction Of 33kv Electricity And Fibre Optic Connections From Point Of Ayr Gas Terminal To The Mean Low Water Spring Mark; And Other Associated	**Intertidal mudflats and sandflats** Environmental Statement (ES) Chapter 4: Consideration of Alternatives, paragraph 4.5.10 Foreshore Cables, explains that "The yellow route was discounted, but the dashed yellow option may eventually be selected over the orange option depending on the shifting nature of the sand banks". We advise that you seek clarification on whether the dashed yellow route is still in scope for this application and whether it has been assessed.	The dashed yellow and orange (Vol 2, Chapter 4 Fig 4.2) routes both remain under consideration and were both assessed within this Offshore ES, and the HRA. The dashed yellow and orange routes are in the same location (east side of the existing PoA to Douglas Pipeline between MHWS and MLWS), following the same alignment up to the MLWS covered by the ES and HRA supporting the Planning Application FUL/000246/23. The benefit of the dashed yellow route is that it follows the orange route onshore, so it does not protrude east and provides a more accessible route for construction vessels. However, the issue associated with constructability between the two spits offshore remains (water rushes between the two spits at speed). Therefore, the dashed yellow route and the orange route are both still under consideration. The final choice will be made during detailed design. This is because each route requires bespoke cable installation vessels to implement, and the availability of the vessels cannot be confirmed at this time. Sediment dispersion modelling has been carried out for the reasonable worst-case installation scenario, and both options are being assessed in the Offshore EIA that will support the Marine Licence application to NRW-MLT. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats With reference to ES Chapter 9: Biodiversity, para. 9.5.21, Impact assessment methodology, Duration, we advise that habitat loss longer than 5 years should be classed as long-lasting. This is based on the reporting cycle requirements outlined in Article 6a of the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019.	**Section 9.5.21** of **Chapter 9 Biodiversity of the Town and Country Planning Act (TCPA) Onshore ES** defines the criteria for the duration of time an impact/effect is expected to last. Short-term is up to one year; medium-term is between one and 10 years and long-term is greater than 10 years. The Applicant notes NRW's advice on the length of time against which habitat loss should be considered long-term. Notwithstanding, due to the temporary nature and scale of the cable laying works, as well as the composition of the macrofaunal communities present, rapid recolonisation of disturbed sediment is expected within two

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
	Development At Land West Of Station Road, Talacre.		years. Therefore, this remains a medium-term impact and would not change the impact assessment or conclusions of the ES. It should also be noted that the area in which the works will be undertaken is classed a depositional area, so any trenches will be quickly infilled over a short period of time. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats In ES Chapter 9, para. 9.8.7 the applicant proposes the use of a plough to excavate a trench and bury the cable within the intertidal zone. However, in ES Chapter 3: para. 3.4.58, the applicant notes that whilst the use of a plough is the preferred option, if proved to be unsuitable for the cable installation then a cable trencher will be employed. Potential impacts to intertidal habitats from the use of a cable trencher (including the recovery time) are greater than that of the use of a plough. We therefore advise that the worst-case scenario (i.e. the use of the cable trencher) should be assessed, in line with the Rochdale Envelope approach. This equally applies to the consideration of water quality impact in the HRA.	The use of a cable trencher as opposed to a cable plough could result in a greater area of impact due to the potential impacts of sediment compaction from the trencher's tracks. This could potentially result in an estimated impacted area of 18,000 m^2 using the trencher compared to an estimated 1,800 m^2 using the plough. Notwithstanding the above, the impacts from sediment mobilisation on receptors will be the same as that for the plough methodology, as the area of sediment mobilisation will be the same for both methods. As discussed in the response to NRW's comment above relating to Section 9.5.21 of Chapter 9 Biodiversity of the TCPA Onshore ES, due to the temporary nature and scale of cable laying works, combined with the cable laying works being located within a depositional area for sediment, any trenches will be quickly infilled over a short period of time. Furthermore, rapid recolonisation of disturbed sediment is expected within two years. Therefore, in a worst-case scenario, the use of a cable trencher is still anticipated to have the same medium-term impact presented within the submitted ES and HRA on the intertidal habitat in the absence of any additional mitigation. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats Potential impacts to the Annex I mudflat and sandflat habitat from siltation and turbidity effects and accidental pollution during construction have been identified in ES Chapter 9: para. 9.9.25 but have not subsequently been assessed. Furthermore, several potential impacts resulting from the cable installation activities that could have an impact on the Annex I mudflat and sandflat habitat have not been assessed. We therefore advise that the following potential impacts should be scoped in and assessed:	Temporary disturbance of priority habitat/Annex I mudflat and sandflat habitat will be caused by the cable installation works through the foreshore, by either a cable plough or cable trenching machine. Sediment disturbed during the installation will be backfilled by the machine, so loss would be temporary and localised. If using the cable trenching machine (worst-case scenario) and in the absence of any additional mitigation, an area of approximately 18,000 m^2 (1.8 ha) would be impacted. This includes the area of sediment directly disturbed by the installation of the cable and the

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
		• Impacts from accidental pollution events • Impacts from increases in suspended sediment concentration and associated deposition (siltation and turbidity effects). This includes impacts from cable installation and repair/maintenance activities and indirect impacts to intertidal habitats (including the Annex I mudflats and sandflats feature) from increased suspended sediment and smothering from suspended sediment plumes generated during construction. This is of particular importance if a cable trencher is used. • Release of sediment bound contaminants – Disturbance of the seabed during construction, operation and decommissioning activities could cause toxicity effects through mobilisation of contaminated sediment during preparation works, cable laying and cable repair activities, which could impact the surrounding benthic communities. • Introduction and spread of invasive non-native species via marine vessels proposed to be used as part of the cable installation works. • Impacts from EMF. With reference to ES Chapter 9: para. 9.9.93, potential EMF impacts from the operation of the cables have been assessed against the fish species that were recorded within the Dee Estuary SAC. As noted by the applicant, many benthic invertebrate species are known to be able to detect EMF. There is some evidence that EMFs affect crustacea behavioural patterns which would potentially include certain species under Section 7 (Environment Wales Act 2016) e.g., crawfish/spiny lobster *Palinurus elephas*. We advise that these should be reviewed and assessed (where appropriate) as part of the application.	area of sediment potentially compacted under the tracks of the machine. Based on this information, the area of habitat within the red line boundary to be temporarily disturbed is expected to be 18.40% of the total intertidal mudflats and sandflats habitat area within the red line boundary of the TCPA Proposed Development, although only 0.017% of the extent of the mudflats and sandflats habitat within the Dee Estuary SAC. Due to the temporary and localised nature of the works and the habitats present, it is considered that effects will be of minor adverse significance (therefore not significant). Potential impacts resulting from the cable installation activities on the Annex I mudflat and sandflat habitat have been considered and are discussed below. There would be no changes to the overall conclusions of the **ES** and **HRA**: • Accidental pollution events during construction activities have the potential to impact the mudflat and sandflat habitats, through release of industrial chemicals such as fuel and lubricants. As the intertidal works will be undertaken at low tide where possible, it will allow any potential pollution events to be contained and localised to the works area. This would therefore reduce the potential for spread and scale of impacts. If a spill occurs during high tide works, the release will be dispersed through tidal flow, thus reducing the severity of the spill. In addition to these factors, the species present within the works area are of medium sensitivity to pollution and have a medium resistance (to hydrocarbons and synthetic compounds) and have the ability to recolonise areas relatively quickly. Accidental pollution events and control measures will be detailed within the detailed CEMP and standard procedures will be followed in order to reduce potential impacts. Pollution controls are currently detailed within measures T-GN-002, T-BD-017 and T-BD-019 the Register of Environmental Actions and Commitments (REAC) (Document Reference: T.5.3) and Section 4.2 of the Outline Construction Environment Management Plan (OCEMP) (Document Reference: T.5.1). • The release of sediment-bound contaminants during cable laying and cable maintenance activities has the potential to impact benthic communities through toxicity effects. However, where possible the works will be undertaken at low tide and the trenches

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
			would be backfilled through natural deposition. As such, this reduces the potential impacts, which will be localised in nature. In addition, the species present within the works area are of medium sensitivity and resilience to chemical pressures and are able to recolonise rapidly. Therefore, the effects from sediment-bound contaminant release are likely to be negligible (not significant). • As described Section 1.7.3.1 of Vol 3, appendix H, suspended sediment plumes for seabed preparation activities were quantified. In all cases, the material released was native to the bed sediments and, although there are periods of increased turbidity, the material was retained in the sediment cell and would be subsequently assimilated into the existing sediment transport regime. Suspended sediments may reach into the estuary during cable trenching from PoA to Douglas, but generally do so at background levels, i.e. 30 mg/l. As such, significant effects are not predicted. • Mobilisation of specialised vessels in order to undertake the cable laying work has the potential to introduce INNS, through release of ballast water and from larval release from the hulls of vessels. As the vessels will be moored below MLWS and will offload the cable into the intertidal zone, the spread of INNS will be controlled by the implementation of a Biosecurity Risk Assessment as described in Section 2.8 Biosecurity Risk Assessment. Biosecurity mitigation measure detailed within T-BD-032 of the REAC (Document Reference: T.5.3) and OCEMP (Document Reference: T.5.1) • EMF generated by the cables is likely to be ~0.1 µT at the seabed for a cable buried at 1m deep, which is below the levels which have impacts upon marine life, including fish and marine invertebrates. In addition, the cables will be buried 3 m below the surface through the intertidal zone, which will mean that the EMF at the surface will be even less than the ~0.1 µT. Furthermore, the habitats present along the intertidal section of the cable route – intertidal sand and mudflats – are not optimal for species such as the crawfish/spiny lobster, which has a habitat preference of rocky exposed coasts with depths of 5-400 m. In addition to this, the desk study and field surveys did not identify any other benthic invertebrates that are sensitive to EMF. Therefore, the potential effects are likely to be negligible (not significant).

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			Cable repair is unlikely, and not planned. The Applicant will be laying and burying single, unjointed cables to avoid the need for maintenance. In the unlikely event that cable repair was required, the activities would be no worse in terms of potential impacts than installation activities already assessed. Additionally, It is anticipated that the external cable protection at existing cable crossings is unlikely to require maintenance, as the rock and concrete mattresses are expected to remain in place. Maintenance or repairs are only anticipated should the cable protection be impacted by either fishing activity, or anchor snagging. Any movement of the rock and mattresses from these external interventions would be identified through the annual asset integrity surveys, and the necessary repairs carried out accordingly. These repairs would be carried out within the maximum design envelope described for the cable crossings external protection. **This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**
		Intertidal mudflats and sandflats With reference to ES Chapter 9: para. 9.9.21, we advise that clarification is sought on what activity is expected to result in the "*loss of sections of intertidal mudflat S7 Priority habitat/mudflat and sandflat Annex I habitat"* and what area of habitat loss this equates to. We would not expect any long-lasting habitat loss as a result of the cable trenching as the trench would be backfilled.	Temporary disturbance (rather than loss) to priority habitat will be caused by the installation of the cable installation works through the foreshore, by either a cable plough or cable trenching machine. The term disturbance has been used in this response as the Applicant agrees that there would be no long-term habitat loss given the backfilling of the trench. If using the cable trenching machine (worst-case scenario) and in the absence of any additional mitigation, an area of approximately 18,000 m^2 (1.8 ha) would be impacted. This includes the area of sediment directly disturbed by the installation of the cable and the area of sediment potentially crushed under the tracks of the machine. Based on this information, the area of habitat within the red line boundary of the TCPA Proposed Development to be temporarily disturbed is expected to be 18.40% of the total intertidal mudflats and sandflats habitat area, although only 0.017% of the extent of the mudflats and sandflats habitat within the Dee Estuary SAC. Sediment disturbed during the installation will be backfilled by the machine, subsequent infilling from deposited suspended sediments,

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
			as well as natural deposition, so disturbance would be temporary and localised. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats Based on the sensitivity of the biotopes to the impact and the expected recovery rate we do not expect the impact from temporary habitat loss, and/or disturbance from the cable installation on the biotopes that were encountered during the Phase I Habitat Survey, to be of major and/or moderate significance. This impact is expected to be temporary, and the habitat should return to pre-impact conditions within the short-term following return of the sediment. However, we are unable to confirm this without clarification of the extent of the area that will be impacted. Mitigation measures such as the use of matting to reduce compaction of the sediment could be used, but further information is needed to understand these impacts. Therefore, until the following information is provided, we are unable to agree with the assessment conclusions regarding biotopes.	Due to the temporary and localised nature of the works and the habitats present, the Applicant agrees that effects would not be of moderate or major significance. It is considered that effects of habitat disturbance during construction will be of minor adverse significance (therefore, not significant). The use of track matting to reduce the impacts from compaction could reduce the area of impact to that within the trenched area. However, this may not be required due to the short-term nature of the works and the high resilience of the habitat types and species present. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats An assessment of the impact of temporary habitat loss and/or disturbance from cable installation against the biotopes (ES Habitat Survey Report, Annex E, Figure 3.1 Biotope Map of the Survey Area) recorded during the Phase I habitat survey using the information provided in Marine Evidence based Sensitivity Assessment (MarESA).,e.g., sensitivity, resilience and expected recovery rate). This should assess the impact from disturbing the sediment as a result of the cable laying activities and potentially from the use of vehicles on the beach to install the cable (e.g., use of a mobile tracked machine). The assessment should also include the total extent of the impact i.e., the area in m^2 and or km^2 of impact and furthermore, what this equates to (percentage) of the Annex I mudflat and sandflat feature of the Dee Estuary SAC and to the whole Dee	The predominant habitat type identified within the survey area was *Macoma balthica* and *Arenicola marina* in littoral muddy sand. This habitat and its associated species are resilient to change and able to recolonise following disturbance relatively quickly, with studies showing that recolonisation of dug/disturbed areas taking place with two to three months[2]. Recolonisation time will depend upon factors such as recruitment and migration of adults into the disturbed area, however it is expected that disturbed areas will be fully recolonised within two years. The Dee Estuary SAC covers a total of 10,573.73 ha of intertidal mudflats and sandflats not covered by water at low tide. The intertidal cable works have the potential to impact 1.8 ha (worst-case scenario when considering the use of a cable trenching machine), equating to 0.017% of this habitat type within the SAC. Therefore, effects to the intertidal mudflats and sandflats of the SAC are considered to be of

[2] https://www.marlin.ac.uk/habitats/detail/1087#sensitivity_review

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		Estuary SAC. Clarification is also sought on any mitigation measures in relation to the impact of tracked vehicles that might be required.	negligible significance due to the scale of the impacts and the resilience of the habitats present. The use of track matting to reduce the impacts from compaction could reduce the area of impact to that within the trenched area. However, this may not be required due to the short-term nature of the works and the high resilience of the habitat types and species present. **This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**
		Intertidal mudflats and sandflats Regarding ES Chapter 9: para. 9.9.85 we note that the operation of the repurposed pipeline is expected to increase the temperature of the soil and associated habitats around the pipeline. We advise that clarification is sought on whether an increase in temperature is expected in the intertidal zone; if so, potential impacts on the Annex I mudflats and sandflat feature should be assessed.	Soil temperature analysis of three locations, including the intertidal mudflats and sandflats habitat, was carried out by Wood in 2023**.** The results of this analysis concluded that there was no significant impact on soil/sand temperature near the surface as a result of the Foreshore Pipeline. The report concluded that during summer months, the temperature at 0.1 m below the surface would be 1.8°C above ambient temperature (18.6°C compared to 17°C), whereas during winter it would be 2.3°C above ambient (5.3°C compared to 3°C). A more detailed analysis method (CFD modelling) was undertaken, which indicated that the temperature of soil/sand 10m either side of the pipe was affected by the presence of the pipeline. However, the greatest impacts to temperature change were within 1m of the pipe. These temperature changes are within the tolerance levels of the habitats and species present within the pipeline area. Therefore, significant effects are not predicted. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats With reference to ES Chapter 19: Combined and Cumulative Effects, until the potential impacts to intertidal habitats from the cabling activities have been scoped in and assessed appropriately, we are unable to agree that the effects to ecological receptors are non-negligible and can therefore be scoped out of the cumulative effects assessment. Please note these comments are also applicable to appendix 19.1 Inter-Project effects assessment.	See **ES Chapter 3 – Proposed Development Description** for details on the methods and activities involved for the cable installation. Approximately 1.8 ha of the intertidal mudflats and sandflats habitat within the red line boundary of the Proposed Development is expected to be temporarily disturbed by the cable trenching activities. However, this equates to only 0.017% of the extent of the mudflats and sandflats habitat within the Dee Estuary SAC. The habitats and species present within the works area are resilient to disturbance and

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
			have the potential to recolonise within months of the works being completed. The MarESA assessment for this habitat type indicates that the habitat and populations should be fully recovered within two years of cessation of works. The species present are also moderately tolerant to increases in sediment temperature, with the modelled temperature changes falling within these tolerances. This ES concludes that no significant effects (moderate significance or above, in line with the EIA methodology used throughout the assessment) will be incurred because of the proposed cable trenching works. **This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**
		Intertidal mudflats and sandflats With reference to ES Chapter 19: Table 6-2. Potential effects upon the Dee Estuary/Aber Dyfrydwy SAC, Annex I mudflat and sandflat feature the potential for the cable installation and repair/maintenance activities to result in increases in sediment-bound contaminants and suspended sediment concentration (SSC) leading to siltation and turbidity effects and thus impacts to the Annex I features of the Dee Estuary SAC has not been screened in and assessed. This is of particular importance if a cable trencher is to be used so we advise that it should be appropriately assessed.	Results from the sediment dispersion numerical modelling presented in this ES (see volume 3, Appendix H) show that suspended sediment plumes from all cable installation activities showed that while there are periods of increased turbidity, the suspended material is retained in the same sediment cell and would be subsequently assimilated into the existing sediment transport regime. Suspended sediments may reach into the Dee Estuary during cable installation, but generally do so at background levels, i.e. 30 mg/l. The sediment plume modelling also concluded that most of the sediment deposition would take place within 30 m of the cable laying activities. Therefore, impacts and effects will be localised and temporary. Overall, LSE are not predicted in relation to siltation and turbidity. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats With reference to ES Chapter 19: Table 6-2. Potential effects upon the Dee Estuary/Aber Dyfrydwy SAC, subsection (a), we advise that further assessment should be undertaken to support the conclusions of the HRA. LSE from habitat loss and/or disturbance to the Annex I mudflat and sandflat feature resulting from cable installation activities have been identified and some evidence relating to the resilience and recovery of the habitat has been presented. We advise that given an	Table 6.2 referenced by NRW is found within the **Onshore TCPA HRA report (Document Reference T.5.4)** and not ES Chapter 19. As such, the Applicant assumes that this comment relates to the HRA. Table 6.2 of the **Onshore TCPA HRA report (Document Reference T.5.4)** assesses LSE upon the Dee Estuary SAC. This includes an assessment of direct habitat loss of the mudflats and sandflats Annex I habitat. In summary, no LSE in relation to habitat loss of the

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
		LSE has been identified, the impact should be assessed at Stage 2 Appropriate Assessment against the conservation objectives for the feature, with the appropriate evidence to rule out an adverse effect on site integrity presented.	mudflats and sandflats SAC qualifying feature were identified. The only LSE identified for the mudflats and sandflats qualifying feature was in relation to hydrological effects. This was carried through to the Appropriate Assessment, mitigation measures were detailed, and no adverse effects on the integrity of this feature were predicted. Since the HRA for the Onshore TCPA was undertaken, further details on the cable installation methodology, presented in this Offshore ES at **Chapter 3 – Proposed Development Description**, have been reaffirmed the conclusions made in the HRA report of no LSE in relation to mudflats and sandflats associated with habitat loss. The Dee Estuary SAC covers a total of 10,573.73 ha of intertidal mudflats and sandflats not covered by seawater at low tide. The intertidal cable works have the potential to temporarily disturb 1.8 ha, equating to 0.017% of this habitat type within the Dee Estuary SAC. There would be no long-term habitat loss given the backfilling of the trench (temporary disturbance of habitat only). Due to the nature of the foreshore within the project area, the topography will return to its pre-works state after several tidal cycles due to the physical processes in this location and as described in this Offshore ES in volume 3, appendix H. The predominant habitat type identified within the survey area (and cable route) was *Macoma balthica* and *Arenicola marina* in littoral muddy sand. This habitat and its associated species are resilient to change and able to recolonise following disturbance relatively quickly, with studies showing that recolonisation of dug/disturbed areas taking place with two to three months. Recolonisation time will depend upon factors such as recruitment and migration of adults into the disturbed area. However, it is expected that disturbed areas will be fully recolonised within two years. As such, it is expected that the abundance of typical species of the mudflat and sandflat feature within the SAC will be maintained. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats With regards to appendix A – Section 6.4.2 (a) of the shadow HRA, we welcome plans to work at low water to avoid the potential impacts of SSC plumes on Annex I protected features (Chapter 9, Table 9-21). However, we advise further assessment regarding the	The Applicant confirms that it cannot be guaranteed that the cable installation across the intertidal area would only be carried out at low tide. There are many factors that would influence the timing that cannot be guaranteed at this time. Please refer to this Offshore ES at **Chapter 3 – Proposed Development Description** for proposed

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		practicality of working only at low water if trenching is employed as the cable installation method. For example, whether it would be possible to undertake the cable laying work within one low water period as outlined in appendix 18.3 Water Framework Directive Assessment, Table 4-14. If any cable laying works take place outside low water, we advise that the potential for SSC plumes should be assessed, in particular, the possibility for smothering of protected features, by the deposition of sands and fine material, mobilised by trenching activities.	schedules of cable laying activities, suggesting that it would not be possible to undertake the cable laying within one low tide water period. The potential for suspended sediment concentrations and potential for smothering of protected features has been considered above, with no LSE to qualifying mudflat and sandflat habitat of the Dee Estuary SAC predicted. **This has been taken into consideration within this Offshore ES.**
		Intertidal mudflats and sandflats We also advise further assessment regarding the transition of cable laying methods beyond MLWS. We acknowledge that this application covers activities to MLWS, however, in order to assess the impacts of cable laying activities within the intertidal zone the methods for continuing these works past MLWS need to be understood. For example, whether intertidal cable laying would commence only once a Marine License for cabling below MHWS has been granted.	The Applicant confirms that intertidal cable laying would commence only once a Marine Licence for cabling below MHWS has been granted. Cable laying would commence offshore from the Douglas platform towards the shore, and to do this would require a Marine Licence. **The impacts of the cable laying beyond MLWS have been assessed in this Offshore ES for the Marine Licence.**
		Estuaries We note that, providing the exit pit and cables can be situated 2-3m below the ground, rock armour and cable protection would not be required. However, we advise that you seek clarification that backfilling associated with the exit pit would restore the original profile of the beach, to ensure the alongshore sediment transport pathways will not be interrupted.	The Applicant confirms that backfilling associated with the exit pit would restore the original profile of the beach, to ensure the alongshore sediment transport pathways will not be interrupted. It should also be noted that the HDD exit pit would be located above the MHWS mark, which is illustrated in the cross-section extract in this Offshore ES at **Chapter 3 – Proposed Development Description**.
		Estuaries We also advise that you seek clarification that cable laying methods would not change the overall profile of the intertidal area. For example, if trenching methods are employed, backfilling methods should ensure the original gradient of the Intertidal area is restored, to minimise the potential for secondary impacts to physical processes and thus sediment transport pathways.	The Applicant confirms that cable laying methods would not change the overall profile of the intertidal area.
		Fish Features We note that ES Chapter 15: Noise and Vibration, para. 15.9.14 details the potential for piling to be required as part of the modifications to the Point of Ayr (PoA) terminal. However, it is not clear where within the PoA application site the piling may be	The Applicant confirms that no piling activities will be required within the intertidal zone during the cable laying and burial, therefore further mitigation is not proposed.

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		required. We therefore advise that your Authority confirms whether piling would be required within the intertidal zone. If piling would occur in the intertidal zone, then further information/mitigation would be required. We advise that project-specific noise modelling may be required if other mitigation cannot be implemented, depending on the size of piles and duration of piling.	
		General We note reference to conservation status but no specific reference to Current Conservation Status (CCS) or Favourable Conservation Status (FCS). There is also no reference to EC EPS Guidance regarding this e.g. Commission notice Guidance document on the strict protection of animal species of Community interest under the Habitats Directive C/2021/7301 final. However, we would not be concerned about this being considered as part of the EPS licensing application for the proposals. The Applicant should note that a hierarchical geographical scaled approach may not be applicable when demonstrating no detriment to maintenance of FCS; the above EC guidance indicates assessments at various spatial scales.	Consideration of CCS and FCS will be included within any subsequent EPS licence application. The Applicant has considered impacts to species at the appropriate geographical scale and the context of likely impact from construction and operation.
		Schedule 1 birds We advise that as currently proposed, the works could cause disturbance to little tern. For example, paragraph 7.5.7 of appendix A: Habitats Regulations Assessment Information to Inform an Appropriate Assessment, states that 'a watching brief would be undertaken by the Ecological Clerk of Works (ECoW) in relation to the established Little Tern colony if any construction works are to be undertaken around the PoA Terminal between April and July, inclusive para. 7.5.8 states that 'If any birds are showing disturbance behaviour within the 300m buffer zone during any stage of the works, the ECoW would stop work until it can be determined that disturbance has subside''. We advise that disturbing the birds, then stopping works after the disturbance has occurred, would still be classed as a disturbance of a Schedule 1 species, as the disturbance event will have already occurred. We therefore advise that the detailed CEMP should include a commitment that, if construction works are due to be undertaken between April and July inclusive, and if there is any habitat with the potential to be used for little tern nesting within 300m of the development, the ECoW should check for little tern breeding activity	The Applicant has noted this comment, which would be covered under the scope of the ECoW.

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		before any works are undertaken. If nesting little tern are present within 300m of the proposed development, no works should be undertaken.	
31 May 2023	Flintshire County Council comments received in relation to planning application to FCC, application reference FUL/000246/23	**Dee Estuary SAC – Intertidal Works** An intertidal plough will be used to lay cable on completion of creation of the cable route through the dunes. The zone of disturbance for the cable installation is expected to be around 15 metres total width for each cable. The two cables from PoA Terminal to Douglas Offshore Platform are expected to be laid at a minimum separation distance of 30 metres, within two separate trenches. The minimum cables burial depth (top of cables) is expected to be between two and three metres. The spatial extent of the effect will be very small and of short duration. Works will be undertaken at low tide to reduce the risk of sediment contamination. NRW have raised issues regarding their installation; clarification is required regarding their concerns the key one being confirmation that an intertidal plough will be used rather than trenching as suggested elsewhere in the ES. Operational impacts: Compression at the Terminal will increase the temperature of the CO_2 and although cooled by the air coolers as far as practicable, the CO_2 will remain above ambient temperature. Heat modelling (ref 9.56) indicates that ground soil 10m either side of the pipeline will be affected by the presence of hot fluid inside the pipe but there will be a minimal impact on change in temperatures of soil or sand beyond a distance of approx. 1m from the top of the pipe due to the low thermal conductivity of soil and sand. EMFs are generated by the current that passes through the cables. However, they are only likely to be detectable within the immediate vicinity of the cables with negligible impact at 0.5m above them. The depth of the cables means there is not likely to be a significant impact on fish or benthic invertebrates, however NRW require clarification.	See this **Offshore ES at Chapter 3 – Proposed Development Description** for further details on the cable trencher installation methodology. See response to NRW comments in relation to TCPA Onshore ES Chapter 3: para. 3.4.58, ES Chapter 9, para. 9.8.7 and ES Chapter 9: para. 9.9.21 for clarification on potential impacts to the priority habitat/Annex I habitat caused by the cable installation works using a cable plough or cable trenching machine through the Foreshore area. Please see responses to NRW comments in relation to TCPA Onshore ES Chapter 9: para. 9.9.85 and ES Chapter 9: para. 9.9.93 for details relating to heat modelling and EMF, respectively. Please see responses to NRW comments in relation to TCPA Onshore ES Chapter 9: para. 9.9.21 for clarification on potential impacts to the Dee Estuary from sediment dispersion numerical modelling

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
		Dee Estuary SAC – Foredunes The HDD exit hole location and relevant equipment yard will fall within the intertidal habitat adjacent to the sensitive embryonic/foredune habitat. A temporary access route for the foreshore works is proposed along the boundary of the dune habitat which comprises bare sand. The route will be matted to minimize damage. REAC: T- BD- 005 REAC: T BD 047 references the specific pollution prevention measures to be put in place.	**This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**
		Dee Estuary SAC – Compound (temporary parking area) Compound (temporary Parking Area) will be located in the Talacre Beach car park, on bare ground within the existing fenced parking area and will avoid sensitive saltmarsh habitat. Protective measures/fencing and monitoring will be provided to avoid damage REAC T-BD-006	**This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**
		Dee Estuary SAC – Impacts to aquatic environment construction pollution / operational discharge Pollution prevention and surface water management is included within the OCEMP and REAC. A Biosecurity Risk Assessment and a non native invasive species management plan will be produced to address potential spread of invasive non-native species from intertidal ploughing activities. REAC T-BD-032-033	The Applicant confirms that pollution prevention measures and surface water management are secured within measures **T-WR-004 to T-WR-029** of the **REAC.** The Applicant also confirms that mitigation in relation to INNS (Biosecurity Method Statement) is secured within measures **T-BD-032 and 033** of the **REAC.** **This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**
		Dee Estuary SAC – Changes in air quality Dust management plan to be provided as part of the agreed CEMP to include use of screens/barriers, covering of stockpile soils, dust suppression techniques etc as necessary to prevent dust deposition on the saltmarsh habitat.	A Dust Management Plan was submitted with the planning application within **Annex A of the OCEMP.** It will be implemented by the Construction Contractor and includes measures to control emissions, in addition to dust and PM10 mitigation measures. **This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**

Date	Consultee and Type of Response	Issues Raised	Response to Issue Raised and/or where Considered in this Chapter/ES
		Dee Estuary SAC – Heat generation and EMFs Compression at the PoA Terminal will increase the temperature of the CO_2 and although cooled by the air coolers as far as practicable, the CO_2 will remain above ambient temperature. Although the Foreshore Pipeline will be buried and insulated by its concrete coating, there is the potential for this to increase the temperature of the surrounding environment of the Foreshore Pipeline which has the potential to impact natterjack toad and sand lizard breeding opportunities and hibernation behaviour. Currently there are no natterjack toad or sand lizards found within the red line boundary but the long-term proposals are to enable the populations to expand. Heat modelling (ES Ch 9 Ref 9.56) indicates that ground soil 10m either side of the pipeline will be affected by the presence of hot fluid inside the pipe but there will be a minimal impact on change in temperatures of soil or sand beyond a distance of approx. 1m from the top of the pipe. What is the estimated depth of cables under the dunes? Presumably this will be as a depth that will not impact burrowing natterjacks (or sand lizards)? iii) PoA Construction compound within colliery site in close proximity to the Dee estuary and associated saltmarsh/mudflats/reedbeds to the south and east. There is already tree and shrub planting *in situ* but temporary screening can be provided to prevent noise and visual impacts on the estuarine habitats.	See the response to NRW comments above in relation to TCPA Onshore ES Chapter 9: para. 9.9.85, which provides further details regarding temperature modelling. In relation to the estimated depth of the cables, cables would be buried to the desired depth of 2-3 m. Soil temperature analysis showed that the pipeline had minimal impact on the change in soil/sand temperature over a distance of approximately 1m from the top of the pipe. Natterjack toads typically burrow to depths of less than 50 cm (although can be deeper in winter) and sand lizard burrow to up to 1 m deep. Therefore, when considering the depth of the pipe (3 m) and the minimal impact on change in temperature beyond 1m from the top of the pipe, impacts to burrowing natterjack toad and sand lizard are not predicted because of heat changes. The Applicant acknowledges the potential for screening in relation to working areas close to saltmarsh/mudflat/reedbed habitat, notably in relation to reducing disturbance to qualifying bird species of The Dee Estuary SPA and Ramsar. Measure **T-BD-037** of the **REAC** refers to this provision, if needed. **This has been taken into consideration within this Offshore ES, and the REAC and OCEMP commitments made within the Onshore ES, will be implemented by the Contractor for the Offshore works.**

7.5 Methodology to Inform the Baseline

A site-specific benthic characterisation survey and Phase 1 intertidal walkover survey were undertaken in 2022, which provided detailed information on the following:

- species assemblage and community structure;
- habitat classification;
- sediment contamination; and
- presence of species and habitats of conservation importance.

This survey was undertaken based on published guidance and best industry practice. A summary of this survey is presented in Table 7.6.

Table 7.6: Summary Of Site-Specific Survey Data

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
HyNet Carbon Capture and Storage (CCS) and Decommissioning Benthic Characterisation Survey	The survey covered two areas: (1) the CCS area and all associated infrastructures, and (2) existing Eni oil and gas infrastructure that is proposed to be either partly or fully decommissioned and repurposed.	Data was collected at 85 sampling stations using Drop Down Cameras (DDCs) and grab sampling (0.1 m^2 Day grab, 0.2 m^2 dual Van Veen grab, and a 0.1 m^2 mini-Hamon grab).	Ocean Ecology	2022	Summarised in volume 3, appendix I and presented in full in volume 3, appendix I1.
Phase 1 Intertidal Walkover Survey	A 500 m buffer either side of the existing 20" natural gas pipeline connecting the Point of Ayr Terminal to the Douglas platform was surveyed from MHWS to approximately Mean Low Water Springs (MLWS). This was undertaken on Talacre Beach at the Point of Ayr, near Prestatyn, North Wales.	A walkover survey was conducted over two days. Detailed notes on shore type, wave exposure, and sediments and species/biotopes present were collected. Exploratory digging for sub-surface fauna was undertaken on an ad hoc basis. Sieving was undertaken at seven sampling stations using a 0.5 mm mesh.	RPS	2022	Summarised in volume 3, appendix I and presented in full in volume 3, appendix I2.

There were no site-specific surveys undertaken to inform the fish and shellfish or marine mammal and marine turtle baseline characterisations. These topics were characterised in full through a detailed desktop review of key datasets, reports, and scientific publications. These included the results of site-specific monitoring undertaken at Consented Offshore Wind Farms (OWFs) which either overlap or are situated in proximity to the Proposed Development (e.g. Gwynt y Môr). These key desktop data sources are presented in Table 7.8, Table 7.11, and Table 7.14 for each marine biodiversity topic.

7.6 Identification of Designated Sites

All designated sites within the various marine biodiversity study areas defined for the three topic (refer to section 7) and relevant qualifying features that could be affected by the construction, operational and maintenance, and decommissioning phases of the Proposed Development were identified using the three-step process described below:

- Step 1: All designated sites of international, national and local importance within the marine biodiversity study areas were identified using various sources. These included interactive maps showing designated sites in the United Kingdom (UK) and Ireland from the National Park and Wildlife Service (NPWS) and the Joint Nature Conservation Committee (JNCC).
- Step 2: Information was compiled on the relevant Marine Biodiversity interest features for each designated site identified.
- Step 3: Using the above information and expert judgement, sites were considered further if:
  - A designated site with relevant Marine Biodiversity features directly overlapped with the Proposed Development, therefore having the potential to be directly affected by the Proposed Development; or
  - A designated site and associated features are located within the potential Zone of Influence (ZoI) for impacts associated with the Proposed Development, and therefore have the potential to be indirectly affected by the Proposed Development.

7.7 Important Ecological Features

IEFs are species or habitats considered to be important and potentially affected by the Proposed Development. They are considered to be important due to the quality or extent of the habitat, rarity of the species or habitat, or the extent to which the species or habitat is threatened (Chartered Institute of Ecology and Environmental Management (CIEEM), 2022). They are considered IEFs if they are designated under international, national, regional, or local legislation or conservation plans (e.g., Annex I habitats or Annex II species designated under the Habitats Directive, Oslo Paris Convention (OSPAR) List of Threatened and/or Declining habitats or species, or the UK Post-2010 Biodiversity Framework). In 2012, the UK Post-2010 Biodiversity Framework succeeded the UK Biodiversity Action Plan (UK BAP), and Species of Principal Importance (SPI) and Habitats of Principal importance (HPI) were drafted for England, Scotland, Wales, and Northern Ireland under the following legislation:

- Section 41 of the Natural Environment and Rural Communities Act 2006 (England);
- Section 2(4) of the Nature Conservation (Scotland) Act 2004;
- Section 7 of the Environmental Act (Wales); and
- Section 3(1) of the Wildlife and Natural Environment Act (Northern Ireland) 2011.

The criteria used to inform the valuation of IEFs are presented in Table 7.7, while the IEFs identified and their conservation status and valuation of importance are presented in their respective marine biodiversity sections below (Table 7.10, Table 7.13, and Table 7.20).

Table 7.7: Criteria Used To Evaluate The IEFs In The Marine Biodiversity Sections

Value of IEF	Criteria to Define Value
International	• Internationally designated sites (e.g., Special Areas of Conservation (SACs)). • Habitats and species protected under international law that are listed as a qualifying feature of an internationally designated site (e.g., Annex I habitats, Annex II species, or European Protected Species (EPS) within a SAC boundary). • Listed under Appendix I and II of the Bonn Convention on the Conservancy of Migratory Species of Wild Animals (hereafter: 'The Bonn Convention'). • Listed under Annex II (strictly protected fauna) or Annex III (protected fauna) of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (hereafter: 'The Bern Convention'). • Listed under the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES).
National	• Nationally designated sites (e.g., MCZs). • Species or habitats protected under national law (e.g., UK Post-2010 Biodiversity Framework).

Value of IEF	Criteria to Define Value
	• OSPAR List of Threatened and/or Declining Species and Habitats within OSPAR Region III (Celtic Seas). • Annex I habitats not within a SAC boundary. • Internationally protected species (including EPS) that are not qualifying interest features of a designated site but are regularly recorded within the various marine biodiversity study areas in relatively low densities. Therefore, this area is not considered to be important for these species at an international context. • Internationally protected species or habitats that are not qualifying interest features of a designated site but are listed as SPIs or HPIs on a local action plan within the various marine biodiversity study areas.
Regional	• Habitats or species that provide important prey items for other species of conservation value. • Fish and shellfish species that have spawning and/or nursery grounds within the regional fish and shellfish ecology study area that are important regionally (i.e., they may spawn in other parts of UK and Irish waters but this is a key spawning/nursery area). • Internationally protected species or habitats that are not qualifying interest features of any designated sites and are infrequently recorded within the local marine biodiversity study areas in very low numbers compared to other regions of the UK and Ireland.
Local*	• Habitats and species which are not protected under conservation legislation, and may be common in UK and Irish waters, but form a key component of the marine biodiversity within the various marine biodiversity study areas. • Fish and shellfish with spawning and/or nursery grounds out with the Proposed Development but within the regional fish and shellfish ecology study area.

* The Local criteria are not applicable to marine mammals due to the high level of protection under international law for all marine mammal species.

7.8 Existing Baseline Description

7.8.1 Benthic Subtidal and Intertidal ecology

7.8.1.1 Study Area

To support the development of the benthic subtidal and intertidal ecology section, two study areas are defined:

- The Proposed Development benthic ecology study area: this is defined as the area encompassing the Proposed Development, offshore pipelines (including intertidal habitats up to the MHWS), and associated cables in Liverpool Bay (Figure 7.1). This is the area within which site-specific benthic surveys have been undertaken, the results of which will inform the baseline characterisation within this Technical Report.
- The regional benthic ecology study area: this is defined as the area encompassing the wider Irish Sea habitats and includes the neighbouring consented OWFs and designated sites (Figure 7.1). This area will be characterised by desktop data and will provide a wider context to the site-specific data collected within the benthic ecology study area.

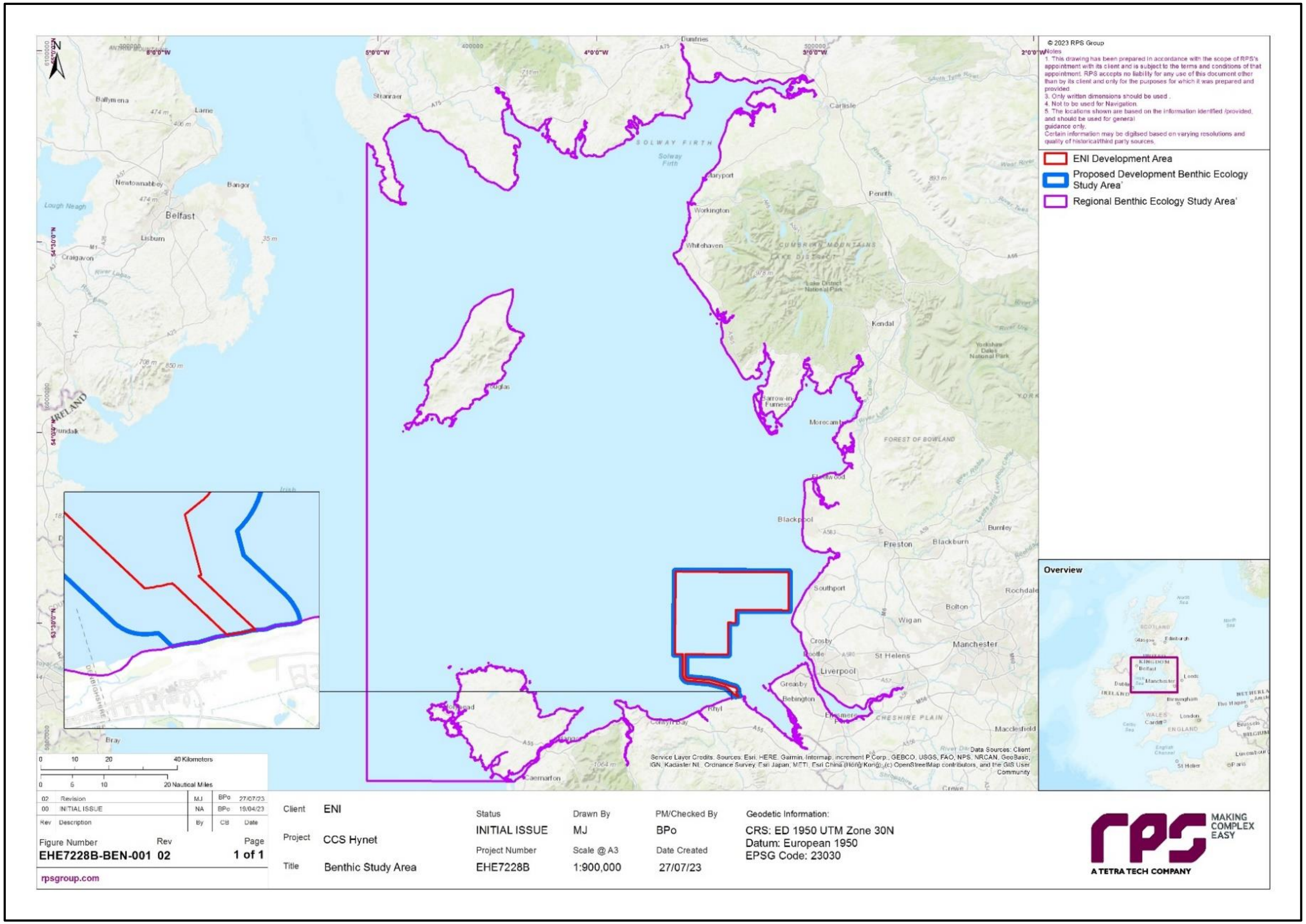


Figure 7.1: Benthic Ecology Study Area

7.8.1.2 Desktop Datasets

Information on benthic ecology was collected through a detailed desktop review of existing studies and datasets. These are summarised at Table 7.8 below. Further, two site-specific benthic surveys were undertaken in 2022, the results of which were used to characterise the benthic ecology baseline. Brief details on this survey are provided in Table 7.6, with a thorough summary presented in volume 3, appendix I and presented in full in volume 3 appendix I1 and appendix I2.

Table 7.8: Summary Of Key Desktop Reports For The Characterisation Of The Benthic Subtidal And Interdial Ecology Baseline

Title	Source	Year	Author
UK Offshore Energy Strategic Environmental Assessment Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil & Gas and Gas Storage and Associated Infrastructure OESEA4 2022 Environmental Report	BEIS	2022	BEIS
NBN Atlas	NBN Atlas	2021	NBN Atlas
Awel y Môr Preliminary Environmental Information Report: volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology	RWE Renewables UK	2021	RWE Renewables UK, 2021a
Awel y Môr Preliminary Environmental Information Report: volume 4: Annex 5.3: Benthic Ecology Intertidal Characterisation	RWE Renewables UK	2021	RWE Renewables UK, 2021b
JNCC MPA Mapper	JNCC	2020	JNCC
European Union (EU) SeaMap	European Marine Observations and Data Network (EMODNet)	2019	EMODnet
Subtidal Ecology: In: Manx Marine Environmental Assessment (2nd Edition)	The Government of the Isle of Man	2018	Howe, 2018a
A big data approach to macrofaunal baseline assessment, monitoring and sustainable exploration of the seabed	Centre for Environment, Fisheries, and Aquaculture Science (Cefas)	2017	Cooper and Barry
Dredged material disposal site monitoring around the coast of England: results of sampling (2015-2016).	Cefas	2016	Bolam *et al.*
Burbo Bank OWF Benthic and Annex I Habitat Pre-construction Survey Field Report	Burbo Bank OWF (UK) Ltd and DONG Energy	2015	Centre for Marine and Coastal Studies (CMACS)
Rhiannon OWF Preliminary Environmental Information Chapter 9 Benthic Ecology	Celtic Array Ltd.	2014	Celtic Array Ltd. 2014a
Walney OWF Year 3 postconstruction benthic monitoring technical survey report (2014 survey).	Walney OWF (UK) Ltd and DONG Energy	2014	CMACS

Title	Source	Year	Author
Burbo Bank Extension OWF Environmental Statement volume 2 – Chapter 12: Subtidal and Intertidal Benthic Ecology	DONG Energy	2013	DONG Energy, 2013a
Volume 1 Environmental Statement Walney Extension, Chapter 10: Benthic Ecology	DONG Energy	2013	DONG Energy, 2013b
Ormonde OWF Year 1 post-construction benthic monitoring technical survey report (2012 survey)	RPS Energy	2012	CMACS, 2012a
Walney OWF Year 1 post construction benthic monitoring technical survey report (2012 survey)	Walney OWF (UK) Ltd and DONG Energy	2012	CMACS, 2012b
Burbo Bank Extension OWF EIA Scoping Report	DONG Energy	2010	Sørensen *et al*.
Burbo Bank OWF Pre-construction Contaminants Investigation	Burbo Bank OWF (UK) Ltd and DONG Energy	2005	CMACS, 2005a
Gwynt y Môr OWF Marine Ecology Technical Report	Centre for Marine and Coastal Studies (CMACS)	2005	CMACS, 2005b
Gwynt y Môr OWF Environmental Statement volume 1	npower renewables Ltd. and Gwynt y Môr OWF	2005	npower renewables Ltd.
Post-construction Results from The North Hoyle OWF	North Hoyle OWF	2005	May
Broadscale seabed survey to the east of the Isle of Man	The University of Liverpool for British Petroleum	1997	Holt *et al.*
Offshore benthic communities of the Irish Sea	Mackie	1990	Mackie

7.8.1.3 Subtidal Sediments

Overall, the regional benthic ecology study area was predominantly comprised of deep circalittoral coarse sediment, circalittoral sandy mud, circalittoral fine sand, circalittoral muddy sand, and deep circalittoral sand (EMODnet, 2019). Tide-swept circalittoral mixed sediments are present in deeper sections, such as in the south of the regional benthic ecology study area (BEIS, 2022). In the nearshore, along the North Wales coast and west coast of England, the sediment is largely sandy mud or muddy sand (BEIS, 2022). Liverpool Bay, and more specifically the regional benthic ecology study area, is therefore largely comprised of sandy, gravelly and muddy sediments.

Overall, the Proposed Development benthic ecology study area was predominantly comprised of deep circalittoral coarse sediment, circalittoral coarse sediment, circalittoral find sand or circalittoral muddy sand, and deep circalittoral sand (EMODnet, 2019). The results of the site-specific survey demonstrated varying amounts of mud, gravel, and sand across the sampling stations, with sand being the main component. Finer sediments were also recorded in the decommissioning sampling stations, which could be associated with drill cuttings. No known Annex I Sandbanks, or OSPAR threatened and declining habitats found to be located within the Proposed Development benthic ecology study area. However, there was a small area of Annex I Reef located within the Proposed Development along the northern border. Furthermore, Subtidal Mixed Muddy

Sediment, which is listed as a HPI under the UK Post-2010 Biodiversity Framework, was identified across the south-west of the Proposed Development.

7.8.1.4 Sediment Contamination

Arsenic (As) and Cadmium (Cd) exceeded Cefas Action Level (AL) 1 at one sampling station each (GS23 and GS34, respectively), and Mercury (Hg) was above the OSPAR Background Assessment Concentration (BAC) levels in seven sampling stations (GS10, GS31, GS32, GS33, GS34, GS66, GS68). Zinc (Zn) was the most abundant metal across all samples; however, concentrations never exceeded any reference levels. All metals occurred in concentrations comparable to existing background data or in line with the range of concentrations known for areas located in proximity of active platforms. None of the polycyclic aromatic hydrocarbons (PAHs) exceeded Cefas AL1 at any of the CCS and full decommissioning stations, while chrysene and benzo[a]pyrene were above Cefas AL1 at one partial decommissioning station (GS36). A positive correlation was observed between chrysene, benzo[a]pyrene and mud content with higher PAHs concentrations in muddier sediments apart from station GS36 which had the highest chrysene and benzo[a]pyrene concentrations but an average mud content. No relationship was observed between the concentration of PAHs and proximity to platforms that could have indicated dispersal of drill cuttings. Total hydrocarbon content (THC) was the highest (30,600 µg/kg) at partial decommissioning station GS36, where chrysene and benzo[a]pyrene were found to exceed Cefas AL1. In the North Sea, THC concentrations at locations between 1 and 2 km from an active platform range between 32,710 µg/kg and 33,810 µg/kg, in line with the findings at station GS36 which was located in proximity of a platform. All polychlorinated biphenyls (PCBs) were measured below detection limits at all CCS stations and did not exceed Cefas AL1 at any of the decommissioning stations. All organotins measured (dibutyltin and tributyltin) were below the detection limit at all sampling stations.

7.8.1.5 Seabed Communities

A diverse macrobenthic assemblage was identified across the site-specific survey area, including both CCS and decommissioning areas. A total of 2,001 individuals and 215 taxa recorded across CCS stations, with the brittlestar *Amphiura filiformis* being the most abundantly recorded taxon accounting for 15.3% of all individuals identified. Key epifaunal taxa identified in CCS samples were the tube worm *Spirobranchus triqueter*, which accounted for 20% of all individuals, and Actinaria which was identified in 30% of all samples. A total of 13,332 individuals and 322 taxa were recorded within decommissioning samples. Most decommissioning stations were characterised by the presence of Nemertea and *Kurtiella bidentata*, which occurred in 98% of samples. The epifaunal community was characterised by relatively high numbers of the common brittlestar *Ophiothrix fragilis* and Actiniaria, with the latter being also the most frequently occurring taxon.

The Particle Size Analysis (PSA) and the macrobenthic data clearly indicated the presence of a heterogeneous substrate and a diverse macrobenthic community across the site-specific survey area. Despite sand being the dominant size fraction at all sampling stations, the relative contributions of mud and gravel greatly varied among stations, resulting in the presence of an intricate mosaic of substrates across the survey area. Sediment heterogeneity and the diverse macrobenthic community observed meant that no clear biotopes could be defined. As such, EUNIS classifications were limited to a EUNIS level 4 at most stations. However, several biotopes illustrative of the HPIs 'Subtidal sands and gravels' and 'Mud habitats in deep water' were identified (Table 7.10).

7.8.1.6 Intertidal Communities

The Phase 1 Intertidal Walkover survey recorded a range of species and biotopes typical for the area, and commonly occurring around the UK. The survey area was within the Dee Estuary/Aber Dyfrdwy SAC. A primary reason for the selection of this SAC was the Annex I Habitat (1140) Mudflats and sandflats not covered by seawater at low tide. This habitat includes the following biotopes which were recorded in the survey area:

- Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal);
- Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa);
- Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa); and

- *Macoma balthica* and *Arenicola marina* in littoral muddy sand (LS.LSa.MuSa.MacAre).

Species recorded during this intertidal survey included polychaetes (A. *marina, L. koreni, A. defodiens, O. fusiformis, L. conchilega*, and *Glycera* sp.), bivalves (*M. Balthica, M. Tenius,* and *S. plana*), gastropods (*L. littorea* and *P. catenus*), and various fish and shellfish species (such as green shore crab *Carcinus maenus*, common cockle *Cerastoderma edule*, brown shrimp *Crangon crangon*, and juvenile flatfish).

7.8.1.7 Designated Sites

There are a number of designated sites that occur within the regional benthic ecology study area. These sites are further detailed in Table 7.9. Several of these sites are included in the Natural England and JNCC advice document on key sensitivities of habitats and MPAs to offshore cabling (Natural England and JNCC, 2019). These include: the Solway Firth SAC, West of Copeland MCZ, West of Walney MCZ, Morecambe Bay SAC, Shell Flat and Lune Deep SAC, and the Dee Estuary SAC/Aber Dyfrdwy SAC.

Table 7.9: Sites Designated For Relevant Benthic Subtidal And Intertidal Qualifying Features Located Within The Regional Benthic Ecology Study Area

Designated Site	Minimum Distance to Proposed Development (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
Fylde MCZ	0.00	The Fylde MCZ was designated in 2013 in order to maintain the broadscale habitat "subtidal sand" and the habitat of conservation importance "subtidal sands and gravels", which are situated within the MCZ boundary. **Relevant Qualifying Features:** subtidal sand (EUNIS Habitat A5.3) and subtidal mud (EUNIS Habitat A5.3). These habitats are highly productive and have been shown to support diverse bivalve mollusc populations, including species the nut shell *Nucula nitidosa*, razor shell *Pharus legumen* and white furrow shell *Abra alba* (Natural England, 2019).
Dee Estuary SAC/Aber Dyfrdwy SAC	0.00	The Dee Estuary is one of the largest estuaries within the UK, comprising an area of over 140 km^2, with an intertidal area made up of predominantly mudflats, sandflats and saltmarsh. The estuary lies on the boundary between England and Wales. **Relevant Qualifying Features:** the following Annex I habitats are primary reasons for the designation of this SAC: Mudflats and sandflats that are not covered by seawater at low tide (1140), Salicornia and other annuals colonizing mud and sand (1310), and Atlantic salt meadows *Glauco-Puccinellietalia maritimae* (1330). Annex 1 Estuaries (1130) are also present, but not a primary reason for designation (JNCC, 2023a).
Ribble Estuary SSSI	2.70	The Ribble Estuary SSSI is located on the coast of Lancashire and Merseyside and covers an area of 92.26 km^2. The SSSI also contains the Ribble Marshes National Nature Reserve. **Relevant Qualifying Features:** A survey in the north of the site (Natural England, 2015), near Lytham-St-Annes, found the upper shore to be characterised by sandy habitat with a range of polychaete species and amphipods. The fauna in sediments on the lower shore area identifying high numbers of juvenile brittlestars and fragments of hydroids and bryozoans. A large number of empty razor shells *Ensis* spp. were also present scattered over the sediment surface.
Menai Strait and Conwy Bay SAC/Y Fenai a Bae Conwy SAC	13.54	The Menai Strait and Conwy Bay SAC is located in north-west Wales and characterised as having unique physiographic conditions that are critical for marine wildlife (NRW, 2018). The variations in sediment composition, water clarity, and tidal regime result in a diverse collection of marine communities (NRW, 2018).

Designated Site	Minimum Distance to Proposed Development (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
		Relevant Qualifying Features: the following Annex I habitats are primary reasons for the designation of this SAC: Mudflats and sandflats that are not covered by seawater at low tide (1140), Sandbanks which are slightly covered by sea water all the time (1110), and Reefs (1170). Annex 1 Large shallow inlets and bays (1160) and Submerged or partially submerged sea caves (8330) are also present, but not a primary reason for designation (JNCC, 2023c).
Shell Flat and Lune Deep SAC	15.18	The Shell Flat and Lune Deep SAC is located approximately 3 and 20 km from the east of the Lancashire Coast, at the mouth of Morecambe Bay, and is named after the deep water channel at Lune Deep and large sandbank features (Shell Flat) in the north and south of the SAC (JNCC, 2023b). **Relevant Qualifying Features:** Annex I Sandbanks which are slightly covered by sea water all the time (1110) and Reefs (1170) are the primary reasons for the designation of the SAC (JNCC, 2023b).
Creigiau Rhiwledyn/Little Ormes Head SSSI	15.45	Creigiau Rhiwledyn/Little Ormes Head SSSI is located on the north Wales coastline and overlaps the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay SAC. This SSSI covers an area of 0.36 km^2 (Countryside Council for Wales (CCW), 2002). **Relevant Qualifying Features:** This site is notable for various marine biological features including specialised and nationally scarce cave, rockpool, overhang and rock-boring bivalve biotopes (physical habitats and their associated community of species including animals and plants) within the intertidal zone (CCW, 2002).
Pen Y Gogarth/Great Ormes Head SSSI	18.29	Pen Y Gogarth/Great Ormes Head SSSI is located on the north Wales coastline and overlaps the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay SAC, and covers an area of 3.03 km^2 (CCW, 2013). **Relevant Qualifying Features:** This site is notable for having a large area of moderately exposed rock, supporting a complete zonation of marine biotopes. It also has specialised and nationally scarce flora and fauna, most typically associated with rock pool, cave and limestone rock habitats found between the Great Orme and the Solway Firth (CCW, 2013).
Aber Afon/Conwy SSSI	21.43	Aber Afon/Conwy SSSI is located on the north Wales coastline, at the mouth of the river Conwy and overlapping with the Y Fenai a Bae Conwy/Menai Strait and Conwy Bay SAC, and covers an area of 12.95 km^2 (CCW, 2003). **Relevant Qualifying Features:** This site is notable as a high-quality example of an intertidal estuarine community (CCW, 2003). The site supports nationally important 'piddock' communities on eulittoral peat, eulittoral firm clay with blue mussel, lower eulittoral soft rock with toothed wrack *Fucus serratus* and sublittoral fringe soft rock with oarweed *Laminaria digitata* (CCW, 2003). In addition, the site supports specialised communities of shallow pools on mixed substrata with hydroids, ephemeral algae and common periwinkle *Littorina littorea* (CCW, 2003).
Morecambe Bay SAC	26.50	The Morecambe Bay SAC is a predominantly sandy bay at the confluence of the Leven, Kent, Lune and Wyre estuaries. It is one of the largest areas of intertidal flats in Britain and includes various habitat and sediment types (JNCC, 2023d). **Relevant Qualifying Features**: the following Annex I habitats are primary reasons for the designation of this SAC: Estuaries (1130), Mudflats and sandflats that are not covered by seawater at low tide (1140), Large shallow inlets and bays (1160), Salicornia and other annuals colonizing mud and sand (1310), and Atlantic salt

Designated Site	Minimum Distance to Proposed Development (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
		meadows (*Glauco-Puccinellietalia maritimae*) (1330). Annex 1 Sandbanks which are slightly covered by seawater all the time (1110), Coastal lagoons (1150), and Reefs (1170) are also present, but not a primary reason for designation (JNCC, 2023d).
West of Walney MCZ	28.73	The West of Walney MCZ is located offshore of Walney Island, Cumbria, and covers a total area of 388 km^2. The seabed habitat within the West of Walney MCZ is predominantly comprised of subtidal mud. This broad-scale habitat feature is considered part of an area known as the eastern Irish Sea mud belt. Sea-pen and burrowing megafauna communities (which is considered Threatened and/or Declining habitat in the north-east Atlantic, and specifically in the Irish Sea, by the OSPAR commission) makes up a component part of the subtidal mud habitat occurring within the site's boundary. This habitat is characterised by the presence of sea-pens (feather-like soft corals) and burrowing animals such as mud shrimp *Corophium valuator* and the Norway lobster *Nephrops norvegicus*, which is a commercially important species (JNCC, 2021a) **Relevant Qualifying Features:** Subtidal sand (EUNIS Habitat A5.3), Subtidal mud (EUNIS Habitat A5.3), and Sea-pen and burrowing megafauna communities (OSPAR list of threatened or declining habitats).
West of Copeland MCZ	47.13	The West of Copeland MCZ covers an area of 158 km^2, with seabed comprising of predominatly subtidal sand and subtidal coarse sediments. These habitats support a range of benthic species, such as worms, sea urchins, anemones, crustaceans, molluscs, and sea mats (JNCC, 2021b). **Relevant Qualifying Features:** subtidal coarse sediments (A5.1), subtidal sand (A5.2), and subtidal mixed sediments (A5.4) (JNCC, 2021b).
Drigg Coast SAC	70.06	The Drigg Coast SAC encompasses around 11 km, and is composed of extensive sand dunes, saltmarsh, intertidal mudflats and sandflats, and estuaries (MMO, 2019). **Relevant Qualifying Features:** The Annex I habitat, Estuaries (1130), present as a primary feature for site selection. Furthermore, the following Annex I habitats are also present as qualifying features but not primary reasons for site selection: Mudflats and sandflats not covered by seawater at low tide (1140), Atlantic salt meadows (Glauco-Puccinellietalia maritimae) (1330), and Salicornia and other annuals colonizing mud and sand (1310) (JNCC, 2023g).
Isle of Man Marine Nature Reserves (MNRs)	70.06 to 91.05	There are ten MNRs around the Isle of Man, encompassing 10.8% of Manx waters: Baie Ny Carrickey, Calf and Wart Bank, Douglas Bay, Langness, Laxey Bay, Little Ness, Niarbyl Bay, Port Erin Bay, Ramsay Bay, and West Coast (Manx Wildlife Trust, 2023). **Relevant Qualifying Features:** although it varies between site, these MNRs are collectively designated for maerl, rocky reefs, kelp forests, eelgrass beds, brittlestar beds, sea caves, subtidal sandbanks, sea anemones, ocean quahog *Arctica islandica*, and the nudibranch *Cumanotus beaumonti* (Designation of MNR Guidance Notes, undated). Under Section 33 of the Wildlife Act (1990), the following benthic subtidal and intertidal features cannot be removed or damaged in any of the Isle of Man MNRs: maerl, rocky reefs, sea anemones, ocean quahog, and sea caves (Manx Marine Nature Reserves Byelaw, 2018).
Cumbria Coast MCZ	73.09	The Cumbria Coast MCZ is located on the west coast of England and stretches for approximately 27 km along the coast, covering a total area of 22 km^2 (Department for Environment, Food, and Rural Affairs (DEFRA), 2019d). This site is notable as it is an extensive

Designated Site	Minimum Distance to Proposed Development (km)	Site Description and Qualifying Features Related to Benthic Subtidal and Intertidal Ecology
		and important example of intertidal rocky shore habitats and associated communities on the sedimentary coast of north-west England (DEFRA, 2019d). **Relevant Qualifying Features:** high energy intertidal rock, honeycomb worm *Sabellaria alveolata* reefs, intertidal biogenic reefs, intertidal sand and muddy sand, intertidal underboulder communities, moderate energy infralittoral rock, and peat and clay exposures (DEFRA, 2019d).
Allonby Bay MCZ	116.32	The Allonby Bay MCZ is an inshore site on the English side of the Solway Firth, covering approximately 40 km^2. **Relevant Qualifying Features:** intertidal biogenic reefs, intertidal coarse sediment, intertidal sand and muddy sand, moderate energy infralittoral rock, subtidal biogenic reefs, subtidal coarse sediments, subtidal sand, subtidal mixed sediments, and *S. alveolate* beds (DEFRA), 2016).
Luce Bay and Sands SAC	122.06	The Luce Bay and Sands SAC is located on the south-west coast of Scotland. The variation in physical and environmental conditions throughout the site, including rock and soft sediment types, water clarity and exposure to tidal currents and wave action result in a wide range of habitats and associated marine communities (JNCC, 2023t). **Relevant Qualifying Features:** The Annex I habitats Large shallow intlets and bays (1160) and Shifting dunes along the shoreline with *Ammophila arenaria* (2120) are present as primary features for site selection. Furthermore, the Annex I habitats Reefs (1170), Sandbanks which are slightly covered by seawater at all time (1110), and Mudflats and sandflats not covered by seawater at low tide (1140) are present as qualifying features, but not a primary reason for site selection (JNCC, 2023t).
Solway Firth SAC	123.85	Solway Firth SAC is a large, shallow, and complex estuary with a diverse mix of intertidal habitats (tidal rivers, estuaries, mud flats, sand flats, lagoons, salt marshes and salt steppes) (JNCC, 2023f). **Relevant Qualifying Features:** The Annex I habitats Estuaries (1130), Sandbanks which are slightly covered by sea water at all times (1110), Mudflats and sandflats not covered by seawater at low tide (1140), Salicornia and other annuals colonizing mud and sand (1310), and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) are present as primary features for site selection. Furthermore, the Annex I habitat: Reefs (1170) is present as a qualifying feature, but not a primary reason for site selection (JNCC, 2023f).

7.8.1.8 IEFS

As detailed in section 7.7, the valuation of benthic subtidal and intertidal IEFs is defined at four levels: international, national, regional, and local. IEFs identified within the regional benthic ecology study area are presented in Table 7.10.

Table 7.10: Benthic Subtidal And Intertidal IEFs Within The Proposed Development Benthic Ecology Study Area

IEF	Description and Illustrative Biotopes	Importance within the Proposed Development Benthic Ecology Study Area	Justification
Subtidal Habitats and Species			
Subtidal Sands and Gravels	Subtidal sands and gravel sediments are the most common habitats found below the level of the lowest low tide around the coast of the United Kingdom and Ireland. Illustrative biotopes identified within the Proposed Development were: • Circalittoral coarse sediment (SS.SCS.CCS; A5.14) – *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen) • Infralittoral fine sand (SS.SSa.IfiSav; A5.23) – *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat) • Circalittoral fine sand (SS.SSa.CfiSa; A5.25) • Circalittoral muddy sand (SS.SSa.CmuSa; A5.26)	National	HPI under the UK Post-2010 Biodiversity Framework.
Mud Habitats in Deep Water	Mud habitats in deep water (circalittoral muds) that occur below 20 to 30 m in many areas of the UK and Ireland's marine environment. Illustrative biotopes identified within the Proposed Development were: • Circalittoral sandy mud (SS.SMu.CsaMu; A5.35) – *Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)	National	HPI under the UK Post-2010 Biodiversity Framework.
Subtidal Mixed Muddy Sediment	Subtidal Mixed Muddy Sediment was identified across the southern Proposed Development. This habitat may support a wide range of infauna and epibiota, including polychaetes, bivalves, echinoderms, anemones, hydroids and Bryozoa. Illustrative biotopes identified within the Proposed Development were: • *O. fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx).	National	OSPAR list of threatened and/or declining habitats and a HPI under the UK Post-2010 Biodiversity Framework.

IEF	Description and Illustrative Biotopes	Importance within the Proposed Development Benthic Ecology Study Area	Justification
Annex I Reef	An area of Annex I Reef was identified within the north of the Proposed Development (Figure 7.4). Representative biotopes are not available for this reef, however, based on existing habitat mapping derived from the JNCC, bedrock or stony reefs are thought to be present. In the assessment, it will be assessed alongside the other subtidal habitats and species IEFs.	National	Annex I Habitat out with an SAC boundary that overlaps with the Proposed Development.
Ross Worm (*Sabellaria spinulosa*)	A filter-feeding polychaete worm which can form biogenic reefs on the seabed and intertidal zone.	Local	*S. spinulosa* reefs are listed on the OSPAR list of threatened and/or declining habitats and a HPI under the UK Post-2010 Biodiversity Framework. However, no reefs were identified, only individual animals.
Intertidal Habitats and Species			
Mudflats and sandflats not covered by seawater at low tide	The following habitats were recorded during the Phase 1 Intertidal Walkover Survey, and are included in the Annex I Habitat Mudflats and sandflats not covered by seawater at low tide (1140): • Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal) • Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa) • Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa) • *M. balthica* and *A. marina* in littoral muddy sand (LS.LSa.MuSa.MacAre).	International	Annex I Habitat that overlaps with the Proposed Development. This habitat is a qualifying feature of the Dee Estuary/Aber Dyfrdwy SAC (see row below).
Designated Sites			
Dee Estuary/Aber Dyfrdwy SAC	The Dee Estuary is one of the largest estuaries within the UK, comprising an area of over 140 km^2, with an intertidal area made up of predominantly mudflats, sandflats and saltmarsh. The estuary lies on the boundary between England and Wales. The SAC is designated for the following Annex I Habitats: Mudflats and sandflats not covered by seawater at low tide (1140) and 1130 Estuaries (1130) (JNCC, 2023a). Mudflats and sandflats not covered by seawater at low tide are extensive	International	The Dee Estuary/Aber Dyfrdwy SAC is an internationally designated site which overlaps with the Proposed Development. The SAC overlaps with 0.21 km^2, which accounts for 0.13% of the total SAC area. Several Annex I Habitats are listed as qualifying features of this SAC.

IEF	Description and Illustrative Biotopes	Importance within the Proposed Development Benthic Ecology Study Area	Justification
	throughout the site and are present in the intertidal sections which overlap with the Proposed Development. For example, the sandy areas between Prestatyn and the Point of Ayr (PoA) mainly consist of mobile sands dominated by amphipods and polychaetes (Natural England and CCW, 2010). Although no defined biotopes are available, those presented for the Mudflats and sandflats not covered by seawater at low tide IEF above will also be applicable to the Dee Estuary/Aber Dyfrdwy SAC and used in the assessment.		
Fylde MCZ	Highly productive sediments of subtidal sand and subtidal mud that support a range of crustaceans, starfish, and shellfish, such as small nut-shell, razor shell, and white furrow shell. The area of the Fylde MCZ which overlaps with the Proposed Development has been assigned the biotope: Sublittoral sands and muddy sands (SS.SSa) (Envision Mapping, 2015), however has not been assigned more specific biotopes. As this area overlaps with the Subtidal sands and gravels IEF identified during the site-specific survey within the Proposed Development, the representative biotopes will also be used to characterise the Fylde MCZ in the assessment.	National	The Fylde MCZ is a nationally designated site which overlaps with the Proposed Development at parts. It overlaps with 41.40 km^2, which accounts for 15.87% of the total MCZ area.

7.8.1.9 Future Baseline Scenario

As per Offshore Oil & Gas Exploration, Production, Unloading and storage (Environmental Impact Assessment) Regulations 2020 and the Marine Works (Environmental Impact Assessment) Regulations 2007, an assessment of the future baseline conditions has been carried out in the event that the Proposed Development does not come forward. This is presented for each marine biodiversity topic, presented here for benthic subtidal and intertidal ecology, in section 7.8.2.10 for fish and shellfish, and in section 7.8.3.9 for marine mammals and marine turtles.

The baseline environment presented in this section and in volume 3, RPS Group (2024a) is extensive, and accurately representative, accounting for seasonality and interannual variability. However, this baseline is not static, and will exhibit larger degrees of natural change over longer time periods, due to naturally occurring cycles and processes and any potential changes resulting from climate change. This long-term change will occur even if the Proposed Development does not come forward. Thus, it will be necessary to contextualise any potential impacts that might occur over the expected 25-year operational lifetime of the Proposed Development when undertaking impact assessments.

In addition to the effects of climate change on the marine environment, variability and long-term changes on physical processes may cause direct and indirect effects to benthic habitats and communities in the mid to long term future (Department of Energy and Climate Change (DECC), 2016). The best evidence indicates that long term changes to benthic ecology may be related to long term changes in the climate or in nutrients (DECC, 2016), with shifts in abundances and species composition being driven by climatic processes. Currently, benthic communities are also influenced by anthropogenic activities. These include pollution and contamination, and seabed disturbing activities such as dredging, trawling, and development. A scientific review by the Marine Climate Change Impacts Partnership (MCCIP) concluded that climatic processes both directly (e.g. winter mortality), and indirectly (e.g. via hydrographic conditions), influence the abundance and species composition of seabed communities (MCCIP, 2008). In turn, alteration to the seabed communities could alter rates and timing of processes such as nutrient cycling, planktonic larval supply, and organic waste assimilation. Recently, DEFRA's focus on the risk of climate change to ecosystem services has centred on the following topics:

- INNS and their likely detriment to native communities and ecosystems;
- the increased risk to species as their distributions shift of disease from new pathogens; and
- the impacts on areas of high biodiversity value in the coastal zone from increased storms and erosion (HM Government, 2022).

DEFRA also highlight the risks associated with ocean acidification and higher water temperatures which are linked to climatic changes (HM Government, 2022).

7.8.2 Fish and Shellfish ecology

7.8.2.1 Study Area

Fish and shellfish are known to be highly variable, both spatially and temporally. Therefore, to effectively characterise the fish and shellfish ecology baseline, two study areas have been defined:

- The regional fish and shellfish ecology study area includes waters within England, Ireland, Wales, Scotland and the Isle of Man. The regional fish and shellfish ecology study area will allow for the characterisation of fish and shellfish receptors within the eastern Irish Sea, accounting for migration and additional spatial and temporal variability. The regional fish and shellfish ecology study area is therefore defined as the area encompassing the ICES Statistical Area VIIa, Proposed Development, offshore pipelines (including intertidal habitats up to the MHWS), and associated cables in Liverpool Bay (Figure 7.2).
- Where information is available, fish and shellfish ecology has been assessed on a local scale, within the Proposed Development fish and shellfish ecology study area. This area is the same as the Proposed Development, which includes the offshore pipelines (including intertidal habitats up to the MHWS) and associated cables in Liverpool Bay (Figure 7.2).

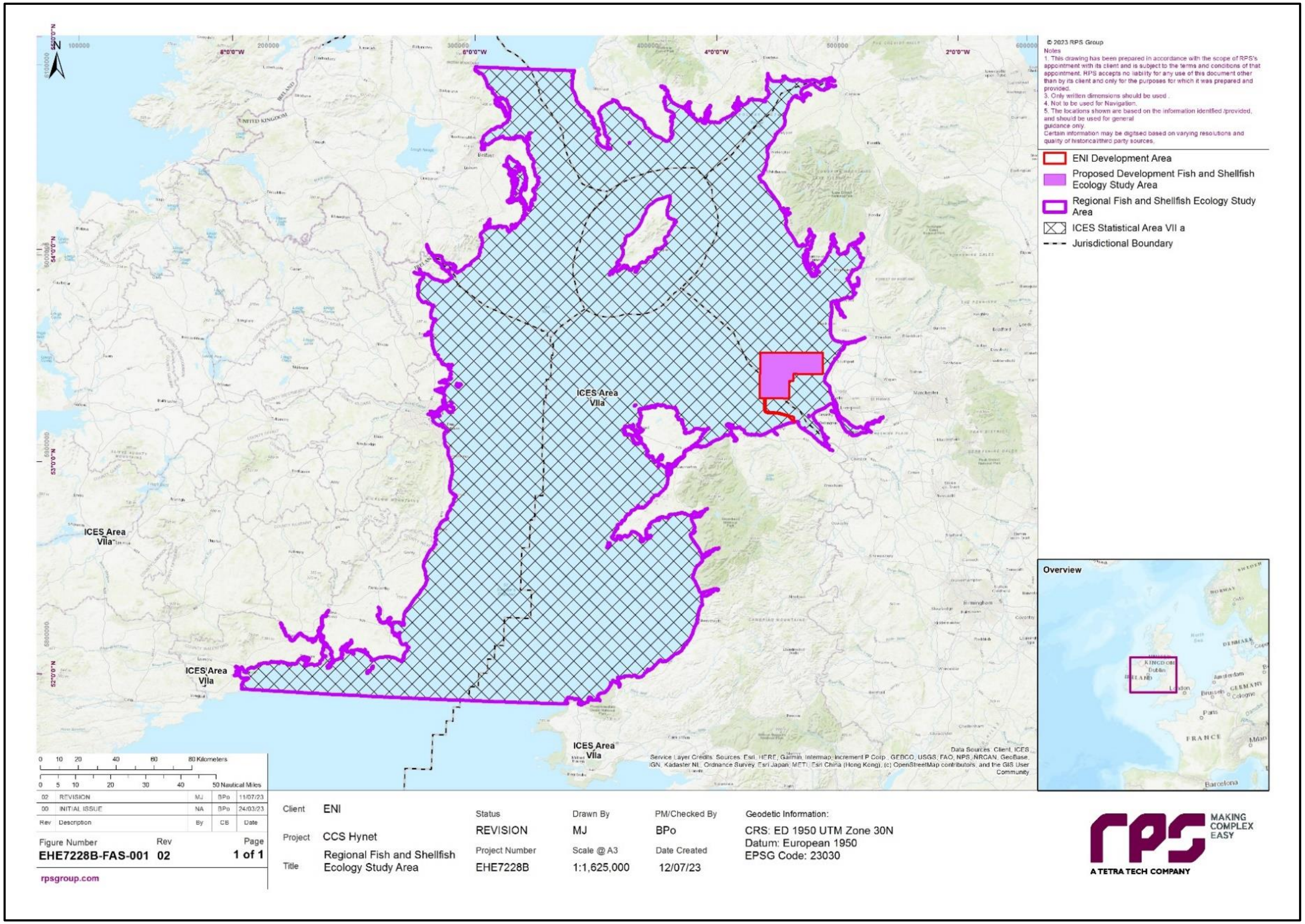


Figure 7.2: Regional Fish And Shellfish Ecology Study Area

7.8.2.2 Desktop Datasets

The fish and shellfish ecology baseline within the regional fish and shellfish ecology study area was characterised by a thorough review of key desktop datasets. Information on these and full details are presented in volume 3, appendix I, and a summary of the key desktop sources utilised is presented in Table 7.11.

Table 7.11: Summary Of Key Desktop Reports For The Characterisation Of The Fish And Shellfish Ecology Baseline

Title	Source	Year	Author
Fishbase Species Records	Fishbase	2023	Fishbase
National Parks and Wildlife Service (NPWS) Designations Viewer	NPWS	2023	NPWS
Celtic Seas ecoregion – Fisheries overview, including mixed-fisheries considerations	International Council for the Exploration of the Seas (ICES)	2022	ICES
Review of the Irish Sea	Irish Sea Network	2022	Irish Sea Network
CMACS Rhly Flats OWF Benthic Grab Survey, 2006 Survey	Ryhl Flats OWF	2021	Marine Data Exchange
NBN Atlas	NBN Atlas	2021	NBN Atlas
Spawning and nursery grounds of forage fish in Welsh and surrounding waters	Cefas	2021	Campanella and van der Kooij
Pressures on forage fish in Welsh Waters	Cefas	2021	van der Kooij *et al.*
JNCC MPA Mapper	JNCC	2020	JNCC
Bass and Ray Ecology in Liverpool Bay	Bangor University	2020	Moore *et al.*
Marine Life Information Network (MarLIN): Biology and Sensitivity Key Information Reviews	MarLin and Plymouth Marine Biological Association of the United Kingdom	2007 – 2020	MarLIN (assorted authors)
Application for Offshore Carbon Storage Licence Environmental Appendix Liverpool Bay Area Environmental Sensitivity Assessment	Eni	2019	Eni UK
Sectoral Marine Plan for Offshore Wind Energy. Strategic Habitat Regulations Appraisal (HRA): Screening and Appropriate Assessment Information Report – Final. Appendix I: Fish Literature Review	ABPMer	2019	ABPMer
Welsh Waters Scallop Surveys and Stock Assessment	Bangor University	2019	Delargy *et al.*

Title	Source	Year	Author
Updating fisheries sensitivity maps in British Waters	Marine Scotland	2014	Aires *et al.*
Ormonde OWF Adult and Juvenile Fish and Epi-benthic Post-construction Survey	Ormonde OWF	2013a	Brown and May Marine Ltd.
Walney Offshore Wind Farm, Year 2 Post-construction Monitoring Fish and Epibenthic Survey.	Walney OWF	2013b	Brown and May Marine Ltd.
Burbo Bank Extension Adult and Juvenile Fish Characterisation Surveys	Burbo Bank OWF	2013a	DONG Energy, 2013
Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat	MarineSpace	2013	Latto *et al.*
Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas	MarineSpace	2013	Reach *et al.*
Spawning and nursery grounds of selected fish species in UK waters	Cefas	2012	Ellis *et al.*
Ormonde OWF Adult and Juvenile Fish and Epi-benthic Post-construction Survey	Ormonde OWF	2012a	Brown and May Marine Ltd.
West of Duddon Sands Offshore Wind Farm, Adult and Juvenile Fish and Epibenthic Pre-Construction Surveys	West of Duddon Sands OWF	2012b	Brown and May Marine Ltd.
EIA Scoping Report	Rhiannon Wind Farm Limited	2012	Centrica Energy and DONG Energy
Pre-construction monitoring 2010 survey	Gwynt y Mor OWF	2011	CMACS
Burbo Bank OWF, Year 3 Post-construction 2m beam trawl report (2009 survey)	Burbo Bank OWF	2011	SeaScape
Autumn fish trawl survey	Celtic Array (Zone 9)	2010	CMACS
Burbo Bank OWF, First Post-Construction 2m beam trawl report (2007 survey)	Burbo Bank OWF	2008	SeaScape

Title	Source	Year	Author
Burbo Bank OWF Post-construction Marine Fish 4m Beam Trawl Survey	Burbo Bank OWF	2006	CMACS
Post-construction Results from The North Hoyle OWF	North Hoyle OWF	2005	May
Gwynt y Mor Offshore Wind Farm Marine Ecology Technical Report	Gwynt y Mor OWF	2005b	CMACS
Fisheries Sensitivity Maps in British Waters	Cefas	1998	Coull *et al.*

7.8.2.3 Marine fish

There are a range of marine fish with the potential to be present within the regional fish and shellfish ecology study area, comprised of demersal, pelagic, and benthopelagic species. Demersal species include sandeels Ammodytidae, blennies Blenniiformes, gobies Gobiidae, wrasses Labridae, and a wide range of flatfish, such as flounder *Platichthys flesus*, halibut *Hippoglossus hippoglossus*, lemon sole *Microstromus kitt*, plaice *Pleuronectes platessa*, sole *Solea solea*, solenette *Buglossidium leteum*, thickback sole *Microchirus variegatus*, and turbot *Scophthalmus maximus*. Benthopelagic species include anglerfish *Lophius piscatorius*, cod *Gadus morhua*, European hake *Merluccius merluccius*, haddock *Melanogrammus aeglefinus*, ling *Molva molva*, pollock *Pollachius pollachius*, poor cod *Trisopterus minutus*, and saithe *Pollachius virens*. Finally, pelagic species include herring *Clupea harengus*, mackerel *Scomber scombrus*, sprat *Sprattus sprattus*, and potentially European anchovy *Engraulis encasicolus*, European sardine *Sardina pilchardus*, and garfish *Belone belone.*

7.8.2.4 Diadromous fish

Diadromous fish species with the potential to be present within the regional fish and shellfish ecology study area during at least one portion of their migratory life cycle include Atlantic salmon *Salmo salar,* allis shad *Alosa alosa*, European eel *Anguilla anguialla*, river lamprey *Lampetra fluviatilis*, sea lamprey *Petromyzon marinus*, sea trout *S. trutta*, smelt *Osmerus eperlanus*, and twaite shad *A. fallax*.

7.8.2.5 Elasmobranchs

Elasmobranchs (e.g. sharks, rays, and skates) with the potential to be present within the regional fish and shellfish ecology study area include basking shark *Cetorhinus maximus*, blonde ray *Raja brachyura*, common smoothhound *Mustelus mustelus*, cuckoo ray *R. naevus,* lesser spotted dogfish *Scyliorhinus canicula,* nursehound *S. stellaris*, spotted ray *R. montagui*, spurdog *Squalus acanthias*, thornback ray *R. clavata,* and tope *Galeorhinus galeus*.

7.8.2.6 Shellfish

Shellfish species with the potential to be present within the regional fish and shellfish ecology study area include molluscs such as blue mussel *Mytilus edulis*, common cockle, common whelk *Buccinum undatum*, king scallop *Pecten maximus*, queen scallop *Aequipecten opercularis*, and squid *Loligo* spp and ommastrephidae. Crustaceans include brown crab *Cancer pagurus*, brown shrimp, green shore crab, European lobster *Hommarus gammarus*, Norway lobster *Nephrops norvegicus*, spiny lobster, swimming crabs *Liocarcinus spp.*, and velvet swimming crab *Necora puber*.

In addition, freshwater pearl mussel *Margaritifera margaritifera* in rivers and streams flowing into the regional fish and shellfish ecology study area has the potential to be indirectly affected due to its obligate parasitic life cycle stage with Atlantic salmon and sea trout.

7.8.2.7 Spawning and nursing grounds

The regional fish and shellfish ecology study area provides spawning and nursery grounds for a number of ecologically and commercially important fish and shellfish species. These are briefly summarised here, with a detailed account (including figures) provided in volume 3,

Data from Cefas (Ellis *et al.*, 2012) and fisheries sensitivity maps (Coull *et al.*, 1998) provide spatially explicit diagrams of the nursery and/or spawning areas for key species. These data illustrate that spawning grounds for species such as cod, ling, mackerel, plaice, sandeel, sole, sprat, and whiting overlap with the Proposed Development. In addition, there are spawning grounds in the vicinity of the Proposed Development in the wider Liverpool Bay area for horse mackerel, lemon sole, and Norway lobster. Nursery grounds for anglerfish, cod, herring, mackerel, plaice, sandeel, sole, spotted ray, spurdog, thornback ray, tope shark, and whiting also overlap with the Proposed Development. In addition, there are nursery grounds in the vicinity of the Proposed Development in the wider Liverpool Bay area for haddock, lemon sole, and Norway lobster.

More recently, Aires *et al.* (2014) and Campanella and van der Kooij (2021) published reports which enhanced the spawning and nursery ground data presented in Coull *et al.* (1998) and Ellis *et al.* (2012) for certain species. Further detail on these can be found in on a species-by-species basis volume 3, appendix I.

In addition, the results of the PSA conducted during the site-specific benthic characterisation survey (section 7.8.1) were used to assess herring and sandeel spawning habitat suitability within the Proposed Development. This was undertaken following the methodology presented in Latto *et al.* (2013) and Reach *et al.* (2013). These species spawn on the seabed and are, therefore, particularly sensitive to seabed disturbance. They have specific spawning habitat preferences, based on the composition of sands, gravels, and muds. For herring, 1.31% of all sampling stations were classified as 'suitable' spawning habitat, 5.26% as 'sub-prime', and 93.42% were 'unsuitable'. For sandeel, a total of 14.47% of sampling stations were classified as 'prime' spawning habitat, 19.74% as 'suitable', 22.37% as 'sub-prime', and 43.42% as 'unsuitable'.

7.8.2.8 Designated sites

There are a number of designated sites that occur within the Proposed Development and the regional fish and shellfish ecology study area. These sites are further detailed in Table 7.12.

Table 7.12: Sites Designated For Relevant Fish And Shellfish Qualifying Features Located Within The Regional Fish And Shellfish Ecology Study Area

Designated Site	Minimum Distance to Proposed Development (km)	Site Description and Qualifying Features Relevant to Fish and Shellfish
Dee Estuary/Aber Dyfrdwy SAC	0.00	The Dee Estuary is one of the largest estuaries within the UK, comprising an area of over 140 km^2, with an intertidal area made up of predominantly mudflats, sandflats, and saltmarsh (ENI, 2021). The estuary lies on the boundary between England and Wales. **Relevant Qualifying Features:** Annex II sea lamprey and river lamprey are present as a qualifying feature but not a primary reason for site selection (JNCC, 2023a).

Designated Site	Minimum Distance to Proposed Development (km)	Site Description and Qualifying Features Relevant to Fish and Shellfish
Ribble Estuary MCZ	9.58	The Ribble Estuary MCZ I is located on the north-west coast of England, near Preston, and covers an area of approximately 15 km^2. **Relevant Qualifying Features:** Smelt is a protected feature within the MCZ and is known to congregate in large shoals, migrating to freshwater areas to spawn. This MCZ provides crucial habitat that is necessary for smelt to complete their lifecycle (DEFRA), 2019a).
Wyre-Lune MCZ	21.45	The Wyre-Lune MCZ is located in the southern part of Morecambe Bay and covers an area of approximately 92 km^2. **Relevant Qualifying Features:** Smelt is a protected feature within the MCZ and is known to congregate in large shoals, migrating to freshwater to spawn. This MCZ provides crucial habitat that is necessary for smelt to complete their lifecycle (DEFRA, 2019b).
River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC	22.53	The River Dee is one of North Wales' premier rivers for Atlantic salmon populations, and also supports important populations of migratory lampreys and non-migratory fish, such as the brook lamprey *Lampetra planeri* and bullhead *Cottus gobio.* **Relevant Qualifying Features:** Annex II Atlantic salmon is present as a primary reason for site selection, while Annex II sea lamprey and river lamprey are present as qualifying features but not the primary reason for site designation (JNCC, 2023j).
Afon Gwyrfai a Llyn Cwellyn SAC	50.95	Afon Gwyrfai a Llyn Cwellyn is representative of small montane rivers in north-west Wales. **Relevant Qualifying Features**: Annex II Atlantic salmon are a primary reason for site designation (JNCC, 2023p)
Afon Eden - Cors Goch Trawsfynydd SAC	60.81	The tributary of the Afon Mawddach supports the only known viable freshwater pearl mussel population in Wales. **Relevant Qualifying Features**: Annex II freshwater pearl mussel are a primary reason for site designation, and Annex II Atlantic salmon are present as a qualifying feature but not a primary reason for site selection (JNCC, 2023q)
Isle of Man MNRs	70.06 – 91.05	As detailed in Table 7.9, there are ten MNRs around the Isle of Man, encompassing 10.8% of Manx waters (Manx Wildlife Trust, 2023). **Relevant Qualifying Features:** although it varies between site, these MNRs are collectively designated for basking shark, common skate *Dipturus batis*, European eel, flame shell *Limaria hians,* horse mussel, sandeel, and spiny lobster (Designation of MNR Guidance Notes, undated). Under Section 33 of the Wildlife Act (1990), the following fish and shellfish features cannot be removed or damaged in any of the Isle of Man MNRs: European eel (except by catch and release), flame shell, horse mussel, spiny lobster, king scallop, and queen scallop (Manx Marine Nature Reserves Byelaws, 2018).
River Derwent and Bassenthwaite Lake SAC	87.43	The River Derwent and Bassenthwaite Lake SAC is an inland body of water and river of approximately 18 km^2. **Relevant Qualifying Features:** Annex II sea lamprey, river lamprey, and Atlantic salmon are present as primary reasons for site selection (JNCC, 2023i).
River Ehen SAC	91.14	The River Ehen SAC supports England's largest population of Freshwater pearl mussel, which is listed on the IUCN Red List as 'critically endangered' in Europe. Atlantic salmon are also present and are involved in the complicated life histories of freshwater pearl mussel (Natural England, 2022). **Relevant Qualifying Features:** Annex II Freshwater pearl mussel are a primary reason for site selection, and Annex II Atlantic salmon are present but not a primary reason (JNCC, 2023h).
Allonby Bay MCZ	116.32	The Allonby Bay MCZ is an inshore site on the English side of the Solway Firth, covering approximately 40 km^2. **Relevant Qualifying Features:** blue mussel beds (DEFRA, 2016).

Designated Site	Minimum Distance to Proposed Development (km)	Site Description and Qualifying Features Relevant to Fish and Shellfish
River Teifi /Afon Teifi SAC	119.81	The Teifi is a predominantly mesotrophic river in mid Wales. **Relevant Qualifying Features**: Annex II Atlantic salmon and river lamprey are a primary reason for site designation, and Annex II sea lamprey are present as a qualifying feature but not a primary reason for site selection (JNCC, 2023r)
Cardigan Bay SAC/Bae Ceredigion SAC	122.76	Cardigan Bay SAC is located between Pembrokeshire and Ceredigion, extending 20 km from the coast, and protecting an area of the sea greater than 1,000 km^2. **Relevant Qualifying Features:** Annex II sea lamprey and river lamprey are present as a qualifying feature but not a primary reason for site selection (JNCC, 2023e).
Solway Firth SAC	123.85	Solway Firth SAC is a large, shallow, and complex estuary with a diverse mix of intertidal habitats (tidal rivers, estuaries, mud flats, sand flats, lagoons, salt marshes and salt steppes) (JNCC, 2023f). **Relevant Qualifying Features:** Annex II sea lamprey and river lamprey are a primary reason for site selection (JNCC, 2023f).
Solway Firth MCZ	131.87	The Solway Firth MCZ is an inshore site of approximately 45 km^2. **Relevant Qualifying Features:** Smelt is a protected feature within the MCZ, which provides critical habitat for feeding and post-larval development (DEFRA, 2019c).
Slaney River Valley SAC	198.26	The Slaney River Valley SAC overlaps Raven Point Nature Reserve SAC, The Raven SPA and Wexford Harbour and Slobs SPA (NPWS, 2011). **Relevant Qualifying Features**: The Slaney River Valley SAC is designated in part for Annex II freshwater pearl mussel, sea lamprey, river lamprey, Atlantic salmon, and twaite shad (NPWS, 2011a).

7.8.2.9 IEFs

As detailed in section 7.7, the valuation of fish and shellfish IEFs is defined at four levels: international, national, regional, and local. Fish and shellfish IEFs identified within the regional fish and shellfish ecology study area are presented in Table 7.13.

Table 7.13: Fish And Shellfish IEFs Within The Proposed Development

IEF	Scientific Name	Importance within the Proposed Development	Justification
Demersal Fish (Flatfish)			
Lemon sole	*Microstomus kitt*	Local	Undetermined and unspecified spawning and nursery grounds that do not overlap with the Proposed Development but are within the regional fish and shellfish ecology study area.
Plaice	*Pleuronectes platessa*	National	Listed as a SPI under the UK Post-2010 Biodiversity Framework. Low and high intensity spawning, and low intensity nursery grounds overlapping with the Proposed Development.
Sole	*Solea solea*	National	Listed as a SPI. Low and high intensity spawning, and nursery grounds overlapping with the Proposed Development.
Other flatfish species	-	Local	Other flatfish species, including dab (*Limanda limanda*), flounder *(Platichthys flesus*), halibut (*Hippoglossus hippoglossus*), solenette (*Buglossidium leteum*), and thickback sole (*Microchirus variegatus*), are likely to occur within the regional fish and shellfish ecology study area. These species, however, have no documented spawning or nursery grounds within the regional fish and shellfish ecology study area.
Demersal Fish (Gadoids)			
Cod	*Gadus morhua*	National	Listed as a SPI, as 'vulnerable' on the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). High intensity spawning and nursery grounds overlap with the Proposed Development. Juvenile cod are an important forage fish species, as they provide prey for a range of larger fish, birds, and marine mammals.
Ling	*Molva molva*	National	Listed as a SPI. Low intensity spawning grounds overlap with the Proposed Development.
Whiting	*Merlangius merlangius*	National	Listed as a SPI. Low intensity spawning and high intensity nursery grounds overlap with the Proposed Development. Juvenile whiting are an important forage fish species, as they provide prey for a range of larger fish, birds, and marine mammals
Demersal Fish (Others)			
Anglerfish	*Lophius piscatorius*	National	Listed as a SPI.

IEF	Scientific Name	Importance within the Proposed Development	Justification
			Low intensity nursery grounds overlap with the Proposed Development.
Sandeel species	Ammodytidae spp.	National	Listed as a SPI. There are five sandeel species present in UK and Irish waters, with lesser sandeel *Ammodytes tobianus* and greater sandeel *Hyperoplus lanceolatus* being the most common. All sandeel species are important forage fish, as they are prey species for a wide range of larger fish, birds and marine mammals, and constitute an important component of marine food webs. High intensity spawning grounds and low intensity nursery grounds overlap with the Proposed Development. Similarly, over 50% of the sediment samples collected within the Proposed Development during the site-specific surveys indicated prime, suitable, and sub-prime spawning habitat preference.
Pelagic Fish			
Herring	*Clupea harengus*	National	Listed as a SPI. There are high intensity nursery grounds overlapping with the Proposed Development. However, the majority of sediment samples collected within the Proposed Development site-specific surveys indicated unsuitable spawning habitat preference.
Mackerel	*Scomber scombrus*	National	Listed as a SPI. Like sandeel, mackerel are an important forage fish for a range of larger fish, birds, and marine mammals and are thus, an important element of marine food webs. Low intensity spawning and nursery grounds overlap with the Proposed Development.
Sprat	*Sprattus sprattus*	Regional	Important forage fish species for a range of larger fish, birds, and marine mammals and are thus, an important element of marine food webs. Undetermined spawning grounds overlap with the Proposed Development.
Elasmobranchs			
Basking shark	*Cetorhinus maximus*	International	Listed as a SPI, under Appendix II of CITES, and under Appendix I and II of the Bonn Convention. Basking shark are also listed on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Further, the north-east Atlantic population are classed as ‘Endangered’ on the IUCN Red List and are protected in the UK under the Wildlife and Countryside Act 1981.
Spotted ray	*Raja montagui*	National	Listed as ‘of least concern’ by the IUCN Red List and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Low intensity nursery grounds identified within the Proposed Development.
Spurdog	*Squalus acanthias*	Regional	Listed as a SPI, as ‘vulnerable’ on the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas).

IEF	Scientific Name	Importance within the Proposed Development	Justification
			High intensity nursery grounds identified within the Proposed Development.
Thornback ray	*Raja clavata*	Regional	Low intensity nursery grounds identified within the Proposed Development.
Tope	*Galeorhinus galeus*	Regional	Listed as a SPI, and as 'vulnerable' on the IUCN Red List. Low intensity nursery grounds identified within the Proposed Development.
Diadromous Fish			
Atlantic salmon	*Salmo salar*	International	Listed as a SPI, as 'vulnerable' by the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Atlantic salmon are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional fish and shellfish ecology study area. Atlantic salmon are likely to migrate through the regional fish and shellfish ecology study area during their life cycle.
Allis shad	*Alosa alosa*	National	Listed as a SPI, as 'of least concern' by the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Allis shad are an Annex II species under the Habitats Directive but are not a qualifying feature of any designated sites within the regional fish and shellfish ecology study area. Allis shad may potentially migrate through the regional fish and shellfish ecology study area during their life cycle.
European eel	*Anguilla anguilla*	National	Listed as a SPI, as 'critically endangered' by the IUCN Red List, and on the OSPAR list of threatened and declining species on within OSPAR Region III (Celtic Seas). Listed as a qualifying feature of multiple MNRs within the regional fish and shellfish ecology study area. European eel are likely to migrate through the regional fish and shellfish ecology study area during their life cycle.
River lamprey	*Lampetra fluviatilis*	International	Listed as a SPI and as of 'least concern' by the IUCN Red List. River lamprey are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional fish and shellfish ecology study area. River lamprey are likely to migrate within the regional fish and shellfish ecology study area during their life cycle, although only within coastal and estuarine areas.
Sea lamprey	*Petromyzon marinus*	International	Listed as a SPI, as of 'least concern' by the IUCN Red List, and on the OSPAR list of threatened and declining species within OSPAR Region III (Celtic Seas). Sea lamprey are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional fish and shellfish ecology study area.

IEF	Scientific Name	Importance within the Proposed Development	Justification
			Sea lamprey are likely to migrate through the regional fish and shellfish ecology study area during their life cycle
Sea trout	*Salmo trutta*	National	Listed as a SPI, as 'of least concern' by the IUCN Red List, and on the OSPAR list of threatened and declining species. Sea trout are likely to migrate through the regional fish and shellfish ecology study area during their life cycle
Smelt	*Osmerus eperlanus*	National	Listed as a SPI, as 'of least concern' by the IUCN Red List. Smelt is not an Annex II species but is listed as a qualifying feature of multiple MCZs within the regional fish and shellfish ecology study area. Smelt are likely to migrate within the regional fish and shellfish ecology study area during their life cycle, although only within coastal and estuarine areas.
Twaite shad	*Alosa fallax*	National	Listed as a SPI and as 'of least concern' by the IUCN Red List. Twaite shad are an Annex II species under the Habitats Directive but are not a qualifying feature of any designated sites within the regional fish and shellfish ecology study area. Twaite shad may potentially migrate through the regional fish and shellfish ecology study area during their life cycle
Shellfish			
Freshwater pearl mussel	*Margaritifera margaritifera*	International	Listed as a SPI and as 'endangered' by the IUCN Red List. Listed as an Annex II species under the habitats directive and is a qualifying feature of numerous designated sites within the regional fish and shellfish ecology study area.
Spiny lobster	*Palinurus elephas*	National	Listed as a SPI and as a qualifying feature of multiple MNRs within the regional fish and shellfish ecology study area.
Blue mussel	*Mytilus edulis*	Local	Species which are not protected under conservation legislation, and are common in UK and Irish waters, but form a key component of the marine biodiversity within Proposed Development.
Brown crab	*Cancer pagurus*		
Common whelk	*Buccinum undatum*		
European lobster	*Homarus gammarus*		
King scallop	*Pecten maximus*		

IEF	Scientific Name	Importance within the Proposed Development	Justification
Queen scallop	*Aequipecten opercularis*		
Velvet swimming crab	*Necora puber*		
Norway lobster	*Nephrops norvegicus*	Local	Species which is not protected under conservation legislation, and is common in UK and Irish waters, but forms a key component of the marine biodiversity within Proposed Development. Spawning grounds of undetermined intensity and nursery grounds of unspecified intensity identified within the regional fish and shellfish ecology study, but not overlapping with the Proposed Development.
Other shellfish	-	Local	Other shellfish, such as common cockle (*Cerastoderma edule*), swimming crabs (*Liocarcinus spp.*), and squid (*Loligo spp.*) have been identified as being likely to occur within the regional fish and shellfish ecology study area. These are species which are not protected under conservation legislation, and may be common in UK and Irish waters, but form a key component of the marine biodiversity within Proposed Development.

7.8.2.10 Future Baseline Scenario

As stated in section 7.8.1.9, an assessment of the future baseline conditions has been carried out in the event that the Proposed Development does not come forward, in line with the Offshore Oil & Gas Exploration, Production, Unloading and storage (Environmental Impact Assessment) Regulations 2020 and the Marine Works (Environmental Impact Assessment) Regulations 2007.

The baseline environment presented in this section and in volume 3, appendix I is extensive, and accurately representative, accounting for seasonality and interannual variability. However, this baseline is not static, and will exhibit larger degrees of natural change over longer time periods, due to naturally occurring cycles and processes and any potential changes resulting from climate change. This long-term change will occur even if the Proposed Development does not come forward. Thus, it will be necessary to contextualise any potential impacts that might occur over the expected 25-year operational lifetime of the Proposed Development when undertaking impact assessments.

Direct and indirect changes to fish and shellfish populations and communities may occur as a result of variability and long-term changes within the Irish Sea. These changes include projected increases in average sea surface temperature of up to 1.9°C and changes in the timing of maximum and minimum temperatures (Olbert *et al.,* 2012). As a result of rising sea temperatures, species adapted to colder water (such as cod and herring) will begin to seek cooler waters, while warm water adapted species will become more established in the previous locations (Drinkwater, 2005). This potential future change will occur in tandem with the known overall reduction in production and stock recovery in Irish Sea fish populations (Bentley *et al.,* 2020). Future changes are expected to be exacerbated by these increasing temperatures and extreme weather events, which can increase stratification of phytoplankton food sources in the Irish Sea, which leads to decoupling of predator and prey interactions and impacts fish population survival rates (Morrison *et al*., 2020).

The geographical range and virulence of diseases affecting economically important shellfish populations may also be exacerbated by rising sea temperatures (Rowley *et al.,* 2014). This could cause potential threats to long-term survivability, and adversely impact overall shellfish population levels. Combined with increasing temperatures, ocean acidification could also adversely impact shell strength (Mackenzie *et al.,* 2014), resulting in reduced protection against predators, and significant reductions in the economic value (Narita *et al*., 2012).

There are many uncertainties around how climate change will affect the marine environment, which makes the future baseline scenario difficult to accurately predict. Any changes that may occur during the lifespan of the Proposed Development should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

7.8.3 Marine Mammals and Marine Turtles

7.8.3.1 Study Area

Marine mammals and marine turtles are known for being highly mobile and covering vast distances within their range of distribution. Therefore, two study areas have been defined:

- the Proposed Development marine mammal and marine turtle study area: this is defined as the area encompassing the Proposed Development, (including the offshore pipelines, and associated cables in Liverpool Bay) plus a buffer of 10 km (Figure 7.3).
- the regional marine mammal and marine turtle study area: this is defined as the area encompassing the wider Irish Sea (Figure 7.3). This area has been informed by marine mammal Management Units (MUs) and will provide wider context for characterising the baseline. The regional marine mammal study area will also aid in informing the assessment where the ZoI for given impacts, such as underwater noise, which may potentially extend beyond the Proposed Development marine mammal study area.

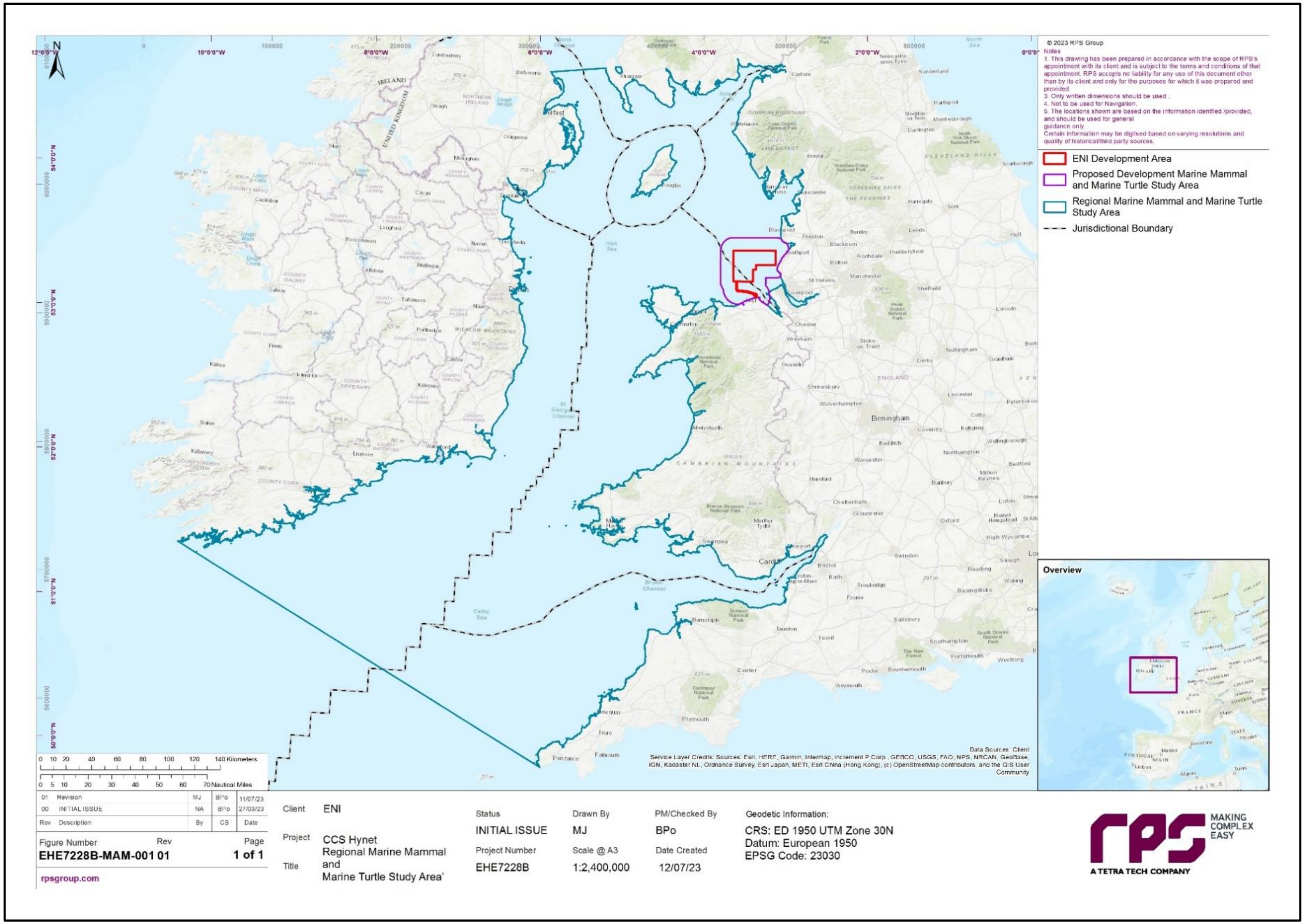


Figure 7.3: Marine Mammal And Marine Turtle Study Areas

7.8.3.2 Desktop Datasets

The marine mammal baseline within the Proposed Development marine mammal study area and the regional marine mammal study area was characterised by a thorough review of key desktop datasets and reports. Information on these and full details are presented in volume 3, appendix I and a summary of the key desktop sources utilised is presented in Table 7.14. There were no site-specific marine mammal surveys conducted for the Proposed Development, so the results of site-specific surveys undertaken for OWFs in close proximity to the Proposed Development have been utilised. This included Gwynt y Môr OWF and Awel y Môr OWF.

Table 7.14: Summary Of Key Desktop Reports For The Characterisation Of The Marine Mammal Baseline

Title	Source	Year	Author
NPWS Designations Viewer	NPWS	2023	NPWS
Sympatric seals, satellite tracking and protected areas: habitat-based distribution estimates for conservation and management	Frontiers in Marine Science.	2022	Carter et al.
Updated abundance estimates for cetacean management units in UK waters (Revised 2022)	JNCC	2022	Inter-Agency Marine Mammal Working Group (IAMMWG)
Review of the Irish Sea	Irish Sea Network	2022	Irish Sea Network
British and Irish Marine Turtle Strandings and Sightings. Annual Report 2021	Marine Environmental Monitoring	2022	Penrose et al.
Estimates of cetacean abundance in European Atlantic waters from the SCANS-III (Small Cetaceans in the European Atlantic and North Sea) aerial and shipboard surveys	Sea Mammal Research Unit (SMRU), University of St. Andrews	1994 - 2021	Hammond et al. 2002, 2017, 2021
NBN Atlas	NBN Atlas	2021	NBN Atlas
Awel Y Môr OWF Marine Mammal Baseline Characterisation	SMRU	2021	Sinclair, et al.
Scientific Advice of Matters Related to the Management of Seal Populations	Special Committee on Seals (SCOS) and Natural Environment Research Council (NERC)	2020, 2021	SCOS
JNCC MPA Mapper	JNCC	2020	JNCC
Habitat-based predictions of at-sea distribution for grey and harbour seals in the British Isles	SMRU, University of St Andrews	2020	Carter et al.
Distribution maps of cetacean and seabird populations in the North-East Atlantic	Journal of Applied Ecology	2020	Waggitt et al.

Title	Source	Year	Author
Long-term insights into marine turtle sightings, strandings and captures around the UK and Ireland (1910–2018)	Journal of the Marine Biological Association of the United Kingdom	2020	Botterell et al.
Gwynt y Môr OWF Post-construction Aerial Surveys 2016 to 2019	APEM Ltd.	2017 - 2019	Goddard et al., 2017, 2018, Goulding et al., 2019
Marine Mammals- Cetaceans. In; Manx Marine Environmental Assessment (1.1 Edition - partial update)	The Government of the Isle of Man	2018	Howe, 2018b
Bottlenose Dolphin Monitoring in Cardigan Bay, 2014 – 2016. NRW Evidence Report 191	NRW	2018	Lohrengel et al.,
Aerial thermal-imaging surveys of Harbour and Grey Seals in Northern Ireland	Department of Agriculture, Environment, and Rural Affairs, Northern Ireland	2019	Duck and Morris
Aerial surveys of cetaceans and seabirds in Irish waters: Occurrence, distribution and abundance in 2015-2017	Department of Communications, Climate Action, and Environment	2018	Rogan et al.
Revised Phase III Data Analysis of Joint Cetacean Protocol (JCP) Data Resource	JNCC	2016	Paxton *et al.*
The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area	JNCC	2015	Heinänen and Skov
Atlas of the distrIcution and relative abundance of marine mammals in Irish offshore waters 2005 - 2011	Irish Whale and Dolphin Group	2013	Wall *et al.*
Phase II Data Analysis of Joint Cetacean Protocol (JCP) Data Resource	JNCC	2011	Paxton *et al.*
Burbo Bank Extension Offshore Wind Farm: Environmental Impact Assessment Scoping Report	DONG Energy	2010	Sørensen *et al.*
Cetaceans in Irish waters: A review of recent research	Royal Irish Academy.	2009	O'Brien *et al.*
Atlas of Marine Mammals of Wales	Countryside Council for Wales	2009	Baines and Evans
Gwynt y Mor Offshore Wind Farm Marine Ecology Technical Report	Gwynt y Mor OWF	2005	CMACS, 2005b
Background information on marine mammals for Strategic Environmental Assessment	SMRU	2005	Hammond *et al.*
Cetacean Distribution Atlas	JNCC	2003	Reid *et al.*

Title	Source	Year	Author
Cetacean distributions in the waters around the British Isles	Natural Environment Research Council	1998	Evans

7.8.3.3 Cetaceans

There are five cetacean species likely to be present and/or occur regularly within the regional marine mammal study area:

- bottlenose dolphin *Tursiops truncatus;*
- harbour porpoise *Phocoena phocoena;*
- minke whale *Balaenoptera acutorostrata;*
- risso's dolphin *Grampus griseus*); and
- short-beaked common dolphin *Delphinus delphus* (hereafter: 'common dolphin').

As detailed in section 7.8.3.1, the regional marine mammal study area was informed by species MUs. The most recent abundance estimates for each species respective MU are provided by the Inter-Agency Marine Mammal Working Group (IAMMWG, 2022) and are presented in Table 7.15. Further detail on the ecology, abundance, and densities of these five cetacean species is provided in volume 3, appendix I.

Table 7.15: Cetacean Abundance Estimates Within Their Respective MUs (Rogan *et al.,* 2018; Hammond *et al.,* 2021; IAMMWG, 2022)

Species	Management Unit (MU)	Abundance of animals in MU	95% Confidence Interval (CI)
Harbour porpoise	Celtic and Irish Sea	62,517 (CV = 0.13)	48,324 - 80,877
Bottlenose dolphin	Irish Sea	293 (CV = 0.54)	108 – 793
	Offshore Channel, Celtic Sea & South West England	10,947 (0.25)	6,727 – 17,814
Common dolphin	Celtic and Greater North Seas	102,656 (CV = 0.29)	58,932 – 178,822
Risso's dolphin		12,262 (CV = 0.46)	5,227 – 28,764
Minke whale		20,118 (CV = 0.18)	14,061 – 28,786

7.8.3.4 Pinnipeds

There are two pinniped species likely to be present and/or occur regularly within the regional marine mammal study area: grey seal *Halichoerus grypus*, and harbour seal *Phoca vitulina*. As detailed in section 7.8.3.1, the regional marine mammal study area was informed by species MUs. There are five MUs that are encompassed or overlap with the regional marine mammal study area: the Northern Ireland MU, Wales MU, Southwest (SW) Scotland MU, SW England MU, and Northwest (NW) England MU. The most recent abundance estimates for each species respective MU are provided by the Special Committee on Seals (SCOS) and are presented in Table 7.16. There are limited data available on the SW England MU, Wales MU, and NW England MU, with grey seal population estimates unavailable for these MUs and the harbour seal population estimates should be regarded as rough estimates only. Further detail on the ecology, abundance, and densities of grey seal and harbour seal is provided in volume 3, appendix I.

Table 7.16: Most Recent August Haul-Out Counts And Population Estimates Of Grey And Harbour Seal In Their Respective MUs (SCOS, 2020, 2021)

Management Unit (MU)	Grey Seal		Harbour Seal	
	August Haul-Out Count	**Population Estimate**	**August Haul-Out Count**	**Population Estimate**
Northern Ireland	505	2,113	1,012	1,405
SW Scotland	517	2,163	1,709	2,373
NW England	250	Estimate not available	5	6
Wales	900		10	13
SW England	500		0	0

7.8.3.5 Marine Mammal Population Densities

The marine mammal population densities and populations estimates that will be taken forward to the assessment is presented in Table 7.17. Further information on these data sources is provided in volume 3, appendix I. As this information is not available for marine turtles, population-based assessment will only be included for the marine mammal IEFs.

Table 7.17: Summary Of Marine Mammal Densities That Will Be Taken Forward To The Assessment

Species	Density (animals per km²)	Management Unit (MU)[5]	Population Estimate in MU
Harbour porpoise	0.086[1]	Celtic and Irish Sea	62,517
Bottlenose dolphin	0.0082 to 0.035[2]	Irish Sea	293
Short-beaked common dolphin	0.018[3]	Celtic and Greater North Seas	102,656
Risso's dolphin	0.0313[2]	Celtic and Greater North Seas	12,262
Minke whale	0.0173[2]	Celtic and Greater North Seas	20,118
Grey seal	0.467 to 4.06[4]	Wales	3,766
		NW England	1,046
		Northern Ireland	2,113
		SW Scotland	2,163
		Isle of Man estimate	400
		East of Ireland Southeast of Ireland	1,749[6] 2,326[6]
		OSPAR Region III	60,780
Harbour seal	0.0049 to 0.593[4]	Wales	14
		NW England	7
		Northern Ireland	1,406
		Isle of Man	No estimate available

[1] SCANS-III (Hammond *et al*., 2021) Block F

[2] SCANS-III (Hammond *et al.,* 2021) for adjacent Block E, as none observed for Block F and high-density coastal area density in outer Cardigan Bay from Lohrengel *et al*. (2018)

[3] SCANS-II (Hammond *et al*., 2013) Block O, as no values for SCANS-III for this species

Species	Density (animals per km^2)	Management Unit (MU)[5]	Population Estimate in MU

[4] Carter *et al.* (2022) – average and maximum densities calculated to per km^2 using absolute mean values for cells overlapping with the Proposed Development marine mammal and marine turtle study area.

[5] All population estimates include the Isle of Man unless population estimate is given separately.

[6] Population estimates based upon counts from Duck and Morris (2019), using scalars from Lonergan *et al.* (2013) for harbour seal and Russell *et al.* (2016) for grey seal

7.8.3.6 Marine Turtles

Six species of marine turtle have been documented within UK and Irish waters:

- green turtle *Chelonia mydas*;
- hawksbill turtle *Eretmochelys imbricata*;
- kemp's ridley turtle *Lepidochelys kempii*;
- leatherback turtle *Dermochelys coriacea*;
- loggerhead turtle *Caretta caretta*; and
- olive ridley turtle *Lepidochelys olivacea* (Botterell *et al.,* 2020).

Due to the relative paucity of information surrounding the ecology, distribution, and abundance of these six species within UK and Irish waters in comparison to that available for marine mammals, they have been grouped together as 'marine turtles' for the purposes of this assessment.

There are no MUs available for marine turtles in UK and Irish waters, with the majority of information surrounding their abundance, seasonality, and distribution coming from records of sightings and strandings. These data have been recorded since 1748, and are reported annually by Marine Environmental Monitoring, most recently for 2021 (Penrose *et al.,* 2022). Overall, a total of 2,882 marine turtles have been recorded throughout this 273-year dataset, with the majority attributed to leatherback turtle (n = 2,172), followed by unidentified species (n = 394), loggerhead turtle (n = 268), Kemp's ridley turtle (n = 76), green turtle (n = 15), hawksbill turtle (n = 1), and olive ridley turtle (n = 1) (Penrose *et al.,* 2022). Of these 2,882 records, the majority have been recorded in Ireland (Table 7.18).

Table 7.18: Number Of Sightings And Strandings Of All Marine Turtles Between 1748 And 2021 (Penrose *et al.,* 2022)

Region	Number of Sightings and Strandings of all Marine Turtle Species	
	2021	1748 - 2021
Ireland	6	1,358
England	7	699
Scotland	11	425
Wales	5	292
Northern Ireland	0	41
Isle of Man	1	37
Channel Islands	0	17
Offshore waters	0	13
Total	**30**	**2,882**

7.8.3.7 Designated sites

There are a number of designated sites with marine mammal qualifying features within the regional marine mammal study area, as detailed in Table 7.19. There are no designated sites with marine turtle qualifying features.

Table 7.19: Sites Designated For Relevant Marine Mammal Qualifying Features Located Within The Regional Marine Mammal Study Area

Designated Site	Minimum Distance to Proposed Development (km)	Qualifying Features Related to Marine Mammals and Site Description
North Anglesey Marine /Gogledd Môn Forol SAC	39.68	The North Anglesey Marine SAC stretches from the northern coast of the Isle of Anglesey into the Irish Sea. Relevant Qualifying Features: Annex II harbour propose are a primary reason for site selection (JNNC, 2021c).
Isle of Man MNRs	70.06 – 91.05	As detailed in Table 7.9, there are ten MNRs around the Isle of Man, encompassing 10.8% of Manx waters (Manx Wildlife Trust, 2023). Relevant Qualifying Features: although it varies between individual MNRs, these sites are collectively designated for harbour seal, grey seal, harbour porpoise, minke whale, and Risso's dolphin (Designation of MNR Guidance Notes, undated).
Lleyn Peninsula and the Sarnau/Pen Llŷn a'r Sarnau SAC	85.70	The Lleyn Peninsula and Sarnau SAC encompasses area of sea, coast, and estuary that is known to support a wide array of marine habitat, flora and fauna. Relevant Qualifying Features: Annex II marine mammals (bottlenose dolphin and grey seal) are present as qualifying features but not primary reasons for site selection (JNCC, 2023k).
West Wales Marine /Gorllewin Cymru Forol SAC	82.99	The West Wales Marine SAC covers an area of 7,377 km^2, extending into the Irish Sea from North Wales to West Wales. The average water depth in the area ranges from 40-50 m and up to 100 m. Relevant Qualifying Features: Annex II harbour propose are a primary reason for site selection (JNCC, 2023l).
North Channel SAC	111.78	The North Channel SAC comprises an area of 1,604 km^2, located along the east coast of Northern Ireland and extending into the northern portion of the Irish Sea (JNCC, 2021d). Relevant Qualifying Features: Annex II harbour propose are a primary reason for site selection (JNCC, 2021d).
Cardigan Bay/Bae Ceredigion SAC	122.76	Cardigan Bay SAC is located between Pembrokeshire and Ceredigion, extending 20 km from the coast, and protecting an area of the sea greater than 1,000 km^2. Relevant Qualifying Features: Annex II bottlenose dolphin are a primary reason for site selection, while Annex II grey seal are present as a qualifying feature but not a primary reason for site selection (JNCC, 2023e).
Strangford Lough SAC	142.70	The main feature of the Strangford Lough SAC is the sea inlet itself, which is known to have emerged from melting ice sheets and is less than 10 m in depth, however the SAC supports a range of species and habitats (Department of the Environment, 2007). Relevant Qualifying Features: Annex II harbour seal are present as a qualifying feature but not a primary reason for site selection (JNCC, 2023m).

Designated Site	Minimum Distance to Proposed Development (km)	Qualifying Features Related to Marine Mammals and Site Description
Murlough SAC	146.97	This SAC is relatively shallow (depth up to 33 m) and supports a range of coastal species and habitats. Relevant Qualifying Features: Annex II harbour seal are present as a qualifying feature but not a primary reason for site selection (JNCC, 2023n).
Rockabill to Dalkey Island SAC	155.10	This site includes a range of dynamic inshore and coastal waters win the Western Irish Sea and is roughly 7 km wide and 40 km long (National Parks and Wildlife Service (NPWS), 2013a). Relevant Qualifying Features: Rockabill to Dalkey Island SAC is designated for Annex II harbour porpoise (NPWS, 2013a).
Lambay Island SAC	157.45	Lambay is the largest Irish east coast island, situated approximately 4 km off the Dublin coast dominated by igneous rock, ash, shale and limestone (NPWS, 2013b). Relevant Qualifying Features: Lambay Island SAC is designated in part for Annex II grey seal and harbour seal (NPWS, 2013b).
The Maidens SAC	190.72	The Maidens SAC is formed by a group of rocky reefs off the coast of Larne, Northern Ireland. Relevant Qualifying Features: Annex II grey seal are a primary marine feature responsible for the designation of the SAC (Department of Agriculture, Environment and Rural Affairs (DAERA), 2023).
Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC	194.73	The Bristol Channel Approaches SAC spans the Bristol Channel between the northern coast of Cornwall and Wales. Relevant Qualifying Features: Annex II harbour porpoise are a primary reason for site selection (JNCC, 2021e).
Pembrokeshire Marine/Sir Benfro Forol SAC	195.44	The Pembrokeshire Marine SAC is located on the south-west coast of Wales. Relevant Qualifying Features: Annex II grey seal are a primary reason for site selection (JNCC, 2023o).
Slaney River Valley SAC	198.26	The Slaney River Valley SAC overlaps Raven Point Nature Reserve SAC, The Raven SPA and Wexford Harbour and Slobs SPA (NPWS, 2011). Relevant Qualifying Features: The Slaney River Valley SAC is designated in part for Annex II harbour seal (NPWS, 2011a).
Saltee Islands SAC	239.28	The Saltee Islands SAC is located off the coast of Wexford, Ireland, which feature sea caves and cliffs. Relevant Qualifying Features: Annex II grey seal are a qualifying interest feature for this site (NPWS, 2011b).
Lundy SAC	251.48	The Lundy SAC is situated within the Bristol Channel. Relevant Qualifying Features: Annex II grey seal are a primary reason for site selection (JNCC, 2023s).
Roaringwater Bay and Islands SAC	445.50	The Roaringwater Bay and Islands SAC is located off the coast of Cork, Ireland, at the western edge of the regional marine mammal study are. Relevant Qualifying Features: Annex II harbour porpoise and grey seal are a qualifying interest features for this site (NPWS, 2011c).

7.8.3.8 IEFs

As detailed in section 7.7, the valuation of marine mammal and marine turtle IEFs is defined at four levels: international, national, regional, and local. Marine mammal and marine turtle IEFs identified within the regional marine mammal study area are presented in Table 7.20.

Table 7.20: Marine Mammal And Marine Turtle IEFs Within The Proposed Development Marine Mammal And Marine Turtle Study Area

IEF	Scientific Name	Importance within the Proposed Development Marine Mammal and Marine Turtle Study Area	Justification
Bottlenose dolphin	*Tursiops truncatus*	International	Listed as a SPI, EPS, and under Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Bottlenose dolphin are also protected in UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Bottlenose dolphin are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal study area.
Common dolphin	*Delphinus delphis*	International	Listed as a SPI, EPS, and under Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Common dolphin are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990.
Grey seal	*Halichoerus grypus*	International	Listed as a EPS, and under Appendix I and II of the Bonn Convention, Appendix III of the Bern Convention, and Appendix II of CITES. Grey seal are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Grey seal are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal study area.
Harbour porpoise	*Phocoena phocoena*	International	Listed as a SPI, EPS, and under Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. They are listed on the OSPAR list of threatened and declining species within OSAPR Region III (Celtic Seas). Harbour porpoise are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Harbour porpoise are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal study area.
Harbour seal	*Phoca vitulina*	International	Listed as a SPI, EPS, and under Appendix I and II of the Bonn Convention, Appendix III of the Bern Convention, and Appendix II of CITES. Harbour seal are also protected un UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990. Grey seal are also listed as Annex II species under the Habitats Directive and are qualifying features of numerous SACs within the regional marine mammal study area.
Marine turtles	Green (*Chelonia mydas*), hawksbill	International	Leatherback turtle are listed on the OSPAR List of threatened and declining species within OSPAR Region III (Celtic Seas). Loggerhead turtle are also on the OSPAR list, but not within OSPAR Region III (Celtic Seas). Both leatherback and loggerhead turtle are also listed as SPIs. Leatherback, loggerhead, green, hawksbill, and Kemp's ridley turtle are all classed as EPSs.

IEF	Scientific Name	Importance within the Proposed Development Marine Mammal and Marine Turtle Study Area	Justification
	(*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), and olive ridley (*Lepiodchelys olivacea*)		All marine turtles are proteced under CITES and in UK waters under the Wildlife and Countryside Act 1981. Olive ridley turtles are only protected under section 9 (as ammended) of the Wildlife and Countryside Act 1981.
Minke whale	*Balaenoptera acutorostrata*	International	Listed as a SPI, EPS, and under Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Minke whale are also protected in UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990.
Risso's dolphin	*Grampus griseus*	International	Listed as a SPI, EPS, and under Appendix I and II of the Bonn Convention, Appendix II of the Bern Convention, and Appendix II of CITES. Risso's dolphin are also protected in UK waters under the Wildlife and Countryside Act 1981 and in Manx waters under the Isle of Man Wildlife Act 1990.

7.8.3.9 Future Baseline Scenario

As stated in section 7.8.1.9, an assessment of the future baseline conditions has been carried out in the event that the Proposed Development does not come forward, in line with the Offshore Oil & Gas Exploration, Production, Unloading and storage (Environmental Impact Assessment) Regulations 2020 and the Marine Works (Environmental Impact Assessment) Regulations 2007.

The baseline environment presented in this section and in volume 3, appendix I is extensive, and accurately representative, accounting for seasonality and interannual variability. However, this baseline is not static, and will exhibit larger degrees of natural change over longer time periods, due to naturally occurring cycles and processes and any potential changes resulting from climate change. This long-term change will occur even if the Proposed Development does not come forward. Thus, it will be necessary to contextualise any potential impacts that might occur over the expected 25-year operational lifetime of the Proposed Development when undertaking impact assessments.

Marine mammals and marine turtles are known to be impacted by various anthropogenic activities, such as offshore developments, fisheries, and shipping. For example, Avila *et al*. (2018) reported that between 1991 and 2016, globally almost all marine mammals species (98%) were documented to be affected by at least one threat. Bycatch of marine mammals in active fishing gear was the most common threat category for odontocetes (toothed whales) and mysticetes (baleen whales), followed by pollution (solid waste), commercial hunting, and vessel collisions. For pinnipeds, the main threats were entanglement in ghost-net (lost or discarded fishing gear), solid and liquid wastes, and infections (Avila *et al.,* 2018). Similarly, fisheries bycatch and coastal development are major threats to marine turtles (Donlan *et al.,* 2010), along with entanglement in ghost-nets and debris (Duncan *et al.,* 2017).

In addition to anthropogenic impacts, marine mammals are also vulnerable to indirect impacts, such as climate change, which can result in increasing sea temperatures. Shifts in spatial distribution is one of the most common responses to temperature changes by marine species and has the potential to modify their ranges. For example, common dolphin are a wide ranging species with a capacity for range expansion (Murphy *et al.,* 2013), and they appear to be extending their shelf sea range further north off western Britain and around the northern North Sea (Evans *et al.,* 2003; MacLeod *et al.,* 2005). This species shows a positive relationship with increasing temperature (Evans and Waggit, 2020), and thus increasing sea temperatures may lead to a shift in the range of common dolphin (MacLeod *et al.,* 2005). Warming sea temperatures may also alter the life cycles of marine mammal and marine turtle prey species through changes in prey abundance and distribution, and enhanced stratification forcing earlier occurrence of the spring phytoplankton bloom and potential cascading effects through the food chain (Evans and Bjørge, 2013). This may result in a predator-prey mismatch, (a discrepancy between the abundances of prey species and predators), affecting migratory species and species which display some site fidelity. For example, the impacts of climate change on marine predator-prey distributions in Sadykova *et al.* (2020) predicted a large future distribution shift in sandeel and harbour porpoise habitat overlap (164 km) but a small shift (16 km) in overlap between herring and porpoise. Loss of predator–prey population overlap was also predicted for harbour seal, with large declines in the common spatial trend for both sandeel (71 km) and herring (91 km) prey (Sadykova *et al.,* 2020). In grey seal, the authors predicted a future distribution shift in overlap with sandeel (71 km) and herring (41 km) populations (Sadykova *et al.,* 2020).

Additionally, climate change could affect survival rates of marine mammals and marine turtles by affecting reproductive success, increasing stress levels, and fostering the development of pathogens (Albouy *et al*., 2020). Further, Evans and Waggitt (2020) highlighted both the frequency and severity of toxic algal blooms are also predicted to increase due to increased temperature (via climate change) and nutrient enrichment (via increased rainfall and freshwater runoff) and salinity. Consequently, mass die-offs due to fatal poisonings from toxic algal blooms have been reported in bottlenose dolphin (Fire *et al*., 2007, 2008).

There are many uncertainties around how climate change will affect the marine environment, which makes the future baseline scenario difficult to accurately predict. Any changes that may occur during the lifespan of the

Proposed Development should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

7.9 Key Parameters for Assessment

7.9.1 Maximum Design Scenario

The Project Design Parameters identified in Table 7.21, Table 7.22, and Table 7.23 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the details provided in the project description (volume 1, chapter 3). Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Description (e.g. different infrastructure layout), to that assessed here be taken forward in the final design scheme.

Table 7.21: Project Design Parameters Considered For The Assessment Of Potential Impacts On Benthic Subtidal And Intertidal Ecology

Potential impact	Phase			Project Design Parameters	Justification
	C	O	D		
Temporary subtidal habitat loss and/or disturbance	✓	✓	✓	**Construction phase** Up to 1.91 km^2 of subtidal habitat loss due to: • Footprints of jack-up vessels: - Up to 736 m^2 of disturbance from the use of jack-up vessels during the installation of the new Douglas Platform • Up to 1.89 km^2 of disturbance from the installation of up to 126.04 km of subsea power cables (MDS assumes 100% will be buried). This value of 1.89 km^2 includes 18,000 m^2 of disturbance along the 1,200 m of cables installed within the intertidal zone (between MHWS and MLWS). • Up to 21,000 m^2 of disturbance due to dredging at West Hoyle Bank for the installation of subsea power cables between the PoA terminal and the new Douglas platform. A dredged channel with a length of 1,000 m, width of 21 m, and depth of 7 m is to be excavated using a backhoe dredger. • A channel cleared through a length of 115 m of sand waves, with a width of 10 m and height of 3 m, using a max flow excavator. **Operation and Maintenance Phase** Up to 72,000 m^2 of subtidal habitat loss due to: • Footprints of jack-up vessels for routine maintenance works. Up to 15 events per year over the 25-year lifecycle of the Proposed Development, resulting in a total value of 34,500 m^2 over the lifecycle. • Up to 37,500 m^2 due to the reburial of up to 500 m of cable every 5 to 10 years, over the 25-year lifecycle. Only a smaller portion of this (7,500 m^2 will occur at any one time). **Decommissioning Phase** Temporary subtidal habitat loss and/or disturbance due to:	The MDS represents the maximum footprint which would be affected during the construction, operations and maintenance and decommissioning phases. **Construction phase** For cable installation, the MDS assumes a trench width of 15 m. The MDS assumes that the width of disturbance for sand wave clearance also includes subsequent burial. The total footprint of seabed affected has been calculated, for the purposes of the MDS, assuming a mound of uniform thickness of 0.5 m height. The MDS assumes temporary loss of benthic habitat is beneath this. **Operations and maintenance phase** The MDS for this impact includes the use of jack-up vessels for maintenance of offshore infrastructure and cable repair and reburial. Reburial of up to 500 m of cable every 5 to 10 years in anticipated (assuming 15 m width of seabed disturbance). **Decommissioning phase** Parameters for decommissioning will be lower or equal to that of the construction phase as sand wave clearance will not be required in advance of cable removal. The MDS assumes that cable removal in the intertidal will involve open cut trenching and that all cables would be removed. The MDS assumes the removal of all infrastructure except that which will remain *in situ* for reservoir modelling (which will eventually be removed – to be confirmed at a later date in the Decommissioning Plan). This includes removal of some foundations, cables, and cable crossing protection. Rock placement will be left *in situ.*

Potential impact	Phase			Project Design Parameters	Justification
	C	O	D		
				• Footprint of affected seabed from the use of jack-up vessels during infrastructure removal.	
Increased SSCs and associated deposition	✓	×	✓	**Construction phase** Sand wave clearance: • A channel cleared through a length of 115 m of sand waves, with a width of 10 m and height of 3 m, using a max flow excavator. • Dredging a 1,000 m channel at West Hoyle Bank for the installation of subsea power cables between the PoA terminal and the new Douglas platform. A dredged channel with a length of 1,000 m, width of 21 m, and depth of 7 m is to be excavated using a backhoe dredger. Drilling of two new monitoring wells at Hamilton Main and Hamilton North • Clearance of 30.48 m of sand and silt and 84.43 m of coarser sediment (assuming a 100% washout). Subsea power cable installation • Installation of up to 126.04 km of subsea power cables, with a trench width of 15 m and a depth of at least 2 m. This includes 1,200 m of cable within the intertidal zone (between MHWS and MLWS). **Decommissioning Phase** Increased SSCs and associated deposition due to: • Removal of up to 126.04 km of cables and 121.77 km pipelines.	**Construction phase** Boulder and debris clearance activities will not be required. The MDS assumes that sand wave clearance will be limited and that the volume of material to be cleared from individual sand waves will vary according to the local dimensions of the sand wave (height, length and shape) and the level to which the sand wave must be reduced. Cable routes inevitably include a variety of seabed material and in some areas, 2 m depth may not be achieved or may be of a coarser nature which settles in the vicinity of the cable route. The assessment therefore considers the upper bound in terms of suspended sediment and dispersion potential. Cables are proposed to be buried by ploughing. The use of open trenching in the intertidal area releases the greatest volume of material into the water column and therefore provides the upper bound of impacts as compared with Horizontal Directional Drilling (HDD) installation. **Decommissioning phase** The removal of cables may be undertaken using similar techniques to those employed during installation, therefore the potential increases in SSC and deposition would be in-line with the construction phase.
Long-term subtidal habitat loss	✓	✓	✓	**Construction and Operation and Maintenance Phases** Up to 64,169 m^2 of subtidal long-term habitat loss due to: • The installation of the foundations for the new Douglas platform, which represents up to 169 m^2 • The installation of cable crossings and their protection, which represents up to 58,800 m^2. Cable crossing protection will have a maximum height of 0.8 m and width of 7 m and will be required at up to 32 crossings. The cable	The MDS represents the maximum footprint which would be affected during the construction, operations and maintenance and decommissioning phases. **Construction and Operation and Maintenance phase** The maximum area of long-term subtidal habitat loss due to the installation of the foundations for the new Douglas platform, cable crossings and protection, and rock placement in the construction phase, persisting into the operation and maintenance phase. There is potential for cable crossing protection installed during the construction phase to impact seabed morphology and cause secondary scour. These could have long-term impacts to available habitats given that cable

<table>
<tr><th rowspan="2">Potential impact</th><th colspan="3">Phase</th><th rowspan="2">Project Design Parameters</th><th rowspan="2">Justification</th></tr>
<tr><th>C</th><th>O</th><th>D</th></tr>
<tr><td></td><td></td><td></td><td></td><td>crossings will be required within a range of depths between 5.8 to 30.3 m (Chart Datum (CD)).
• The installation of 2,400 m² of pipeline spools and 2,800 m² of pipeline mattresses
• Rock placement.
Decommissioning Phase
Minor permanent subtidal habitat loss due to rock placement that will remain in situ after the lifecycle of the Proposed Development.</td><td>crossing protection will be consistently present throughout the operation and maintenance phase. Cable crossing protection is the only cable protection measure proposed for the Proposed Development, as the nature of the seabed sediment within the Proposed Development accommodates cable burial to the required depth (and thus does not require protection). Therefore, buried cables are not anticipated to become exposed and require additional protection throughout the operation and maintenance phase.
Decommissioning Phase
This long-term habitat loss will persist throughout the operation and maintenance phase and into the decommissioning phase, as some rock placement will be left in situ. The MDS for decommissioning (and permanent habitat loss following decommissioning) assumes removal of the foundations, cables, and cable crossing protection, if any additional infrastructure is decommissioned, this will result in a reduced area of permanent habitat loss.</td></tr>
<tr><td>Introduction of artificial habitat and colonisation of hard structures</td><td>×</td><td>✓</td><td>×</td><td>Operation and Maintenance Phase
Up to 64,169 m² of artificial hard habitat introduced due to:
• The installation of the foundations for the new Douglas platform, which represents up to 169 m²
• The installation of cable crossings and their protection, which represents up to 58,800 m². Cable crossing protection will have a maximum height of 0.8 m and width of 7 m and will be required at up to 32 crossings. The cable crossings will be required within a range of depths between 5.8 to 30.3 m (CD).
• The installation of 2,400 m² of pipeline spools and 2,800 m² of pipeline mattresses
• Rock placement.</td><td>Maximum number of foundations, length of cables, and cable crossing protection resulting in greatest surface area for colonisation.
The estimate of habitat creation from the presence of foundations has been calculated as if the foundations were a solid structure. This is, therefore, likely to be a conservative estimate of habitat creation on the basis that the jacket foundations will have a lattice design rather than a solid surface.</td></tr>
</table>

Potential impact	Phase			Project Design Parameters	Justification
	C	O	D		
Increased temperature impacting benthic communities	×	✓	×	**Operation and Maintenance Phase** <u>Subsea power cables:</u> • Installation of up to 126.04 km of subsea power cables with a voltage of 33 kV, at a target depth of 2 to 3 m. This includes 1,200 m of cable within the intertidal zone (between MHWS and MLWS). <u>Subsea gas pipelines for CO_2 transport</u> • Utilisation of up to 121.77 km of existing subsea gas pipelines for the transportation of liquid CO_2, which will be transported at a maximum temperature of up to 50ºC and pressure of up to 72.3 bara. • These pipelines are buried at a target depth of 2 to 3 m.	The MDS is based on the maximum length of subsea gas pipelines and power cables.
Impacts resulting from the release of sediment bound contaminants	✓	×	✓	**Construction Phase** The MDS is as described above for increased SSCs and associated deposition during the construction phase. **Decommissioning Phase** The MDS is as described above for increased SSCs and associated deposition during the decommissioning phase.	**Construction and Decommissioning Phases** The MDS for this impact is the same as presented for 'Increased SSC and associated deposition above', as the MDS of the latter results in the release of the largest volume of sediment and its associated contaminants.
Accidental pollution to the surrounding area	✓	✓	✓	**Construction phase** There will be a total of 236 round trips of vessels associated with the construction phase. This includes a total of 219 round trips of vessels associated with installation of the new Douglas platform and wells (return trips are presented as total across construction period). This includes the following: • up to 2 heavy lift vessel return trips; • up to 14 tug/anchor handler return trips; • up to 12 cargo barge return trips; • up to 80 support vessel return trips; • up to 4 survey vessel return trips;	**All Phases** There is a risk of pollution to water and sediment through accidental release of chemicals and pollutants from vessels/vehicles and equipment/machinery during all stages of installation of the development area.

Potential impact	Phase			Project Design Parameters	Justification
	C	O	D		
				• up to 4 pre-comm vessel return trips; • up to 1 seabed preparation vessel return trips; and • up to 104 crew vessel return trips. A total of 17 round trips of vessels associated with installation of the cables (return trips are presented as total across construction period): • up to 4 cable lay and installation and support vessels making up to 4 return trips; • up to 1 jack-up vessel making up to 1 return trip; • up to 2 multicat vessels making up to 2 return trips; • up to 3 working boats making up to 3 return trips; • up to 1 support vessel (for trenching) making up to 1 return trip; • up to 1 vessel for cable pull-in making up to 1 return trip; • up to 1 survey vessel making up to 1 return trip; • up to 1 seabed preparation vessel making up to 1 return trip; • up to 1 crew transfer vessel making up to 4 return trips; • up to 1 cable crossing protection installation vessel making up to 1 return trip; and • up to 1 cable burial installation vessel making up to 1 return trip. Other activities: • laying of 126.04 km of the cable (including 1,200 m within the intertidal zone); • drilling of 11 wells for co_2 injection; total duration of drilling per well is 15 days; and • use of jack-up rigs **Operation and Maintenance Phase** There will be a total of 750 vessel round trips over the entire operation and maintenance phase. This encompasses vessels used during routine inspections, geophysical surveys, removal of marine growth, replacement of corrosion protection anodes, replacement of access ladders and boat landings, modification to/replacement of J tubes at platforms,	

Potential impact	Phase			Project Design Parameters	Justification
	C	O	D		
				topsides, inter-platform cables/pipelines and PoA terminal to the new Douglas platform cables/pipelines. Maximum vessels on site at any one time: • up to 1 jack-up vessel making up to 15 return trips per year; and • up to 3 multi-purpose support vessels making up to 15 return trips per year. Other activities: • potential for cable maintenance in the subtidal and intertidal zone. **Decommissioning Phase** A total of 128 round trips of vessels associated with the decommissioning phase (return trips are presented as total across construction period): • up to 4 decommissioning and support vessel making up to 7 return trips; • up to 6 tug/anchor handlers making up to 8 return trips; • up to 4 cargo barges making up to 5 return trips; • up to 1 survey vessel making up to 1 return trip; and • up to 2 crew transfer vessels making up to 108 return trips. Other activities: • removal of infrastructure within the Proposed Development.	
Increased risk of introduction and spread of Invasive Non-Native Species (INNS)	✓	✓	✓	**Construction Phase** • Creation of up to 64,169 m^2 of habitat as described in 'long-term habitat loss' above • A total of up to 236 return trips made by vessels during the construction phase (as described above for accidental pollution). **Operation and Maintenance Phase** Increased risk of INNS due to: • Presence of up to 64,169 m^2 of artificial habitat described in 'Introduction of artificial habitat and colonisation of hard structures' above (including cable crossing protection)	**All Phases** The maximum surface area created by installed infrastructure and rock placement, and the maximum number of vessel movements during all phases of development. Vessels have the potential to transport INNS to and/or from the Proposed Development via ballast water or attached to their hulls. The MDS assumes the removal of all infrastructure except that which will remain *in situ* for reservoir modelling (which will eventually be removed – to be confirmed at a later date in the Decommissioning Plan). This includes removal of some foundations, cables, and cable crossing protection. Rock

Potential impact	Phase			Project Design Parameters	Justification
	C	O	D		
				• Up to 750 return trips made by vessels over the 25-year operation and maintenance phase (as described above for accidental pollution). **Decommissioning Phase** Increased risk of INNS due to: • Creation of permanent artificial habitat due to rock placement remaining *in situ,* as described in 'long-term habitat loss' above. • A total of up to 128 round trips made by vessels during the decommissioning phase (as described above for accidental pollution).	placement will be left *in situ*. Infrastructure removal will result in a lower risk of available substrate for INNS to colonise.

Table 7.22: Project Design Parameters Considered For The Assessment Of Potential Impacts On Fish And Shellfish Ecology

Potential impact	Phase			Project design parameters	Justification
	C	O	D		
Temporary habitat loss and/or disturbance	✓	✓	✓	**All Phases** The MDS for this impact is as described above for benthic subtidal and intertidal ecology (Table 7.21).	The justification for this impact is as described above for benthic subtidal and intertidal ecology (Table 7.21).
Long-term subtidal habitat loss	✓	✓	✓	**All Phases** The MDS for this impact is as described above for benthic subtidal and intertidal ecology (Table 7.21).	The justification for this impact is as described above for benthic subtidal and intertidal ecology (Table 7.21).
Underwater noise impacting fish and shellfish receptors	✓	×	×	**Construction phase** Piling during installation of the new Douglas platform foundations • Up to 4 piled jacket foundations, with one leg per foundation and up to 2 x 1.524 m diameter piles per leg (8 piles); • Maximum hammer energy up to 3,000 kJ; • Up to 100 minutes piling per pile; and • Piling of up to two adjacent piles at the same platform at one time. Clearance of UXOs within the Proposed Development • Maximum UXO size of up to 907 kg; • Intention for low order clearance of all UXOs using low order techniques with a single donor charge of up to 80 g net explosive quantity (NEQ) for each clearance event; • Up to 500 g NEQ clearance shot for neutralisation of residual explosive material at each location; • Risk of potential for unintended consequence of low order techniques to result in high order detonation of UXO (maximum size = 907 kg); • A maximum of one UXO clearance within 24 hours; • Total duration of clearance activities up to 12 days; and • Clearance during daylight hours only. Geophysical and seismic site-investigation surveys • Site investigation surveys will involve the use of up to 2 survey vessels (1 shallow water and 1 deep	Impact piling, UXO clearance, and geophysical and seismic site investigation surveys during construction may result in in injury and/or behavioural disturbance/displacement of sensitive fish and shellfish receptors. The largest hammer energy could lead to the largest area of ensonification at any one time. The longest duration of piling at any location results in the greatest number of days when piling could occur. Duration of piling assumes single vessel piling at any one time. UXO donor charge is maximum required to initiate low order detonation. Assumption of a clearance shot of up to 500 g NEQ at all locations although noting that this may not always be required. Maximum range of geophysical and seismic surveys likely to be undertaken using equipment typically employed for these types of surveys will result in the greatest potential impact.

Potential impact	Phase			Project design parameters	Justification
	C	O	D		
				water) carrying out 2 surveys each, and take place over a period of up to 3 months. • Vertical Seismic Profiling (VSP): - number of guns= 6; - total volume= 1,200 cu in; - source depth = 5 m; - firing pressure = 2,000 psi; - SEL = 220 dB re 1 µPa2s @1m; - 0-peak SPL = 238 db re. 1 µpa @ 1m; - pulse interval = 20 s (during operations); and - total number of pulses per 24 h period = 4,320 (three per minute).	
Increased SSCs and associated deposition	✓	×	✓	**Construction and Decommissioning Phases** The MDS for this impact is as described above for benthic subtidal and intertidal ecology (Table 7.21)	The justification for this impact is as described above for benthic subtidal and intertidal ecology (Table 7.21).

Table 7.23: Project Design Parameters Considered For The Assessment Of Potential Impacts On Marine Mammals And Marine Turtles

Potential impact	Phase			Project design parameters	Justification
	C	O	D		
Injury and disturbance from underwater noise generated from piling	✓	×	×	**Construction phase** New Douglas platform foundations: • up to 4 piled jacket foundations, with one leg per foundation and up to 2 x 1.524 m diameter piles per leg (8 piles); • maximum hammer energy up to 3,000 kJ; • up to 100 minutes piling per pile; and • piling of up to two adjacent piles at the same platform at one time.	Impact piling during construction may result in hearing damage/auditory injury, behavioural disturbance/displacement of marine mammals and marine turtles as well as barrier affects. The largest hammer energy could lead to the largest area of ensonification at any one time. The longest duration of piling at any location results in the greatest number of days when piling could occur.
Injury and disturbance from underwater noise generated from UXO detonation	✓	×	×	**Construction phase** Clearance of UXOs within the Proposed Development; • maximum uxo size of up to 907 kg; • intention for low order clearance of all UXOs using low order techniques with a single donor charge of up to 80 g NEQ for each clearance event; • up to 500 g NEQ clearance shot for neutralisation of residual explosive material at each location; • risk of potential for unintended consequence of low order techniques to result in high order detonation of UXO (maximum size = 907 kg); • a maximum of one UXO clearance within 24 hours; • total duration of clearance activities up to 12 days; and • clearance during daylight hours only	Marine mammals and marine turtles are sensitive to increased subsea noise generated during UXO clearance, which can lead to auditory injury, behavioural disturbance as well as barrier effects. UXO Donor charge is maximum required to initiate low order detonation. Assumption of a clearance shot of up to 500 g NEQ at all locations although noting that this may not always be required.
Injury and disturbance from underwater noise generated during geophysical and seismic surveys	✓	✓	×	**Construction phase** Site investigation surveys will involve the use of up to 2 survey vessels (1 shallow water and 1 deep water) carrying out 2 surveys each and take place over a period of up to 3 months. • MBES (170 to 450 kHz; 220 dB re 1 µPa (Root Mean Squared (rms); pulse rate up to 60 Hz). • SBP (85 to 115 kHz, 247 dB re 1µPa (rms), pulse rate up to 40 Hz). • VSP: – Number of guns= 6;	Geophysical and seismic surveys have the potential to cause direct and/or indirect effects (including injury or disturbance) on marine mammals and marine turtles as well as barrier effects. Maximum range of geophysical and seismic surveys likely to be undertaken using equipment typically employed for these types of surveys will result in the greatest potential impact.

Potential impact	Phase			Project design parameters	Justification
	C	O	D		
				– total volume= 1,200 cu in; – source depth = 5 m; – firing pressure = 2,000 psi; – SEL = 220 dB re 1 μPa2s @1m; – 0-Peak SPL = 238 dB re. 1 μPa @ 1m; – pulse interval = 20 s (during operations); and – total number of pulses per 24 h period = 4,320 (three per minute). **Operation and maintenance phase** Routine geophysical and seismic survey are estimated to occur annually.	
Injury and disturbance from vessel activity and other noise producing activities	✓	✓	✓	**All phases** The MDS for this impact is as described in 'Accidental pollution to the surrounding area' upon benthic subtidal and intertidal ecology (Table 7.21).	Injury and disturbance of marine mammals and marine turtles may arise during the construction, operation and maintenance and decommissioning phases of the Proposed Development from vessel use and other noise producing activities (e.g. seabed preparation, drilling, and rock placement over the cable crossings). Underwater noise from vessels and other activities may also result in barrier effects. Maximum numbers of vessels on site at any one time and largest numbers of round trips during each phase of the Proposed Development and broad range of vessel types representative of vessels to be used during construction, operation and maintenance and decommissioning will result in the greatest potential impact. Range of other activities including maximum timescales (where available) during which activities are conducted.
Injury to marine mammals from collision risk with marine vessels	✓	✓	✓	**All phases** The MDS for this impact is as described in 'Accidental pollution to the surrounding area' upon benthic subtidal and intertidal ecology (Table 7.21).	An increase in vessel activity during construction, operation and maintenance and decommissioning phases of the Proposed Development, may result in increased vessel collisions with marine mammals and marine turtles. Maximum numbers of vessels on site at any one time and largest numbers of round trips during each phase of the Proposed Development and broad range of vessel types representative of vessels to be used during construction, operation and maintenance and decommissioning will result in the greatest potential impact.

Potential impact	Phase			Project design parameters	Justification
	C	O	D		
Effects on marine mammals due to changes in prey availability	✓	✓	✓	**Construction Phase** The MDS for impacts to prey species are presented in Table 7.22, for fish and shellfish ecology. In the construction phase, these impacts are: • temporary habitat loss and/or disturbance; • long-term subtidal habitat loss; • underwater noise impacting fish and shellfish receptors; and • increased SSCs and associated deposition. **Operation and Maintenance Phase** The MDS for impacts to prey species are presented in Table 7.22, for fish and shellfish ecology. In the operation and maintenance phase, these impacts are: • temporary habitat loss and/or disturbance; and • long-term subtidal habitat loss. **Decommissioning Phase** The MDS for impacts to prey species are presented in Table 7.22, for fish and shellfish ecology. In the decommissioning phase, these impacts are: • temporary habitat loss and/or disturbance; • long-term subtidal habitat loss; and • increased SSCs and associated deposition.	There is potential for changes in prey abundance resulting from activities during the construction and decommissioning phase of the Proposed Development, which could have an indirect impact on the foraging success of marine mammals and marine turtles within the Proposed Development and surrounding vicinity. Maximum design scenarios described for fish and shellfish receptors (Table 7.22) will result in the greatest potential impact.

7.9.2 Impacts Scoped out of the Assessment

Based on the marine biodiversity existing baseline description presented in section 7.8, one impact is proposed to be scoped out of the assessment for benthic subtidal and intertidal ecology, four for fish and shellfish ecology, and five for marine mammals. This was either agreed with key stakeholders through consultation as discussed in section 7.3.3, or the impact was proposed to be scoped out in the HyNet Carbon Dioxide transportation and Storage Project - Offshore Scoping Report (Eni, 2022). These impacts are outlined, together with a justification for scoping it out, in Table 7.24, Table 7.25 and Table 7.26.

Table 7.24: Impacts Scoped Out Of The Assessment For Benthic Subtidal And Intertidal Ecology (Tick Confirms The Impact Is Scoped Out)

Potential Impact	Phase			Justification
	C	O&M	D	
Impacts to benthic ecology due to EMF	×	✓	×	**Operation and maintenance phase** Low-frequency EMFs are present along subsea cables used to transmit electricity from the Proposed Development to the appropriate substation and terminal locations. There are limited findings on the electro sensitivity of benthic organisms and on the associated impact of EMFs on the surrounding benthic invertebrates. Bochert and Zettler (2006) studied the effects of EMF on the survival and physiology of various crustaceans, marine worms, and echinoderms in the context of cables associated with OWFs in the Baltic Sea. The authors demonstrated no significant effects for any species after three months of exposure. Furthermore, Wilhelmsson *et al.* (2010) demonstrated that there were no differences between benthic community assemblages observed in visual surveys of OWF subsea cables and their peripheral areas. Finally, the presence of diverse and seemingly healthy benthic communities on existing offshore infrastructure indicates that EMF is unlikely to cause a long-term significant effect upon benthic receptors (Linley *et al.,* 2007; Walker *et al.,* 2009). Embedded mitigation for this impact includes cable burial and/or protection when not available (such as at cable crossings). The target cable burial depth of 2 to 3 m is sufficient to reduce the potential for impacts from EMF on benthic invertebrates. Based on this, and the literature provided above, it is proposed to scope this impact out of the assessment on benthic subtidal and intertidal ecology.

Table 7.25: Impacts Scoped Out of the Assessment for Fish and Shellfish ecology (Tick Confirms the impact is Scoped Out)

Potential Impact	Phase			Justification
	C	O&M	D	
Underwater noise from marine vessels during construction, operation and maintenance and decommissioning phases	✓	✓	✓	**All phases** The potential for underwater noise generated from marine vessels will only occur within the Proposed Development and the immediate vicinity. Fish and shellfish receptors are unlikely to remain in the area for long periods of time during offshore construction, maintenance, and decommissioning activities.
Impacts to fish and shellfish ecology due to EMF	×	✓	×	**Operation and maintenance phase** Low-frequency EMFs are present along subsea cables used to transmit electricity from the Proposed Development to the appropriate substation and terminal locations. Fish and shellfish receptors may be receptive to EMF; however a recent study has demonstrated that increased cable burial depth reduces the intensity of EMF for receptive species (Hutchison *et al*., 2021). As an embedded mitigation measure, cables within the Proposed Development will be buried (target cable burial depth of 2 to 3 m) and/or protected therefore, there is limited scope for impacts from EMF on fish and shellfish ecology.

Potential Impact	Phase			Justification
	C	O&M	D	
Accidental pollution during construction, operation and maintenance, and decommissioning phases	✓	✓	✓	**All phases** The potential for accidental pollution to be released during the construction, operation and maintenance, and decommissioning phases of the Proposed Development is present. This pollution could potentially result from sources including vessels/vehicles and equipment/machinery. However, the risk of these events is managed through embedded mitigation, such as an EMP, which includes Marine Pollution Contingency Plans (MPCPs).

Table 7.26: Impacts Scoped Out Of The Assessment For Marine Mammals And Marine Turtles (Tick Confirms The Impact Is Scoped Out)

Potential Impact	Phase			Justification
	C	O&M	D	
Impacts to marine mammal ecology due to EMF	×	✓	×	**Operation and maintenance phase** Low-frequency EMFs are present along subsea cables used to transmit electricity from the Proposed Development to appropriate substations and terminal locations. Cables within the development area will be buried (to a minimum of 2 m), and/or protected therefore, there is little expected impact on marine mammals and marine turtles. Additionally, there is limited data illustrating marine mammals and turtles being affected by or responding to EMF.
Accidental pollution during construction, operation and maintenance, and decommissioning phases	✓	✓	✓	**All phases** The potential for accidental pollution to be released during the construction, operation and maintenance, and decommissioning phases of the Proposed Development is present. This pollution could potentially result from sources including vessels/vehicles and equipment/machinery. However, the risk of these events is managed through EMP, including MPCPs.
Injury, disturbance, and displacement to marine mammals from operational noise	×	✓	×	**Operation and maintenance phase** The operational noise expected to occur from the Proposed Development will be minimal due to the nature of the infrastructure; there will only be heaters on the platforms. Additionally, the Proposed Development exhibits varying levels of subsea ambient noise sources, the most dominant being offshore shipping. Operational noise is unlikely to add to the existing underwater noise baseline in any significant manner given the context of industrial shipping in the vicinity.
Increased Suspended Sediment Concentrations (SSCs) and associated deposition	✓	×	✓	**Construction and decommissioning phase** Increased suspended sediment concentrations and sediment deposition from construction and decommissioning activities related to subsea pipeline refurbishment and cable installation may potentially result in indirect impacts on marine mammal ecology related to effects on prey species; however, marine mammals are well known to forage in tidal areas where water conditions are turbid and visibility conditions are subsequently poor. Whilst elevated levels of SSCs arising during construction of the Proposed Development may decrease light availability in the water column and produce turbid conditions, the maximum impact range is expected to be localised with sediments rapidly dissipating over one tidal excursion. Therefore, it is proposed to scope this impact out for marine mammals and marine turtles.

7.10 Methodology for Assessment of Effects

The methodology for the assessment of effects follows that set out in volume 1, chapter 5. The following guidance and legislation have also been considered:

- Environmental Protection Agency (EPA) (2022) Guidelines on the Information to be Contained in Environmental Impact Assessment Reports;
- CIEEM (2022) Guidelines for Ecological Impact Assessment (EcIA) in the UK and Ireland;
- Natural England and JNCC (2022) Nature conservation consideration and environmental best practice for subsea cables in English Inshore and UK offshore waters;
- Tougaard (2021) Thresholds for behavioural responses to noise in marine mammals;
- Natural England and JNCC (2019) advice on key sensitivities of habitats and MPAs in English Waters to offshore wind farm cabling within Proposed Round 4 leasing areas;
- Institute of Environmental Management and Assessment (IEMA) (2016) Environmental Impact Assessment Guide to Delivering Quality Development;
- NPWS (2014) Guidance to Manage the Risk to Marine Mammals from Man-Made Sound in Irish Waters;
- European Communities (Birds and Natural Habitats) Regulations 2011;
- Marine Strategy Framework Directive (MSFD) 2008/56/EC; and
- The Wildlife Act 1997 (Amendment 2000).

7.10.1 Magnitude of Impact

Determining the significance of effects is based on a matrix containing the magnitude of the impact and the sensitivity of the receptors. Therefore, the magnitude of the impact and the sensitivity of the receptors must be defined against set criteria. The terms used to define the magnitude of impact and sensitivity of the receptors are presented briefly in the following sections and are described in further detail in volume 1, chapter 5. The criteria used for defining the magnitude of impact are presented in Table 7.27.

Table 7.27: Definition Of Terms Relating To The Magnitude Of Impact

Magnitude of Impact	Definition	
	Adverse Effect(s)	**Beneficial Effect(s)**
High	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features, or elements	Large scale or major improvement or resource quality; extensive restoration or enhancement; major improvement of attribute quality
Medium	Loss of resource, but not adversely affecting integrity of resource; partial loss of/damage to key characteristics, features, or elements	Benefit to, or addition of, key characteristics, features, or elements; improvement of attribute quality
Low	Some measurable change in attributes, quality or vulnerability, minor loss of, or alteration to, one (maybe more) key characteristics, features, or elements	Minor benefit to, or addition of, one (maybe more) key characteristics, features, or elements; some beneficial impact on attribute or a reduced risk of adverse impact occurring
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features, or elements	Very minor benefit to, or positive addition of one or more characteristics, features, or elements
No change	No loss or alterations of characteristics, features, or elements and no observable adverse impact	No loss or alterations of characteristics, features, or elements and no observable beneficial impacts

7.10.2 Sensitivity of Receptors

Benthic Subtidal and Intertidal Ecology

The Marine Evidence Based Sensitivity Assessment (MarESA) has been used to define the sensitivity of benthic subtidal and intertidal ecology IEFs. MarESA involves the likelihood or damage (thus resistance) due to the pressure of an effect and the rate of recovery (i.e., recoverability) once said pressure is removed. Resistance is defined as the level at which a receptor can absorb disturbance or stress without changing character. Recoverability is defined as the ability of the habitat to return its state that existed prior to the effect which caused the change. However, full recovery does not necessarily mean that every species component of the habitat has recovered to its prior condition, abundance, and/or extent. Instead, full recovery is reached if the relevant functional components are present, and the habitat is structurally and functionally recognisable as it was prior to the change.

MarESA is a database developed through the Marine Life Information Network (MarLIN) of Britain and Ireland and maintained by the Marine Biological Association (MBA). The MarESA database consists of a detailed review of available evidence on the effects of pressures on marine species and habitats. Subsequently, it also contains a scoring of sensitivity against a standard list of pressures, and their benchmark levels of effect. The MarESA evidence base is peer reviewed and is the largest review undertaken to date on the effects of human activities and natural events on marine species and habitats. It is one of the best available sources of evidence regarding the recovery of seabed species and habitats.

The MarESA sensitivity assessment correlates resistance and recoverability in order to characterise sensitivity of benthic subtidal and intertidal receptors (Table 7.28.). This has been used to define the sensitivity of benthic subtidal and intertidal receptors in this ES chapter, as set out in

Table 7.29.

Table 7.28: Matrix Used To Determine The Sensitivity Of Benthic Subtidal And Intertidal Receptors (Reproduced From MarESA Sensitivity Assessment)

		Resistance			
		None	Low	Medium	High
Recoverability	Very Low	High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	Low	High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	Medium	Medium sensitivity	Medium sensitivity	Medium sensitivity	Low sensitivity
	High	Medium sensitivity	Low sensitivity	Low sensitivity	Not sensitive (Negligible)

Table 7.29: Definition Of Terms Relating To The Sensitivity Of The Receptor

Sensitivity	Definition
Very High	Nationally and internationally important receptors with high vulnerability and low to no recoverability.
High	Regionally important receptors with high vulnerability and no ability to recover.
Medium	Nationally and internationally important receptors with medium vulnerability and medium recoverability. Regionally important receptors with medium to high vulnerability and low recoverability. Locally important receptors with high vulnerability and no ability to recover.
Low	Nationally and internationally important receptors with low vulnerability and high recoverability. Regionally important receptors with low vulnerability and medium to high recoverability. Locally important receptors with medium to high vulnerability and low recoverability.
Negligible	Locally important receptors with low vulnerability and medium to high recoverability. Receptor is not vulnerable to impacts regardless of value/importance.

7.10.2.1 Fish and Shellfish Ecology

In a similar approach to Benthic Subtidal and Intertidal Ecology, an assessment of the combined vulnerability of the receptor to a given impact and the likely rate of recoverability to pre-impact conditions has been used to determine the sensitivity of fish and shellfish IEFs.

Vulnerability is defined as the susceptibility of a species to disturbance, damage, or death, from a specific external factor. Recoverability is the species' ability to return to a state close to that which existed prior to the damage caused by the activity or event. Recoverability is defined by the receptor's ability to recover or recruit after subjected to the extent of disturbance/damage incurred. Information on these factors informing sensitivity of the fish and shellfish IEFs to given impacts has been informed by the best available evidence, including the MarESA, where available. This is derived from evidence of environmental impact and/or experimental manipulation in the field from offshore industries, such as oil and gas activities, electrical cabling, offshore wind farms, and aggregate extraction. These sensitivity assessments have been combined with the assessed conservation status of the fish and shellfish IEFs (section 7.7; Table 7.7). The criteria for defining receptor sensitivity in this ES chapter are outlined in

Table 7.29.

Marine Mammals and Marine Turtles

Similar to the approaches outlined above for the other Marine Biodiversity topics, the sensitivity of marine mammal and turtle IEFs has been defined by an assessment of the following:

- the ability of the receptor to adapt to the effect of an impact;
- the receptor's tolerance to that impact; and
- the receptor's ability to recover back to pre-impact conditions.

Tolerance is defined as the susceptibility of the receptor to disturbance, damage, or death, caused by a specific external factor. Recoverability is the ability of the receptor to return to a state close to that which existed prior to the activity or event which caused change. Recoverability is dependent on the ability of the local population to recover, subject to the extent of disturbance/damage incurred. The sensitivity of the marine mammal and turtle IEFs to given impacts has been informed by the best available evidence, such as studies on captive animals and observations from field studies. In particular, evidence of environmental impact and/or experimental manipulation in the field from offshore industries, such as oil and gas activities, electrical cabling, offshore wind farms, and aggregate extraction have been used, where available. The review of vulnerability and recoverability of marine mammal and turtle IEFs has been combined with their assessed conservation status (section 7.7; Table 7.7). The criteria for defining receptor sensitivity in this ES chapter are outlined in Table 7.30.

Table 7.30: Definition Of Terms Relating To The Sensitivity Of The Receptor For Marine Mammal And Turtle IEFs

Sensitivity	Definition
Very High	No ability to adapt behaviour so that survival and reproduction rates may be affected. No tolerance; effect is very likely to cause a change in both reproduction and survival of individuals. No ability for the animal to recover from the effect
High	No or limited ability to adapt behaviour so that survival and reproduction rates may be affected. No or limited tolerance; effect may cause a change in both reproduction and survival of individuals. No or limited ability for the animal to recover from the effect.
Medium	Ability to adapt behaviour so that reproduction rates may be affected but survival rates not likely to be affected. Some tolerance; effect unlikely to cause a change in both reproduction and survival rates. Ability for the animal to recover from the effect.
Low	Receptor is able to adapt behaviour so that survival and reproduction rates are not affected. Receptor is able to tolerate the effect without any impact on reproduction and survival rates. Receptor is able to return to previous behavioural states/activities once the impact has ceased.
Negligible	Very little or no effect on the behaviour of the receptor.

7.10.3 Significance of Effect

The significance of the effect upon Marine Biodiversity is determined by correlating the magnitude of impact (Table 7.27) and the sensitivity of the receptor, as presented in Table 7.31. Where a range of significances of effect are presented (i.e. 'moderate or major') the final assessment for each effect is based upon expert judgement, with clear justification, and evidence, if necessary, provided. For the purposes of this assessment, any effects with a significance level of 'minor' or less will be considered to be insignificant.

Table 7.31: Matrix Used To Assess The Significant Of Effect

Sensitivity of Receptor	Magnitude of Impact: Negligible	Low	Medium	High
Negligible	Negligible	Negligible or Minor	Negligible or Minor	Minor
Low	Negligible or Minor	Negligible or Minor	Minor	Minor or Moderate
Medium	Negligible or Minor	Minor	Moderate	Moderate or Major
High	Minor	Minor or Moderate	Moderate or Major	Major or Substantial
Very High	Minor	Moderate or Major	Major or Substantial	Substantial

7.10.4 Designated Sites

This chapter summarises the assessments made on the interest features of internationally designated sites as described in sections 7.8.1.7, 7.8.2.8, and 7.8.3.7 (with the assessment on the site itself deferred to the RIAA). With respect to nationally and locally designated sites, where these sites fall within the boundaries of an internationally designated site (e.g., Sites of Special Scientific Interest (SSSIs) which have not been assessed within the RIAA), only the international site has been taken forward for assessment. This is because potential effects on the integrity and conservation status of the nationally designated site are assumed to be inherent within the assessment of the internationally designated site (i.e., a separate assessment for the national site is not undertaken).

For benthic subtidal and intertidal ecology, two designated sites have been included in this assessment as IEFs, as they overlap with the Proposed Development: the Dee Estuary/Aber Dyfrdwy SAC and the Fylde MCZ (see section 7.8.1.7). Although Annex II sea lamprey and river lamprey are also present as qualifying features of the Dee Estuary/Aber Dyfrdwy SAC (JNCC, 2023a) (Table 7.12), these species are assessed under ‘Diadromous fish’ within the assessment for fish and shellfish ecology. Thus, the Dee Estuary/Aber Dyfrdwy SAC has not been assessed as an IEF for fish and shellfish ecology. Fish and shellfish which are qualifying interest features of designated sites have been defined as IEFs and are assessed as such (where relevant). Finally, for marine mammals and marine turtles, there are no designated sites which overlap with the Proposed Development. However, all Annex II species which are qualifying interest features of designated sites within the regional marine mammal study area (Table 7.19) have also been defined as IEFs and are assessed as such (where relevant).

7.11 Embedded Mitigation

For the purposes of the EIA process, the term 'Embedded Mitigation’ is used to include the following measures (adapted from IEMA, 2016):

- Measures included as part of the project design. These include modifications to the location or design envelope of the Proposed Development which are integrated into the application for consent. These measures are secured through the consent itself throughout the description of the development and the parameters secured in the Development Consent Order (DCO) and/or marine licence (referred to as ’primary mitigation’ in IEMA, 2016).
- Measures required to meet legislative requirements, or actions that are standard practice used to manage commonly occurring environmental effects and are secured through the DCO requirements and/or the conditions of the marine licences (referred to as ’tertiary mitigation’ in IEMA, 2016).

A number of embedded mitigation measures (primary and tertiary) have been adopted as part of Proposed Development to reduce the potential for impacts on marine biodiversity. These are outlined in Table 7.32

below. As there is a secured commitment to implementing these measures, they are considered inherently part of the design of the Proposed Development. Therefore, these measures have been considered in the assessment of significance, presented in section 7.12 below. This means that the determination of magnitude and therefore significance assumes implementation of these measures.

Where significant effects have been identified in section 7.12 below, further mitigation measures (referred to as ‘secondary mitigation’ in IEMA 2016) have been identified to reduce the significance of effect to acceptable levels following the initial assessment. These are measures that could further prevent, reduce and, where possible, offset any adverse effects on the environment.

Table 7.32: Embedded Mitigation Measures Adopted As Part Of The Proposed Development

Embedded Mitigation	Justification	How these Measures will be Secured
Primary Mitigation: Measures Embedded into the Project Design		
Development of, and adherence to, a Cable Specification and Installation Plan (CSIP) which will include cable burial where possible (in accordance with the specific policies set out in the North West Inshore and North West Offshore Marine Plan (MMO, 2021)) and cable protection, as necessary.	The CSIP will set out appropriate cable burial depth in accordance with industry good practice, minimising the risk of cable exposure. The CSIP will also ensure that cable crossings are appropriately designed to mitigate environmental effects, these crossings will be agreed with relevant parties in advance of CSIP submission. The CSIP will include a detailed Cable Burial Risk Assessment (CBRA) to enable informed judgements regarding burial depth to maximise the chance of cables remaining buried whilst limiting the amount of sediment disturbance to that which is necessary. Measures will seek to reduce the amount of EMF which benthic and fish and shellfish receptors are exposed to during the operations and maintenance phase by increasing the distance between the seabed surface and the surface of the cables.	Proposed to be secured as a condition of the marine license(s).
Implementation of piling initiation, soft-start, and ramp-up measures within the Marine Mammal Mitigation Protocol (MMMP). An initiation stage and soft starts will be used during the installation of pin piles. This involves the implementation of an initial low hammer energy with a low number of strikes, followed by lower hammer energies at a higher strike rate at the beginning of the piling sequence before energy input is ‘ramped up’ (increased) over time to required higher levels.	This measure will minimise the risk of injury to fish, marine mammal, and marine turtle species in the immediate vicinity of piling activities, allowing individuals to move away from the area before noise levels reach a level at which injury may occur.	
Inclusion of low order techniques as a UXO clearance option noting, however, that it is not possible to fully commit to this measure at this stage. Low order techniques are not always possible and are dependent upon the individual situations surrounding each UXO. Given that high order detonation may be required, the MMMP will also include mitigation to reduce the risk of injury from UXO clearance.	Low order techniques generate less underwater noise than high order techniques and therefore present a lower risk to sound-sensitive receptors such as fish, marine mammals, and marine turtles during UXO clearance.	

Embedded Mitigation	Justification	How these Measures will be Secured
Development of and adherence to an EMP that will be prepared and implemented during the construction, operational and maintenance and decommissioning phases of the Proposed Development. The EMP will include appendices detailing actions to minimise INNS (the INNS Management Plan (INNSMP)), and a MPCP will be developed which will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details	Measures will be adopted to ensure that the potential for release of pollutants from construction, operational and maintenance and decommissioning plant is minimised. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and takes containing hazardous substances, and storage of these substances in impenetrable bunds. All vessels will be required to comply with the standards set out in the International Convention for the Prevention of Pollution from Ships (MARPOL).	
Tertiary Mitigation: Measures Required to meet Legislative Requirements, or Adopted Standard Industry Practice		
Development of and adherence to a MMMP, based on a draft MMMP submitted alongside the ES. The MMMP will present appropriate mitigation for activities that could potentially lead to injurious effects on marine mammals including: piling, UXO clearance and some types of geophysical activities. The MMMP will be developed on the basis of the most recent published statutory guidance and in consultation with key stakeholders.	**Piling:** for the purpose of developing the MMMP, a mitigation zone of 500 m will be applied, following the JNCC (2010a) guidance. The Draft MMMP will set out the measures to apply in advance of and during piling activity including the use of Marine Mammal Observers (MMObs), Passive Acoustic Monitoring (PAM), and Acoustic Deterrent Devices (ADD), thereby following the latest JNCC guidance (JNCC, 2010a). **UXO Clearance:** Measures including visual and acoustic monitoring (MMObs and PAM), the use of an ADD, and soft start charges will be applied to deter animals from the mitigation zone as defined by sound modelling for the largest possible UXO following the latest JNCC (2010b) guidance. **Geophysical and Seismic Surveys:** Mitigation for injury during high resolution geophysical and seismic site-investigation surveys using a sub-surface sensor from a conventional vessel will involve the use of MMObs and PAM to ensure that the risk of injury over the defined mitigation zone is reduced in line with JNCC (2017) guidance (500 m). Soft start is not possible for SBP equipment but will be applied for other high-resolution surveys where possible. It should be noted that some multi-beam surveys in shallow waters (<200m) are not subject to the requirements of mitigation.	Proposed to be secured through a condition in the marine licence(s).
Development of, and adherence to, a CMS.	This measure will confirm the actual methodology that will be employed to construct the Proposed Development, provide details on aspects of the methodology not known at the application stage and confirm that the methodology falls within the parameters assessment in the ES.	

Embedded Mitigation	Justification	How these Measures will be Secured
Actions to minimise INNS, including a biosecurity plan to limit spread and introduction of INNS	These measures will aim to manage and reduce the risk of potential introduction and spread of INNS so far as reasonably practicable to best protect the biological integrity of the local natural environment and communities.	
Development of, and adherence to, an EMP, which will be issued to all vessel operators, requiring them to: • not deliberately approach marine mammals, marine turtles, and basking sharks; • keep vessel speed to a minimum; and • avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride.	To minimise the potential for collision risk, or potential injury to, marine mammals and megafauna this code of conduct outlines in the EMP will be adhered to at all times.	An EMP will be issued to all Project vessel operators. Proposed to be secured through a condition in the marine licence(s).
Development of, and adherence to, a Decommissioning Plan	The aim of this plan is to adhere to the relevant UK and international legislation and guidance in place at the time, with decommissioning industry practice applied to reduce the amount of long-term disturbance to the environment so far as reasonably practicable.	Proposed to be secured as a condition of the marine license(s).

7.12 Assessment of Significance

The potential impacts of the construction, operation and maintenance, and decommissioning of phases of the Proposed Development have been assessed for benthic subtidal and intertidal ecology, fish and shellfish, and marine mammals and marine turtles. These potential impacts are presented in Table 7.21, Table 7.22, and Table 7.23, alongside the MDS against which impact has been assessed.

Benthic Subtidal and Intertidal Ecology

7.12.1 Temporary Subtidal Habitat Loss and/or Disturbance

Temporary habitat loss and/or disturbance of subtidal and intertidal habitats will occur during the construction, operations and maintenance, and decommissioning phases of the Proposed Development. The MDS for temporary habitat loss/disturbance is summarised in Table 7.21. The relevant MarESA pressures and their benchmarks which have used to inform this impact assessment are described here:

- Habitat structure changes - removal of substratum (extraction): the benchmark for which is the extraction of substratum to 30 cm. This pressure is considered to be analogous to the impacts associated with sand wave clearance and the construction of exit pits.
- Abrasion/disturbance at the surface of the substratum or seabed: the benchmark for which is damage to surface features (e.g. species and physical structures within the habitat). This pressure corresponds to the impacts associated with jack-up vessel operations and anchor placements.
- Penetration and/or disturbance of the substratum subsurface: the benchmark for which is damage to sub-surface features (e.g. species and physical structures within the habitat). This pressure corresponds to the impacts associated with cable installation and jack-up vessel operations.
- Smothering and siltation rate changes (heavy): the benchmark for which is heavy deposition of up to 30 cm of fine material added to the habitat in a single discrete event. This pressure corresponds to impacts associated with the deposition of dredged sand wave material and drill cutting deposits.

7.12.1.1 Construction Phase

There is potential for temporary subtidal habitat loss and/or disturbance in the Proposed Development due to site preparation activities and the installation of development infrastructure (such as subsea power cables and the new Douglas platform).

Magnitude of Impact

Subtidal Habitats and Species

The MDS accounts for up to a total of 1.91 km^2 of temporary subtidal habitat loss and/or disturbance during the construction phase (Table 7.21). The represents 0.32% of the total Proposed Development.

Temporary habitat disturbance in the construction phase is likely to result from seabed preparations (e.g. sand wave clearance and associated deposition), jack-up events, and cable installation. Any mounds of cleared material will erode over time and displaced material will re-join the natural sedimentary environment, gradually reducing the size of the mounds. As the sediment type deposited on the seabed will be similar to that of the surrounding areas, benthic assemblages would be expected to recolonise these areas (see 'Sensitivity of the Receptor' section below). The use of jack-up vessels at the new Douglas platform will result in 736 m^2 of temporary habitat loss and/or disturbance during the construction phase (Table 7.21). There will be four foundations, and two jack-up events required per foundation.

Temporary habitat loss and/or disturbance will result due to depressions formed during jack-up events, which may remain for multiple years. For example, monitoring studies at Barrow Offshore Wind Farm demonstrated that depressions were almost entirely infilled 12 months post construction, while monitoring at the Lynn and Inner Dowsing Offshore Wind Farm demonstrated some evidence of infilling but visible depressions two years post construction (Barrow Offshore Wind, 2008; EGS, 2011). Jack-up depressions are likely to be temporary in areas with mobile sands, such as the Proposed Development. For example, monitoring of the Walney Wind Farm Extension, showed that fine sands and muds within this area were highly mobile and likely to return to a relatively undisturbed habitat within a period of months to a few years (CMACS, 2014).

Subsea cable installation will result in 1.89 km^2 of temporary habitat loss and/or disturbance due to trenching within the construction phase (Table 7.21). This will include the installation of 126.04 km of subsea power cables with a trench width of 15 m. For the purposes of modelling the MDS, the total footprint of affected seabed has been calculated, assuming a mound of uniform thickness of 0.5 m height. However, it should be noted that, mounds may be taller and more unevenly distributed. Any mounds of cleared material will, however, erode over time and displaced material will re-join the natural sedimentary environment, gradually reducing the size of the mounds.

A recent study by RPS (2019) reviewed the effects of cable installation on subtidal sediments and habitats, drawing on monitoring reports from over 20 UK offshore wind farms. Sandy sediments were shown to recover quickly following cable installation, with little or no evidence of disturbance in the years following cable installation. It also presented evidence that remnant cable trenches in coarse and mixed sediments were conspicuous for several years after installation. However, these shallow depressions were of limited depth (i.e. tens of centimetres) relative to the surrounding seabed, over a horizontal distance of several metres and therefore did not represent a large shift from the baseline environment (RPS, 2019). Remnant trenches (and anchor drag marks) were observed years following cable installation within areas of muddy sand sediments, although these were relatively shallow features (i.e. a few tens of centimetres).

The majority of sand wave clearance and cable installation may potentially take place within the Subtidal mixed muddy sediment IEF. However, as detailed above by the RPS (2019) study, this habitat is likely to recover from activities of this nature. There is unlikely to be any disturbance to the Annex I Reef IEF identified within this assessment due to its distance from the area of project physical work (see Figure 7.4).

Dredging will be undertaken at West Hoyle Bank, which is a sandbank situated off the coast of the PoA, to install subsea power cables between the new Douglas platform and the PoA terminal. This will require dredging a channel (most likely with the backhoe dredger) approximately 1,000 m in length, 21 m in width, and 7 m in depth (~3m to take bank down to LAT, then ~3m depth for cable burial). The excavated material will be side cast along the length of the trench, and then backfilled after cable installation. It would take approximately two to three weeks to excavate the trench. Even if the cable was routed further to the east of West Hoyle Bank, the water remains extremely shallow. It will, therefore, still require pre-lay dredging to allow for a self-beaching cable lay vessel to ground itself at low tide on a ‘flat’ area of sandbank. It would take approximately four to seven days to excavate the area depending on dredging technique applied. In total, dredging at West Hoyle Bank will result in 21,000 m^2 of disturbance. Physical processes modelling demonstrated that much of the material is deposited along the dredge path itself, supporting the fact the sediment will remain within the sediment cell and minimising loss to West Hoyle Bank. Taking into account the eastward migration of the existing channel through West Hoyle Bank, it is recommended as a mitigating measure that the placement of dredged material directly to the west of seabed preparation operations would aid in the recovery of morphological features, and further encourage the feature to naturally infill. The temporary change to the morphology of West Hoyle Bank will have minimal impact on the feature’s ability to act as a natural breakwater for waves propagating towards the Dee Estuary/Aber Dyfrdwy SAC. Given the location and orientation of the channel, cutting through the middle of the bank from its southern face to its northern face, there will be no change to the waves breaking on the west of the sand bank.

The maximum duration of the offshore construction phase for the Proposed Development is up to two years. Within this maximum construction period, construction activities are anticipated to occur intermittently. They will be spread out across the full allotted timeframe with only a small proportion of the MDS footprint being affected at any one time.

The ‘Subtidal mixed muddy sediment’, ’Subtidal sands and gravels’, ‘Mud habitats in deep water’ and Annex I Reef IEFs have been assigned national importance (Table 7.10). The impact on these IEFs is predicted to be of local spatial extent (0.32% of the Proposed Development), short term duration (up to two years), intermittent (due to the construction schedule), and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is therefore considered to be low.

Ross worm was identified as an IEF of local importance within this assessment as individual animals, not reefs. As there were only several individual animals recorded during the site-specific benthic characterisation survey and no reefs identified, it is unlikely that the Proposed Development represents an important habitat for this species at a population level. The impact on the Ross worm IEF is predicted to be of highly local spatial extent (due to no reefs observed), short term duration (up to two years), intermittent (due to the construction schedule), and high reversibility. The magnitude is therefore considered to be negligible.

Intertidal Habitats and Species

As outlined in the MDS, the installation of 1,200 m of subsea power cables within the intertidal area, via ploughing or cable trenching techniques, may result in temporary habitat loss and/or disturbance. If using the cable trenching machine (which represents the worst-case scenario) and in the absence of any additional mitigation, an area of approximately 18,000 m^2 (1.8 ha) would be impacted. This includes the area of sediment directly disturbed by the installation of the cable and the area of sediment potentially compacted under the tracks of the machine. The MDS assumes a trench width of 15 m (Table 7.21). Sediment disturbed during the installation will be backfilled by the machine, subsequent infilling from deposited suspended sediments, as well as natural deposition, so disturbance would be temporary and localised.

Temporary disturbance to the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF may also arise as a result of the movement of machinery, equipment, vehicles and personnel. These activities are likely to result in surface level abrasion and disturbance or compaction of sediments. The area of sediment potentially compacted under the tracks of the cable trenching machine is included within the 18,000 m^2 above.

The ‘Mudflats and sandflats not covered by seawater at low tide’ IEF has been assigned international importance (Table 7.10). The impact on this IEF is predicted to be of local spatial extent (up to 18,000 m^2), short term duration (up to two years), intermittent (due to the construction schedule), and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Designated Sites

The Dee Estuary/Aber Dyfrdwy SAC and the Fylde MCZ overlap with the Proposed Development in parts and have been assessed as IEFs of international and national importance, respectively, as a result (Table 7.10). The Proposed Development overlaps with 0.21 km^2 of the Dee Estuary/Aber Dyfrdwy SAC, corresponding to 0.13% of the SAC’s total area. The Proposed Development overlaps with 260.60 km^2 of the Fylde MCZ, corresponding to 15.87% of the MCZ’s total area. Therefore, there is a small overlap between the Proposed Development and these two designated sites, particularly the Dee Estuary/Aber Dyfrdwy SAC.

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), temporary habitat loss and/or disturbance may arise in the Dee Estuary/Aber Dyfrdwy SAC due to installation of 1,200 m of offshore export cables within the intertidal area, and as a result of the movement of machinery, equipment, vehicles and personnel. The installation of 1,200 m of subsea power cables within the intertidal area may result in up to 18,000 m^2 of temporary habitat disturbance. This includes the area of sediment directly disturbed by the installation of the cable and the area of sediment under the tracks of the machine. Based on this information, the area of habitat within the Proposed Development with the potential to be temporarily disturbed is expected to be 18.40% of the total intertidal mudflats and sandflats habitat area, although only 0.017% of the extent of the Annex I mudflats and sandflats habitat within the Dee Estuary/Aber Dyfrdwy SAC.

As stated above for the subtidal habitats and species IEFS, dredging at the West Hoyle Bank prior to cable installation is highly recoverable due to natural and mitigated infilling. Temporary changes to the morphology of West Hoyle Bank are not expected to impact its ability to act as a natural breakwater for waves propagating towards the Dee Estuary/Aber Dyfrdwy SAC and its Annex I mudflat and sandflat feature.

As the Fylde MCZ overlaps with the Proposed Development offshore, potential impacts that may arise are the same as those identified above for 'Subtidal Habitats and Species'. However, there is unlikely to be any disturbance to the Fylde MCZ as it is a minimum 1.82 km away from the area of project physical work (see Figure 7.4).

Overall, the impact on the designated site IEFs is predicted to be of local spatial extent, short term duration, intermittent, and high reversibility. For the designated sites IEFs, it is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be low.

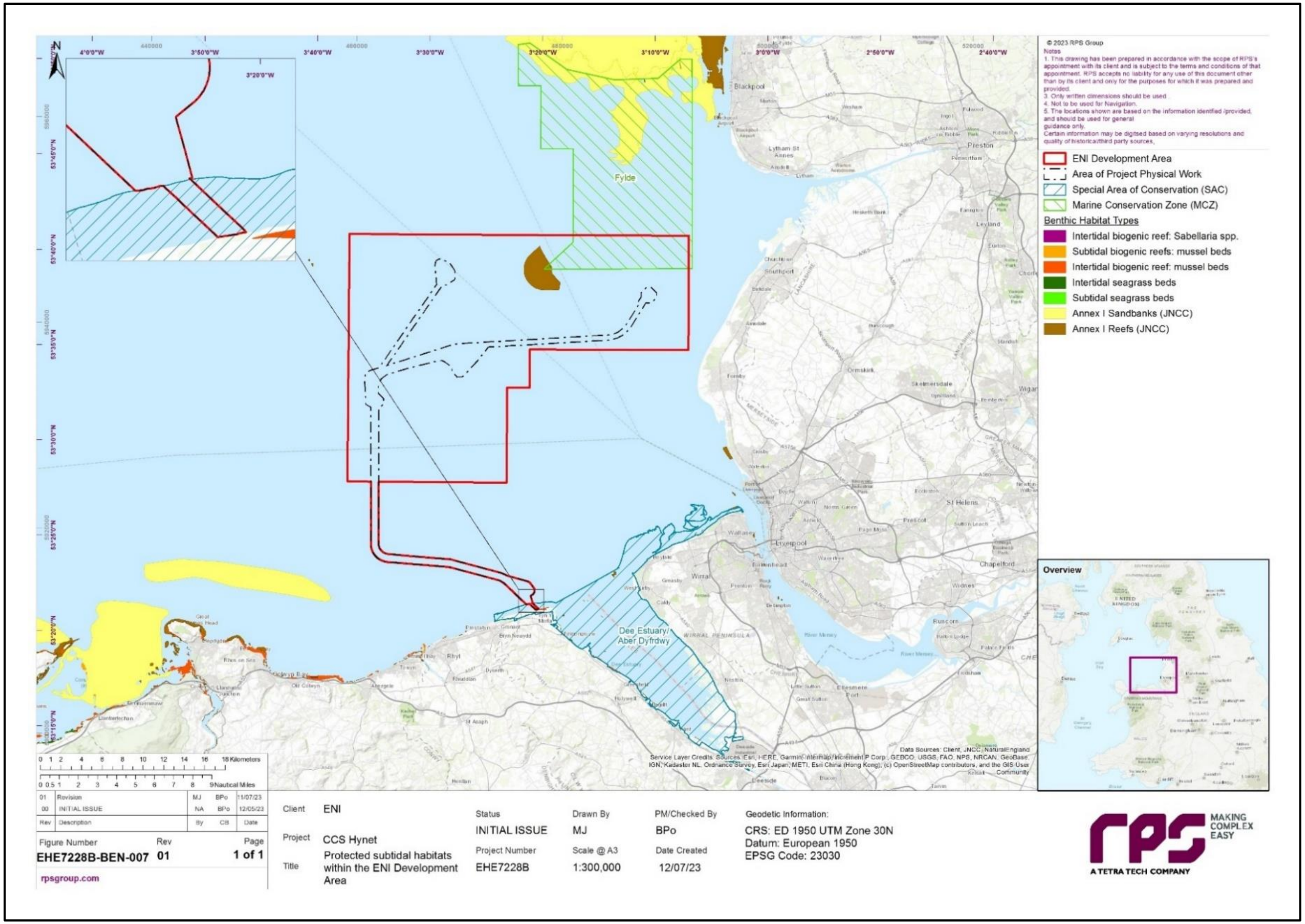


Figure 7.4: Protected Habitats Identified Within The Proposed Development

Sensitivity of Receptor

Subtidal Habitats and Species

The sensitivity of the IEFs to temporary subtidal habitat loss and/or disturbance are presented in Table 7.33. These sensitivities are based on assessments made by the MarESA (where available).

The subtidal habitats and species IEFs have an overall medium sensitivity to this impact. The biotopes within these IEFs have no to medium sensitivity to abrasion and penetration related disturbance because these habitats are largely characterised by infauna (Table 7.33). Resilience is thought to be high although abrasion or penetration may result in damage or mortality to some epifaunal organisms (De-Bastos and Marshall, 2016; Tillin, 2022a; 2022b). Sensitivity to habitat structure change was assessed as medium, as sedimentary communities are likely to be intolerant of substratum removal, which will lead to partial or complete defaunation (Dernie *et al.,* 2003). Infilling would allow for recovery of these sedimentary habitats, although some recovery of the biological assemblage may take place before the original topography is restored, if the exposed, underlying sediments are similar to those that were removed. This recovery will be site-specific, following construction activities such as sand wave clearance and will be influenced by currents, wave action, and sediment availability (Desprez, 2000). The sensitivity of these IEFs to heavy smothering, such as that which might result from the deposition of sand wave clearance material, has been assessed as sensitive to medium. Many of the bivalves and polychaete species in these IEFs are able to migrate through depositions of sediment greater than the benchmark (30 cm of fine material added to the seabed in a single discrete event) (Maurer *et al.,* 1982; Bijkerk, 1988; Powilleit *et al.,* 2009). The effects of smothering have also been found to depend upon the volume and type of sediment involved, however the mortality of some amphipods and isopods is likely. Individuals are however more likely to escape from smothering if the sediments are similar to those in which the species is found (Tillin, 2016). As the sediment which will be deposited from this impact will be deposited close to its original location. It is likely that it will be similar to the seabed sediment increasing the potential for survival and recolonisation making resilience high. It is considered probable that Ross worm can tolerate smothering for several weeks, although feeding and growth will be curtailed (Jackson and Hiscock, 2008).

Overall, all the subtidal habitats and species IEFs are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Intertidal Habitats and Species

The sensitivity of the 'Mudflats and sandflats not covered by seawater at low tide' IEF to temporary subtidal habitat loss and/or disturbance is presented in Table 7.33. These sensitivities are based on assessments made by the MarESA and were overall assessed as 'not sensitive' to 'high' to the defined MarESA pressures.

Each of the representative biotopes were assessed as 'medium' to habitat structure changes (removal of substratum) (Table 7.33). For example, the biotope '*M. balthica* and *A. marina* in littoral muddy sand (LS.Lsa.MuSa.MacAre)', requires substratum to return to fine sand and muddy sand with scattered pebbles, boulders, and cobbles (Ashley *et al.,* 2023). The characterising species for this biotope have been shown to be less impacted by habitat structure changes (removal of substratum) on a smaller scale, as *A. marina* rapidly recolonises basins left by bait digging, while *M. balthica* was unaffected by bait digging (McLusky *et al.,* 1983). This biotope was also assessed as medium sensitivity to 'Abrasion/disturbance of the surface of the substratum or seabed' and to 'Smothering and siltation rate changes (heavy)' and high to 'Penetration or disturbance of the substratum subsurface'. The burrowing traits of *A. marina* and *M. balthica* may provide some resistance to these pressures, however Boldina and Beninger (2014) reported decreases in naturally occurring aggregations of *A. marina* in trawled areas, which suggests that these pressures may have consequences on reproduction, recruitment, growth, and feeding. Further, Collie *et al*. (2000) identified that well established sand and muddy sand intertidal communities (such as this biotope) suffered the greatest impact from bottom towed fishing activities (which have similar effects as temporary habitat loss and/or disturbance). This biotope was most sensitive to the 'Penetration or disturbance of the substratum subsurface' pressure, as *A. marina* and *M. balthica* are burrowing species. Thus, damage to the subsurface would cause greater damage than damage to the substratum (Ashley *et al.,* 2023). However, as the disturbance to the intertidal zone as a result of the Proposed Development is proposed to be limited, and it is not likely that this area represents a significant portion of this biotope's distribution around the UK and Ireland, the overall sensitivity of is proposed to be medium.

The biotope 'Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal)', was assessed as medium sensitivity to habitat structure changes (removal of substratum) and to smothering and siltation rate changes (heavy). These pressures could both destroy the habitat, however refugia are important in maintaining populations of characterising species (talitrid amphipods) (Fanini *et al.,* 2005). Therefore, the overall sensitivity was assessed as medium. This biotope was also assessed as low sensitivity to the abrasion and penetration pressures (Table 7.33). This is because this biotope is typically subjected to physical disturbance due to tidal and wave action, and the movement of marine debris. Characterising species (talitrid amphipods) are susceptible to abrasion and penetration (Ugolini *et al.,* 2008), however overall sensitivity is low due to migration from adjacent populations and *in situ* reproduction (Tillin and Budd, 2004).

The biotope 'Polychaete/bivalve-dominated muddy sand shores (LS.Lsa.MuSa)' was assessed as medium sensitivity to habitat structure changes (removal of substratum) and low for the other pressures. The sedimentary communities, characteristic of this biotope, are likely to be highly intolerant of substratum removal, which will lead to partial defaunation, exposure of the underlying sediment and changes in the topography of the area (Dernie *et al.,* 2003). However, this biotope can recover once substratum returns to prior conditions, pits or trenches are filled, and species recolonization can occur. This has been observed over a range of time periods, such as 40 days (Hall, 1994), 50 days, and 111 days (Ferns *et al.,* 2000), depending on the species. This subsequent recovery was the rationale behind the low sensitivity assessment to abrasion and smothering pressures.

The biotope 'Barren or amphipod-dominated mobile sand shores (LS.Lsa.MoSa)' was only assessed as sensitive to 'habitat structure changes (removal of substratum)' but as 'not sensitive' to the other three pressures relevant to the impact of temporary habitat loss and/or displacement (Table 7.33). For this biotope, removal of substratum would mean removal of the abiotic habitat. However, infilling is likely to be rapid and recovery from habitat structure changes would occur in less than a year (Tillin, 2018). As this biotope is characterised by the absence of species through sediment mobility rather than the presence of characteristic species, abrasion and penetration of the substratum and smothering would not alter the biotope's character (Tillin, 2018). Thus, this biotope is not sensitive to these pressures.

Overall, the 'Mudflats and sandflats not covered by seawater at low tide' IEF is deemed to be of medium vulnerability, high recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Designated Sites

The Annex I habitat 'Mudflats and sandflats not covered by seawater at low tide' is extensive throughout the site and are present in the intertidal sections which overlap with the Proposed Development. Therefore, the sensitivities presented for the 'Mudflats and sandflats not covered by seawater at low tide' IEF in the preceding section is applicable to the Dee Estuary/Aber Dyfrdwy SAC IEF. Thus, the Dee Estuary/Aber Dyfrdwy SAC IEF is deemed to be of medium vulnerability, high recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

As detailed in Table 7.10, the area of the Fylde MCZ which overlaps with the Proposed Development has been assigned the biotope 'Sublittoral sands and muddy sands (SS.Ssa)' (Envision Mapping, 2015), however has not been assigned more specific biotopes. As this area overlaps with the 'Subtidal sands and gravels' IEF identified during the site-specific survey within the Proposed Development, the representative biotopes identified for this IEF have also been used to characterise the Fylde MCZ IEF in the assessment. Therefore, the Fylde MCZ IEF is deemed to be of medium vulnerability, high recoverability, and national value. The sensitivity of the receptor is therefore, considered to be medium.

Table 7.33: Sensitivity Of The Benthic Subtidal And Intertidal Ecology IEFs To Temporary Subtidal Habitat Loss And/Or Disturbance

IEF	Representative Biotopes Identified	Sensitivity to Defined MarESA Pressure				Overall Sensitivity (Based on Table 7.29)
		Habitat structure changes – removal of substratum	Abrasion/disturbance of the surface of the substratum or seabed	Penetration or disturbance of the substratum subsurface	Smothering and siltation rate changes (heavy)	
Subtidal Habitats and Species						
Subtidal Sands and Gravels	*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)	Medium	Low	Low	Medium	Medium
	N. cirrosa and *Bathyporeia* spp. In infralittoral sand (SS.Ssa.IfiSa.NcirBat)	Medium	Low	Low	Low	Medium
Mud Habitats in Deep Water	*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.Smu.CsaMu.AfilKurAnit)	Medium	Medium	Medium	Medium	Medium
Subtidal Mixed Muddy Sediment	*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)	Medium	Medium	Medium	Medium	Medium
Ross Worm *S. spinulosa*	-	Medium	Low	Not assessed	Not sensitive	Medium
Intertidal Habitats and Species						
Mudflats and sandflats not covered by seawater at low tide	Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal)	Medium	Low	Low	Medium	Medium
	M. balthica and *A. marina* in littoral muddy sand (LS.Lsa.MuSa.MacAre)	Medium	Medium	High	Medium	Medium
	Barren or amphipod-dominated mobile sand shores (LS.Lsa.MoSa)	Medium	Not sensitive	Not sensitive	Not sensitive	Medium
	Polychaete/bivalve-dominated muddy sand shores (LS.Lsa.MuSa)	Medium	Low	Not assessed	Low	Medium

Significance of Effect

Subtidal Habitats and Species

Overall, the magnitude of this impact on all subtidal habitats and species IEFs except Ross worm was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Ross worm IEF, the magnitude this impact was deemed to be negligible, and the sensitivity of the receptor was considered to be medium. As per Table 7.31, this results in a ‘negligible or minor’ significance of effect. As there were no Ross worm reefs identified, there is unlikely to be any loss or detrimental alteration to the Ross worm IEF due to this impact (see Table 7.27). Therefore, it has been concluded that the effect of temporary habitat loss and/or disturbance will be of **negligible adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, the magnitude this impact on the intertidal habitats and species IEF was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, the magnitude this impact on the designated sites IEFs was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.1.2 Operation and Maintenance Phase

Temporary habitat loss and/or disturbance may occur during the operation and maintenance phase, via use of jack-up vessels for repair and maintenance activities.

Magnitude of Impact

Subtidal Habitats and Species

The MDS accounts for up to 72,000 m^2 of temporary habitat loss and/or disturbance within this phase (Table 7.21). This equates to a small proportion (0.01%) of the Proposed Development. It should also be noted that only a small proportion of the total temporary habitat loss and/or disturbance is likely to occur at any one time, with the MDS for this impact spread over the 25-year lifetime. Therefore, individual maintenance activities will be small scale and intermittent events.

These operation and maintenance activities may impact an area up to 34,500 m^2 due to jack-up events at the infrastructure and up to 37,500 m^2 due to cable reburial over the 25-year lifetime of the Proposed Development.

The impacts of jack-up vessel activities will be similar to those identified for the construction phase above and will be restricted to the immediate area where the spud cans are placed on the seabed, with recovery occurring following removal of spud cans. The impacts of cable reburial will be similar to those identified for the construction phase above, but will only impact up to 7,500 m^2 at any one time.

The spatial extent of this impact is small in relation to the whole Proposed Development, although there is the potential for repeat disturbance to the habitats in the immediate vicinity the infrastructure because of these activities. However, these effects are expected to be similar to the construction phase, but of a much lower magnitude.

The impact on all the subtidal habitats and species IEFs except Ross worm is predicted to be of local spatial extent (0.01% of the Proposed Development), short term duration, intermittent over the lifecycle of the

Proposed Development, and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is therefore considered to be low.

As only individual Ross worm were recorded in places during the site-specific subtidal benthic characterisation survey and no reefs were identified, it is unlikely that the Proposed Development represents an important habitat for this species at a population level. Thus, the impact on the Ross worm IEF is predicted to be of highly local spatial extent (due to no reefs observed and only 0.01% of the Proposed Development potentially affected), short term duration, intermittent over the lifecycle of the Proposed Development, and of high reversibility. The magnitude is therefore considered to be negligible.

Intertidal Habitats and Species

Temporary disturbance to the 'Mudflats and sandflats not covered by seawater at low tide' IEF may arise as a result of the movement of machinery, equipment, vehicles and personnel involved in operation and maintenance activities. These activities are likely to result in surface level abrasion and disturbance or compaction of sediments. It should also be noted that only a small proportion of the total temporary habitat loss and/or disturbance is likely to occur at any one time, with the MDS for this impact spread over the 25-year lifetime. Therefore, individual maintenance activities will be small scale and intermittent events.

The impact on the 'Mudflats and sandflats not covered by seawater at low tide' IEF is predicted to be of highly local spatial extent, short term duration, intermittent over the lifecycle of the Proposed Development, and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Designated Sites

As stated above for the construction phase, the Dee Estuary/Aber Dyfrdwy SAC and the Fylde MCZ overlap with the Proposed Development in parts and have been assessed as IEFs of international and national importance, respectively, as a result (Table 7.10). The Proposed Development overlaps with 0.21 km^2 of the Dee Estuary/Aber Dyfrdwy SAC, corresponding to 0.13% of the SAC's total area. The Proposed Development overlaps with 260.60 km^2 of the Fylde MCZ, corresponding to 15.87% of the MCZ's total area. Therefore, there is a small overlap between the Proposed Development and these two designated sites, particularly the Dee Estuary/Aber Dyfrdwy SAC.

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), temporary habitat loss and/or disturbance may arise in the Dee Estuary/Aber Dyfrdwy SAC as a result of the movement of machinery, equipment, vehicles and personnel. These activities are likely to result in surface level abrasion and disturbance or compaction of sediments. As the Fylde MCZ overlaps with the Proposed Development offshore, potential impacts that may arise are the same as those identified above for the Subtidal habitats and species IEFs. However, there is unlikely to be any disturbance to the Fylde MCZ as it is a minimum of 1.82 km from the area of project physical work (see Figure 7.4).

Overall, the impact on the designated site IEFs is predicted to be of local spatial extent, short term duration, intermittent, and high reversibility. For the Dee Estuary/Aber Dyfrdwy SAC IEF, it is predicted that the impact will affect the receptor directly, but not for the Fylde MCZ IEF due to no overlap. The magnitude is therefore, considered to be low.

Sensitivity of Receptor

All IEFs

The sensitivity of all IEFs is considered to be medium, as defined above for the construction phrase (see Table 7.33).

Significance of Effect

Subtidal Habitats and Species

Overall, the magnitude this impact on all subtidal habitats and species IEFs except Ross worm was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is not significant in EIA terms.

For the Ross worm IEF, the magnitude this impact was deemed to be negligible, and the sensitivity of the receptor was considered to be medium. As per Table 7.31, this results in a 'negligible or minor' significance of effect. As there were no Ross worm reefs identified, minor loss or detrimental alteration to the Ross worm IEF is considered unlikely due to this impact (see Table 7.27). Therefore, it has been concluded that the effect of temporary habitat loss and/or disturbance will be of **negligible adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, the magnitude this impact on the intertidal habitats and species IEF was deemed to be low and the sensitivity of the receptor was considered medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, the magnitude this impact on the designated sites IEFs was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.1.3 Decommissioning Phase

Decommissioning activities within the Proposed Development will result in temporary habitat loss and/or disturbance in this phase.

Magnitude of Impact

All IEFs

The MDS for the decommissioning phase assumes that all infrastructure will be removed (except some rock placement which may remain *in situ*) (Table 7.21). The extent of temporary habitat loss and/or disturbance during this phase will be significantly lower than that of the construction phase, as seabed preparation activities will not be required.

The spatial extent of this impact is small in relation to the whole Proposed Development and effects on seabed habitats and associated benthic communities are expected to be similar to the construction phase, but of a much lower magnitude.

Overall, for all IEFs except Ross worm, this impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptors directly. The magnitude is therefore, considered to be low.

As only individual Ross worm were recorded in places during the site-specific subtidal benthic characterisation survey and no reefs identified, it is unlikely that the Proposed Development represents an important habitat for this species at a population level. Thus, the impact on the Ross worm IEF is predicted to be of highly local spatial extent (due to no reefs observed), short term duration, intermittent over the decommissioning phase, and of high reversibility. The magnitude is therefore considered to be negligible.

Sensitivity of Receptor

All IEFs

The sensitivity of all IEFs is considered to be medium, as defined above for the construction phrase (see Table 7.33).

Significance of Effect

Subtidal Habitats and Species

Overall, the magnitude this impact on all subtidal habitats and species IEFs except Ross worm was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Ross worm IEF, the magnitude this impact was deemed to be negligible, and the sensitivity of the receptor was considered to be medium. As per Table 7.31, this results in a ‘negligible or minor’ significance of effect. As there were no Ross worm reefs identified, loss or detrimental alteration to the Ross worm IEF is unlikely to occur due to this impact (see Table 7.27). Therefore, it has been concluded that the effect of temporary habitat loss and/or disturbance will be of **negligible adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, the magnitude this impact on the intertidal habitats and species IEF was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, the magnitude this impact on the designated sites IEFs was deemed to be low and the sensitivity of the receptor was considered to be medium. Therefore, the effect of temporary habitat loss and/or disturbance will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.2 Increased SSCs and Associated Deposition

Increased suspended sediment concentrations and sediment deposition from construction and decommissioning activities related to subsea pipeline refurbishment, cable installation/protection, and release of drill cuttings may potentially result in indirect impacts on the benthic habitats and communities. In addition, seabed preparation (such as sand wave clearance) in the construction phase may also cause increased SSCs and associated deposition. These indirect impacts include increased turbidity and smothering effects, which could affect the water quality in the surrounding area and habitat degradation affecting spawning and nursery grounds. A full description of the physical assessment, including numerical modelling used to inform the predictions made with respect to increases in suspended sediment and subsequent deposition, is provided in volume 2, appendix H.

The benchmarks for the relevant MarESA pressures which have been used to inform this impact assessment are:

- Changes in suspended solids (water clarity): the benchmark for which is a change in one rank on the WFD scale (e.g. from clear to intermediate for one year, caused by activities disturbing sediment or organic particulate material and mobilising it into the water column such as dredging, disposal at sea, cable and pipeline burial).
- Smothering and siltation rate changes (light): the benchmark for light deposition is up to 5 cm of fine material added to the habitat in a single discrete event.

These pressures correspond to the impacts associated with sand wave clearance, the installation of foundations the new Douglas platform, and the installation of cables via ploughing.

With regards to background SSC, the Cefas Climatology Report 2016 (Cefas, 2016) and associated dataset provides the spatial distribution of average non-algal Suspended Particulate Matter (SPM) for the majority of the UK Continental Shelf. Between 1998 and 2005, the greatest plumes are associated with large rivers such as those that discharge into the Thames Estuary, The Wash and Liverpool Bay, which show mean values of SPM above 30 mg/l. Based on the data provided within this study, the SPM associated with the Proposed Development has been estimated as approximately 0.9mg/l to 3mg/l over 1998 to 2005.

7.12.2.1 Construction Phase

Magnitude of Impact

All IEFs

A numerical modelling study was undertaken to inform and qualify the potential impacts of the Proposed Development on physical processes (see volume 3, appendix H). This included tidal current, wave climate, and sediment transport under both calm and storm conditions. Numerical modelling has been used to quantify the changes in physical processes, predominantly suspended sediment concentrations, due to seabed preparation activities, the drilling of new monitoring wells, and laying of cables. The following activities in the construction phase have been considered:

- seabed preparation (such as sand wave clearance);
- drill cuttings; and
- cable installation.

Due to the nature of the seabed in the Proposed Development, the cable installation will require seabed preparation in the form of sand wave clearance. The MDS assumes that sand waves are to be cleared along the cable route in two locations, south of the existing Douglas platforms, and at West Hoyle Bank (Table 7.21). Clearance activities south of the new Douglas platform are set to be undertaken across two sections where sand waves are present with average heights of approximately 3 m and lengths of around 100 m and 15 m respectively. To enable the laying of cables, a corridor width of approximately 10 m will be excavated using a mass flow excavator/jet sled, which will suspend sediment at the seafloor. At West Hoyle Bank, in order to allow the laying of the cable directly across the feature, a dredged channel will be necessary. During clearance activities material will be side cast along around 1,000 m of channel, and backfilled after cable installation. The trench is expected to be approximately 21 m in width and 7 m in depth. Sediment plumes for seabed preparation activities were quantified during modelling. In all cases, the material released was native to the bed sediments and, although the model showed periods of increased turbidity, the material was retained in the Solway Firth sediment cell and would be subsequently assimilated into the existing sediment transport regime. Suspended sediments may reach into the estuary during cable trenching from the PoA to Douglas, but are generally expected to do so at background levels (i.e. 30 mg/l).

The MDS for this impact includes the drilling of two new monitoring wells situated at Hamilton Main and Hamilton North (Table 7.21). Both wells require the drilling of two sections the first of which is a 26” opening in which the 20” conductor will be encased, and a second and deeper 17” section. The first section will involve penetration of the surface sand and silt layer and then the use of seawater and sweeps drilling to penetrate the coarser Mercia Mudstone Group below. The first section will see the clearance of approximately 30.48 m of sand and silt and the drilling of 84.43 m of coarser sediment. The second section will be drilled with water-based mud and will also penetrate through the Mercia Mudstone Group, which is largely composed of claystone, over a vertical length of ~518.16 m. Both lengths of the 26” and 17” holes have been modelled with an assumed 100% washout, (i.e. twice the volume of the cavity is released as cuttings). The rate of drilling for both wells was 40 m/h with the individual operations taking approximately 16 hours each. Both SSC and deposition related to the drill cutting releases were more limited than the seabed preparation and cable installation activities both spatially and in magnitude. With sedimentation restrained to negligible levels across the drill site and along the tidal ellipse.

The third aspect of the construction phase is installation of up to 126.04 km of power cables between platforms and the onshore terminal PoA (this includes 1,200 m of cable within the intertidal zone). A trench width of 15 m was assumed in the MDS and numerical modelling. A number of trenching techniques may be suited to the ground conditions; however, it was assumed within the modelling that trenched material was mobilised into the lower water column as a result of the burial process, in line with the Business Enterprise and Regulatory Reform (BERR) guidelines (BERR, 2008). In reality, the installation technique implemented may result in less sediment being mobilised and the maximum depth may not always be achieved with a corresponding reduction in the amount of material disturbed. Trenching rates can vary widely depending on the bed material and equipment used; typically, rates are between 25 m/h and 780 m/h. For the simulation, a relatively high rate of 450 m/h was used over an extensive sample route ensuring that material was released at all tidal states over a number of tides and ensuring initial concentrations were not underestimated.

For the PoA Terminal to Douglas cable, during peak concentrations over the course of trenching, the plume may extend up to 15 km to the west, however, it reaches background levels (<1 mg/l) at approximately 1 km from the cable trenching. Average SSC values were greatest around the cable route, particularly over the shallow waters of West Hoyle Bank, where they may reach 1,000 mg/l in the shallowest water but are quickly reduced to background levels a short distance from the cable path. Average sedimentation was greatest at the location of the trenching and may be up to 160 mm in depth where the coarser material has settled within close proximity to the cable path. An analysis of sedimentation at slack water one day after the cessation of trenching, shows that some of the previously sedimented material has been re-suspended, only to settle again at slack water.

A large plume was also modelled for the trenching of the Douglas to Lennox platform cable. Average concentrations are <1,000 mg/l and are greatest in the direct vicinity of the cable path, and <10 mg/l at the extent of the Proposed Development benthic ecology study area. Average sedimentation is limited to <100 mm with peak values of 70 mm, however outside the area of project physical work, deposition is limited to negligible levels of <3 mm. Sedimentation one day after the cessation of trenching shows that fine sands and resuspended sediment settle during slack water. Overall, the largest SSC plumes are generated by cable installation activities given the magnitude of sediment disturbed and length of works. Due to the temporary nature and scale of cable laying works, combined with the cable laying works being located within a depositional area for sediment, any trenches will be quickly infilled over a short period of time. Furthermore, rapid recolonisation of disturbed sediment is expected within two years.

Based on this, disturbance due to increased SSCs and associated deposition is expected to affect only 0.017% of the extent of the Annex I mudflats and sandflats habitat within the Dee Estuary/Aber Dyfrdwy SAC SAC. Further, it was noted in the physical processes assessment (volume 3, appendix H) that the magnitude of impact upon West Hoyle Bank (not an IEF in this assessment) and the Dee Estuary/Aber Dyfrdwy SAC IEF was considered to be low.

Overall, for all IEFs, the increased SSCs and associated deposition due to the construction activities described above are predicted to be of local spatial extent within the Proposed Development, short-term duration over the two-year construction phase, intermittent in nature, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, for all IEFs, the magnitude of impact is predicted to be low.

Sensitivity of Receptor

Subtidal Habitats and Species

The sensitivity of the IEFs to increased SSCs and associated deposition are presented in Table 7.34. These sensitivities are based on assessments made by the MarESA and range from negligible to medium. For the 'Subtidal sands and gravels' IEF, both representative biotopes have low sensitivity to changes in suspended solids and low and no sensitivity to smothering and siltation rate changes (light). This is because the characterising species are adapted for burrowing and/or live in the sand and are therefore unlikely to be directly affected by the pressures associated with increased SSCs. Within the biotope '*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)', venerid bivalves are shallow burring infauna and suspension feeders, which have been reported to typically escape something of up to 50 cm and burrow to their preferred depth (Kranz (1974), cited in Maurer *et al.,* 1986).

The representative biotopes for the 'Mud habitats in deep water' IEF and 'Subtidal mixed muddy sediment' IEF, and Ross worm were all assessed as not sensitive to changes in suspended sediments (water clarity). For Ross worm, tube growth is dependent on the presence of suspended particles, hence an increase in SSCs could facilitate growth and increase populations. Although, the MarESA accounts for the fact that increased siltation could clog feeding apparatus, with immediate recovery following recommencement of feeding (Jackson and Hiscock, 2008). Ross worm is also not sensitive to smothering and can tolerate this for up to several weeks (Jackson and Hiscock, 2008). The representative biotope identified for the 'Mud habitats and deep water' IEF (*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)) is characterised by a number of suspension feeding species (De-Bastos and Hill, 2016). These species are able to switch between feeding methods (Budd, 2007; Carter, 2008; Hill and Willson, 2008) and can change to deposit feeding in areas of low water flow or stagnant waters (Ockelmann and Muus, 1978). Thus, where a change in suspended solids results in increased turbidity and change of light, the community is unlikely to be directly affected (De-Bastos and Hill, 2016). Further, this biotope is not sensitive to smothering and siltation rate changes (light), as it is characterised by burrowing species, which can resist additional, fine sediments (De-Bastos and Hill, 2016). In contrast, however, the representative biotope identified for the 'Subtidal mixed muddy sediment' IEF (*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)) was assessed as medium sensitivity to this pressure (Table 7.34). This is because dense brittlestar beds do not occur in areas of excessive sedimentation, as they are susceptible to suffocation and fouling of their feeding apparatus (Aronson, 1989,1992). These brittlestar species are not affected by changes in suspended solids (water clarity) due to limited visual perception (De-Bastos *et al.,* 2020).

Overall, the 'Subtidal sands and gravels' IEF is deemed to be of low vulnerability, medium to high recoverability, and national value. Therefore, the sensitivity of this receptor to this impact is considered to be **low.**

Overall, the 'Mud habitats in deep water' IEF and Ross worm IEF are deemed to be of low to no vulnerability, high recoverability, and national value. Therefore, the sensitivity of these receptors to this impact is considered to be **negligible.**

Overall, the 'Subtidal mixed muddy sediment' IEF is deemed to be of medium vulnerability, medium recoverability, and national value. Therefore, the sensitivity of this receptor to this impact is considered to be **medium.**

Intertidal Habitats and Species

The sensitivity of the Mudflats and sandflats not covered by seawater at low tide IEF to increased SSCs and associated deposition is presented in Table 7.34. These sensitivities are based on assessments made by the MarESA (where available) and range from negligible to low. Overall, three out of the four biotopes identified for this IEF were assessed as not sensitive to both pressures associated with this impact. Only the biotope 'Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa)', was assessed as having low sensitivity to both pressures. This is because although some species within this biotope may be impacted by these pressures, recovery would be high on the return to original conditions (Tyler-Walters and Marshall, 2006).

The biotope 'Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal)' has been assessed as not sensitive to these pressures as it occurs on the limit of tidal inundation, thus exposure to the pressures would be limited to very short periods (Tillin and Budd, 2004). For the biotope '*M. balthica* and *A. marina* in littoral muddy sand (LS.LSa.MuSa.MacAre)', changes in suspended solids (water clarity) is not relevant, as the characteristic species live within the sediment to depths of 40 cm and 6 cm, respectively, and are thus adapted to increased SSCs and turbidity (Ashley *et al.,* 2023). Finally, the biotope 'Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa)' is also not sensitive to these pressures as it occurs in scoured habitats and is likely exposed to chronic or intermittent episodes of high levels of suspended solids (Tillin, 2018). It is characterised by the absence of species through sediment mobility, thus changes in suspended solids and smothering will not alter the biotope (Tillin, 2018).

Overall, the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF is deemed to be of low vulnerability, high recoverability, and international value. Therefore, the sensitivity of this receptor to this impact is considered to be **low.**

Designated Sites

As detailed in Table 7.10, the sensitivities presented for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF in the preceding section is applicable to the Dee Estuary/Aber Dyfrdwy SAC IEF. Thus, the Dee Estuary/Aber Dyfrdwy SAC IEF is deemed to be of low vulnerability, high recoverability, and international value. The sensitivity of the receptor is therefore, considered to be low.

As detailed in Table 7.10, the area of the Fylde MCZ which overlaps with the Proposed Development has been assigned the biotope ‘Sublittoral sands and muddy sands (SS.SSa)’ (Envision Mapping, 2015), however has not been assigned more specific biotopes. As this area overlaps with the ‘Subtidal sands and gravels’ IEF identified during the site-specific survey within the Proposed Development, the representative biotopes identified for this IEF have also been used to characterise the Fylde MCZ IEF in the assessment. Therefore, the Fylde MCZ IEF is deemed to be of low vulnerability, medium to high recoverability, and national value. The sensitivity of the receptor is therefore, considered to be low.

Table 7.34: Sensitivity Of The Benthic Subtidal And Intertidal Ecology IEFs To Increased SSCs And Associated Deposition

IEF	Representative Biotopes Identified	Sensitivity to Defined MarESA Pressures		Overall Sensitivity (Based on Table 7.29)
		Changes in Suspended Solids (water clarity)	Smothering and Siltation Rate Changes (light)	
Subtidal Habitats and Species				
Subtidal Sands and Gravels	*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)	Low	Low	Low
	N. cirrosa and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat)	Low	Not sensitive	Low
Mud Habitats in Deep Water	*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)	Not sensitive	Not sensitive	Negligible
Subtidal Mixed Muddy Sediment	*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)	Not sensitive	Medium	Medium
Ross Worm *S. spinulosa*	-	Not sensitive	Not sensitive	Negligible
Intertidal Habitats and Species				
Mudflats and sandflats not covered by seawater at low tide	Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal)	Not sensitive	Not sensitive	Negligible
	M. balthica and *A. marina* in littoral muddy sand (LS.LSa.MuSa.MacAre)	Not sensitive	Not sensitive	Negligible
	Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa)	Not sensitive	Not sensitive	Negligible
	Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa)	Low	Low	Low

Significance of Effect

Subtidal Habitats and Species

Overall, for the ‘Subtidal sands and gravels IEF’, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased SSCs and associated deposition is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

For the ‘Mud habitats in deep water’ IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the effect of increased SSCs and associated deposition is considered to be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the ‘Subtidal mixed muddy sediment’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect of increased SSCs and associated deposition is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased SSCs and associated deposition is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased SSCs and associated deposition is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.2.2 Decommissioning Phase

Increased SSCs and associated deposition may occur during decommissioning activities, such as removal of foundations, cables, and cable crossing protection.

Magnitude of Impact

Subtidal Habitats and Species

Based on the MDS (Table 7.21), the removal of foundations, cables, and cable crossing protection would result in increased SSCs and associated deposition within the Proposed Development. It is assumed that the increases in SSCs and associated sediment deposition generated in the decommissioning phase would be of a lower extent than that of the construction phase. This is due to the absence of seabed preparation activities, drilling, and depositing of drill cuttings, which account for additional increases in SSCs and associated deposition in the construction phase.

The impact is predicted to be of local spatial extent within the Proposed Development, short term duration (for the individual decommissioning activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

The MDS assumes that the 1,200 m of intertidal power cables that connect the new Douglas platform to the PoA terminal will be removed. Therefore, the impact to intertidal habitats and species is likely to be of a similar magnitude than that defined above for the construction phase.

The impact is predicted to be of local spatial extent within the Proposed Development, short term duration (for the individual decommissioning activities), intermittent, and high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), increased SSCs and associated deposition may arise in the Dee Estuary/Aber Dyfrdwy SAC due to removal of 1,200 m of power cables within the intertidal area. As the Fylde MCZ overlaps with the Proposed Development offshore, potential impacts that may arise are the same as those identified above for 'Subtidal Habitats and Species'. However, there is unlikely to be any disturbance to the Fylde MCZ as it is a minimum of 1.82 km from the area of project physical work (see Figure 7.4).

Overall, the impact on the designated site IEFs is predicted to be of local spatial extent within the Proposed Development, short term duration, intermittent, and high reversibility. For the Dee Estuary/Aber Dyfrdwy SAC IEF, it is predicted that the impact will affect the receptor directly, but not for the Fylde MCZ IEF due to no overlap. The magnitude is therefore, considered to be low.

Sensitivity of Receptor

All IEFs

The sensitivities of all the IEFs are considered to be as previously described for the construction phase (Table 7.34) and range from negligible to medium.

Significance of Effect

Subtidal Habitats and Species

The significance of effect is considered to be as above for the construction phase. Overall, for the 'Subtidal sands and gravels' IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased SSCs and associated deposition is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

For the 'Mud habitats in deep water' IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the effect of increased SSCs and associated deposition is considered to be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the 'Subtidal mixed muddy sediment' IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect of increased SSCs and associated deposition is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

The significance of effect is considered to be as above for the construction phase. Overall, for the 'Mudflats and sandflats not covered by seawater at low tide' IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased SSCs and associated deposition is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

The significance of effect is considered to be as above for the construction phase. Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased SSCs and associated deposition is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.3 Long-term Subtidal Habitat Loss

7.12.3.1 Construction and Operation and Maintenance Phases

Long-term subtidal habitat loss within the Proposed Development will begin in the construction phase, as infrastructure is installed. Long-term subtidal habitat loss could potentially occur due to the installation of cable crossing protection and under the foundation structures for the new Douglas platform. Additionally, rock placement associated with the construction will also result in long-term subtidal habitat loss.

In this impact assessment, long-term subtidal habitat loss does not represent complete removal of habitat, but rather a physical change in a sedimentary habitat and replacement with a hard, artificial substrate. The relevant MarESA pressures and their benchmarks which have used to inform this impact assessment are described here:

- physical change (to another seabed type): the benchmark for which is change in sediment type by one Folk class and change from sedimentary or soft rock substrata to hard rock or artificial substrata or vice-versa.

These pressures are relevant to the installation of foundation structures for the new Douglas platform, cables and their associated protection which will replace the sedimentary seabed with hard structures for the duration of the operations and maintenance phase (25 years). The effects of long-term subtidal habitat loss are assessed in this section, however the potential for colonisation of hard substrates by benthic species have been assessed in section 7.12.4. The construction and operation and maintenance phases are assessed in combination as the impacts of long-term subtidal habitat loss from the construction phase will persist into the operation and maintenance phase and will be continuous over the 25-year lifetime of the Proposed Development.

Magnitude of Impact

The construction of infrastructure associated with the Proposed Development will result in long-term subtidal habitat loss. The MDS accounts for up to 64,169 m^2 of long-term subtidal habitat loss due to installation of foundations and cable crossing protection in the construction phase (Table 7.21), which equates to 0.01% of the overall Proposed Development. The total area subject to long-term subtidal habitat loss will be comprised from the installation of 58,800 m^2 of cable crossing protection, up to 169 m^2 from the jacket legs of the new Douglas platform, 2,400 m^2 from pipeline spools, and 2,800 m^2 from pipeline mattresses (Table 7.21).

Long-term subtidal habitat loss will occur during the construction phase and be continuous and irreversible throughout the 25-year operations and maintenance phase. Some long-term subtidal habitat loss will persist indefinitely after the operations and maintenance phase, such as that caused by rock placement which will be left *in situ* following decommissioning of the Proposed Development.

Subtidal Habitats and Species

There will be no infrastructure installed within, or in the nearby vicinity of the Annex I Reef IEF, and thus no long-term subtidal habitat loss (Figure 7.4). Overall, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the Annex I Reef IEF (see Table 7.27). The magnitude is therefore considered to be no change.

Offshore cable crossing protection will be required at up to 32 crossings, with each crossing up to 0.8 m in height and 7 m wide. The design of the cable crossing protection will have tapered profiles to reduce the impacts upon physical processes and seabed morphology. Cable crossing protection is the only cable protection measure proposed for the project, as the nature of the seabed sediment within the Proposed Development accommodates cable burial to the required depth. Therefore, no protection is required for buried cables, which are not anticipated to become exposed and require additional protection throughout the operation and maintenance phase. For example, cable crossings include one between the PoA to new Douglas platform cable and the Burbo Bank Offshore Wind Farm Extension Export Cable. Where practicable, the requirements will be compliant with the Maritime and Coastguard Agency (MCA) navigation guidance which includes that there will be no more than a 5% reduction in water depth (referenced to CD) at any point along the cable route (MCA, 2021), without prior written approval from the Licensing Authority in consultation with the MCA. In compliance with the MCA navigation guidance, the maximum height of the shallowest cable crossing would be restricted to 5% of the water depth and therefore exhibit no change in wave climate, however, given the majority of cable crossings fall in waters deeper than 25 m (CD) they will change water depths to a much lesser degree than the 5% limit. With most of the cable crossing protection installed in waters of approximately 25 m (CD), which equates to 28 m mid tide, the introduction of 0.8 m height cable crossing protection represents less than a 3% change in water depth and therefore likely < 3% change to tidal currents. This change is approximately a quarter of the size as exhibited in the natural variation between peak spring and peak neap tidal flows. Given the small scale of cable crossing protection to be installed, and further measures such as tapered profiles and compliance with the MCA navigation guidance, it is not expected that impacts from cable crossings would be sufficient to disrupt offshore bank morphological processes, experience significant secondary scour or destabilise coastal features.

Overall, for all other subtidal habitats and species IEFs, the MDS for this impact presents some measurable, minor loss of and alteration to the affected areas of the seabed within the Proposed Development. The impact is predicted to be of local spatial extent (0.01% of the Proposed Development), long-term duration over the lifecycle of the Proposed Development, continuous, and irreversible during the construction and operation and maintenance phases. It is predicted that the impact will affect the receptors directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

There will be no above surface cable or cable crossing protection placed in the intertidal zone. There will, therefore, be no long-term loss of intertidal habitats or IEFs as a result of cable or cable crossing protection. The MDS for the installation of the offshore export cable in the intertidal zone is for open cut trenching. This method will remove the top layers of sediment to create a trench, the majority of habitats within the intertidal zone will be able to recover from this potential impact. For the representative biotopes of the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, this has been assessed as temporary habitat loss/disturbance in section 7.12.1.

Overall, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF (see Table 7.27). The magnitude is therefore considered to be no change.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), long term subtidal habitat loss will not arise within the Dee Estuary/Aber Dyfrdwy SAC due to the lack of above surface cable or cable crossing protection proposed for the intertidal zone. Although the Fylde MCZ overlaps with the Proposed Development offshore, there will be no infrastructure installed within it, and it is a minimum of 1.82 km from the area of project physical work (see Figure 7.4).

Therefore, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impacts to the sites. The magnitude of impact on the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs is therefore, considered to be no change.

Sensitivity of Receptor

Subtidal Habitats and Species

The sensitivity of the IEFs to increased SSCs and associated deposition are presented in Table 7.35. These sensitivities are based on assessments made by the MarESA (where available) and are assessed as high for all IEFs except Ross worm, which was assessed as moderate. It should be noted that the MarESA available for Ross worm is considered outdated and does not contain the ‘Physical change (to another seabed type)’ pressure. Therefore, Ross worm has been assessed against the pressure 'substratum loss', which was presented in the outdated MarESA available at the time of writing.

The 'Subtidal sands and gravels' IEF, 'Mud Habitats in Deep Water' IEF, and 'Subtidal Mixed Muddy Sediment' IEF were all assessed as highlight sensitive to physical change (to another seabed type) as the representative biotopes identified are characterised by the sedimentary habitat. Therefore, a change to an artificial or rock substratum would result in a fundamental change to the physical characteristic of the biotope and result in the loss of the sedimentary communities and characterising species. This would lead to loss or reclassification of the biotopes (De-Bastos and Hill, 2016; De-Bastos *et al.,* 2020; Tillin, 2022a; Tillin and Garrard, 2022). Although Ross worm does not have a MarESA for this specific pressure, it has been assessed as moderate sensitivity to 'substratum loss' (Jackson and Hiscock, 2008). This is because it is fixed to the substratum, so removal will cause mortality, however, recovery could be quite rapid due to high recruitment rates (Jackson and Hiscock, 2008).

Overall, all IEFs, except Ross worm, are deemed to be of high vulnerability, low recoverability, and national value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

The Ross worm IEF is deemed to be of high vulnerability, medium recoverability, and local value. Therefore, the sensitivity of the receptor to this impact is considered to be medium.

Intertidal Habitats and Species

The sensitivity of the 'Mudflats and sandflats not covered by seawater at low tide' IEF to long-term habitat loss is presented in Table 7.35. These sensitivities are based on assessments made by the MarESA (where available) and are assessed as high for all biotopes except for 'Polychaete/bivalve-dominated muddy sand shores', which was assessed as moderate. It should be noted that the MarESA available for this biotope is outdated and does not contain the 'Physical change (to another seabed type)' pressure. This biotope has, therefore, been assessed against the pressure 'substratum loss', which was presented in the outdated MarESA available at the time of writing.

As above for the subtidal biotopes, the other three representative biotopes for the 'Mudflats and sandflats not covered by seawater at low tide' IEF are highly sensitive to physical change (to another seabed type). Under the same reasoning presented for the subtidal biotopes above, a change to an artificial or rock substratum would result in a fundamental change to the physical characteristic of the biotopes and result in the loss of the sedimentary communities and characterising species (Tillin and Budd, 2004; Tillin, 2018; Ashley *et al.,* 2023).

Overall, the 'Mudflats and sandflats not covered by seawater at low tide' IEF is deemed to be of high vulnerability, low recoverability, and international value. Therefore, the sensitivity of the receptor to this impact is considered to be high.

Designated Sites

As detailed in Table 7.10, the sensitivities presented for the 'Mudflats and sandflats not covered by seawater at low tide' IEF in the preceding section is applicable to the Dee Estuary/Aber Dyfrdwy SAC IEF. Thus, the Dee Estuary/Aber Dyfrdwy SAC IEF is deemed to be of high vulnerability, low recoverability, and international value. The sensitivity of the receptor is therefore, considered to be high.

As detailed in Table 7.10, the area of the Fylde MCZ which overlaps with the Proposed Development has been assigned the biotope 'Sublittoral sands and muddy sands (SS.SSa)' (Envision Mapping, 2015), however has not been assigned more specific biotopes. As this area overlaps with the 'Subtidal sands and gravels' IEF identified during the site-specific survey within the Proposed Development, the representative biotopes identified for this IEF have also been used to characterise the Fylde MCZ IEF in the assessment. Therefore, the Fylde MCZ IEF is deemed to be of high vulnerability, low recoverability, and international value. The sensitivity of the receptor is therefore, considered to be high.

Table 7.35: Sensitivity Of The Benthic Subtidal And Intertidal Ecology IEFs To Long Term Subtidal Habitat Loss

IEF	Representative Biotopes Identified	Sensitivity to Defined MarESA Pressure	Overall Sensitivity (Based on Table 7.29)
		Physical Change (to another seabed type)	
Subtidal Habitats and Species			
Subtidal Sands and Gravels	*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)	High	High
	N. cirrosa and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat)	High	High
Mud Habitats in Deep Water	*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)	High	High
Subtidal Mixed Muddy Sediment	*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)	High	High
Ross Worm *S. spinulosa*	-	Moderate	Medium
Intertidal Habitats and Species			
Mudflats and sandflats not covered by seawater at low tide	Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal)	High	High
	M. balthica and *A. marina* in littoral muddy sand (LS.LSa.MuSa.MacAre)	High	High
	Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa)	High	High
	Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa)	Moderate	Medium

Significance of Effect

Subtidal Habitats and Species

For the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Annex I Reef IEF, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms. As per the matrix used to assess the significance of effects, a low magnitude of impact and high sensitivity of receptor yields 'minor or moderate' significance (Table 7.31), this results A minor adverse significance has been concluded as the long-term habitat loss will only affect a small proportion of the Proposed Development (0.01%) in which these IEFs occupy. This is unlikely to compromise the integrity of these habitats such that they wouldn't be able to support their characterising communities or perform their ecosystem function.

Intertidal Habitats and Species

Overall, for the 'Mudflats and sandflats not covered by seawater at low tide' IEF, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.3.2 Decommissioning Phase

The impacts of long-term subtidal habitat loss from the operation and maintenance phase will persist into the decommissioning phase and will be continuous after the 25-year lifetime of the Proposed Development. This will be of a lesser extent to the area of long-term subtidal habitat loss presented in the construction and operation and maintenance phases.

Magnitude of Impact

Subtidal Habitats and Species

In the decommissioning phase, some infrastructure will be left in place for reservoir modelling, before being removed. The current assumption is that all infrastructure will be removed over the decommissioning phase, and this will be confirmed within the Decommissioning Plan at the relevant time (Table 7.21). Some rock deposits may be left *in situ* during the decommissioning. Therefore, the MDS for this impact presents some measurable, minor loss of and alteration to the affected areas of the seabed within the Proposed Development (Table 7.21). The impact is predicted to be of local spatial extent, long-term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is therefore, considered to be low for all IEFs except the Annex I Reef.

There will be no infrastructure installed within, or in the nearby vicinity of the Annex I Reef IEF, and thus no long-term subtidal habitat loss during the decommissioning stage either (Figure 7.4). Overall, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the Annex I Reef IEF (see Table 7.27). The magnitude is therefore considered to be no change.

Intertidal Habitats and Species

There will be no infrastructure left *in situ* within the intertidal zone, therefore, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the 'Mudflats and sandflats not covered by seawater at low tide' IEF (see Table 7.27). The magnitude is therefore considered to be no change.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), long term subtidal habitat loss will not arise within the Dee Estuary/Aber Dyfrdwy SAC due to the lack of infrastructure requiring removal or being left *in situ* in the intertidal zone. Although the Fylde MCZ overlaps with the Proposed Development offshore, there will be no infrastructure installed within it, therefore, none requiring removal or being left *in situ* (see Figure 7.4). Therefore, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impacts to the site. The magnitude of impact on the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs is therefore, considered to be no change.

Sensitivity of Receptor

All IEFs

The sensitivities of all the IEFs are considered to be as previously described for the construction phase (Table 7.35) and range from medium to high.

Significance of Effect

Subtidal Habitats and Species

Overall, for the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Annex I Reef IEF, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms. As per the matrix used to assess the significance of effects, a low magnitude of impact and high sensitivity of receptor yields 'minor or moderate' significance (Table 7.31). A minor adverse significance has been concluded as the long-term habitat loss will only affect a small proportion of the Proposed Development in which these IEFs occupy. This is unlikely to compromise the integrity of these habitats such that they wouldn't be able to support their characterising communities or perform their ecosystem function.

Intertidal Habitats and Species

Overall, for the 'Mudflats and sandflats not covered by seawater at low tide' IEF, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of long-term subtidal habitat loss is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.4 Introduction of Artificial Habitat and Colonisation of Hard Structures

7.12.4.1 Operation and Maintenance Phase

The introduction of new habitat, such as foundations and cable crossing protection, in the offshore marine environment may potentially affect the established benthic community by providing new habitat and ecosystem function. It is expected that the artificial structures will be colonised by a range of organisms which could lead to increases in biodiversity locally.

The environmental pressures associated with this impact are the same as those associated with long term subtidal habitat loss because the physical change (to another substratum type) pressure involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type component such as the installation of foundations and cable crossing protection. The pressure is described for the MarESA in section 7.12.3.

Magnitude of Impact

Subtidal Habitats and Species

The MDS accounts for up to 64,169 m^2 of artificial habitat creation due to the installation of foundations for the new Douglas platform, cable crossing protection, pipeline spools, pipeline mattresses, and rock placement. This equates to approximately 0.01% of the total Proposed Development. This value however is likely an over estimation of habitat creation as it has been calculated assuming the foundations were a solid structure. In reality they will have a lattice design rather than a solid surface, which would result in a smaller surface area than has been assumed for the MDS. It is expected that the foundations and cable crossing protection will be colonised by epifaunal species already occurring in the Proposed Development benthic ecology study area (e.g. tunicates, bryozoans, mussels and barnacles which are typical of temperate seas).

The introduction of new artificial habitat will represent a shift in the baseline conditions from soft to hard substrate in the areas where infrastructure is present. This may result in beneficial effects. For example, increased biodiversity, individual abundance of reef species, and total number of species over time has been observed at the monopile foundations installed in Sweden (Bender *et al*., 2020). In general, colonising communities on offshore installations are dominated by mussels, macroalgae, and barnacles near the water surface, essentially creating a new intertidal zone. In intermediate depths, they are dominated by filter feeding arthropods, and by anemones in deeper locations (De Mesel *et al*., 2015). Colonisation by these species will likely represent an increase in biodiversity and a change compared to the baseline if no hard substrates were present (Lindeboom *et al.,* 2011). Furthermore, the structural complexity of the artificial substrate may provide refuge as well as increasing feeding opportunities for larger and more mobile species. For example, Mavraki *et al.* (2020), found higher food web complexity was associated with zones which had high accumulation of organic material (such as soft substrate or scour protection), suggesting potential reef effect benefits from the presence of the hard structures.

The increased biodiversity and reef effects may also provide greater foraging opportunities for some fish species. For example, a monitoring study of Beatrice OWF recorded fish and shellfish at the base of turbine foundations, although no biological material was recorded on the seabed (APEM, 2022). However, material may be rapidly consumed or relocated due to tidal currents and further monitoring is required to clarify if biological material builds up over time (APEM, 2022).

As detailed above in 'Long-term Subtidal Habitat Loss (section 7.12.3), offshore cable crossing protection will be required at up to 32 crossings, with each crossing up to 0.8 m in height and 7 m wide. Given the small scale of cable crossing protection to be installed (58,800 m^2), and further measures such as tapered profiles and compliance with the MCA navigation guidance, it is not expected that impacts from cable crossings would be sufficient to disrupt offshore bank morphological processes or experience significant secondary scour. Any colonisation of cable crossing protection is therefore not expected to be hindered or facilitated by changes in physical processes or secondary scour.

For all IEFs except the Annex I Reef, this impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the 25-year lifetime of the Proposed Development. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

There will be no infrastructure installed within, or in the nearby vicinity of the Annex I Reef IEF, and thus no introduction of artificial habitat or subsequent colonisation of hard structures (Figure 7.4). Overall, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the Annex I Reef IEF (see Table 7.27). The magnitude is therefore considered to be no change.

Intertidal Habitats and Species

There will be no above surface cable protection placed in the intertidal zone. There will, therefore, be no introduction of artificial habitat or subsequent colonisation of hard structures.

Overall, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the 'Mudflats and sandflats not covered by seawater at low tide' IEF (see Table 7.27). The magnitude is therefore considered to be no change.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), introduction of artificial habitat and colonisation of hard structures will not arise within the Dee Estuary/Aber Dyfrdwy SAC due to the lack of above surface cable protection proposed for the intertidal zone. Although the Fylde MCZ overlaps with the Proposed Development offshore, there will be no infrastructure installed within it (1.82 km away; see Figure 7.4), similar to the Annex I Reef IEF. Therefore, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impacts to the site. The magnitude of impact on the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs is therefore, considered to be no change.

Sensitivity of Receptor

Subtidal Habitats and Species

Introduction of artificial, hard structures within the Proposed Development will represent a shift in community type and affect the subtidal habitats and species IEFs through colonisation of hard structures. In terms of the MarESA, the sensitivity of the IEFs to this impact are as previously described for physical change (to another seabed type) in the long term subtidal habitat loss assessment (section 7.12.3 and Table 7.35). The MarESA sensitivities were high for all IEFs except Ross worm (medium) and the Annex I Reef (MarESA not available due to no assigned biotope).

Colonisation of hard structures may have indirect adverse effects on the baseline communities and habitats identified within the Proposed Development due to increased predation on and competition with the existing soft sediment species. However, these effects are difficult to predict, especially as monitoring to date has focused on the colonisation and aggregation of species close to OWF turbine foundations rather than broad scale studies. Installing hard structures on the seabed not only creates new habitat but also modifies or removes existing habitat. Often it replaces an essentially two-dimensional (2D) sedimentary seabed, such as subtidal sandbanks, with a complex three-dimensional (3D) structure, thereby increasing surface area, surface complexity and number of niches (Dannheim *et al.,* 2019). The development of such surfaces and their role in connectivity of populations is dependent on suitable surface being created but also on the right location and distances from source populations. Surfaces may also only be suitable for colonisation after being suitably weathered, through the loss of any surface contaminants, the production of biofilms, and the sequence of development of the community after settlement. Rougher textures facilitate greater microhabitat diversity (Anderson and Underwood, 1994) and will likely induce greater colonisation.

Several studies have also shown that the installation of artificial habitat have no significant impact on the soft sediment environments. For example, the soft sediment epibenthos underwent no drastic changes eight to nine years after the installation of C-power and Belwind OWFs (Belgium) (De Backer *et al.*, 2020). Furthermore, the species originally inhabiting the sandy bottom substrate were still present and remained dominant in both OWFs (De Backer *et al.,* 2020). Additionally, monitoring from Block Island OWF in the US showed no strong gradients of change in sediment grain size, enrichment, or benthic macrofauna within 30 to 90 m distance bands of the wind turbines (Hutchison *et al*., 2020). Recent post-construction monitoring of the Beatrice OWF has found extensive biofouling on all the wind turbines with signs of zonation and successional development (APEM, 2022). Across all wind turbines, plumose anemones *Metridium senile* and tube worms *S. triqueter* were the most abundant species, with the highest biomass of 40 m depth (APEM, 2022). At the base of the wind turbines, hermit crab *Pagurus bernhardus*, flatfish, and common sea urchin *Echinus esculentus* were found with decreasing abundance further from the turbine foundations, indicating a source of food although no biological matter could be seen (APEM, 2022). Similarly, plumose anemones and tube worms *Spirobranchus* sp. dominated the bottom and mid-section of turbines at the Hywind Scotland Pilot Park, with a general increase in epifouling growth between 2018 to 2020 recorded (Karlsson *et al.,* 2022).

The introduction of artificial habitat can influence larval distribution, which may also have potential impacts on the distribution of species. Research from the oil and gas sector has examined the potential impact of infrastructure in the interception and production of larvae (McLean *et al.,* 2022). Larval settlement can be triggered by sound, chemical cues, light, and vibrations. Where artificial structures, such as platforms, exist in offshore waters far away from natural reefs, their influence on larval dispersal and settlement may be comparatively high, in relation to platforms in more naturally connected environments, therefore influencing geographic and population connectivity (McLean *et al.,* 2022). As species become established on oil and gas structures, they can start producing larvae, with one study demonstrating that networks of oil and gas infrastructure in the North Sea could facilitate ecological connectivity by acting as stepping stones for larval connectivity (Henry *et al*., 2018). Similarly, another North Sea study found interannual variability in the North Atlantic Oscillation results in cold-water coral *Lophelia pertusa* larvae being dispersed from oil and gas structures across distances of ~300 km (Fox *et al*., 2016). The influence of oceanographic features in species dispersal and distribution however emphasizes the importance in characterising the hydrodynamics underpinning potential connectivity (Boschetti *et al.,* 2020). Potential barriers to settlement, growth, reproduction and survival of larvae on offshore infrastructure also exist, including cleaning regimes, surface coatings (e.g. antifoulant), and operational discharges.

In addition, manmade artificial habitats can often support higher densities of INNS than natural environments, due to reduced competition from established native species, more-vacant habitat, and year-round settlement allowing opportunistic colonisation of vacant space (Mineur *et al.,* 2012). However, increased risk and spread of INNS is assessed separately in section 7.12.6.

Overall, all IEFs are deemed to be of high vulnerability, low recoverability, and local to national value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

Intertidal Habitats and Species

Introduction of artificial, hard structures within the Proposed Development will represent a shift in community type and affect the subtidal habitats and species IEFs through colonisation of hard structures. In terms of the MarESA, the sensitivity of the intertidal habitats and species IEF to this impact are as previously described for physical change (to another seabed type) in the long term subtidal habitat loss assessment (section 7.12.3 and Table 7.35). These sensitivities are based on assessments made by the MarESA (where available) and are assessed as high for all biotopes except for 'Polychaete/bivalve-dominated muddy sand shores', which was assessed as moderate. It should be noted that the MarESA available for this biotope is outdated and does not contain the 'Physical change (to another seabed type)' pressure. This biotope has, therefore, been assessed against the pressure 'substratum loss', which was used in the outdated MarESA available at the time of writing.

As described above for the subtidal zone, intertidal species also colonise artificial hard structures installed within their habitat. For example, an experimental artificial structure was deployed in the intertidal zone in the English Channel and monitored for four years (Dauvin *et al.,* 2021). A total of 84 intertidal taxa were recorded to have colonised the structures over the study period, including 13 sessile and 71 motile taxa (Dauvin *et al.,* 2021). Artificial structures in the intertidal zone also have the ability to increase connectivity. For example, artificial coastal defences have been reported to act as stepping stones for rocky intertidal species across areas of soft sediment habitat, with species including black-footed limpet *Patella depressa*, flat top shell *Steromphala umbilicalis*, and small periwinkle *Melarhaphe neritoides* using structures to breach habitat barriers and colonise natural rocky habitat where they could not previously reach via natural dispersal (Mieszkowska *et al.,* 2020).

A study on artificial and natural structures in marinas in western Italy demonstrated that intertidal assemblages on seawalls were largely distinct from those on rocky shores or breakwaters, and that seawalls supported a smaller number of species than rocky shores or breakwaters (Bulleri and Chapman, 2004). This study provided evidence for differences between intertidal assemblages supported by artificial habitats and those on adjacent rocky shores. Differences in habitat-structure (and/or wave-exposure in the case of seawalls) could explain the occurrence of distinct intertidal assemblages (Bulleri and Chapman, 2004).

Overall, the 'Mudflats and sandflats not covered by seawater at low tide' IEF is deemed to be of high vulnerability, low recoverability, and international value. Therefore, the sensitivity of the receptor to this impact is considered to be high.

Designated Sites

As detailed in Table 7.10, the sensitivities presented for the Mudflats and sandflats not covered by seawater at low tide IEF in the preceding section is applicable to the Dee Estuary/Aber Dyfrdwy SAC IEF. Thus, the Dee Estuary/Aber Dyfrdwy SAC IEF is deemed to be of high vulnerability, low recoverability, and international value. The sensitivity of the receptor is therefore, considered to be high.

As detailed in Table 7.10, the area of the Fylde MCZ which overlaps with the Proposed Development has been assigned the biotope 'Sublittoral sands and muddy sands (SS.SSa)' (Envision Mapping, 2015), however has not been assigned more specific biotopes. As this area overlaps with the 'Subtidal sands and gravels' IEF identified during the site-specific survey within the Proposed Development, the representative biotopes identified for this IEF have also been used to characterise the Fylde MCZ IEF in the assessment. Therefore, the Fylde MCZ IEF is deemed to be of high vulnerability, low recoverability, and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of Effect

Subtidal Habitats and Species

Overall, for the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect of introduction of artificial habitat and colonisation of hard structures is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Annex I Reef IEF, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of introduction of artificial habitat and colonisation of hard structures is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. Therefore, the effect of introduction of artificial habitat and colonisation of hard structures is considered to be of **minor adverse** significance, which is **not significant** in EIA terms. As per the matrix used to assess the significance of effects, a low magnitude of impact and high sensitivity of receptor yields 'minor or moderate' significance (Table 7.31). A minor adverse significance has been concluded as this impact will only affect a small proportion of the Proposed Development (0.01%) in which these IEFs occupy. This is unlikely to compromise the integrity of these habitats such that they wouldn't be able to support their characterising communities or perform their ecosystem function.

Intertidal Habitats and Species

Overall, for the 'Mudflats and sandflats not covered by seawater at low tide' IEF, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of introduction of artificial habitat and colonisation of hard structures is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be high. Therefore, the effect of introduction of artificial habitat and colonisation of hard structures is considered to be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.5 Increased Temperature Impacting Benthic Communities

7.12.5.1 Operation and Maintenance Phase

There is potential for increased temperatures from the subsea pipeline and power cables to impact the immediate environment, in-turn affecting the benthic species associated with the sediment.

The relevant MarESA pressures and their benchmarks which have used to inform this impact assessment are described here:

- temperature increase (local): the benchmark for which is a 5°C increase in temperature for one month or 2°C for an entire year.

Magnitude of Impact

Subtidal Habitats and Species

The MDS accounts for the utilisation of up to 121.77 km of existing subsea pipelines for transporting liquid carbon dioxide (CO_2) (Table 7.21). Additionally, up to 126.04 km of 33 kV subsea power cables will be used throughout the Proposed Development (Table 7.21). These subsea pipelines and power cables will be buried at a depth of at least 2 m and protected at cable crossings where burial is not possible (Table 7.21). CO_2 will be transported in a liquid state, at a range of temperatures and pressures. The MDS assumes a maximum temperature of 50ºC at a pressure of 72.3 bara. The temperature of the subsea pipelines will be similar to or lower than when the pipelines were used for natural gas transportation, where pipeline temperatures of a maximum of 60ºC were maintained. This was to prevent hydrate and wax deposition, which occurs at a critical temperature of approximately 40ºC (Park and Seo, 2018). Subsea gas pipelines are designed to ensure that heat loss is low enough to avoid reaching this critical temperature of 40ºC and can have internal temperatures as high as 100ºC while the external temperature is as low as 5ºC (Park and Seo, 2018).

The subsea power cables associated with the Proposed Development can generate heat through resistive heating. This is caused by energy loss as electrical currents flow, resulting in heating of the cable surface and potential warming of the surrounding environment. High voltage cables are used to minimise the amount of energy lost as heat, thus minimising the warming effect.

Schedule 4 of the EIA Regulations require a consideration of the LSE of the project resulting from emission of heat, light, and radiation. Soil and sand temperature modelling for the onshore pipeline has been conducted, the results of which are applicable to this impact (Wood, 2023). This study included onshore modelling alongside modelling in the intertidal zone at both high and low tide. It was therefore considered appropriate to represent the MDS for the offshore pipeline conditions, based on the modelled pipeline depth, water temperature, and external pipeline temperature. The results of this modelling concluded that pipeline temperature did not significantly impact sand temperature near the surface in either high or low tide conditions, due to the low thermal capacity of sand (Wood, 2023). Further, the presence of sea water at high tide resulted in a lower sand surface temperature, suggesting that the offshore pipeline would have similar results.

The results of other cable and pipeline projects showed similar results to those of the Proposed Development. For example, the Humber Low Carbon Pipelines (HLCP) is a similar project being developed by the National Grid. The HLCP project comprises dual pipelines to transport carbon dioxide for Carbon Capture, Usage, and Storage (CCUS) and hydrogen. Increased temperature due to the presence of pipelines was scoped out in the scoping stage for the HLCP (National Grid, 2022). There were no significant effects from the temperature of the carbon dioxide or hydrogen stream as the pipelines were below ground and no relevant pathways or receptors were identified (National Grid, 2022), however, it should be noted that these are onshore pipelines, thus potentially differing from those associated with the Proposed Development. However, in the EIA for the Nord Stream 2 subsea gas pipeline, generation of heat from gas flow through the pipelines was assessed as having negligible effects on water temperature. Only unburied sections of the pipeline could create a difference in temperature between the pipeline and the surrounding seawater, of up to 0.5^{o}C (Ramboll, 2017). However, natural mixing of seawater ensures that the temperature will reach equilibrium with the surrounding water within 0.5 to 1 m after crossing the pipeline (Ramboll, 2017). This impact was assessed as having negligible impacts upon biodiversity, including benthic species (Ramboll, 2017).

Subsea power cables also have negligible capacity to heat the surrounding water column due to the very high heat capacity of water. A field study at the Nysted Offshore Windfarm in Denmark demonstrated a mean temperature difference of 1^{o}C in sediment temperatures at the power cable and 25 cm away (Meißner *et al.,* 2007). Similarly, a high voltage power cable burial project in New York, USA, estimated that the 0.19^{o}C rise in temperature in the seabed immediately above the buried cable (Connecticut Sitting Council, 2001).

Overall, the temperature of the subsea pipelines will be lower than when the pipelines were used for natural gas transportation, and impacts are predicted to be minimal. Furthermore, temperatures generated by subsea power cables are also predicted to be minimal. Burial and cable crossing protection are embedded mitigation measures that will reduce the potential for this impact to affect benthic subtidal and intertidal IEFs. The impact on all benthic subtidal habitats and species IEFs (except the Annex I Reef IEF) is predicted to be of local spatial extent (within metres of the cables and pipelines), long term duration, continuous, and of high reversibility (as CO_2 and electricity will not be transmitted post decommissioning). It is predicted that there will be very minor loss or detrimental alteration to the characteristics, features, or elements of the IEFs. Therefore, the magnitude of impact is considered to be negligible.

There will be no cables or pipelines within, or in the nearby vicinity of the Annex I Reef IEF, and thus no potential for increased temperature as a result (Figure 7.4). Overall, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the Annex I Reef IEF (see Table 7.27). The magnitude is therefore considered to be no change.

Intertidal Habitats and Species

The MDS accounts for the presence of up to 1,200 m of power cables within the intertidal zone (Table 7.21). These subsea pipelines and power cables will be buried at a depth of a minimum of 2 m (Table 7.21). As described above for the subtidal habitats and species IEFS, the sand temperature study included modelling in the intertidal zone at both high and low tide (Wood, 2023). The results concluded that pipeline temperature did not significantly impact sand temperature near the surface in either high or low tide conditions, due to the low thermal capacity of sand (Wood, 2023).

Given the results of the site-specific modelling study and the results from similar projects presented above for the subtidal habitats and species IEFs, the impact on the 'Mudflats and sandflats not covered by seawater at low tide' IEF is predicted to be of local spatial extent (within metres of cables and pipelines), long term duration, continuous, and of high reversibility (as CO_2 and electricity will not be transmitted post decommissioning). It is predicted that there will be very minor loss or detrimental alteration to the characteristics, features, or elements of the IEFs. Therefore, the magnitude of impact is considered negligible.

Designated Sites

As above for the Annex I Reef IEF, there will be no cables or pipelines within, or in the nearby vicinity of the Fylde MCZ IEF, and thus no potential for increased temperature as a result (minimum of 1.82 km away; Figure 7.4). Overall, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impact to the Fylde MCZ IEF (see Table 7.27). The magnitude is therefore considered to be no change.

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), introduction of artificial habitat and colonisation of hard structures will not arise within the Dee Estuary/Aber Dyfrdwy SAC due to the lack of above surface cable protection proposed for the intertidal zone. Although the Fylde MCZ overlaps with the Proposed Development offshore, there will be no infrastructure installed within it (see Figure 7.4), similar to the Annex I Reef IEF. Therefore, the MDS for this impact will result in no loss or alterations of characteristics, features, or elements and no observable adverse impacts to the site. The magnitude of impact on the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs is therefore, considered to be no change.

Sensitivity of Receptor

All IEFs

For the subtidal and intertidal IEFs with a MarESA available, their sensitivity to increase in temperature is presented in Table 7.36. These sensitivities range from negligible to low.

The Renewables Grid Initiative (2016) conducted a literature review and collected stakeholder data on the effects of subsea power cables in the marine environment. They reported that there was a lack of field data on the effect of thermal radiation from subsea cables and concluded that increased temperature from subsea power cables is small and localised, with any potential impacts to benthic ecology only possible within a few centimetres from the cable (Renewables Grid Initiative, 2016). Similarly, a report on the potential thermal impacts of subsea power cables between Denmark and the UK concluded that only deep burrowing invertebrates could potentially be exposed to any non-trivial heating effects (such as the crustaceans *Callianassa subterranea* and *Upogebia deltaura,* and the sand gaper *Mya arenaria)* (National Grid and Viking Link, 2017). However, the modelling for the worst-case thermal scenario suggested that the footprint of temperature increases will be extremely narrow (National Grid and Viking Link, 2017). The MarESA for *C. subterranea* presents a high tolerance, high recoverability and low sensitivity to increased temperature, as it is distributed in a wide range of temperatures from Norway to the Mediterranean (Hill, 2005). For example, within North Sea waters, this species lives in temperatures varying between 6 and 15^{o}C (Rowden *et al.,* 1998). Similarly, a MarESA is available for sand gaper, which presents a high tolerance, very high recoverability, and very low sensitivity to increased temperature (Tyler-Walters, 2003). Again, this is due to the species wide distribution in the North Atlantic and the wide variation in natural temperatures it can survive, with a maximum temperature tolerance of 28^{o}C (Stickney, 1964; Kennedy and Mihursky, 1972; Strasser, 1999).

Similarly, a laboratory study on the effects of heat emission from subsea cables on two infaunal invertebrates, mud shrimp *Corophium volutator* and polychaete *Maranzellaria viridis,* illustrated that the distribution of mud shrimp was not correlated with the sediment temperature (Borrmann, 2006). *M. viridis* displayed a tendency to avoid areas of higher sediment temperatures (25 – 40^{o}C) (Borrmann, 2006), which suggests potential avoidance behaviour in this species. Both species have the potential to be present within the regional benthic ecology study area, with a MarESA available for the mud shrimp. This assessment proposes a high tolerance, very high recoverability, and very low sensitivity to increases in temperature (Neal and Avant, 2006). This is based on the natural fluctuations in temperature throughout the year, from 1^{o}C in the winter to 17^{o}C in the summer (Wilson and Parker, 1996), and that this species can tolerate higher temperatures (Meadows and Ruagh, 1981).

Overall, although temperature increases are unlikely to occur in the first place, it is likely that only deep burrowing species or sessile benthic species within centimetres from the pipelines could be impacted. Due to the natural fluctuations in temperature throughout the year, it is also likely that benthic subtidal and intertidal receptors will be tolerant to small temperature increases associated with this impact. All IEFs are deemed to be of low vulnerability, high recoverability, and of local to international importance. The sensitivity of the receptor is therefore considered to be low.

Table 7.36: Sensitivity Of The Benthic Subtidal And Intertidal Ecology IEFs To Increased Temperature

IEF	Representative Biotopes Identified	Sensitivity to Defined MarESA Pressure	Overall Sensitivity (Based on Table 7.29)
		Temperature Increase (local)	
Subtidal Habitats and Species			
Subtidal Sands and Gravels	*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)	Low	Low
	N. cirrosa and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat)	Not sensitive	Negligible
Mud Habitats in Deep Water	*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)	Not sensitive	Negligible
Subtidal Mixed Muddy Sediment	*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)	Not sensitive	Negligible
Ross Worm *S. spinulosa*	-	Low	Low
Intertidal Habitats and Species			
Mudflats and sandflats not covered by seawater at low tide	Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal)	Not sensitive	Negligible
	M. balthica and *A. marina* in littoral muddy sand (LS.LSa.MuSa.MacAre)	Low	Low
	Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa)	Not sensitive	Negligible
	Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa)	Not sensitive	Negligible

Significance of Effect

Subtidal Habitats and Species

Overall, for the Annex I Reef IEF, the magnitude of impact is deemed to be no change, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased temperature is considered to be of **negligible adverse** significance, which is **not significant** in EIA terms.

For all other subtidal habitats and species IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased temperature is considered to be of **negligible adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

For the 'Mudflats and sandflats not covered by seawater at low tide' IEF, the magnitude of the impact is deemed to be no change, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased temperature is considered to be of **negligible adverse** significance, which is **not significant** in EIA terms.

Designated Sites

For the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of the impact is deemed to be no change, and the sensitivity of the receptor is considered to be low. Therefore, the effect of increased temperature is considered to be of **negligible adverse** significance, which is **not significant** in EIA terms.

7.12.6 Increased Risk of Introduction and Spread of INNS

7.12.6.1 Construction Phase

Vessels utilised during all stages of the development area could inadvertently transport INNS resulting in significant impacts on the local fauna which have the potential to spread throughout the area. The relevant MarESA pressures and their benchmarks which have used to inform this impact assessment are described here:

- introduction or spread of INNS: the benchmark for which is the introduction of one or more INNS.
- This impact is linked with the impact 'introduction of artificial habitat and colonisation of hard structures' (section 7.12.4), which may lead to an increased risk of habitat that could be colonised by INNS.

Magnitude of Impact

Subtidal Habitats and Species

The installation of artificial hard substrates and the presence of construction vessels may lead to an increased risk of introduction and spread of INNS. The MDS is represented by up to 236 vessel round trips during the construction phase, including those required during site preparation activities (Table 7.21). There are however a number of existing vessel movements occurring within the Proposed Development. As ferries represent a large proportion of the vessel traffic in this region. These ferries primarily move between the mainland UK and Ireland or Northern Ireland (see volume 3, appendix L). Shipping is also a major contributor with busy ports such as Liverpool in the vicinity. There is also an active fishing industry in this region, with fishing ports such as Amlwch, Conwy, Holyhead, and Fleetwood being the most active (see volume 3, appendix M). The addition of the Proposed Development construction traffic to this region does not represent a level of vessel activity uncommon to this area, therefore it does not represent a large increase in risk as many of these vessels will be travelling further afield than the construction vessels potentially exposing themselves to INNS.

As presented in Table 7.21, the risk of introduction and spread of INNS will be increased through the construction phase due to the creation of 64,169 m^2 of artificial substrate from the installation of foundations for the new Douglas platform, cable crossing protection, pipeline spools, pipeline mattresses, and rock placement.

Many marine INNS that are now widespread and well established in this region of Wales and north-east England. The Welsh Government has published a monitoring and surveillance list for marine INNS to focus efforts on 'priority' marine species, representing those that do or could have a high environmental impact. The most recent list presents the following species as high risk of invasiveness:

- compass sea squirt *Asterocarpa humilis;*
- american slipper limpet *Crepidula fornicata;*
- carpet sea squirt *Didemnum vexillum;*
- chinese mitten crab *Eriocheir sinensis;*
- devil's tongue weed *Grateloupia turuturu;* and
- red ribbon bryozoan *Watersipora subatra* (Welsh Government, 2017).

The carpet sea squirt has been identified in the Holyhead region of northern Wales. It tends to colonise artificial structures, rocks, boulders, and even tide pools. It is usually found in low energy environments where water motion is limited (Gibson-Hall and Bilewitch, 2018). An experimental attempt to remove the carpet sea squirt from Holyhead harbour by isolating, smothering, and killing it using physical (plastic wrapping) and chemical (calcium hypochlorite) methods was documented by Holt and Cordingley (2011). This was largely successful following an eight-month treatment period however five months following cessation of removal activities survey work revealed large numbers of very small colonies of carpet sea squirt and rapidly growing larger colonies over a much larger proportion of the marina (Holt and Cordingley, 2011). Further efforts to remove the colonies were not pursued. This study highlights the intense, pervasive nature of this species once it is introduced, and the difficulty in removing it. The American slipper limpet has also been identified in the north of Cardigan Bay, in the Menai Strait and off the north and west coast of Anglesey. They are typically found attached to shells and stones on sedimentary substrata around the low water mark and the shallow sublittoral (Rayment, 2008).

There are several other INNS which can be found along the English coast to the west of the Proposed Development, including species such as wakame *Undaria pinnatifida* and leathery sea squirt *Styela clava* which have been recorded around Liverpool port (NBN Atlas, 2021).

The majority of the vessels used during the construction phase are likely to be from within the vicinity of the Proposed Development, therefore the introduction of species form outside the region is unlikely. Some of the INNS already in the region however are known to spread as fouling on ships hulls (such as compass sea squirt) which could introduce them to the Proposed Development.

As set out in Table 7.32, an INNS Management Plan will be implemented, which will aim to manage and reduce the risk of potential introduction and spread of INNS so far as reasonably practicable. The INNS Management Plan is presented in volume 4, appendix T. Furthermore, vessels will be required to comply with the International Maritime Organisation (IMO) ballast water management guidelines. This will ensure that the risk of potential introduction and spread of INNS will be minimised.

Overall, for all subtidal habitats and species IEFs, the impact is predicted to be of local spatial extent, long term duration, intermittent (in terms of invasions), and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

As construction in the intertidal zone will be limited in comparison to the subtidal zone and will likely be conducted by onshore vehicles it is unlikely that they will introduce marine INNS to the intertidal zone. The risk from INNS from these activities is, therefore, considered to be minimal. No assessment of the 'Mudflats and sandflats not covered by seawater at low tide' IEF is therefore required for this impact.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), no impact to the Dee Estuary/Aber Dyfrdwy SAC IEF is likely to occur. No assessment of the Dee Estuary/Aber Dyfrdwy SAC IEF is therefore required for this impact.

As above for the subtidal habitats and species IEFs, the impact is predicted to be of local spatial extent, long term duration, intermittent (in terms of invasions), and low reversibility for the Fylde MCZ IEF. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of Receptor

Subtidal Habitats and Species

The sensitivities of the benthic subtidal habitats and species IEFs to this impact are presented in Table 7.37 and are based on the relevant MarESA pressure. The sensitivities of the two biotopes within the Subtidal Sands and Gravels IEF were assessed as negligible and high for the relevant MarESA pressure (Table 7.37). The remaining biotopes and species (Ross worm) were not able to be assessed due to insufficient evidence to support a MarESA for the relevant pressure for this impact (Table 7.37).

For the ‘subtidal sands and gravels’ IEF, the two representative biotopes identified had an overall high and negligible sensitivity to this impact. The biotope ‘*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)’, was assessed as high sensitivity despite the fact that few INNS would be able to colonise mobile sands, due to high levels of sediment disturbance associated with them. However, two INNS, the American slipper limpet and carpet sea squirt, may be of concern to this biotope, hence the MarESA sensitivity of ‘high’ (Tillin, 2022a). Within this biotope, the American slipper limpet may settle on stones in substrates and hard surfaces such as bivalve shells. This species sometimes forms dense carpets which can smother bivalves and alter the seabed, making the habitat unsuitable for larval settlement (Tillin, 2022a). Few other bivalves can live amongst dense aggregations of American slipper limpet (Fretter and Graham, 1981; Blanchard, 1997). A study in south-west Wales found that American slipper limpet densities were highest in areas of high gravel content (grain sizes 16 to 2560 mm), suggesting that the availability of this substrata type is beneficial for its establishment (Bohn *et al.,* 2015). The American slipper limpet may colonize this biotope and potentially result in reclassification to the biotope ‘*C. fornicata* and *M. fragilis* in variable salinity infralittoral mixed sediment (SS.SMx.IMx.CreAsAn)’ (Tillin, 2022a). In addition to the American slipper limpet, the carpet sea squirt may also have the potential to colonize and smother offshore gravel habitats, such as this biotope. For example, this species appears to have rapidly colonized gravel areas on the Georges Bank (US/Canada boundary) (Valentine *et al.,* 2007). However, areas of mobile sand bordered communities of carpet sea squirt, which did not appear to be suitable habitats (Valentine *et al*., 2007). Therefore, the mobile sands associated with this biotope may exclude the carpet sea squirt (Tillin, 2022a). Overall, this biotope was assessed as having no resistance and very low resilience to invasion by American slipper limpet, giving an overall high sensitivity (Tillin, 2022a).

In contrast, the other representative biotope identified for the subtidal sands and gravels IEF (*N. cirrosa* and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat)) had a negligible sensitivity to this impact (Tillin and Garrard, 2022). This is because the sediments characterizing this biotope are too mobile and frequent disturbance limits the establishment of marine and coastal INNS. The habitat conditions of this biotope are thus unsuitable for most species in general, as exemplified by the low species richness characterizing this biotope (Tillin and Garrard, 2022). This biotope is therefore considered to have a high resistance to this impact and high resilience, by default (Tillin and Garrard, 2022).

Ross worm, and the biotopes identified for the ‘Mud habitats in deep water’ IEF and ‘Subtidal mixed muddy sediment’ IEF were not assessed by the MarESA due to insufficient evidence (Table 7.37). The representative biotope for the Mud habitats in deep water IEF (*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)) was noted to be considered highly sensitive to INNS as subtidal muds have the potential for habitat change and due to the difficulty of removing INNS (De-Bastos and Hill, 2016). However, ultimately, evidence was not available for this biotope. Although not currently established in UK waters, the whelk *Rapana venosa* may spread to UK and Irish habitats from Europe (Tillin, 2022a). This species preys on bivalves and could therefore adversely affect bivalve species that are characteristic of biotope '*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)'.

Overall, due to the lack of available evidence for several biotopes and Ross worm, all subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to national value as a precaution. The sensitivity of these IEFs is therefore, conservatively, considered to be high.

Designated Sites

As above for the subtidal habitats and species IEFs, the Fylde MCZ IEF is deemed to be of high vulnerability, low recoverability, and national value as a precaution. Therefore, the sensitivity is, conservatively, considered to be high.

Table 7.37: Sensitivity Of The Benthic Subtidal And Intertidal Ecology IEFs To Introduction Or Spread Of INNS

IEF	Representative Biotopes Identified	Sensitivity to Defined MarESA Pressure	Overall Sensitivity (Based on
		Introduction or Spread of INNS	Table 7.29)
Subtidal Habitats and Species			
Subtidal Sands and Gravels	*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)	High	High
	N. cirrosa and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat)	Not sensitive	Negligible
Mud Habitats in Deep Water	*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)	Not assessed, due to insufficient evidence	Not assessed, due to insufficient evidence
Subtidal Mixed Muddy Sediment	*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)	Not assessed, due to insufficient evidence	Not assessed, due to insufficient evidence
Ross Worm *S. spinulosa*	-	Not assessed, due to insufficient evidence	Not assessed, due to insufficient evidence

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFS, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be colonised and due to the precautionary high sensitivity of the receptor. Furthermore, embedded measures have been adopted to minimise the effects of introduction or spread of INNS, such as an EMP and INNS Management Plan (Table 7.32).

Designated Sites

Overall, for the Fylde MCZ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be colonised and due to the precautionary high sensitivity of the receptor. Furthermore, embedded measures have been adopted to minimise the effects of introduction or spread of INNS, such as an EMP and an INNS Management Plan (Table 7.32).

7.12.6.2 Operation and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

The presence of artificial structures installed in the construction phase and the movement of vessels associated with the Proposed Development may lead to an increased risk of introduction and spread of INNS in the operations and maintenance phase. The MDS is represented by up to 750 vessel return trips during the 25-year operations and maintenance phase (Table 7.21). Furthermore, the long-term creation of 64,169 m^2 of artificial hard substrate, in the form of the new Douglas platform foundations, cable crossing protection, pipeline spools, pipeline mattresses, and rock placement, has the potential to contribute to the introduction and spread of INNS. As outlined in section 7.12.4 (Introduction of artificial habitat and colonisation of hard structures), this estimate for habitat creation is considered to be conservative as the lattice nature of jacket foundations will result in a smaller area of habitat created than has been assumed for a foundation with solid sides in the MDS.

Details of INNS of concern in the region are as outlined above for the construction phase. Overall, for all subtidal habitats and species IEFs, the impact is predicted to be of local spatial extent, long term duration, intermittent nature (based upon the numbers of vessel round trips across the project lifetime), and of low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

As above for the construction phase, it is likely that the risk from INNS in the operation and maintenance phase is considered to be minimal. No assessment of the 'Mudflats and sandflats not covered by seawater at low tide' IEF is therefore required for this impact.

Designated Sites

As above for the intertidal IEF "Mudflats and sandflats not covered by seawater at low tide", no impact to the Dee Estuary/Aber Dyfrdwy SAC IEF is likely to occur. No assessment of the Dee Estuary/Aber Dyfrdwy SAC IEF is therefore required for this impact.

As above for the subtidal habitats and species IEFs, the impact is predicted to be of local spatial extent, long term duration, intermittent (based upon the quantity of vessel round trips during the project lifetime), and low reversibility for the Fylde MCZ IEF. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered **low.**

Sensitivity of Receptor

All IEFs

The sensitivities of all the IEFs are considered to be as previously described for the construction phase (Table 7.37) and are assessed to be high.

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFS, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this results in a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be colonised and due to the precautionary high sensitivity of the receptor. Furthermore, embedded measures have been adopted to minimise the effects of introduction or spread of INNS, such as an EMP and an INNS Management Plan (Table 7.32).

Designated Sites

Overall, for the Fylde MCZ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be colonised and due to the precautionary high sensitivity of the receptor. Furthermore, embedded measures have been adopted to minimise the effects of introduction or spread of INNS, such as an EMP and an INNS Management Plan (Table 7.32).

7.12.6.3 Decommissioning Phase

Magnitude of Impact

Subtidal Habitats and Species

In the decommissioning phase, some infrastructure will be left in place for reservoir modelling, before being removed. The current assumption is that all infrastructure will be removed over the decommissioning phase, and this will be confirmed within the Decommissioning Plan at the relevant time (Table 7.21). However, permanent habitat creation (i.e. persisting post-decommissioning) may occur as a some rock placement may be left in situ. This may contribute to an increased risk of introduction and spread of INNS.

Details of INNS of concern in the region are as outlined above for the construction phase. Overall, for all subtidal habitats and species IEFs, the impact is predicted to be of local spatial extent, long term duration, intermittent (in terms of exposure through vessel round trips), and of low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

As above for the construction phase, it is likely that the risk from INNS in the decommissioning phase is considered to be minimal. No assessment of the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF is therefore required for this impact.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), no impact to the Dee Estuary/Aber Dyfrdwy SAC IEF is likely to occur. No assessment of the Dee Estuary/Aber Dyfrdwy SAC IEF is therefore required for this impact.

As above for the subtidal habitats and species IEFs, the impact is predicted to be of local spatial extent, long term duration, intermittent (in terms of exposures via vessel round trips), and low reversibility for the Fylde MCZ IEF. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of Receptor

All IEFs

The sensitivities of all the IEFs are considered to be as previously described for the construction phase (Table 7.37) and are considered to be high.

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFS, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be colonised and due to the precautionary high sensitivity of the receptor. Furthermore, embedded measures have been adopted to minimise the effects of introduction or spread of INNS, such as an EMP and an INNS Management Plan (Table 7.32).

Designated Sites

Overall, for the Fylde MCZ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be colonised and due to the precautionary high sensitivity of the receptor. Furthermore, embedded measures have been adopted to minimise the effects of introduction or spread of INNS, such as an EMP and an INNS Management Plan (Table 7.32).

7.12.7 Impacts Resulting from the Release of Sediment Bound Contaminants

7.12.7.1 Construction Phase

Seabed disturbances due to construction activities could potentially lead to the remobilisation of previously sediment bound contaminants which could impact the surrounding benthic communities. The relevant MarESA pressures to inform this impact assessment are:

- transition elements and organo-metal contamination;
- Hydrocarbon and pah contamination; and
- synthetic compound contamination.

Magnitude of Impact

Subtidal Habitats and Species

The results of the numerical modelling study undertaken for the Physical Processes impact assessment (volume 3, appendix H) will be used to inform this impact. As presented above for ‘Increased SSCs and Associated Deposition’ (section 7.12.2) this modelling has been used to quantify the changes in physical processes, predominantly suspended sediment concentrations, due to seabed preparation activities, the drilling of new monitoring wells, and laying of cables. The following activities in the construction phase have been considered:

- seabed preparation (such as sand wave clearance);
- drill cuttings; and
- cable installation.

As per the MDS for 'Increased SSCs and Associated Deposition' (section 7.12.2; Table 7.21), it is assumes that sand waves are to be cleared along the cable route in two locations, south of the existing Douglas platforms, and at West Hoyle Bank. For the drilling of two new monitoring wells, the MDS assumes clearance of up to 30.48 m of sand and silt and 84.42 m of coarser sediment (assuming 100% washout). Finally, the MDS assumes that suspended sediments will be released due to the installation of up to 126.04 km of subsea power cables.

As stated in section 7.8.1.3, sediment contamination within the subtidal Proposed Development was assessed during the site-specific benthic characterisation survey in 2022, and the following results were recorded:

- As and Cd exceeded Cefas AL1 at one sampling station each.
- Hg was above the OSPAR BAC levels in seven sampling stations but did not exceed Cefas ALs.
- Zn was the most abundant metal across all samples but concentrations never exceeded any reference levels. All metals occurred in concentrations comparable to existing background data or in line with the range of concentrations known for areas located in proximity of active platforms.
- No PAHs exceeded Cefas AL1 at any of the CCS and full decommissioning sampling stations, while chrysene and benzo[a]pyrene were above Cefas AL1 at one partial decommissioning station (GS36). A positive correlation was observed between chrysene, benzo[a]pyrene and mud content with higher PAHs concentrations in muddier sediments apart from station GS36 which had the highest chrysene and benzo[a]pyrene concentrations but an average mud content. No relationship was observed between the concentration of PAHs and proximity to platforms that could have indicated dispersal of drill cuttings.
- THC was also highest at partial decommissioning station GS36 (30,600 µg/kg). In the North Sea, THC concentrations at locations between 1 to 2 km from an active platform range between 32,710 µg/kg to 33,810 µg/kg, in line with the findings at station GS36 which was located in proximity of a platform.
- PCBs and did not exceed Cefas AL1 at any sampling stations.
- Organotins (dibutyltin and tributyltin) were below the limit of detection at all sampling stations.

Based on these sediment contamination results, it is not likely that significant levels of sediment bound contaminants could be released as a result of the construction activities assessed under 'Increased SSCs and Associated Deposition'. Furthermore, the magnitude of impact for 'Increased SSCs and Associated Deposition' was concluded to be low (see section 7.12.2).

Overall, for all subtidal habitats and species IEFs, 'Impacts Resulting from the Release of Sediment Bound Contaminants' is predicted to be of local spatial extent, short-term duration (for the individual activities), intermittent (due to the construction schedule), and of high reversibility. It is predicted that this impact will affect the receptor directly. Therefore, the magnitude of impact is concluded to be negligible.

Intertidal Habitats and Species

There were no sediment samples taken from the intertidal zone during the site-specific benthic characterisation survey or intertidal survey. Therefore, there are no site-specific sediment chemistry values available for the intertidal zone. No assessment of the 'Mudflats and sandflats not covered by seawater at low tide' IEF is therefore possible for this impact.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), no assessment of the Dee Estuary/Aber Dyfrdwy SAC IEF is possible for this impact.

As above for the subtidal habitats and species IEFs, the impact is predicted to be of local spatial extent, short term (for the individual activities), intermittent (due to the construction schedule), and of high reversibility for the Fylde MCZ IEF. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be negligible.

Sensitivity of Receptor

Subtidal Habitats and Species

The four biotopes and were not assessed for any of the defined MarESA pressures for this impact, as shown in Table 7.38, however evidence has been provided where available. Ross worm was assessed for synthetic compound contamination but not for heavy metal or hydrocarbon contamination (Jackson and Hiscock, 2008). Although Ross worm larvae are known to be highly intolerant to some oil dispersants, adult populations been found to thrive in polluted areas, particularly those polluted with an acidified halogenated effluent (Hoare and Hiscock, 1974; Jackson and Hiscock, 2008). The species has been assessed as tolerant to synthetic compound contamination in the MarESA (Table 7.38; Jackson and Hiscock, 2008) but may have differing sensitivities to other contaminants, where information is lacking.

The capacity of bivalves to accumulate heavy metals in their tissues, far exceeding environmental levels, is well known. It has been stated that Hg is the most toxic metal to bivalves while Copper (Cu), Cd and Zn seem to be most problematic in the field (Bryan, 1984). Hg has been reported to have the highest toxicity in bivalves, with mortalities occurring above 0.1 to 1 g/l after four to 14 days exposure (Crompton, 1997). Limited evidence was found directly relating to the bivalves characteristic of the representative biotopes (*K. bidentata, A. nitida,* and venerid bivalves), however, inferences may be drawn from studies of other species. Burial of the venerid bivalve, *Venerupis senegalensis*, was inhibited by sediments spiked with Cu, and at very high concentrations, individuals closed up and did not bury at all (Kaschl and Carballeira, 1999). Similarly, Stirling (1975) investigated the effect of exposure to Cu on the bivalve *Tellina tenuis* and demonstrated that exposure to Cu concentrations of 250 µg/l and above also inhibited burrowing behaviour, which would presumably result in greater vulnerability to predators. Hiscock *et al*. (2004; from Rygg, 1985 and Olsgard, 1999) recorded that *A. nitida, Ennacula tenuis,* and *Nucula sulcata* were not tolerant to Cu contamination in sediments.

Echinoderms (such as brittlestars) are also regarded as being intolerant of heavy metals (Bryan, 1984). They are also known to be efficient concentrators of heavy metals including those that are toxic (Silver (Ag), Zn, Cd, and Cobalt (Co)) (Hutchins *et al.,* 1996), although there is no information available regarding the effects of this bioaccumulation. Deheyn and Latz (2006) reported that heavy metal accumulation in brittlestars in San Diego (Untied States (US)) occurs both through dissolved metals as well as through diet, to the arms and disc, respectively. Similarly, concentrations of heavy metals (Cu, Nickel (Ni), Cd, Co, Chromium (Cr), and Lead (Pb)) in the body of brittlestar *Ophiocoma scolopendrina* were most concentrated in the central disc rather than arms (Sbaihat *et al.*, 2013).

The tolerance of polychaetes to metal contamination varies throughout the literature. For example, Rygg (1985) classified polychaetes of the *Lumbrineris* genus as not tolerant of Cu, as individuals were only occasionally found at stations in Norwegian fjords where Cu concentrations were >200 Parts per Million (ppm) (mg/kg). It should be noted that the highest Cu concentration recorded in the site-specific sediment contamination analysis was 20.5 mg/kg, which is considerably lower than the value presented in Rygg (1985) (see volume 3, appendix I1). However, the polychaete *Nereis diversicolor* has been reported to display some tolerance to Cu contamination, with tolerant individuals displaying significantly different gene expression profiles compared to those from a nearby population living without elevated Cu levels (McQuillan *et al.,* 2014). In addition, exposure to sediment contaminated with 40 mg/kg of Cd did not result in statistically significant differences in burrowing times of three polychates (*Alitta virens, Glycera dibranchiata,* and *Nephtys caeca*) compared to control conditions (Olla *et al.,* 1988). Cd uptake also varied between the three species, with the highest loads present in *N. virens* tissues after 28 days, followed by *G. dibranchiata,* and *N. cacea* (Olla *et al.,* 1988). Some polychaetes have also been recorded to accumulate toxic metals, such as As, and biotransform them through methylation (reviewed in Fattorini *et al.,* 2005), such as *Laeonereis acuta* (Ventura-Lima *et al.,* 2007).

Overall, the characterisitic species of the representative biotopes have varying tolerance levels to metal contamination, with bivalves and brittlestars likely to be sensitive, and polychaetes to be more tolerant. In terms of hydrocarbon and PAH contamination, sensitivites also vary between taxa and contaminants. Echinoderms are especially intolerant to hydrocarbons and PAH contamination, likely due to the large amounts of exposed epidermis they possess (Suchanek, 1993). Brittlestars in particular host symbiotic sub-cuticular bacteria, which have been demonstrated to reduce in number following hydrocarbon exposure (Newton and McKenzie, 1995). A study on *O. fragilis* demonstrated that exposure to 30,000 ppm of oil reduced this sub-cuticular bacterial load by 50%, resulting in mortality of the brittlestar host (Newton and McKenzie, 1995). Olsgard and Gray (1995) found *A. filiformis* to be very intolerant to oil pollution. Similarly, Addy *et al.* (1978) suggested that lower *A. filiformis* numbers within 2 to 3 km of the Ekofisk oilfield (North Sea) was related to oil discharches from plaforms. Diesel oil has been shown to be acutely toxic to brittlestars *O. fragilis* and *O. nigra,* although no field observations of damage to brittlestar beds because of hydrocarbon pollution have been documented (Hughes, 1998). Shortly after the Amoco Cadiz oil spill (France) mass mortality of the urchin *Echinocardium cordatum* through hydrocarbons exposure was observed down to about 20 m depth, suggesting high intolerance (Cabioch *et al.,* 1978). Similarly, amphipods *Ampelisca* sp., were also very intolerant to oil contamination and the recovery of the populations in the fine sand community took up to 15 years following the Amoco Cadiz oil spill (Poggiale and Dauvin, 2001).

Bivalves are also known to be sensitive to hydrocarbon and PAH contamination. They increase their energy expenditure and decrease their feeding rate after contact with oil, which results in less available energy for growth and reproduction (reviewed in Suchanek, 1993). Sublethal hydrocarbon concentrations also weaken attachment (through reduced byssal thread production) and infaunal burrowing rates (Suchanek, 1993). For example, two years following the Amoco Cadiz oil spill, recruitment of bivable *Fabulina fabula* was very much reduced (Conan, 1982). The author noted that populations of species with long and short-term life expectancies (e.g. *F. fabula*, urchin *E. cordatum,* and amphipod *Ampelisca* sp.) either vanished or displayed long-term decline following the oil spill (Conan, 1982). However, polychaetes (including *Nephtys hombergii*, cirratulids and capitellids) were largely unaffected, and *M. fragilis* increased in abundance after the spill (Dauvin, 2000). Other studies have also supported the conclusion that polychaetes are generally a tolerant taxa to hydrocarbon and PAH contamination. For example, Hiscock *et al.* (2004; from Levell *et al.,* 1989) described the polychates *Capitella capitata, Phloe inomata, Rhaphidrilus nemasoma,* and *Ophryotrocha* spp. as extremely tolerant species, present in high abundances in hydrocarbon contaminated sediments. Similar to metals, there is also evidence that some polychaetes can biotransform PAHs from both particulate and dissolved phases (Jørgensen *et al.,* 2007).

There is less information available on the sensitivities of benthic organisms to organotins and PCBs than for metals, hydrocarbons, and PAHs. One study by Dahllöf *et al.* (1999) investigated the long-term effects of tributyltin (TBT) on the function of a marine sediment system dominated by brittlestars *Amphiura* spp., heart urchin *Brissopsis lyrifera,* polychaetes (*Maldane sarsi* and *Heteromastus filiformis*), and white furrow shell. Within two days of treatment with a TBT concentration above 13.7 µmol/m² brittlestars, *B. lyrifera,* and white furrow shell had crept up to the surface, and after six weeks these fauna had started to decay (Dahllöf *et al.,* 1999). Thus, contamination from organotins, such as TBT, is likely to result in the death of some non-resistant species such as brittlestars. Furthermore, inhibition of arm regeneration in another brittlestar, *Ophioderma brevispina*, following exposure to TBT has been observed (Walsh *et al.,* 1986). Brittlestars are also known to bioaccumulate PCBs (Gunnarsson and Sköld, 1999), and may play an important role in the accumulation, remobilization, and transfer of PCBs to other trophic levels. For example, between 8 to 15% of PCB burden in dab from the Bay of Seine (France) could be explained by brittlestar consumption (Loizeau and Menesguen 1993).

Overall, there is a lack of information available on the sensitivities of the subtidal habitats and species IEFs to the contaminants mentioned, with the majority of available sources now somewhat dated. This has resulted in no MarESA available for the relevant pressures for this impact for any IEFs. Therefore, based on the absence of information, and the potential intolerance of many benthic species to contamination (bivalves and echinoderms in particular), the sensitivity of these receptors will be assessed on a precautionary basis. Overall, all subtidal habitat and species IEFs, are deemed to be of high vulnerability, low recoverability, and local to national value. Therefore, the sensitivity of these receptors to this impact is, precautionarily, considered to be **high.**

Designated Sites

As above for the subtidal habitats and species IEFs, the Fylde MCZ IEF is deemed to be of high vulnerability, low recoverability, and national value as a precaution. Therefore, the sensitivity is, precautionarily, considered to be high.

Table 7.38: Sensitivity Of The Benthic Subtidal And Intertidal Ecology IEFs To The Release Of Sediment Bound Contaminants

IEF	Representative Biotopes Identified	Sensitivity to Defined MarESA Pressures			Overall Sensitivity (Based on Table 7.29)
		Transition Elements and Organo-metal Contamination	Hydrocarbon and PAH Contamination	Synthetic Compound Contamination	
Subtidal Habitats and Species					
Subtidal Sands and Gravels	*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
	N. cirrosa and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
Mud Habitats in Deep Water	*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
Subtidal Mixed Muddy Sediment	*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
Ross Worm *S. spinulosa*	-	Not assessed due to insufficient evidence	Not assessed due to insufficient evidence	Not Sensitive	Could not be defined by the MarESA, refer to text for sensitivity assessment

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be impacted by the release of sediment-bound contaminants, and the relatively low levels of contamination recorded during the site-specific benthic characterisation survey.

Designated Sites

Overall, for the Fylde MCZ IEF, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be impacted by the release of sediment-bound contaminants and the relatively low levels of contamination recorded during the site-specific benthic characterisation survey.

7.12.7.2 Decommissioning Phase

Seabed disturbances due to construction activities could potentially lead to the remobilisation of previously sediment bound contaminants which could impact the surrounding benthic communities.

Magnitude of Impact

Subtidal Habitats and Species

Based on the MDS (Table 7.21), the removal of foundations, cables, and cable crossing protection would result in increased SSCs within the Proposed Development during the decommissioning phase. It is assumed that the increases in SSCs generated in the decommissioning phase would be of a lower extent than that of the construction phase. This is due to the absence of seabed preparation activities, drilling, and depositing of drill cuttings, which account for additional increases in SSCs in the construction phase. These increased SSCs may potentially remobilise previously sediment bound contaminants present within the Proposed Development, which are outlined in section 7.12.2, and above for the construction phase. It is therefore anticipated that this impact will be of a lower extent to that of the construction phase.

Overall, for all subtidal habitats and species IEFs, this impact is predicted to be of local spatial extent, short-term duration (for the individual decommissioning activities), intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Therefore, the magnitude of impact is concluded to be negligible.

Intertidal Habitats and Species

As above for the construction phase, no assessment of the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF is possible for this impact.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), no assessment of the Dee Estuary/Aber Dyfrdwy SAC IEF is possible for this impact.

As above for the subtidal habitats and species IEFs, this impact is predicted to be of local spatial extent, short-term duration (for the individual decommissioning activities), intermittent, and of high reversibility for the Fylde MCZ IEF. It is predicted that this impact will affect the receptor directly. Therefore, the magnitude of impact is concluded to be negligible.

Sensitivity of Receptor

All IEFs

The sensitivities of all the IEFs are considered to be as previously described for the construction phase (Table 7.38) and are considered to be high.

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFS, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be impacted by the release of sediment-bound contaminants, and the relatively low levels of contamination recorded during the site-specific benthic characterisation survey.

Designated Sites

Overall, for the Fylde MCZ IEF, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the Proposed Development that may be impacted by the release of sediment-bound contaminants and the relatively low levels of contamination recorded during the site-specific benthic characterisation survey.

7.12.8 Accidental Pollution to the Surrounding Area

7.12.8.1 Construction Phase

There is a risk of pollution to water and sediment through accidental release of chemicals and pollutants from vessels, equipment, and machinery used during construction activities. The relevant MarESA pressures to inform this impact assessment are:

- transition elements and organo-metal contamination;
- Hydrocarbon and PAH contamination; and
- synthetic compound contamination.

- These pressures are the same as those used in the assessment of 'Impacts Resulting from the Release of Sediment Bound Contaminants' (section 7.12.7).

Magnitude of Impact

Subtidal Habitats and Species

The MDS for this impact assumes a total of 236 round trips by vessels over the duration of the construction phase (Table 7.21). These include cable installation vessels, jack-ups, and support vessels (see Table 7.21 for all details). There is also potential for accidental pollution through discharges of drill cuttings, drilling mud, and cement, during the drilling of monitoring wells.

However, as stated in Table 7.32, embedded mitigation (e.g. an EMP) will reduce the likelihood of accidental pollution occurring. The of development and adherence to an EMP (including a MPCP) will include planning for accidental spills, address all potential contaminant releases, and include key emergency details. Measures will also be adopted to ensure that the potential for release of pollutants is reduced so far as reasonably practicable. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and tanks containing hazardous substances, and storage of these substances in impenetrable bunds. Finally, all vessels will be required to comply with the MARPOL regulations.

Therefore, for all subtidal habitats and species IEFs, this impact is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Intertidal Habitats and Species

The MDS for this impact involves the use of cable installation ploughs to within the intertidal zone (Table 7.21). Due to the lack of other vessel and equipment usage within the intertidal zone in comparison to the subtidal zone, the risk of accidental pollution is lower for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF. Furthermore, the embedded mitigation described above for ‘Subtidal Habitats and Species’ is also relevant to the intertidal zone.

Therefore, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, this impact is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures and limited vessel and equipment usage within the intertidal zone, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), accidental pollution may arise in the Dee Estuary/Aber Dyfrdwy SAC due to the use of cable installation ploughs within the intertidal zone. Although the Fylde MCZ overlaps with the Proposed Development offshore, there is unlikely to be any disturbance to the Fylde MCZ as it is a minimum of 1.82 km from the area of project physical work (see Figure 7.4). Furthermore, the embedded mitigation described above for ‘Subtidal Habitats and Species’ is also relevant to the intertidal zone.

Overall, the impact on the designated site IEFs is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Sensitivity of Receptor

Subtidal Habitats and Species

The sensitivity of the subtidal habitats and species IEFs is as presented for ’Impacts Resulting from the Release of Sediment Bound Contaminants’ (section 7.12.7; Table 7.39). Overall, there is a lack of information available on the sensitivities of the subtidal habitats and species IEFs to the contaminants that may be released as a result of this impact, with the majority of available sources now somewhat dated. This has resulted in no complete MarESA available for the relevant pressures for this impact for any IEFs. Therefore, based on the absence of information, and the potential intolerance of many benthic species to contamination (bivalves and echinoderms in particular), the sensitivity of these receptors will be assessed on a precautionary basis. Overall, all subtidal habitat and species IEFs, are deemed to be of high vulnerability, low recoverability, and local to national value. Therefore, the sensitivity of these receptors to this impact is, precautionarily, considered to be high.

Intertidal Habitats and Species

The representative biotopes for the 'Mudflats and sandflats not covered by seawater at low tide' IEF were not assessed for 'Impacts Resulting from the Release of Sediment Bound Contaminants' (section 7.12.7; Table 7.38) as that impact was not required for the intertidal zone. For Accidental Pollution to the Surrounding Area, however, these biotopes could be impacted. For the four representative biotopes identified for the 'Mudflats and sandflats not covered by seawater at low tide' IEF, a MarESA was only available for *M. balthica* and *A. marina* in littoral muddy sand (LS.LSa.MuSa.MacAre)' and 'Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa)' (Table 7.38).

The characteristic species *M. balthica* and *A. marina* have been demonstrated to be sensitive to various pollutants. Evidence suggests that *A. marina* can experience severe mortality due to exposure to Cd, Cu, and Zn. For example, 100% mortality has been demonstrated after exposure to Cu, Zn and Cd (Bat and Raffaelli, 1998), and Rasmussen and Andersen (2000) reported that Cd contamination increased the susceptibility of *A. marina* to hypo-osmotic stress. Cd and Cu were reported to result in severe mortality of *Macoma* spp., while Ag, As, Cr, Hg, Ni, and Zn were reported to result in significant mortality of *Macoma* spp. (Barlow and Kingston, 2001). Barite (in the form of drilling mud barite) was shown to cause 100% mortality of *M. balthica* within 12 days at a depth but the cause may have been due to physical damage of their gill filaments rather than chemical toxicity (Barlow and Kingston, 2001). Beaumont *et al.* (1989) reported that *A. marina* only occurred in the low-level TBT and the control treatments but not in high-level TBT treatments.

These species are also susceptible to oil and other hydrocarbon and PAH pollution. Hailey (1995) reported substantial mortality of *Macoma* spp., and *Arenicola* spp., after the Sivand oil spill in the Humber estuary in 1983. Levell (1976) examined the effects of crude oil and oil-dispersant mixtures on *A. marina*. Single spills caused 25 to 50% reduction in abundance and an additional reduction in feeding activity. Up to four repeated spillages (over a 10-month period) resulted in complete eradication of the affected population either due to death or migration out of the sediment. The author noted that recolonization was inhibited but not prevented (Levell, 1976). Prouse and Gordon (1976) examined the effects of surface fuel oil contamination and fuel oil sediment mixtures on the *A. marina* in the laboratory. They demonstrated that individuals were drawn out of the sediment by a waterborne concentration of >1 mg/l or sediment concentration of >100 µg/g. Individuals forced out of sediment may be able to migrate out of the affected area but will be exposed to severe predation risk, especially in daylight. Morales-Caselles *et al.* (2008) noted that sediment contaminated with fuel oil from a sunken tanker caused significant mortality in *A. marina*, with 8% fuel oil/dry weight sediment resulting in 100% mortality after 21 days. Stekoll *et al.* (1980) demonstrated that that chronic exposure of *M. balthica* to oil-in-seawater concentrations even as low as 0.03 mg/l would lead to population decreases over time. The individuals in this study were not subjected to any of the stresses that normally occur in their natural environment on mudflats such as changes in salinity, temperature, oxygen availability and wave action, therefore, it is possible that exposure of *M. balthica* to oil under field conditions results in higher mortality.

As the biotope 'Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa)' occurs in sheltered, low energy areas, it can act as a sink for complex mixtures of pollutants. These pollutants can remain in the sediment for some time, and therefore recoverability will be low. Within this biotope, oil and other hydrocarbon pollution smothers the sediment, preventing oxygen exchanged and resulting in anoxic conditions. This leads to death of infaunal species associated with the biotope (Tyler-Walters and Marshall, 2006). Furthermore, some pollutants (such as PCBs and Hg) may also accumulate within the food chain associated with this biotope.

Overall, there is a lack of information available on the sensitivities of the representative biotopes to the contaminants mentioned, with the majority of available sources is now somewhat dated. This has resulted in no MarESA available for the relevant pressures for this impact for two out of the four biotopes. Therefore, based on the absence of information, and the potential intolerance of many benthic species to contamination (bivalves in particular), the sensitivity of these receptors will be assessed on a precautionary basis. Overall, the Mudflats and sandflats not covered by seawater at low tide IEF is deemed to be of high vulnerability, low recoverability, and international value. Therefore, the sensitivity of the receptor to this impact is, precautionarily, considered to be high.

Designated Sites

As detailed in Table 7.10, the sensitivities presented for the Mudflats and sandflats not covered by seawater at low tide IEF in the preceding section is applicable to the Dee Estuary/Aber Dyfrdwy SAC IEF. Thus, the Dee Estuary/Aber Dyfrdwy SAC IEF deemed to be of high vulnerability, low recoverability, and international value. Therefore, the sensitivity of the receptor to this impact is, precautionarily, considered to be high.

As detailed in Table 7.10, the area of the Fylde MCZ which overlaps with the Proposed Development has been assigned the biotope 'Sublittoral sands and muddy sands (SS.SSa)' (Envision Mapping, 2015), however has not been assigned more specific biotopes. As this area overlaps with the 'Subtidal sands and gravels' IEF identified during the site-specific survey within the Proposed Development, the representative biotopes identified for this IEF have also been used to characterise the Fylde MCZ IEF in the assessment. Therefore, the Fylde MCZ IEF is deemed to be of high vulnerability, low recoverability, and national value. Therefore, the sensitivity of these receptors to this impact is, precautionarily, considered to be high.

Table 7.39: Sensitivity Of The Benthic Subtidal And Intertidal Ecology IEFs To Accidental Pollution

IEF	Representative Biotopes Identified	Sensitivity to Defined MarESA Pressure			Overall Sensitivity (Based on Table 7.29)
		Transition Elements and Organo-metal Contamination	Hydrocarbon and PAH Contamination	Synthetic Compound Contamination	
Subtidal Habitats and Species					
Subtidal Sands and Gravels	*M. fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (SS.SCS.CCS.MedLumVen)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
	N. cirrosa and *Bathyporeia* spp. In infralittoral sand (SS.SSa.IFiSa.NcirBat)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
Mud Habitats in Deep Water	*A. filiformis, K. bidentata* and *A. nitida* in circalittoral sandy mud (SS.SMu.CSaMu.AfilKurAnit)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
Subtidal Mixed Muddy Sediment	*O. fragilis* and/or *O. nigra* brittlestar beds on sublittoral mixed sediment (SS.SMx.CMx.OphMx)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
Ross Worm *S. spinulosa*	-	Not assessed due to insufficient evidence	Not assessed due to insufficient evidence	Not Sensitive	Could not be defined by the MarESA, refer to text for sensitivity assessment
Intertidal Habitats and Species					
Mudflats and sandflats not covered by seawater at low tide	Talitrids on the upper shore and strand-line (LS.Lsa.St.Tal)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
	M. balthica and *A. marina* in littoral muddy sand (LS.LSa.MuSa.MacAre)	Medium	Medium	Medium	Medium
	Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa)	Not assessed	Not assessed	Not assessed	Could not be defined by the MarESA, refer to text for sensitivity assessment
	Polychaete/bivalve-dominated muddy sand shores (LS.LSa.MuSa)	High	High	High	High

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

Intertidal Habitats and Species

Overall, for the Mudflats and sandflats not covered by seawater at low tide IEF, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

Designated Sites

Overall, for the Designated Sites IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

7.12.8.2 Operations and Maintenance Phase

There is a risk of pollution to water and sediment through accidental release of chemicals and pollutants from vessels, equipment, and machinery used during operation and maintenance activities.

Magnitude of Impact

The MDS for this impact assumes a total of 750 return trips by vessels over the 25-year duration of the operation and maintenance phase (Table 7.21). These include geophysical survey, maintenance, and support vessels (see Table 7.21 for all details). The risk of accidental pollution during this phase will be lower than that of the construction phase, due to the lack of drilling in the operation and maintenance phase. Thereby, the risk of accidental pollution through the release of drill cuttings, drilling mud, and cement products, will not apply in the operation and maintenance phase.

As stated in Table 7.32, embedded mitigation (e.g. an EMP) will reduce the likelihood of accidental pollution occurring. The development of and adherence to an EMP (including a MPCP) will include planning for accidental spills, address all potential contaminant releases, and include key emergency details. Measures will also be adopted to ensure that the potential for release of pollutants is reduced so far as reasonably practicable. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and tanks containing hazardous substances, and storage of these substances in impenetrable bunds. Finally, all vessels will be required to comply with the MARPOL regulations.

Therefore, for all subtidal habitats and species IEFs, this impact is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Intertidal Habitats and Species

The MDS for this impact involves the use of any machinery required for cable maintenance within the intertidal zone (Table 7.21). Due to the lack of other vessel and equipment usage within the intertidal zone in comparison to the subtidal zone, the risk of accidental pollution is lower for the Mudflats and sandflats not covered by seawater at low tide IEF. Furthermore, the embedded mitigation described above for ‘Subtidal Habitats and Species’ is also relevant to the intertidal zone.

Therefore, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, this impact is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures and limited vessel and equipment usage within the intertidal zone, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), accidental pollution may arise in the Dee Estuary/Aber Dyfrdwy SAC due to the use of machinery for cable maintenance within the intertidal zone. Although the Fylde MCZ overlaps with the Proposed Development offshore, there is unlikely to be any disturbance to the Fylde MCZ as it is a minimum of 1.82 km from the area of project physical work (see Figure 7.4).

Overall, the impact on the designated site IEFs is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Sensitivity of Receptor

All IEFs

The sensitivities of all the IEFs are considered to be as previously described for the construction phase (Table 7.39) and are considered to be high.

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

Intertidal Habitats and Species

Overall, for the Mudflats and sandflats not covered by seawater at low tide IEF, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

Designated Sites

Overall, for the Designated Sites IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

7.12.8.3 Decommissioning Phase

There is a risk of pollution to water and sediment through accidental release of chemicals and pollutants from vessels, equipment, and machinery used during decommissioning activities.

Magnitude of Impact

The MDS for this impact involves the use of vessels, machinery, and equipment that will be used to remove infrastructure within the decommissioning phase (Table 7.21). This includes a total of 128 vessel round trips during the decommissioning phase. This is likely to be of a similar or lesser extent to that of the construction phase. The risk of accidental pollution during this phase will be lower than that of the construction phase, due to the lack of drilling in the decommissioning phase. Thereby, the risk of accidental pollution through the release of drill cuttings, drilling mud, and cement, will not apply in the decommissioning phase.

As stated in Table 7.32, embedded mitigation (e.g. an EMP) will reduce the likelihood of accidental pollution occurring. The of development and adherence to an EMP (including a MPCP) will include planning for accidental spills, address all potential contaminant releases, and include key emergency details. Measures will also be adopted to ensure that the potential for release of pollutants is reduced so far as reasonably practicable. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and tanks containing hazardous substances, and storage of these substances in impenetrable bunds. Finally, all vessels will be required to comply with the MARPOL regulations.

Therefore, for all subtidal habitats and species IEFs, this impact is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Intertidal Habitats and Species

The MDS for this impact involves the use of any machinery required for cable removal within the intertidal zone (Table 7.21). Due to the lack of other vessel and equipment usage within the intertidal zone in comparison to the subtidal zone, the risk of accidental pollution is lower for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF. Furthermore, the embedded mitigation described above for ‘Subtidal Habitats and Species’ is also relevant to the intertidal zone.

Therefore, for the Mudflats and sandflats not covered by seawater at low tide IEF, this impact is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures and limited vessel and equipment usage within the intertidal zone, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Designated Sites

As above for the intertidal IEF (Mudflats and sandflats not covered by seawater at low tide), accidental pollution may arise in the Dee Estuary/Aber Dyfrdwy SAC due to the use of machinery for cable removal within the intertidal zone. Although the Fylde MCZ overlaps with the Proposed Development offshore, there is unlikely to be any disturbance to the Fylde MCZ as it is a minimum of 1.82 km from the area of project physical work (see Figure 7.4).

Overall, the impact on the designated site IEFs is predicted to be of local spatial extent, short-term duration, intermittent, and of high reversibility. It is predicted that this impact will affect the receptor directly. Due to the embedded mitigation measures, this impact will result in very minor loss or detrimental alteration to one or more characteristics, features, or elements. Therefore, as per Table 7.27, the magnitude of impact is concluded to be negligible.

Sensitivity of Receptor

All IEFs

The sensitivities of all the IEFs are considered to be as previously described for the construction phase (Table 7.39) and are considered to be high.

Significance of Effect

Subtidal Habitats and Species

Overall, for the subtidal habitats and species IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

Intertidal Habitats and Species

Overall, for the Mudflats and sandflats not covered by seawater at low tide IEF, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

Designated Sites

Overall, for the Designated Sites IEFs, the magnitude of impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the significance of effect of accidental pollution is **minor adverse,** which is **not significant** in EIA terms. In addition, the effects of this impact will be minimised by the EMP (including a MPCP), which is an embedded mitigation measure (Table 7.32). Under this mitigation, accidental pollution from ships will be minimised.

Fish and Shellfish Ecology

7.12.9 Temporary Subtidal Habitat Loss and/or Disturbance

7.12.9.1 Construction Phase

There is potential for direct habitat and species loss in the Proposed Development due to site preparation activities and the installation of development infrastructure (such as subsea cable pipeline installation and jack-up vessel deployments).

Magnitude of Impact

All species

The installation of the new Douglas platform within the Proposed Development will lead to temporary habitat loss and/or disturbance. The MDS accounts for up to 1.91 km^2 of temporary habitat loss and/or disturbance during the construction phase (Table 7.22). This equates to approximately 0.32% of the area within the Proposed Development overall, although only a small proportion of this will be impacted at any one time. The magnitude of impact is as described above for benthic subtidal and intertidal ecology and is not repeated here (see section 7.12.1).

The impact on all fish and shellfish IEFs is predicted to be of local spatial extent (0.32% of the Proposed Development), short term duration (up to two years), intermittent (due to the construction schedule), and of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is therefore considered to be low.

Sensitivity of Receptor

Indirect effects of this impact on fish and shellfish also include loss of foraging habitat and reduced prey availability. For example, fish and shellfish species, such as forage fish, small benthic fish species, and smaller crustaceans, are considered important prey for larger fish and shellfish species, in addition to benthic invertebrates (which are discussed in section 7.12.1). However, since this impact is predicted to only affect a small proportion of seabed habitats in the regional fish and shellfish ecology study area at any one time, with similar habitats (and prey species) occurring throughout the whole regional fish and shellfish ecology study area, these indirect effects are likely to be limited and reversible. On the contrary, sediment disturbance associated with this impact will also dislodge infaunal prey species from the sediment (discussed in section 7.12.1), potentially offering foraging opportunities to some mobile opportunistic scavenging fish and shellfish species immediately after disturbance. The implications of changes in fish and shellfish prey species in the short-term are also discussed for marine mammals and birds in section 7.12.19 and volume 2, chapter 8. respectively.

Substrate type is the primary driver for recoverability and rate of recovery of an area after large scale seabed disturbance (Newell *et al.,* 1998; Desprez, 2000). Gravelly and sandy habitats, which are found throughout the regional fish and shellfish ecology study area, have been demonstrated to return to baseline species abundance approximately five to ten years after seabed disturbance due to aggregate extraction (Foden *et al.,* 2009). This is dependent on replenishment rates which are related to tidal stress, currents, and availability and transference of conspecifics from less impacted to more impacted environments (Foden *et al.,* 2009). Within the regional fish and shellfish ecology study area, in the eastern Irish Sea, the year one post-construction monitoring of the Walney Wind Farm Extension reported a degraded benthic and demersal fish and shellfish community in comparison to pre-construction levels within the Array Area, but no significant difference within transmission assets (CMACS, 2012). In the three-year post-construction survey, there was a smaller difference in community degradation compared to pre-construction levels, suggesting a that the area was recovering to baseline conditions, with relatively little overall impact (CMACS, 2014).

Shellfish

In general, shellfish are more vulnerable receptors than fish, due to their lower mobility. Of these, slow-recruiting shellfish species are likely to be the most highly impacted by temporary disturbance (Macdonald *et al.,* 1996). For example, a capture-mark-recapture study in Norway demonstrated that 84% of berried (e.g. egg bearing) European lobster remained within 500 m of their release site (Agnalt *et al.,* 2006).

A range of shellfish species are known to be present within the regional fish and shellfish ecology study area, including species of commercial importance (such as brown crab, European lobster, king and queen scallop, Norway lobster, and velvet swimming crab). Temporary habitat loss in the construction phase will represent a maximum of 1.91 km^2 in the Proposed Development. As stated above, this is likely due to cable laying operations and seabed preparation activities. While the total temporary habitat loss and/or disturbance footprint represents a relatively large proportion of the area within the Proposed Development (0.32%), only a small proportion of this area would be affected at any one time. Further, sediments have been demonstrated to recover relatively rapidly (RPS, 2019). In addition, associated benthic communities (see section 7.12.1), including shellfish populations, are expected to recover and species to move back into the affected areas.

King and queen scallop have been evaluated as IEFs of local importance within the regional fish and shellfish ecology study area (Table 7.13). They are predominantly sessile animals, however, can swim limited distances, typically as an escape response, by ejecting water around the hinge of their shells (Marshall and Wilson, 2008; Schalkhausser *et al.,* 2014). King scallop have been documented to swim up to 30 m, with a tagging study in western Scotland demonstrating that the majority of adults were within 30 m of their release point after 18 months (Howell and Fraser, 1984). As a result, king and queen scallop may have improved resilience to this impact, as they could potentially flee areas of disturbance. Scallop tend to occur in aggregations as their larval distribution is reliant on relatively unpredictable hydrographic features (Brand, 1991; Delargy *et al.,* 2019). For example, Le Pennec *et al.* (2003) report that king scallop larvae could travel up to 40 km in 18 days, while Sinclair *et al.* (1985) proposed that larvae can also undertake vertical migrations and retain self-sustaining populations. Nonetheless, king and queen scallop are expected to continue spawning outside the Proposed Development within unimpacted areas of the regional fish and shellfish ecology study area. As suitable settlement habitat will remain following cessation of construction, it is expected that scallop will continue to be recruited within the Proposed Development and within the wider regional fish and shellfish ecology study area, either through vertical or horizontal larval transport. Scallop are therefore likely to recover well from disturbance due to temporary habitat loss. This is supported by the MarESA (Marshall and Wilson, 2008) which concluded king scallop have a high recovery potential for substratum loss. At the time of writing, there is no MarESA available for queen scallop.

Norway lobster, European lobster, and other larger crustaceans are classed as equilibrium species, meaning that they can only recolonise an area once the original substrate has recovered to baseline conditions (Newell *et al.,* 1998). The sensitivity of these IEFs is therefore higher, as recovery of equilibrium species may take up to ten years in some areas of coarse sediments (Phua *et al.,* 2002). For example, Norway lobster is concluded to have a moderate recoverability and sensitivity to substratum loss according to the MarESA, however this assessment is not available for European lobster (Sabatini and Hill, 2008). However, it should be noted that the lowered predation rates in the absence of larger crustacean and flatfish species due to habitat disturbance can increase overall benthic abundance (Skold *et al*., 2018). This suggests resilience among smaller fish and shellfish species which could contribute to a minor short-term change in ecosystem function, which is likely to recover to the baseline in the long-term. Furthermore, construction activities, such as cable installation, within the regional fish and shellfish ecology study area may also impact Norway lobster spawning and nursery grounds, which are in proximity to the Proposed Development, in the eastern Irish Sea (Coull *et al.,* 1998). However, as there is no spatial overlap with the Proposed Development, impacts are likely to be limited. Larval settlement will also increase the rate of recovery of disturbed areas within the Proposed Development (Phua *et al.,* 2002) due to the proximity to spawning and nursery habitats.

In addition, a recent study of European lobster in a north-east England fishing ground found that the size and abundance of individuals increased following temporary closure of the area for construction of the Westermost Rough Offshore windfarm (Roach *et al.,* 2018). These findings indicate that the activities associated the construction, such are foundation and cable installation, did not adversely impact on resident European lobster populations, and actually allowed some population recovery due to suspended fishing activity (Roach *et al*., 2018).

Spiny lobster inhabits rocky substrates with crevices and holes to hide in. Juveniles often remain in algal or seagrass nursery areas until they are large enough to move into rocky crevices (Devon and Severn Inshore Fisheries and Conservation Authority, 2019). Populations in UK and Ireland collapsed due to overfishing in the 1970's, with evidence of recovery in the 21st century (Hiscock *et al.,* 2011; Gibson-Hall *et al.,* 2020). This recovery appears to be very slow, as it has been over 40 years for a significant recruitment to be reported (Hiscock *et al.,* 2011). According to the MarESA, this species has medium resistance, low resilience, and medium sensitivity to abrasion and disturbance of the substratum or seabed surface. However, impacts such as penetration or disturbance of the substratum subsurface and removal of substratum are not relevant for this species, likely due to their preference for hard, rocky substrates (Gibson-Hall *et al.,* 2020). These habitats are not likely to be affected by this impact.

Overall, spiny lobster are deemed to be of medium vulnerability, low to medium recoverability, and of national importance. The sensitivity of the receptor is therefore considered to be medium. European lobster and Norway lobster are deemed to be of high vulnerability, medium to high recoverability and of local importance. The sensitivity of the receptor is therefore considered to be medium.

King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be low.

All other shellfish IEFs are deemed to be of medium vulnerability, medium recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be medium.

Marine Fish

Fish and shellfish IEFs that spawn near or on the seabed are likely to be the most sensitive to temporary habitat loss and/or disturbance, due to reduced spawning habitat. These include herring, sandeel, and elasmobranchs, such as spotted ray and thornback ray. Conversely, pelagic spawning species and highly mobile elasmobranchs, such as basking shark, are unlikely to be sensitive to this impact. Spotted ray and thornback ray were evaluated as IEFs of regional importance and have low intensity spawning grounds in proximity to the Proposed Development (Ellis *et al.,* 2012) (Table 7.13). However, as these spawning grounds are only of low intensity, and that these species also have significant areas spawning grounds within the wider regional fish and shellfish ecology study area, these species are likely to be resilient to temporary habitat loss and/or disturbance within the Proposed Development.

Anglerfish and flatfish, such as lemon sole, sole, plaice, and others, were evaluated as IEFs of local to regional importance (Table 7.13) due to presence of nursery and spawning grounds within proximity to the Proposed Development. These species live in the demersal zone and could therefore potentially be affected by temporary habitat loss and/or disturbance to their habitat. However, neither beneficial nor adverse effects of construction and operation of the Block Island Wind Farm in the US were observed for a range of north American flatfish species (Wilber *et al.,* 2018), suggesting a degree of resilience to this impact in flatfish. It is unlikely that temporary habitat loss and/or disturbance would heavily impact these species, given that their spawning and nursery grounds extend throughout much of the regional fish and shellfish ecology study area.

Herring were evaluated as IEFs of national importance (Table 7.13) and have low and high intensity nursery and spawning grounds in the vicinity of the Proposed Development. Although a pelagic species, herring require suitable seabed habitat for spawning. They deposit thick matts of demersal eggs in areas of suitable sediment composition (Aneer *et al.,* 1983). Suitable spawning grounds are therefore vital for the resilience of herring stocks, although these habitats are often adversely impacted by environmental impacts, such as storms, and anthropogenic pressures (Thurstan and Roberts, 2010; Moll *et al.,* 2018). Herring stocks around the UK and Ireland have historically followed “boom and bust” cycles, with the mechanisms involving recolonisation of spawning grounds and subsequent population recovery not fully understood (Schmidt *et al.,* 2009; Dickey-Collas *et al.,* 2010; Trochta *et al.,* 2020). They are very particular in where they chose to spawn, however their plasticity in spawning ground utilisation can buffer against temporary changes to their environment, and increase population resilience (Schmidt *et al.,* 2009; Frost and Diele, 2022). Furthermore, the results of the PSA conducted on the sediment samples collected during the site-specific survey (Table 7.6) demonstrated that the Proposed Development is largely unsuitable spawning habitat for herring, with only one sampling site (1.3% of the total number of samples) classified as ‘suitable’ habitat under the Reach *et al.* (2013) methodology. There were four samples (5.3% of the total) classified as ‘sub-prime’ spawning habitat. In addition, there were no spawning grounds overlapping with the Proposed Development, with the closest identified around the Isle of Man, and with nationally significant spawning grounds located out with the regional fish and shellfish ecology study area entirely (Coull *et al.,* 1998). Overall, it is unlikely that herring populations will be largely affected by temporary habitat loss and/or disturbance in the construction phase.

Sandeel were evaluated as IEFs of regional importance, (Table 7.13) and have low and high intensity spawning habitats within the regional fish and shellfish ecology study area and overlapping with the Proposed Development. Therefore, any significant seabed disturbance activities carried out during spawning periods may result in mortality of eggs and reduced opportunity due to removal of suitable habitat. In addition, temporary habitat loss and/or disturbance may also lead to adult and juvenile sandeel mortality, as sandeel species spend significant amounts of time buried in the sediment. Adult sandeel spend the winter buried in the sediment, only emerging briefly to spawn. Mortality could therefore occur if individuals are unable to colonise viable sandy sediment habitats nearby, or in habitat patches that are at carrying capacity (Wright *et al*., 2000). Sandeel IEFs are therefore highly sensitive to this impact due to direct physical disturbance (Wright *et al*., 2000). Sandeel may also be particularly vulnerable during the winter, as they spend more time buried in the seabed and are less mobile.

The results of the PSA conducted on the sediment samples collected during the site-specific survey (Table 7.6) highlighted varying degrees of sandeel spawning habitat suitability throughout the Proposed Development with 43.4% of samples classified as ‘unsuitable’, 22.4% as ‘sub-prime’, 19.7% as ‘suitable’, and 14.4% as ‘prime’. There was a patchy distribution in the ‘prime’ and ‘sub-prime’ samples throughout the Proposed Development, however they were mainly present along the pipeline connection towards the Point of Ayr. Overall, the Proposed Development was largely unsuitable and sub-prime, but temporary habitat loss and/or disturbance could still impact some sandeel spawning habitats the area. However, the proportion of these habitats affected is predicted to be relatively small, given the abundance of similar substrate types and the extensive nature of fish spawning grounds across the regional fish and shellfish ecology study area.

The rate of sediment recovery to suitable conditions for sandeel recolonisation will determine the recovery rate of sandeel populations. The effect of offshore windfarm construction and post-construction (i.e. operation and maintenance) activities on sandeel populations have been investigated through short- and long-term monitoring at the Horns Rev offshore wind farm in Denmark (Jensen *et al.,* 2004; van Deurs *et al.,* 2012). Due to the nature and scale of the Horns Rev offshore wind farm, these construction and post-construction activities involve similar, if not higher levels of temporary habitat loss and/or disturbance than expected for the Proposed Development. These monitoring studies demonstrated that the construction and post-construction activities did not result in significant adverse effects on sandeel populations and that sandeel recovered quickly following (Jensen *et al.,* 2004; van Deurs *et al.,* 2012). Sandeel recovery can also be inferred from the results of a fisheries study by Jensen *et al.* (2010), which found that sandeel populations mixed within fishing grounds by up to 28 km. This degree of mixing suggests that adult populations are likely to recover following construction activities, which would have similar effects on the sediments as fishing activities. Recovery of sandeel populations may also occur through larval dispersal into suitable sandy sediments during spring, following the winter and spring spawning period. Similarly, the results of post construction surveys at the Beatrice OWF and the Horns Rev 1 Offshore Wind Farm demonstrated that construction posed neither a benefit nor a threat to sandeel populations (Stenberg *et al.,* 2011; Beatrice Offshore Wind Farm Limited (OWL), 2021a). Construction activities resulting in temporary habitat loss and/or disturbance will not occur simultaneously within the Proposed Development, and once completed, sediments and communities are expected to recover. Based on the information presented in the preceding paragraphs, it is highly likely that sandeel will recolonise disturbed areas, and recovery will occur continuously throughout the construction phase.

Sandeel constitute important prey species for other fish and shellfish IEFs, such as cod, sea trout, and whiting. The effects of temporary habitat loss and/or disturbance on sandeel are predicted to be limited (particularly in the context of available habitats in the wider regional fish and shellfish ecology study area), temporary and reversible, with recovery of sandeel populations occurring during and post-construction. Therefore, larger fish and shellfish IEFs that prey on sandeel are also unlikely to be significantly affected. Changes in prey availability for higher trophic level receptors (i.e. marine mammals and birds) are also discussed in section 7.12.19 and volume 2, chapter 8.

Overall, most fish and shellfish ecology IEFs in the regional fish and shellfish ecology study area (such as pelagic spawners, elasmobranchs, and flatfish) are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be low.

Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be medium.

Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally generate a medium to high sensitivity. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments within the Proposed Development and the core herring spawning ground being located well outside and to the north-east of the regional fish and shellfish ecology study area.

Diadromous Fish

By nature, diadromous fish species are highly mobile and thus generally able to avoid areas subject to temporary habitat loss. In addition, they are less reliant on seabed habitats than other fish and shellfish IEFs discussed, such as sandeel. Diadromous species are only likely to interact within the regional fish and shellfish ecology study area while migrating to and from rivers and freshwater habitats. Thus, temporary habitat loss and/or disturbance of seabed is unlikely to be of particular relevance for diadromous fish species as it will not affect migration.

Diadromous species may be indirectly affected due to impacted prey species. However as outlined in the preceding paragraphs, the majority of marine fish species would be able to avoid temporary habitat loss effects due to their greater mobility and would recover into the areas affected following cessation of construction. Sandeel (and other less mobile prey species) would be affected by temporary habitat loss, although recovery is expected to occur quickly as the sediments recover following activities such as cable installation (RPS, 2019) and adults recolonise, and larvae are recruited into the recovered habitats (RPS, 2019).

Overall, diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. However, the relatively low amount of construction required and short construction period for the Proposed Developments in comparison to other projects (such as offshore wind farm construction) likely highly reduces the probability of either spatial or temporal overlap with many migrating diadromous species. As such, the sensitivity of the receptor is therefore considered to be negligible. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the sensitivity of the freshwater pearl mussel IEF is also considered to be negligible.

Significance of Effect

Shellfish

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For European lobster, Norway lobster, and spiny lobster, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.12.9.2 Operation and Maintenance Phase

Temporary habitat loss and/or disturbance may occur during operation and maintenance activities, such as cable and infrastructure repair and associated vessel anchoring.

Magnitude of Impact

All species

The MDS accounts for up to 72,000m^2 of temporary habitat loss and/or disturbance within this phase (Table 7.22). This equates to a small proportion (0.01%) of the total Proposed Development. It should also be noted that only a small proportion of the total temporary habitat loss and/or disturbance is likely to occur at any one time, with the MDS for this impact spread over the 25-year lifetime. Therefore, individual maintenance activities will be small scale and intermittent events. The magnitude of impact is as described above for benthic subtidal and intertidal ecology and is not repeated here (see section 7.12.1).

The spatial extent of this impact is small in relation to the whole regional fish and shellfish ecology study area, although there is the potential for repeat disturbance to the habitats in the immediate vicinity the infrastructure because of these activities. However, effects on seabed habitats and associated fish and shellfish communities are expected to be similar to the construction phase, but of a much lower magnitude.

Overall, this impact is predicted to be of local spatial extent (0.01% of the Proposed Development), short term duration, intermittent throughout the lifecycle of the Proposed Development, and high reversibility. It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore, considered to be low.

Sensitivity of Receptor

All species

The sensitivities of all fish and shellfish IEFs (shellfish, marine fish, and demersal species) presented in the assessment of this impact in the construction phase equally apply in the operation and maintenance phase (negligible to medium).

Significance of Effect

Shellfish

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For European lobster, Norway lobster, and spiny lobster, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.12.9.3 Decommissioning Phase

Decommissioning activities within the Proposed Development will result in temporary habitat loss and/or disturbance in this phase.

Magnitude of Impact

All species

The MDS for the decommissioning phase assumes that all infrastructure will be removed (except some rock placement which may remain *in situ*) (Table 7.22). The extent of temporary habitat loss and/or disturbance during this phase will be significantly lower than that of the construction phase, as seabed preparation activities will not be required.

The spatial extent of this impact is small in relation to the whole regional fish and shellfish ecology study area and effects on seabed habitats and associated fish and shellfish communities are expected to be similar to the construction phase, but of a much lower magnitude.

Overall, this impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore, considered to be low.

Sensitivity of Receptor

All species

The sensitivities of all fish and shellfish IEFs (shellfish, marine fish, and demersal species) presented in the assessment of this impact in the construction phase equally apply in the decommissioning phase (negligible to medium).

Significance of Effect

Shellfish

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For European lobster, Norway lobster, and spiny lobster, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.12.10 Long-term Subtidal Habitat Loss

7.12.10.1 Construction and Operation and Maintenance Phases

Potentially, long-term subtidal habitat loss could occur as a result of cable crossing protection of the newly installed subsea power cables. Additionally, rock placement associated with the construction will also result in long-term subtidal habitat loss. The installation of the new Douglas platform within the Proposed Development will also lead to long-term subtidal habitat loss around its foundations. In this impact assessment, long-term subtidal habitat loss does not represent complete removal of habitat, but rather a physical change in a sedimentary habitat and replacement with a hard, artificial substrate. In the MarESA, this is defined as the physical change to another seabed type. The effects of long-term subtidal habitat loss are assessed in this section, however the potential for colonisation of hard substrates by benthic species have been assessed in section 7.12.4. The construction and operation and maintenance phases are assessed in combination as the impacts of long-term subtidal habitat loss from the construction phase will persist into the operation and maintenance phase and will be continuous over the 25-year lifetime of the Proposed Development.

Magnitude of Impact

The construction of infrastructure associated with the Proposed Development will result in long-term subtidal habitat loss. The MDS accounts for up to 64,169 m^2 of long-term subtidal habitat loss due to installation of foundations and cable crossing protection in the construction phase (Table 7.22), which equates to 0.01% of the total Proposed Development overall. This will include the installation of 58,800 m^2 of cable crossing protection (Table 7.22). The foundations of the new Douglas platform may account for up to 169 m^2 of long-term subtidal habitat loss.

Offshore cable crossing protection will be required at up to 32 crossings, with each crossing up to 0.8 m in height and 7 m wide. The design of the cable crossing protection will have tapered profiles to reduce the impacts upon physical processes and seabed morphology. Cable crossing protection is the only cable protection measure proposed for the project, as the nature of the seabed sediment within the Proposed Development accommodates cable burial to the required depth. Therefore, no protection is required for buried cables, which are not anticipated to become exposed and require additional protection throughout the operation and maintenance phase. For example, cable crossings include one between the PoA to new Douglas platform cable and the Burbo Bank Offshore Wind Farm Extension Export Cable. Where practicable, the requirements will be compliant with the MCA navigation guidance which includes that there will be no more than a 5% reduction in water depth (referenced to CD) at any point along the cable route (MCA, 2021), without prior written approval from the Licensing Authority in consultation with the MCA. In compliance with the MCA navigation guidance, the maximum height of the shallowest cable crossing would be restricted to 5% of the water depth and therefore exhibit no change in wave climate, however, given the majority of cable crossings fall in waters deeper than 25 m (CD) they will change water depths to a much lesser degree than the 5% limit. With most of the cable crossing protection installed in waters of approximately 25 m (CD), which equates to 28 m mid tide, the introduction of 0.8 m height cable crossing protection represents less than a 3% change in water depth and therefore likely < 3% change to tidal currents. This change is approximately a quarter of the size as exhibited in the natural variation between peak spring and peak neap tidal flows. Given the small scale of cable crossing protection to be installed, and further measures such as tapered profiles and compliance with the MCA navigation guidance, it is not expected that impacts from cable crossings would be sufficient to disrupt offshore bank morphological processes, experience significant secondary scour or destabilise coastal features.

Long-term subtidal habitat loss will occur during the construction phase and be continuous and irreversible throughout the 25-year operations and maintenance phase. Some long-term subtidal habitat loss will persist indefinitely after the operations and maintenance phase, such as that caused by rock placement which will be left *in situ* following the lifetime of the Proposed Development.

Overall, the MDS for this impact presents some measurable, minor loss of and alteration to the affected areas of the seabed within the Proposed Development. As per the terms set out for defining the magnitude of impact (Table 7.27), the impact of long-term subtidal habitat loss is predicted to be of local spatial extent, long-term duration, continuous, and irreversible during the construction and operation and maintenance phases. It is predicted that the impact will affect fish and shellfish receptors directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of Receptor

Marine Fish

Species that rely on the presence of suitable sediment and subtidal habitats for their survival are typically more vulnerable to change, depending on the availability of said habitats within the wider geographical region. The loss of subtidal seabed habitats caused by installation of infrastructure in the Proposed Development will reduce the area of suitable habitat and available food resources for the fish and shellfish communities associated with them. However, this area represents a low percentage of the extensive subtidal habitats present within the regional fish and shellfish ecology study area.

As detailed in the baseline characterisation, the fish and shellfish ecology study area coincides with spawning and nursery habitats for a range of fish and shellfish species, with many overlapping with the Proposed Development in Liverpool Bay. Species with spawning and/or nursery grounds overlapping or in close proximity to the Proposed Development include anglerfish, cod, haddock, herring, horse mackerel, lemon sole, ling, mackerel, Norway lobster, plaice, sandeel, sole, sprat, spotted ray, spurdog, thornback ray, tope, and whiting

(Coull *et al.,* 1998; Ellis *et al.,* 2012; Aires *et al.,* 2014; Campanella and van der Kooij, 2021). Reference should be made to section 7.8.2.7 and volume 3, appendix I for full details and illustrative figures.

Sandeel and herring are the most vulnerable to long-term subtidal habitat loss due to their specific spawning requirements. As stated in section 7.12.9 (for 'Temporary Habitat Loss and/or Disturbance'), these species are demersal spawners (i.e. they lay their eggs on the seabed) and require specific sediment composition in order to spawn successfully. Some elasmobranchs, such as spotted ray and thornback ray, are also demersal spawners, as they lay egg cases in shallow nearshore nurseries. Low intensity nursery grounds for these species were identified as overlapping with the Proposed Development and being present throughout the Liverpool Bay area (Ellis *et al.,* 2012). However, given that these habitats are low intensity, extensive throughout the regional fish and shellfish ecology study area, and that they are predominantly coastal, these species are unlikely to be significantly impacted by long-term subtidal habitat loss. Furthermore, elasmobranchs, such as tope shark and spurdog, are unlikely to be affected by long-term subtidal habitat loss in terms of spawning and nursery habitats as these species give birth to live young and do not lay eggs.

There are known high and low intensity herring spawning grounds within the regional fish and shellfish ecology study area (see section 7.12.9 ('Temporary Habitat Loss and/or Disturbance')). However, the results of the PSA conducted on the sediment samples collected during the site-specific survey (Table 7.6) demonstrated that the Proposed Development is largely unsuitable spawning habitat for herring, with only one sampling site (1.3% of the total number of samples) classified as 'suitable' habitat under the Reach *et al.* (2013) methodology. There were four samples (5.3% of the total) classified as 'sub-prime' spawning habitat. In addition, there were no spawning grounds overlapping with the Proposed Development, with the closest identified around the Isle of Man, and with nationally significant spawning grounds located out with the regional fish and shellfish ecology study area entirely (Coull *et al.,* 1998). Overall, it is unlikely that herring populations will be largely affected by long-term subtidal habitat loss.

Sandeel also have specific habitat requirements during their life cycle. For example, they spend a significant portion of their adult life buried in the sediment and require specific sediment types for spawning. Long-term subtidal habitat loss within the Proposed Development could therefore impact sandeel species. As detailed in section 7.12.9 ('Temporary Habitat Loss and/or Disturbance'), the results of the PSA indicate patchy distribution of 'prime' and 'suitable' spawning habitat throughout the Proposed Development under the Latto *et al.* (2013) methodology. High and low intensity spawning and nursery grounds were identified as overlapping with the Proposed Development, within Liverpool Bay and throughout the regional fish and shellfish ecology study area (Ellis *et al.,* 2012; Campanella and van der Kooij, 2021). Given the extent of sandeel spawning habitat and of suitable sandy substrates for burial throughout the regional fish and shellfish ecology study area, it is unlikely that long-term subtidal habitat loss within the Proposed Development will affect sandeel at a population level. Furthermore, monitoring as the Horns Rev I offshore wind farm in Danish waters has indicated that the presence of operational wind farm infrastructure has not caused significant adverse long-term effects on sandeel populations (Stenberg *et al.,* 2011; van Deurs *et al.,* 2012). Similarly, the initial results of post-construction monitoring at the Beatrice Offshore Wind Farm in the North Sea have demonstrated no adverse effects on sandeel populations (BOWL, 2021a). This additional evidence from the offshore wind sector helps bolster the assessment of this impact, as the infrastructure associated with the Proposed Development will be similar, or even less detrimental, in terms of long-term subtidal habitat loss than that at offshore wind farms.

Overall, sandeel are deemed to be of high vulnerability, high recoverability, and of regional importance. The sensitivity of sandeel is therefore considered to be medium.

Herring are deemed to be of high vulnerability, medium recoverability, and of national importance, which would normally give a medium to high sensitivity. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments overlapping with the Proposed Development and the core herring spawning grounds being located well outside and to the north-east.

Overall, most marine fish IEFs in the regional fish and shellfish ecology study area (with the exception of herring and sandeel) are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be low.

Shellfish

The Proposed Development and regional fish and shellfish ecology study area overlaps spawning and fishing grounds of king and queen scallop. Long-term subtidal habitat loss has the potential to impact these grounds, however a decrease in fishing pressure has been suggested to increase maturity of king scallop populations, with no significant changes in resilience (Raoux *et al.,* 2019). Long-term subtidal habitat loss directly around the infrastructure only represents a very small proportion of habitat within the regional fish and shellfish ecology study area, and so are unlikely to cause significant impacts on wider scallop populations. This is supported by the MarESA (Marshall and Wilson, 2008) which concluded king scallop have a high recovery potential for substratum loss. At the time of writing, there is no MarESA available for queen scallop.

As described in section 7.12.9, Norway lobster, European lobster, and other larger crustaceans are classed as equilibrium species. The sensitivity of these IEFs is therefore higher than non-equilibrium species, as long-term subtidal habitat loss will prevent the original substrate recovering to baseline conditions. Norway lobster spawning and nursery grounds of undetermined intensity are present within the wider Liverpool Bay and the regional fish and shellfish ecology study area, but do not overlap with the Proposed Development (Coull *et al.,* 1998). Long-term subtidal habitat loss within the Proposed Development is therefore unlikely to affect these habitats. Furthermore, Norway lobster is concluded to have a high intolerance, moderate recoverability and overall moderate sensitivity to substratum loss according to the MarESA (Sabatini and Hill, 2008).

As detailed in section 7.12.9 ('Temporary Habitat Loss and/or Disturbance'), adult spiny lobster inhabit rocky substrates with crevices and holes in which they hide, and nearshore vegetated waters as juveniles. Although the availability of these habitats are widespread throughout the regional fish and shellfish ecology study area, the spiny lobster shows high site fidelity, limited movement, and minimal homing range of 7 m^2 (Follesa *et al.,* 2009; Groenenveld *et al.,* 2013). Furthermore, spiny lobster has no resistance, very low resilience, and high sensitivity to physical change to another seabed type, according to the MarESA (Gibson-Hall *et al.,* 2020). However, aspects of the construction phase, such as rock placement which will be left *in situ* throughout and after the lifetime of the Proposed Development, may actually provide suitable habitat for spiny lobster if it occurs within its homing range.

The spawning and nursery habitats of various other shellfish IEFs identified in this assessment, such as brown crab and velvet swimming crab, are not available in the datasets utilised in this assessment (Coull *et al.,* 1998; Ellis *et al.,* 2012; Aires *et al.,* 2014; Campanella and van der Kooij, 2021). Given the wide range of available habitat throughout the regional fish and shellfish ecology study area, it is not likely that this impact will significantly impact these species.

Spiny lobster are deemed to be of high vulnerability, low recoverability, and of regional importance. The sensitivity of spiny lobster is therefore considered to be high.

Norway lobster and European lobster are deemed to be of high vulnerability, medium to high recoverability and of local importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be medium.

King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be low.

All other shellfish IEFs are deemed to be of medium vulnerability, high recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be low.

Diadromous Fish

As diadromous species are highly mobile and not reliant on demersal subtidal habitats for spawning or breeding, they are generally less susceptible to the impact of long-term subtidal habitat loss. Diadromous species are only likely to interact within the regional fish and shellfish ecology study area while migrating to and from rivers and freshwater habitats. Thus long-term subtidal habitat loss is unlikely to be of particular relevance for diadromous fish species as it will not affect migration.

Diadromous species may be indirectly affected due to impacted prey species, such as sandeel. However as outlined in the preceding paragraphs, the majority of marine fish species would be able to avoid long-term subtidal habitat loss effects due to their greater mobility and widespread nursery and spawning grounds and suitable habitats throughout the regional fish and shellfish ecology study area. For prey species with limited mobility, such as sandeel, long-term subtidal habitat loss is not likely to cause population level effects due to the presence of spawning habitats throughout the regional fish and shellfish ecology study areas.

Overall, diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. However, the relatively low footprint of long-term subtidal habitat loss within the Proposed Development in comparison to other projects (such as offshore wind farm construction) is likely to highly reduces the probability of either spatial or temporal overlap with many migrating diadromous species. As such, the sensitivity of the receptor is therefore considered to be negligible. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the sensitivity of the freshwater pearl mussel IEF is also considered to be negligible.

Significance of Effect

Marine Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of most marine fish IEFs in the regional fish and shellfish ecology study area (with the exception of herring and sandeel) is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the regional fish and shellfish ecology study area that may be impacted by long-term subtidal habitat loss.

For Norway lobster and European lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the effect will be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.12.10.2 Decommissioning Phase

Magnitude of Impact

All infrastructure is proposed to be removed in the decommissioning phase, including that left in place for reservoir modelling. However, there may be some rock placement left *in situ* during the decommissioning phase (Table 7.22). The impact is predicted to be of local spatial extent, long-term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is therefore, considered to be low.

Sensitivity of Receptor

All species

The sensitivities of all fish and shellfish IEFs (shellfish, marine species, and demersal species) presented in the assessment of this impact in the construction phase equally apply in the operation and maintenance and decommissioning phases (negligible to high).

Significance of Effect

Marine Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of most marine fish IEFs in the regional fish and shellfish ecology study area (with the exception of herring and sandeel) is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a minor or moderate significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the regional fish and shellfish ecology study area that may be impacted by long-term subtidal habitat loss.

For Norway lobster and European lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the effect will be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.12.11 Underwater Noise Impacting Fish and Shellfish Receptors

7.12.11.1 Construction Phase

There is potential for disturbance and/or displacement to sensitive fish and shellfish species as a direct result of underwater noise resulting from construction activities, such as piling, UXO clearance, and vessel noise.

Magnitude of Impact

Injury and Behavioural Disturbance

The installation of the new Douglas Platform within the Proposed Development may lead to injury and/or disturbance to fish and shellfish species due to underwater noise during pile driving. The MDS considers the greatest effect from underwater noise on fish and shellfish IEFs, considering the greatest hammer energy for pin piling installation (Table 7.22). A maximum hammer energy of up to 3,000 kJ for pin piles was modelled.

The pin piling activities are represented by the installation of up to 4 pin-piled jacket foundations with two piles per leg (up to 8 piles total), with each pile installed via impact piling. Pin pile installation will take place over a period of up to 100 minutes per pile, with piling of up to two adjacent piles on the same platform at one time (Table 7.22). Therefore, there will be up to 800 minutes of piling over the entire piling phase, which equates to just under 13.5 hours. Piling was modelled for pin pile installation within the Proposed Development, see volume 3, appendix J.

UXO clearance (including detonation) also has the capability to cause injury and/or disturbance to fish and shellfish IEFs. Clearance will be completed prior to the construction phase (pre-construction). The precise details and locations of potential UXOs is unknown at this time. For the purposes of this assessment, it has been assumed that the MDS will be clearance of UXO with a NEQ of 1,000 kg, cleared by either low order or high order techniques. Low order techniques are not always possible and are dependent upon the individual situations surrounding each UXO. UXOs may also be left *in situ* and micro-sited around. Detonation of UXO would represent a short term (i.e. seconds) increase in underwater noise (i.e. Sound Pressure Levels (SPL) and particle motion (the vibration of the water molecules which results in the pressure wave)) which will be elevated to levels which may result in injury or behavioural effects on fish and shellfish species. To understand the magnitude of underwater noise emissions from piling and UXO clearance during the construction phase, modelling has been undertaken considering the key parameters summarised above. Full details of the modelling undertaken are presented in volume 3, appendix J. Underwater noise modelling included the use of ‘soft start’ mitigation to reduce the potential for injury effects (as set out in section 7.11). The implications of the modelling for fish and shellfish injury and behaviour are outlined in the following sensitivity section.

All other noise sources including cable installation and drilling are non-percussive and will result in much lower noise levels and therefore much smaller injury ranges (in most cases no injury is predicted) than those predicted for piling operations. For further information on other noise sources see volume 3, appendix J. The pre-construction geophysical surveys, using any of the available techniques outlined in section 7.9.1, are likely to be very short term and spatially limited at any one time, reducing the magnitude of their likely impact on fish and shellfish receptors. They will also operate largely outside of the hearing frequencies of most fish and shellfish IEFs, thereby significantly reducing the potential for behavioural impacts to low or negligible levels. Only the injury ranges due to VSP have been modelled, with mortality and recoverable injury ranges very low (a maximum of 54 m from the source; see Table 7.46).

Overall, this impact is predicted to be of regional spatial extent, short-term duration (e.g. a maximum of eight piles with up to 100 minutes of piling each), intermittent throughout the two-year construction phase, and high reversibility (due to TTS and recoverable injury). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of Receptor

Injury

All Species

The following sections apply to the fish and shellfish IEFs defined within this assessment, with a summary for each of these receptor groups provided below.

Underwater noise can potentially have an adverse impact on fish species, such as behavioural effects, and physical injury and/or mortality. Auditory injury can occur either as a Temporary Threshold Shift (TTS), where an animal's auditory system can recover, or Permanent Threshold Shift (PTS), where there is no hearing recovery in the animal. Recent peer reviewed guidelines have been published by the Acoustical Society of America (ASA) and provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. The Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.,* 2014) are considered the most relevant and best available guidelines for impacts of underwater noise on fish species (see volume 3, appendix J). The Popper *et al.* (2014) guidelines broadly group fish into the following categories according to the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing:

- **Group 1:** Fishes lacking swim bladders (e.g. elasmobranchs, sandeel, flatfish, lampreys). These species are only sensitive to particle motion, not sound pressure and show sensitivity to only a narrow band of frequencies.
- **Group 2:** Fishes with a swim bladder but the swim bladder does not play a role in hearing (e.g. salmonids and some Scombridae). These species are considered more sensitive to particle motion than sound pressure and show sensitivity to only a narrow band of frequencies.
- **Group 3:** Fishes with swim bladders that are close, but not connected, to the ear (e.g. gadoids and eels). These fishes are sensitive to both particle motion and sound pressure and show a more extended frequency range than Groups 1 and 2, extending to about 500 Hz.
- **Group 4:** Fishes that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring, sprat and shad). These fishes are sensitive primarily to sound pressure, although they also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in Groups 1, 2 and 3.

Little is known about the effects of anthropogenic underwater noise upon crustacean species, as relatively few studies have been conducted on them (Morley *et al*., 2013; Williams *et al.,* 2015; Hawkins and Popper, 2016). Therefore, there are no injury criteria that have been developed for shellfish, however, these are expected to be less sensitive than fish species and therefore injury ranges of fish could be considered conservative estimates for shellfish IEFs (risk of behavioural effects are discussed further below for shellfish).

An assessment of the potential for injury/mortality and behavioural effects to be experienced by fish and shellfish IEFs with reference to the sensitivity criteria described above is presented below.

Table 7.40 summarises the fish injury criteria recommended for pile driving based on the Popper *et al*. (2014) guidelines, noting that dual criteria are adopted in these guidelines to account for the uncertainties associated with effects of underwater noise on fish. The recoverable injury threshold for eggs and larvae is categorised in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. in the tens of metres), "intermediate" (i.e. in the hundreds of metres) or "far" (i.e. in the thousands of metres), as shown in Table 7.40. It is important to note that these criteria are qualitative rather than quantitative. Consequently, a source of noise of a particular type (e.g. piling) would result in the same predicted impact, no matter the level of noise produced or the propagation characteristics.

Table 7.40: Criteria for Onset of Injury to Fish due to Impulsive Piling (Source: Popper *et al*., 2014)

Group	Type of Animal	Parameter	Mortality and Potential for Mortal Injury Threshold	Recoverable Injury Threshold
1	Fish: no swim bladder (particle motion detect)	Sound Exposure Level (SEL), dB re 1 μPa^2s	>219	>216
		Peak, dB re 1 μPa	>213	>213
2	Fish: where swim bladder is not involved in hearing (particle motion detection)	SEL, dB re 1 μPa^2s	210	203
		Peak, dB re 1 μPa	>207	>207
3 and 4	Fish: where swim bladder is involved in hearing (primarily pressure detection)	SEL, dB re 1 μPa^2s	207	203
		Peak, dB re 1 μPa	>207	>207
Eggs and larvae	Eggs and larvae	SEL, dB re 1 μPa^2s	>210	(Near) Moderate (Intermediate) Low (Far) Low
		Peak, dB re 1 μPa	>207	

The full results of the underwater noise modelling are presented in volume 3, appendix J. To inform this assessment, Table 7.41 displays the predicted injury ranges associated with impact piling, for Peak Sound Pressure Levels (SPL_{pk}). For SPL_{pk} when piling energy is at its maximum (i.e. 3,000 kJ), mortality and recoverable injury to fish may occur within a minimum of 184 m of the piling activity (smaller ranges for Group 1 fish species, higher ranges for Group 4 species; Table 7.41). The potential for mortality or mortal injury to fish eggs would also occur at distances of up to 314 m (Table 7.41), with a low to moderate risk of recoverable injury to eggs and larvae within the range of hundreds of metres (see Table 7.40 for qualitative criteria). It should be noted that these ranges are for the maximum hammer energy, and it is unlikely that injury will occur in this range due to the embedded mitigation of soft starts during piling operations (Table 7.32), which will allow some fish species to move away from the areas of highest noise levels, before they reach a level that would cause an injury. It is noted that some fish will likely benefit from the implementation of soft starts whereas others may not; fish and shellfish are a very broad group of organisms and the reality of the reaction to sound likely falls somewhere between those remaining static and those moving away. Soft starts will be implemented as standard to mitigate the impacts of underwater noise to marine mammals; therefore, it is considered appropriate to model piling operations with soft starts to ensure a realistic scenario, whether or not the different fish hearing groups experience a benefit. Stationary or passive eggs will likely be protected through scheduling of operational timing to avoid peak egg densities where possible, based on the baseline knowledge available, however the impact ranges modelled for eggs and larvae indicate that mortality ranges are relatively small when put into a population context and as such the necessity for operational scheduling is considered unlikely. The initial injury ranges for soft start initiation will be smaller than the maximum hammer energy ranges presented (i.e. with a minimum of 77 m, depending on the fish species considered; see Table 7.41).

As described, recoverable injury is used in this case to refer to tissue or physical damage or physiological effects that are recoverable but may reduce individual fitness levels. Table 7.41 also includes the predicted ranges of effect for recoverable injury for all fish groups which may occur as a result of peak and initial hammer strike during piling. Recoverable injury was modelled to occur to a maximum range of 314 m from maximum hammer energy for all hearing groups except Group 1 fish. For Group 1 fish, it was modelled to occur at a range of 184 m during maximum hammer energy.

Table 7.41: Summary Of Peak Pressure Injury Ranges For Fish Due To The Phase Of Impact Piling Resulting In The SPL_{pk}, And Due To The First Hammer Strike

Hearing Group	Response	Threshold (SPL_{pk} dB re 1 µPa)	Range (m)	
			Max Peak Experience	First Hammer strike
Group 1 Fish: no swim bladder (particle motion detected)	Mortality	213	184	77
	Recoverable injury	213	184	77
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	Mortality	207	314	131
	Recoverable injury	207	314	131
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	Mortality	207	314	131
	Recoverable injury	207	314	131
Eggs and larvae	Mortality	207	314	131

The results of the noise modelling for fish hearing groups are shown in Table 7.42, based on the Cumulative Sound Exposure Level (SEL_{cum}) thresholds for fleeing and static fish. Two results are shown for fleeing Group 1 fish, one based on a swim speed of 0.5 m/s, and another (in square brackets) showing the range for basking shark using a higher swim speed of 1 m/s. The swimming speed for Groups 2 to 4 fish was also modelled at 0.5 m/s. Fish eggs and larvae have been assumed to be static, resulting in a different impact range to reach the same numerical SEL_{cum} criteria. Under these conditions, the threshold for mortality was 4 m for Group 3 and 4 fish and 387 m for eggs and larvae, and not exceeded for the other hearing groups. For fish modelled as static receptors, the threshold for mortality increased to 125 m for Group 1 fish, 387 m for Group 2, and 561 m for Groups 3 and 4 (Table 7.42).

As described, TTS is a temporary reduction in hearing sensitivity caused by exposure to intense sound. Normal hearing ability returns following cessation of the noise causing TTS, though the recovery period is variable, during which fish may have decreased fitness due to a reduced ability to communicate, detect predators or prey, and/or assess their environment. Table 7.42 also includes the predicted ranges of effect for TTS for all fish groups against the SEL_{cum} thresholds as both moving and static receptors. The TTS range for all fish hearing groups was modelled to occur at a maximum of 5,500 m for moving fish, and 3,820 m for moving basking shark. For all fish groups modelled as static receptors, the TTS range was 7,400 m (Table 7.42).

Table 7.42: Injury Ranges For Single Impact Pile Driving Based On The Cumulative SEL Metric for Fleeing and Static Fish (N/E = Threshold Not Exceeded)

Hearing Group	Response	Threshold (SEL_{cum} dB re 1 µPa²s)	Range: Fleeing Fish (m)	Range: Static Fish (m)
Group 1 Fish: no swim bladder (particle motion detected) – [basking shark ranges shown in square brackets]	Mortality	219	N/E [N/E]	125
	Recoverable injury	216	N/E [N/E]	183
	TTS	186	5,500 [3,820]	7,400
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	Mortality	210	N/E	387
	Recoverable injury	203	9	925
	TTS	186	5,500	7,400
	Mortality	207	4	561

Hearing Group	Response	Threshold (SEL_{cum} dB re 1 µPa^{2}s)	Range: Fleeing Fish (m)	Range: Static Fish (m)
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	Recoverable injury	203	9	925
	TTS	186	5,500	7,400
Eggs and larvae	Mortality	210	387	

As per the MDS, there is a possibility that multiple pin piles will need to be installed in a single 24-hour period. The potential SEL_{cum} injury ranges for fish hearing groups due to impact piling of pin piles are modelled as following the same piling schedule, but with continuous installation for 24 hours, which is an overestimation as the piling vessel will need to reposition. It is assumed that the fish will swim away from the pile installation and not return to the area within the 24-hour period. As the piling schedule, and therefore the hammer energies, remain unchanged, the injury ranges due to the peak metric will be the same as those for the single pile case. The results for consecutive piling scenarios based on the SEL_{cum} threshold are shown in Table 7.43 for both moving and static fish. Under these conditions for moving fish, the threshold for mortality was 4 m for Group 3 and 4 fish and 625 m for eggs and larvae, and not exceeded for the other hearing groups. For fish modelled as static receptors, the mortality ranges increased to 204 m for Group 1 fish, 625 m for Group 2, and 910 m for Group 3 and 4 (Table 7.43).

Although it is highly unlikely that fish will remain static in the water column, consecutive pin pile installation based on the SEL_{cum} threshold for static fish represents the worst case scenario based on the piling parameters provided in the MDS. Figure 7.5 to Figure 7.7 present the noise contours for the four fish hearing groups modelled as static receptors. For Group 1 and 2 fish, the mortality, recoverable injury, and TTS ranges are small in the context of both the Proposed Development and the wider Irish Sea as a whole (Figure 7.5). Figure 7.6 and Figure 7.7 show the noise contours for Group 3 and 4 fish overlaid on the spawning and nursery grounds for herring and cod, respectively. As illustrated in Figure 7.6, there is no potential for overlap between any of the noise contours and the herring spawning grounds, which are situated around the Isle of Man. For cod, the mortality noise contour could overlap with up to 0.01% of the total area of defined high intensity spawning grounds (Ellis *et al.,* 2012) (Figure 7.7). The contours for recoverable injury and TTS could overlap with up to 0.04% and 3.52%, respectively, of the total high intensity cod spawning area. Therefore, even in the unlikely case that fish will remain static in the water column during consecutive pin piling, the ranges for mortality, recoverable injury, and TTS remain low for all hearing groups, and there will be no to minimal overlap with defined spawning grounds for cod and herring.

When consecutive piling is considered and modelled based upon the SEL_{cum} metric, the TTS ranges for fish modelled as fleeing receptors have a maximum range of 8,360 m (5,740 m for basking shark). These ranges are slightly higher than the impacts of the single piling (Table 7.42), however they are unlikely to significantly increase the level of impact given their reversible nature after cessation of the noise source. For fish modelled as static receptors, the TTS range was 11,640 m for all hearing groups (Table 7.43).

Table 7.43: Injury Ranges For Consecutive Pin Pile Installation Based On The Cumulative SEL Metric For Fleeing and Static Fish (N/E = Threshold Not Exceeded)

Hearing Group	Response	Threshold (SEL dB re 1 µPa^{2}s)	Range: Fleeing Fish (m)	Range: Static Fish (m)
Group 1 Fish: no swim bladder (particle motion detected) – [basking shark ranges shown in square brackets]	Mortality	219	N/E [N/E]	204
	Recoverable injury	216	N/E [N/E]	294
	TTS	186	8,360 [5,740]	11,640
	Mortality	210	N/E	625

Hearing Group	Response	Threshold (SEL dB re 1 μPa²s)	Range: Fleeing Fish (m)	Range: Static Fish (m)
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	Recoverable injury	203	10	1,490
	TTS	186	8,360	11,640
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	Mortality	207	4	910
	Recoverable injury	203	10	1,490
	TTS	186	8,360	11,640
Eggs and larvae (static)	Mortality	210	625	

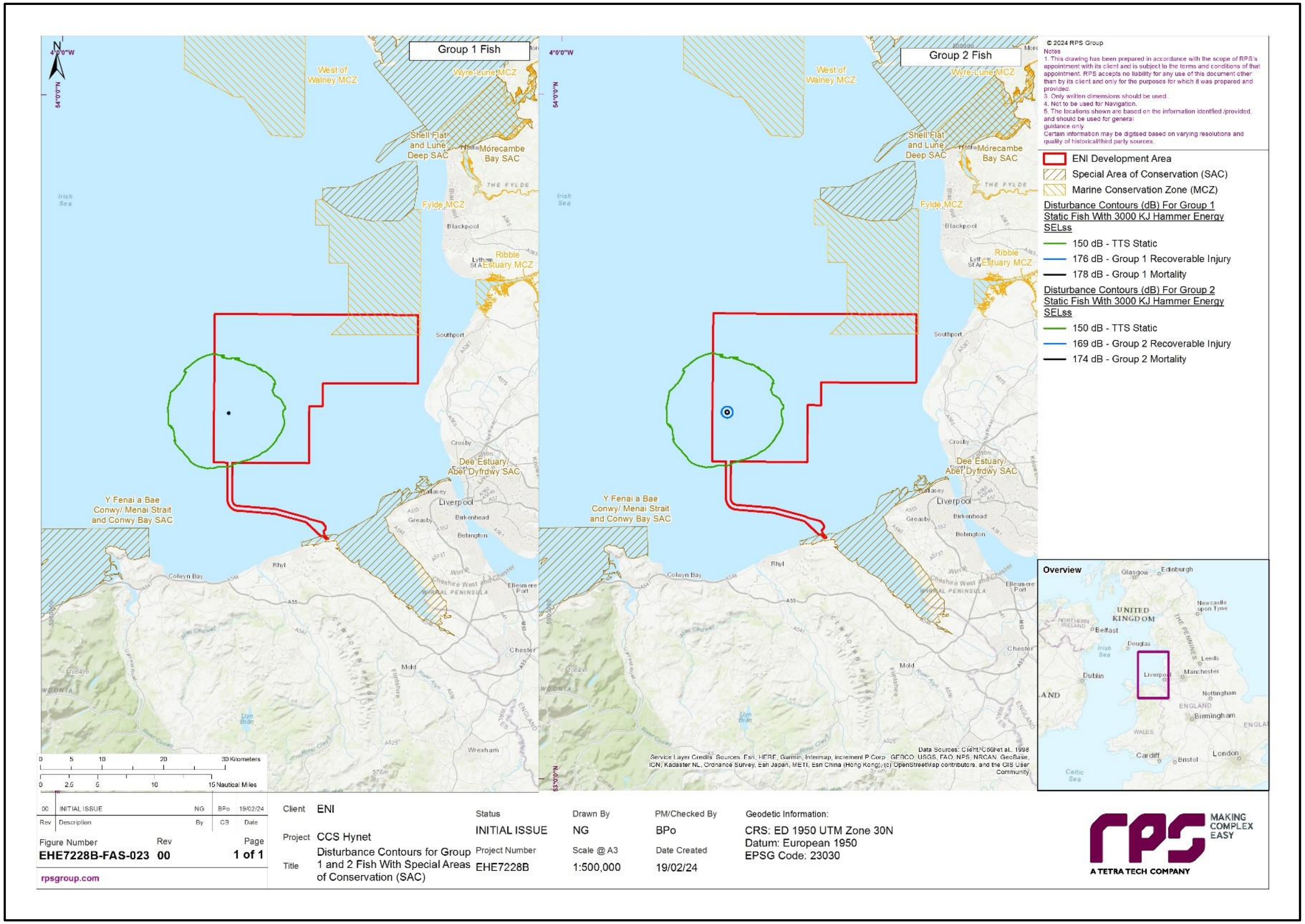


Figure 7.5: TTS, Recoverable Injury, and Mortality Noise Contours (dB) for Group 1 and 2 Fish Exposed to Consecutive Pin Pile Installation when Modelled as Static Receptors

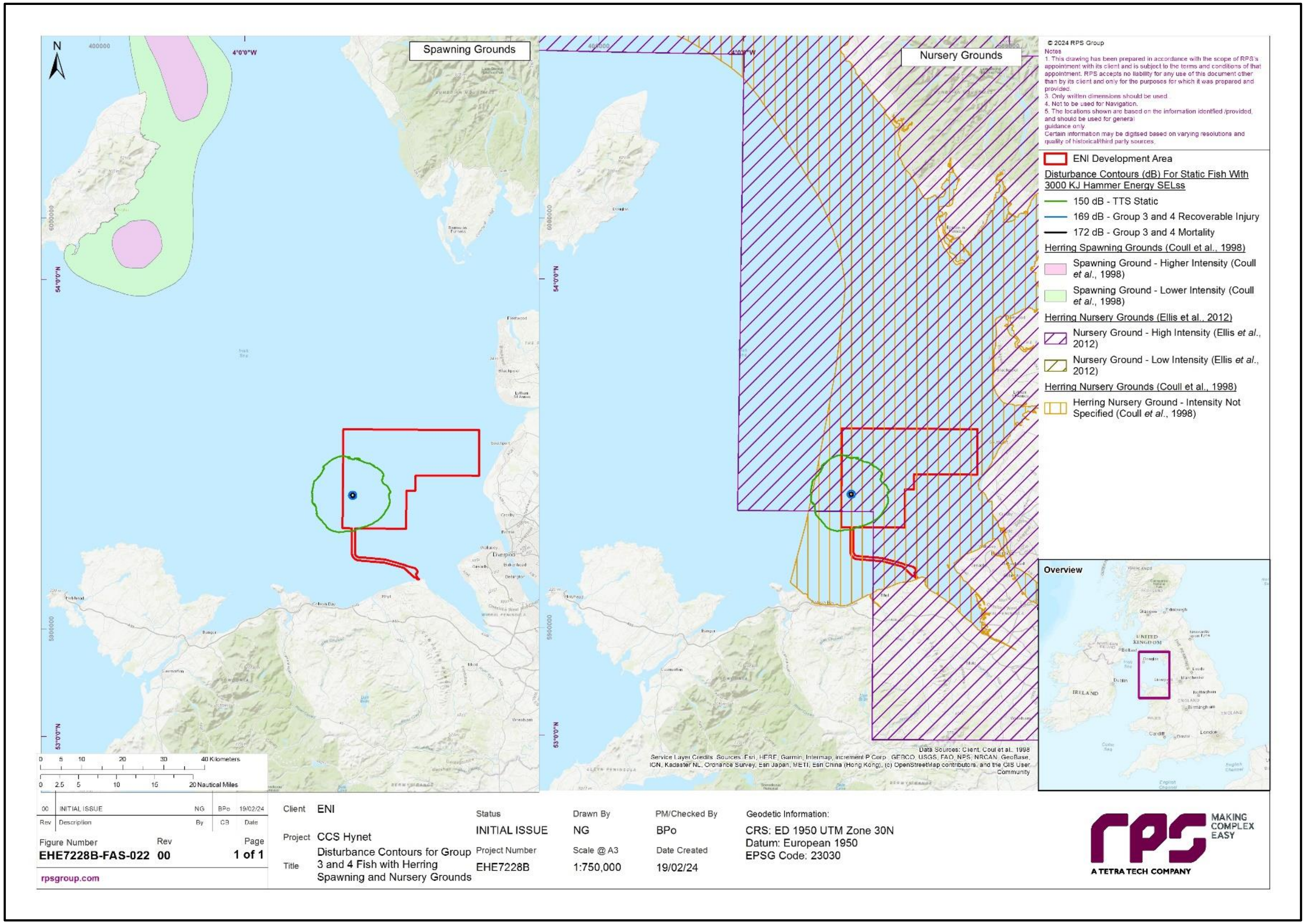


Figure 7.6: TTS, Recoverable Injury, and Mortality Noise Contours (dB) for Herring Exposed to Consecutive Pin Pile Installation when Modelled as Static Receptors

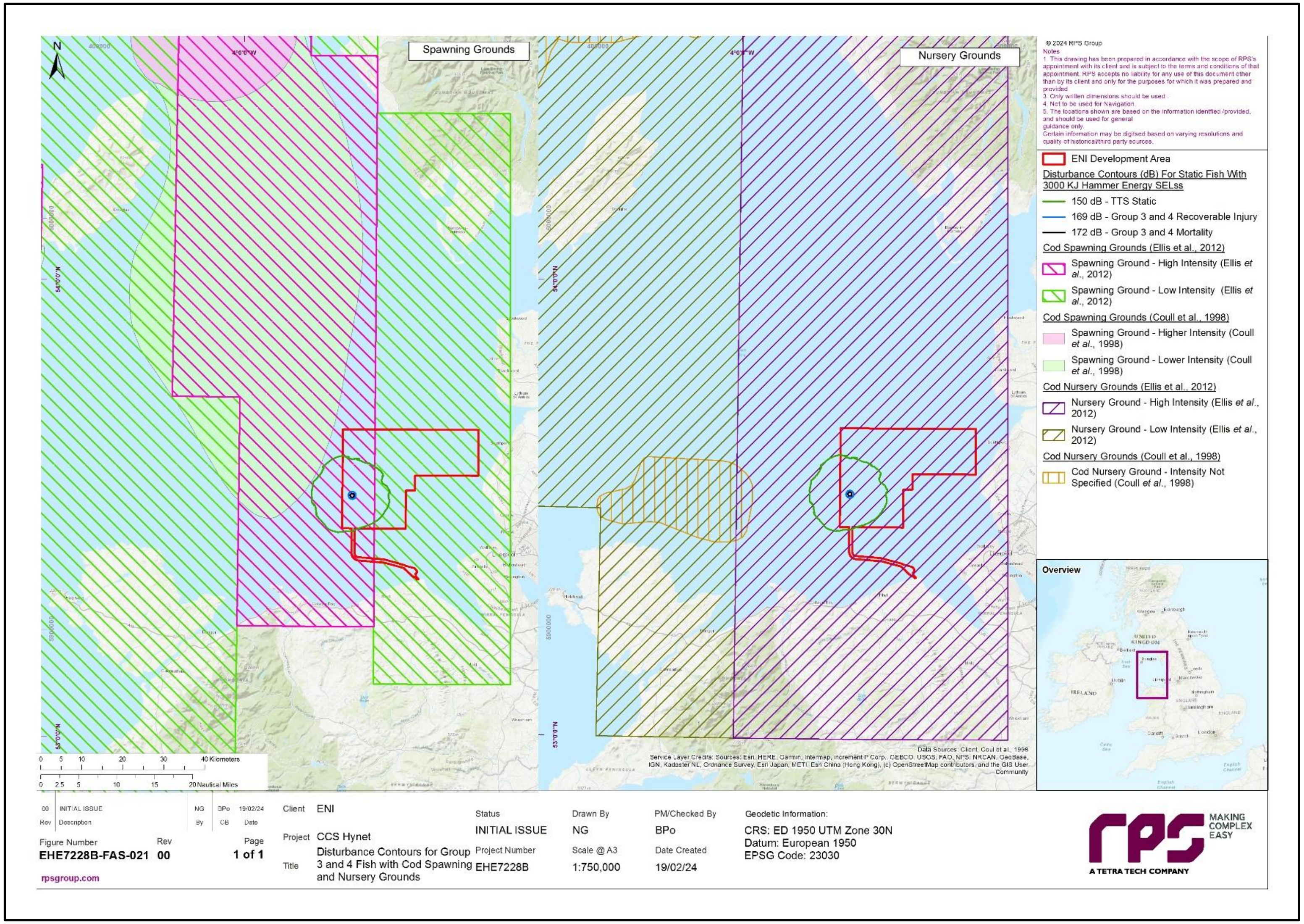


Figure 7.7: TTS, Recoverable Injury, and Mortality Noise Contours (dB) for Cod Exposed to Consecutive Pin Pile Installation when Modelled as Static Receptors

Underwater noise modelling has also been completed for UXO clearance and detonation. Modelling was undertaken for a range of orders of detonation, from a realistic worse case high order detonation to low order detonations (e.g. deflagration and clearance shots) to be used as mitigation to minimise noise levels. Table 7.44 details the injury ranges for fish of all groups in relation to various orders of detonation. For the purposes of this assessment, it has been assumed that the MDS will be clearance of UXO with a NEQ of 1,000 kg cleared by either low order or high order techniques. The maximum PTS ranges for UXO disposal were 985 m and 590 m for the high order detonation of a 907 kg UXO.

Table 7.44: Injury Ranges For All Fish Groups Relating To Various Orders Of UXO Detonation

Detonation Size (kg)	PTS Range SPL_{pk} (m)	
	Fish Lower Range*	Fish Higher Range*
0.08 kg low-order donor charge	44	27
0.5 kg clearing shot	81	49
2 x 0.75 kg low-yield charge	117	70
4 x 0.75 kg low-yield charge	147	88
1.2 kg donor charge for high-order disposal	108	65
3.5 km donor blast-fragmentation charge for high-order disposal	154	93
25 kg high order explosion	297	178
130 kg high order explosion	514	309
907 kg high order explosion	985	590

* The lower range and upper range refer to those provided within volume 3, appendix J of the ES, based upon the Popper et al. (2014) guidance for explosions, where thresholds are quoted as ranges. Values presented herein reflect those associated with the extremes of the ranges presented within volume 3, appendix J.

Recoverable injury and TTS ranges were also modelled for Group 3 and 4 fish for various other underwater noise sources, such as cable trenching, cable laying, use of jack-up rigs, and vessels (Table 7.45). The threshold for recoverable injury and TTS was not exceeded for jack-up rigs, and low ranges were reported for the other activities. For example, the maximum range reported was a TTS range of 68 m for cable laying activities. Group 3 and 4 fish are the most sensitive to underwater noise, and as the modelled injury ranges were low, impacts to Group 1 and 2 fish are likely to be minimal. It should be noted that fish would need to be exposed within these impact ranges for a period of 48 hours continuously in the case of recoverable injury and 12 hours continuously in the case of TTS for the effect to occur. It is therefore considered that these ranges are highly precautionary, and injury is unlikely to occur in reality.

Table 7.45: Estimated Recoverable Injury And TTS Ranges For Group 3 And 4 Fish Due To Other Noise Sources (N/E = Threshold Not Exceeded)

Underwater Noise Source	Range (m)	
	Recoverable Injury 170 dB rms for 48 hrs	TTS 158 dB rms for 12 hrs
Cable trenching/cutting	<10	45
Cable laying	15	68
Jack-up rig	N/E	N/E
Anchor handling vessel	<10	19
Main installation vessel, construction vessel	16	66

Finally, the mortality and recoverable injury ranges due to VSP are presented in Table 7.46, based on the impulsive noise thresholds set out in Popper *et al.* (2014). Both mortality and recoverable injury ranges were low for all hearing groups (i.e. <55 m).

Table 7.46: Summary Of Peak Pressure Injury Ranges For Fish Due To VSP

Hearing Group	Response	Threshold (SPL_{pk}, dB re 1 µPa)	Range (m)
Group 1 Fish: No swim bladder (particle motion detection)	Mortality	213	26
	Recoverable injury	213	26
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	207	54
	Recoverable injury	207	54
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	54
	Recoverable injury	207	54
Fish eggs and larvae	Mortality	207	54

Behavioural Disturbance

Marine Species

Fish species responses to underwater noise related to construction activities include a wide variety of behaviours, including startle (C-turn) responses, strong avoidance behaviour, changes in swimming or schooling behaviour, and/or changes of position in the water column. The Popper *et al.* (2014) guidelines provide qualitative behavioural criteria for fish from a range of noise sources. These categorise the risks of effects in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. tens of metres), "intermediate" (i.e. hundreds of metres) or "far" (i.e. thousands of metres).

Any potential short-term noise effects on fish may not necessarily translate to population scale effect, with a relatively low amount of information available about *in situ* behavioural effects. A review by Carroll et *al.* (2017) showed that noise impact experiments can lead to highly variable results in caged fish. Therefore, many laboratory experiments may be more useful for providing evidence of potential physiological impacts than behavioural or population-level effects. Furthermore, there is no evidence base that is sufficiently robust to propose quantitative criteria for behavioural effects currently available, as the response between and within species to underwater noise is so variable (Popper *et al.,* 2014; Hawkins and Popper, 2016). As such the qualitative criteria for the four fish groups outlined in Table 7.47 are proposed, which propose risk ratings for behavioural effects and masking in the near field (i.e. tens of metres), intermediate field (hundreds of metres) and far field (thousands of metres).

Table 7.47: Potential Risk For The Onset Of Behavioural Effects In Fish (Source: Popper *et al.,* 2014)

Group	Type of Animal	Relative Risk of Behavioural Effects		
		Impulsive Piling	**Explosives**	**Non-Impulsive Sound**
1	Fish: no swim bladder (particle motion detect)	(Near) High (Intermediate) Moderate	(Near) High (Intermediate) Moderate	(Near) Moderate (Intermediate) Moderate

Group	Type of Animal	Relative Risk of Behavioural Effects		
		Impulsive Piling	Explosives	Non-Impulsive Sound
		(Far) Low	(Far) Low	(Far) Low
2	Fish: where swim bladder is not involved in hearing (particle motion detection)	(Near) High (Intermediate) Moderate (Far) Low	(Near) High (Intermediate) High (Far) Low	(Near) Moderate (Intermediate) Moderate (Far) Low
3 and 4	Fish: where swim bladder is involved in hearing (primarily pressure detection)	(Near) High (Intermediate) High (Far) Moderate	(Near) High (Intermediate) High (Far) Low	(Near) High (Intermediate) Moderate (Far) Low
Eggs and larvae	Eggs and larvae	(Near) Moderate (Intermediate) Low (Far) Low	(Near) High (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Moderate (Far) Low

Group 1 fish (e.g. flatfish, elasmobranchs, sandeel, and lampreys), and Group 2 fish (e.g. salmonids) are less sensitive to sound pressure, with these species typically detecting sound in the environment through particle motion. However, sensitivity to particle motion in fish is also more likely to be important for behavioural responses rather than injury (Mueller-Blenkle *et al.,* 2010; Hawkins *et al*., 2014). Group 3 (including gadoids such as cod and whiting) and Group 4 fish (herring, sprat, and shad) are more sensitive to the sound pressure component of underwater noise and, as indicated in Table 7.47, the risk of behavioural effects in the intermediate and far fields are therefore greater for these species.

As discussed above, in terms of physical effects, injury up to and including mortality for many marine and diadromous fish species is to be expected for individuals within very close proximity to piling operations. However, this is unlikely to result in significant mortality due to soft start procedures allowing individuals in close proximity to flee the area, prior to maximum hammer energy levels which may cause injury to greater ranges.

Group 1 elasmobranch species do not possess a swim bladder, and thus will be most impacted by particle motion. There is evidence of startle and fleeing responses of elasmobranchs to piling (minimum of 20 to 30 dB re 1 µPa above background conditions) due to increased particle motion (Casper *et al.,* 2012). It is likely that the embedded soft start procedure will allow any individuals near the construction activities to flee the immediate area. This suggests a low vulnerability to this impact. In terms of recoverability, the construction activities will be temporary, and once they have ceased, elasmobranch species have been observed to gather at operational offshore built infrastructure (Stanley and Wilson, 1991). This indicates the potential for high recoverability after the end of the initial construction activities.

A number of studies have examined the behavioural effects of the sound pressure component of impulsive noise (including piling operations and seismic airgun surveys) on fish species. Mueller-Blenkle *et al.* (2010) measured behavioural responses of cod and sole to sounds representative of those produced during marine piling and recorded considerable variation across individuals. This variation occurred depending on the age, sex, and condition of the fish, as well as the possible effects of confinement in cages on the overall stress levels. The authors concluded that it was not possible to find an obvious relationship between the level of exposure and the extent of the behavioural response in these species, although an observable behavioural response was reported at 140 to 161 dB re 1 µPa (SPL_{pk}) for cod and 144 to 156 dB re 1 µPa (SPL_{pk}) for sole (Mueller-Blenkle *et al.,* 2010). However, these thresholds should not be interpreted as the level at which an avoidance reaction will be elicited, as the study was not able to show this. Recently, modelling on Group 3 cod has shown an expected decrease in population growth rates in response to loud piling noise due to a decrease in food intake and increase in energy expenditure (Soudijn *et al*., 2020). However, it is likely that cod fecundity is underestimated in this model, and this, combined with the short-term nature of the noise impact from piling (i.e. a maximum of eight piles with up to 100 minutes of piling each), suggests that long-term population-level effects are unlikely to occur within the regional fish and shellfish ecology study area.

Pearson *et al.* (1992) investigated the effects of geophysical survey noise on caged Group 2 rockfish *Sebastes* spp. The authors observed a startle (C-turn) response at peak pressure levels beginning around 200 dB re 1 µPa, although this was less common with larger-bodied individuals. Similarly, McCauley *et al*. (2000) exposed various fish species in large cages to seismic airgun noise and assessed behaviour, physiological and pathological changes. In general, they observed a behavioural response to move to the bottom of the cage during periods of high level exposure (greater than rms levels of around 156 to 161 dB re 1 µPa; approximately equivalent to SPL_{pk} levels of around 168 to 173 dB re 1 µPa). This was followed by a return to baseline behaviour within 30 minutes of cessation of airgun activities, with no significant long-term physiological impacts noted, except for likely reversible hearing hair cell damage at shore range (McCauley *et al.,* 2000). The behaviour of moving towards the bottom of the water column was also observed *in situ* by Fewtrell and McCauley (2012), who noted significant alarm responses in all investigated species at noise levels exceeding 147 to 151 dB re 1 µPa (SEL) in every case. These responses were also temporary and returned to baseline behavioural conditions shortly thereafter (Fewtrell and McCauley, 2012).

As outlined previously, the thresholds for behavioural effect proposed by Popper *et al*. (2014) are qualitative, however in order to provide a more quantitative estimation of the range at which behavioural effects may occur, noise modelling was undertaken for SPL (rms) within the Proposed Development. The disturbance range for fish was calculated as 150 dB re 1 µPa (rms) contour is 33 km for impact pile driving (volume 3, appendix J). Based on the studies summarised above, it can be expected that behavioural effects could be expected within the 150 dB contours, noting that this is likely to be conservative given McCauley *et al*. (2000) noted behavioural effects on a range of species at approximately 168 dB re 1 µPa. For Group 1 and Group 2 fish species this is likely to be highly precautionary as they are known to be less sensitive to underwater noise. Further, the noise contours are for the greatest hammer energy for impact piling, and therefore in most scenarios this hammer energy will not be used, and therefore smaller contours would be expected. These ranges and the results discussed below broadly align with qualitative thresholds for behavioural effects on fish as set out in Table 7.47, with moderate risk of behavioural effects in the range of hundreds of metres to thousands of metres from the piling activity, depending on the species.

For the sandeel IEF (Group 1), modelling has indicated a possible temporary reduction in sandeel populations in areas affected by piling noise (Serpetti *et al*., 2021). However, initial outputs of post-construction monitoring at the Beatrice OWF (BOWL, 2021a) concluded there was no evidence of long-term adverse effects on sandeel populations due to construction over the six-year period, demonstrating that any potential effect of piling on sandeel is temporary and reversible. Cod spawning behaviour was also monitored pre and post construction (which included piling operations) at the Beatrice OWF (BOWL, 2021b). Similarly, there was no change in the presence of cod spawning between pre and post construction (although spawning intensity was found to be low across both surveys). From these studies, it can be inferred that noise impacts associated with installation of an OWF development are temporary and that fish communities (specifically cod and sandeel in the case of Beatrice OWF) show a high degree of recoverability following construction. Given the nature of the Proposed Development, underwater noise levels generated during construction (particularly piling) are considerably lower than that an OWF development. Further, the short term and intermittent nature of piling activities associated with the Proposed Development, compared to the spawning period of cod (January-April, peaking in February and March), will likely limit the impact on cod spawning or populations significantly.

As a Group 4 species, herring are known to be particularly sensitive to underwater noise. Specifically, herring possess ancillary hearing structures which involve gas ducts extending into the skull, allowing detection of extremely high frequency sounds (Mann *et al.,* 2001). As they have specific benthic spawning habitat requirements, they are also more vulnerable to disturbance than most fish, which tend to be pelagic spawners. For herring, the core spawning grounds are located southeast and north-east of the Isle of Man, with seabed sediments within the Proposed Development shown to be largely unsuitable for herring spawning (see section 7.8.2.7 and volume 3, appendix J). Significant but reversible diving reactions have been noted for sounds up to 168 dB re 1 µPa (SPL) (Doksaeter *et al.,* 2012; based on sonar noise sources), which is above the 150 dB threshold suggested above.

Aside from the fish and shellfish IEFs mentioned above, other marine fish species utilise the regional fish and shellfish ecology study area for spawning or nursery purposes. However, the relative proportion of these habitats affected by piling operations at any one time will be small in the context of the wider habitat available, and, as outlined above, piling operations will be temporary and intermittent throughout the construction phase. It should also be noted that behavioural responses to underwater noise are highly dependent on a number of factors such as species, sex, age, condition, life history stage, as well as other stressors which it is or has been exposed to. Another important factor is the motivation for individuals to be in a particular area, such as spawning, migration, or foraging. For example, a study found a slight but **not significant** reduction in swimming speed among feeding herring schools exposed to impulsive seismic air gun surveys (Peña *et al*., 2013). This suggests that feeding herring were not displaying avoidance responses to seismic noise sources, even when the vessel came into close proximity to them. This indicated an awareness of and response to impulsive anthropogenic noise, which would be expected in response to piling, but not a significant response when fish were highly motivated (in this case during feeding). It may therefore be expected that increased tolerance (and decreased sensitivity) to underwater noise may occur for some fish and shellfish IEFs during key life history stages, such as spawning or migration.

Furthermore, potential effects on fish eggs and larvae are anticipated to be limited, with only low level of impacts which are limited in extent (relative to the wide-ranging nature of spawning nursery habitats) and high recoverability (Bolle *et al*., 2016). Fish larvae tend to have low sensitivity to impulsive piling noise up to 210 dB re 1 µPa (SPL) (Bolle *et al.,* 2016). Although there is evidence of underwater noise significantly interfering with demersal larval settlement (Stanley *et al.,* 2012), no significant mortality was observed for herring larvae compared to control groups after exposure to piling noise up to 216 dB re 1 µPa SEL_{cum} (Bolle *et al.,* 2014).

Overall, for the impact of underwater noise, most marine fish IEFs, including elasmobranchs are deemed to be of low vulnerability, high recoverability, and local to international importance. The sensitivity of these receptors is therefore, considered to be low.

Sprat (Group 4) are deemed to be of medium vulnerability, high recoverability, and regional importance. The sensitivity of these receptors is therefore, considered to be medium.

Cod (Group 3) and herring (Group 4) are deemed to be of high vulnerability, high recoverability, and national importance. The sensitivity of the receptor is therefore, considered to be high.

Diadromous Species

As discussed above for marine species, diadromous fish species may experience injury or mortality within close proximity to piling operations. However, due to the highly mobile nature of diadromous fish species and that they only tend to pass through the environment within the regional fish and shellfish ecology study area during migration, it is unlikely to result in significant mortality of diadromous species. The use of soft start piling procedures (see section 7.11), allowing individuals in close proximity to piling to flee the ensonified area, further reduces the likelihood of injury and mortality on diadromous species.

Similar to marine fish, diadromous species may experience behavioural effects in response to piling noise, such as a startle response, disruption of feeding, or avoidance of an area. These responses may occur within a range of hundreds of metres to several kilometres from piling operations, depending on the species and their relative sensitivities to underwater noise:

- **Group 1**: sea lamprey and river lamprey.
- **Group 2**: Atlantic salmon and sea trout.
- **Group 3**: European eel and smelt.
- **Group 4**: Allis shad and twaite shad.

Lampreys are known to have relatively simple ear structures (Popper and Hoxter, 1987). They have been recorded to demonstrate very few responses to auditory stimuli overall (Popper, 2005), except a slight increase in swim speed and decrease in resting behaviour when exposed to continuous low frequency sound of 50 to 200 Hz (Mickle *et al.,* 2019). This suggests that they have a low vulnerability to underwater noise impacts overall. The noise modelling outputs discussed in the previous section indicated that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 150 dB re 1 µPa (rms) contours; which is likely to be highly precautionary for lamprey) in the vicinity of the Proposed Development. Further, the noise impacts will be short-term and intermittent in nature during the construction phase (i.e. a maximum of eight piles with up to 100 minutes of piling each). As such, there is negligible risk of disruption to migration of lamprey.

Smelt have the potential to be impacted by noise, possibly in terms of disruption to migration to their preferred spawning habitats, such as in the Ribble Estuary MCZ and Wyre Lune MCZ. Evidence from a port noise study indicates that smelt are able to habituate to repeated noise impacts with no significant loss of ecological function (Jarv *et al.,* 2015). As the piling noise has little overlap with these coastal habitats, and will be short term and intermittent, smelt are likely to have low vulnerability and high recoverability to this impact and are therefore at negligible risk to this impact.

Physiological or behavioural responses were not observed in Atlantic salmon when subjected to noise similar to that of piling (Harding *et al.,* 2016). However, the noise levels tested were estimated at <160 dB re 1 µPa (rms), below the level at which injury or behavioural disturbance would be expected for Atlantic salmon. Nedwell *et al.* (2006) found no significant behavioural response from piling activities in sea trout (slightly less sensitive than Atlantic salmon), with modelling suggesting a similar response in both species. Physical impacts on migrating salmonids have been noted from piling producing sounds of 218 dB re 1 µPa (Bagocius, 2015), although at these levels, avoidance reactions would be anticipating, thus avoiding injury effects. The underwater noise modelling outputs (including noise contours) indicate that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 150 dB re 1 µPa (rms) contours; which is likely to be precautionary for Atlantic salmon and sea trout) in the vicinity of the Proposed Development. Further, the noise impacts will be short-term and intermittent in nature during the construction phase (i.e. a maximum of eight piles with up to 100 minutes of piling each). As such, there is negligible risk of disruption to migration of these species. The low risk of effects on migration of Atlantic salmon and sea trout extends to the freshwater pearl mussel, as part of its life stage is reliant on diadromous fish species including Atlantic salmon and sea trout.

European eel (Group 3) is known to have a wide hearing range (Jerko *et al*., 1989). Behavioural responses observed include startle responses (Sand *et al.,* 2000) and more than a doubling of short-term migration distances close to sources of infrasound deterrents (Piper *et al*., 2019). However, these impacts were noted on juveniles migrating towards the sea, with there being no significant impact expected on juveniles as a result. Eels are also known to be more vulnerable to predation due to difficulty in detecting predators compared to control groups when exposed to simulated underwater noise (Simpson *et al.,* 2014), with recovery noted when the noise source was removed. As noted above, the noise modelling outputs (including noise contours) discussed in the previous sections indicated that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 150 dB re 1 µPa (rms) contours) in the vicinity of the Proposed Development. Further, given the short-term and intermittent nature of any construction activities (i.e. a maximum of eight piles with up to 100 minutes of piling each) alongside the relatively short migration window of eels through the affected zones of the regional fish and shellfish e ecology study area, it is predicted that any impact to European eel will be minor.

Allis and twaite shad, (Group 4 species, like herring), are known to be sensitive to underwater noise, particularly ultrasonic tones. They are able to detect ultrasonic tones of 171 dB re 1 µPa (SPL) at a distance of up to 187 m (Mann *et al*., 1998). In terms of behavioural responses to underwater noise, evasive behaviours were commonly seen in direct response to ultrasonic stimuli (Platcha and Popper, 2003). Due to this sensitivity and evasiveness, it is unlikely that shad species will remain in the vicinity of construction activities, which will utilise the soft-start procedure, for a long enough period to cause significant harm, with this representing a low vulnerability to this impact. With regard to disruption to migration, as noted above, noise modelling outputs (including noise contours) discussed in the previous sections indicated that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 150 dB re 1 μPa (rms) contours) in the vicinity of the Proposed Development. It should also be noted that the ranges presented above are for the maximum hammer energy and all other scenarios (i.e. lower hammer energies) would result in considerably smaller noise impact ranges. Further, the noise impacts will be short-term and intermittent in nature during the construction phase (i.e. a maximum of eight piles with up to 100 minutes of piling each) and shad would only have the potential be affected if piling occurs during the migratory period for these species, which occurs over spring up until June, and peaks in April and May (Acolas *et al.,* 2004). As such, there is low risk of disruption to migration of these species.

Overall, to the impact of underwater noise, most diadromous fish species IEFs are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of these receptors is therefore, considered to be low.

As Group 4 species, Allis shad and twaite shad are deemed to be of high vulnerability, high recoverability, and national importance. The sensitivity of these receptors is therefore considered to be high.

Shellfish Species

As the impact of underwater noise on marine invertebrates is largely unknown, there are no standardised exposure criteria (Hawkins *et al.,* 2014). Studies on marine invertebrates have illustrated a general sensitivity to substrate borne vibration (Roberts *et al*., 2016). Aquatic decapod crustaceans have been shown to possess a number of receptor types potentially capable of responding to the particle motion component of underwater noise and ground borne vibration (Popper *et al.,* 2001). Noise is detected more as particle motion through stimulation of sensory setae within statoliths (Carroll *et al*., 2017), although other mechanoreceptor systems are present, which could be capable of detecting vibration. Generally, there is evidence of crustaceans being sensitive to sounds of frequency <1 kHz, however this is a broad statement for shellfish as a whole (Budelmann, 1992). It has also been reported that the sound wave signature of piling noise can travel considerable distances through sediments (Hawkins and Popper, 2016), with implications for demersal and sediment dwelling shellfish species (e.g. Norway lobster) in close proximity to piling activities.

A recent review by Scott *et al.* (2020) summaries the existing published literature on the influence of anthropogenic noise and vibration and on crustaceans, including some shellfish IEFs identified in this assessment. The authors concluded that some literature sources identified behavioural and physiology effects on crustaceans from anthropogenic noise, however, there were several that showed no effect. This review notes that no effect or influence of noise or vibrations has been reported on mortality rates or fisheries catch rates or yields so far for shellfish. In addition, no studies have indicated a direct effect of anthropogenic noise on mortality, whether that be immediate or delayed effects (Scott *et al.,* 2020).

Of the shellfish IEFs identified in this assessment, decapod crustaceans (e.g. brown crab, European lobster, Norway lobster, spiny lobster, velvet swimming crab) are believed to be physiologically resilient to noise as they lack gas filled spaces within their bodies (Popper *et al.,* 2001). Presently, there have been no lethal effects of underwater noise recorded for these IEFs, however a number of sub-lethal physiological effects have been reported among Norway lobster and related species, specifically a reduction in burying, bioregulation, and locomotion behaviour in response to simulative shipping and construction noise (Solan *et al.,* 2016). However, the authors noted that simulated shipping noise had no effect Norway lobster physiology (Solan *et al.,* 2016).

In snow crab *Chionoecetes opilio*, sub-lethal physiological effects due to impulsive noise sources included bruised hepatopancreas and ovaries after exposure to seismic survey noise emissions (at unspecified SPLs) (Department of Fisheries and Oceans Canada (DFO), 2004). Similarly, changes in serum biochemistry and hepatopancreatic cells were observed in American lobster *Homarus americanus* (Payne et al., 2007), increase in respiration in brown shrimp (Solan *et al.,* 2016), metabolic rate changes and reduced feeding behaviour in green shore crab (Wale *et al*., 2013), and evidence of oxidative stress in blue mussel (Wale *et al*., 2019) have also been identified as a result of underwater noise.

Another study found elevated SPL were correlated with increased incidences of cannibalism and significantly delayed growth in brown shrimp (Lagardère and Spérandio, 1981). The spiny lobster has been reported to have aspects of life history disrupted by anthropogenic noise (such as movement and anti-predation behaviour) in response to simulated shipping noise and offshore activities (Filiciotto *et al.,* 2016; Zhou *et al*., 2016). Such findings have implications regarding species fitness, stress, and compensatory foraging requirements, along with increased exposure to predators. These studies provide useful context for the sub-lethal effects from noise impacts which the spiny lobster IEF (and others, as a proxy) will likely similarly be exposed to.

Behavioural impacts have been noted in the giant scallop *Placopecten magellanicus*, with piling noise travelling through the seabed for up to 50 m and causing significant increases in valve closures with no acclimation to multiple piling exposures (Jezequel *et al.,* 2022). This could potentially have significant impacts on feeding success for the giant scallop. However, as this only occurred in very close proximity to the piling impact, and the giant scallop returned to baseline natural behaviour almost immediately following cessation of piling (Jezequel *et al.,* 2022). Therefore, it is unlikely that impact piling will cause any significant long-term impact on scallop populations within the Proposed Development, given the relatively small proportion of the overall scallop population in the regional fish and shellfish ecology study area potentially affected by this impact.

Shellfish will also likely be exposed to pre-construction seismic and geophysical surveys within the Proposed Development. Christian *et al.* (2013) found no significant difference between acute effects of seismic airgun exposure upon caged adult snow crabs, in comparison with those in control cages with no exposure to seismic pulses. Similarly, the link between seismic surveys and changes in commercial rock lobster *Panulirus cygnus* catch rates over a 26-year period was investigated by Parry and Garson (2006), who found no statistically significant correlative link. Comparison between laboratory and field studies is difficult due to differing sound properties in these controlled and uncontrolled environments (Carroll *et al*., 2017), therefore, setting standardised minimum injury and mortality thresholds proves difficult for this impact (Wright and Cosentino, 2015). Despite this difficulty, direct observation has shown that scallop species show no evidence of increased mortality within 10 months of seismic airgun exposure (Parry *et al.,* 2002), and lobsters show the same trend 8 months following exposure (Day *et al.,* 2016), suggesting a low vulnerability and high recoverability to this noise source.

There is no direct evidence to suggest that shellfish eggs and larvae are at risk of direct harm from high amplitude anthropogenic underwater noise sources, such as piling (Edmonds *et al.,* 2016). However, evidence exists of underwater noise significantly decreasing the capacity of benthic shellfish larvae to settle following their planktonic larval phase (Stanley *et al.,* 2012), potentially impacting long-term population recruitment. Of the few studies that have focused on the eggs and larvae of shellfish species, evidence of impaired embryonic development and mortality has been found to arise from playback of seismic survey noise among scallop, with up to 46% of affected larvae developing abnormalities compared to control groups (De Soto *et al.,* 2013). There is limited information on the effect of impulsive sound upon crustacean eggs, and no research has been conducted on commercially exploited decapod species in the UK, with all available studies focusing on seismic survey noise impacts. Like scallop larvae, exposure to sound from seismic source arrays could be implicated in delayed hatching of snow crab eggs, causing resultant larvae to be smaller than controls (DFO, 2004). However, Pearson *et al*. (1994) found no statistically significant difference between the mortality and development rates of stage II Dungeness crab *Metacarcinus magister* larvae exposed to single field-based discharges (231 dB re 1 µPa (zero-peak) @ 1 m) from a seismic airgun. This highlights the heterogeneity of results in this field, with further study required to refine this understanding. The existing evidence suggests a medium vulnerability of shellfish eggs and larvae to this impact, although recoverability of shellfish into spawning habitats is predicted to be high.

Monitoring of European lobster catch rates at the Westermost Rough OWF indicated that there were no significant adverse effects on shellfish species at a population level during and after construction compared to baseline conditions (Roach *et al.,* 2018). In fact, the respite from fishing activities due to construction exclusion zones potentially resulted in short term benefits for some populations (Roach *et al.,* 2018). While there may be some residual uncertainty with regard to behavioural effects while piling operations are ongoing, the evidence suggests that long term effects will not occur, and any effects will be reversible.

Overall, due to the impact of underwater noise all shellfish IEFs are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of these receptors is therefore, considered to be low.

Significance of Effect

Marine Species

Overall, for most marine IEFS (including elasmobranchs), the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sprat (Group 4) the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be **minor adverse**, which is **not significant** in EIA terms.

For cod (Group 3) and herring (Group 4), the magnitude of impact is deemed to be low, and the sensitivity of the receptors is considered to be high. As per Table 7.31, this yields a 'minor or moderate' significance. Due to the limited piling (up to 800 total hours) required for the Proposed Development and the availability of suitable habitat elsewhere in the regional fish and shellfish ecology study area, the effect has been assessed as **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Species

Overall, for most diadromous IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For Group 4 diadromous IEFs (Allis and twaite shad), the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be high. As per Table 7.31, this yields a 'minor or moderate' significance. Due to the limited piling (up to 800 total hours) required for the Proposed Development and the availability of suitable habitat elsewhere in the regional fish and shellfish ecology study area, the effect has been assessed as **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, for all shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.12 Increased SSCs and Associated Deposition

7.12.12.1 Construction Phase

Construction activities, such as subsea pipeline refurbishment, cable installation and protection (including sand wave clearance), installation of the new Douglas platform, and release of drill cuttings may result in increased SSCs and associated deposition. This may potentially result in indirect impacts on fish and shellfish ecology, such as increased turbidity, smothering effects, and release of additional contaminants into the benthic environment. These impacts could affect the water quality in the surrounding area and habitat degradation affecting spawning and nursery grounds.

A full description of the physical processes baseline characterisation, including the numerical modelling used to assess increased SSCs and associated deposition, is provided in volume 3, appendix H. The 2016 Cefas Climatology Report (Cefas, 2016) and associated dataset provides the spatial distribution of average non-algal SPM around the UK. Between 1998 and 2005, the greatest plumes are associated with large rivers such as those that discharge into the Thames Estuary, The Wash and Liverpool Bay, which show mean values of SPM above 30 mg/l. Based on the data provided within this study, the SPM associated with the Proposed Development has been estimated as approximately 0.9 to 3 mg/l over the 1998 to 2005 (Cefas, 2016).

Magnitude of Impact

All Species

Increases in SSCs and associated deposition due to construction activities has been assessed based on the MDS parameters in Table 7.22.

These parameters have been defined by a numerical modelling study was undertaken on the potential impacts of the Proposed Development on physical processes (see volume 3, appendix H). This included tidal current, wave climate, and sediment transport under both calm and storm conditions. Numerical modelling has been used to quantify the changes in physical processes, predominantly suspended sediment concentrations, due to seabed preparation activities, the drilling of new monitoring wells, and laying of cables. The following activities in the construction phase have been considered:

- seabed preparation (such as sand wave clearance);
- drill cuttings; and
- cable installation.

Details of the modelling and the parameters used are provided in full in for the impact of increased SSCs and associated deposition on benthic subtidal and intertidal ecology and are not repeated here (see section 7.12.2). Overall, the increased SSCs and associated deposition due to the construction activities described above are predicted to be of local spatial extent, short-term duration, intermittent throughout the construction phase, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, for all fish and shellfish IEFs, the magnitude of impact is predicted to be low.

Sensitivity of Receptor

In general, greater increases in SSCs and associated deposition result in greater impact on fish and shellfish receptors. The product of sediment concentration (in mg/l) and the duration of exposure is used to give an indication of effects (Newcombe and MacDonald, 1991).

Marine Fish

Typically, fish eggs and larvae are the most susceptible life stage to the impacts of increased SSCs and associated deposition. In general, SSCs have to be on the scale of mg/l to be lethal to eggs and larvae but on the scale of g/l to be lethal to juveniles and adults (Engell-Sørensen and Skyt, 2001). The development of fish eggs and larvae can be impacted by suspended sediments at concentrations of thousands of mg/l (Auld and Schubel, 1978; Appleby and Scarratt, 1989). Modelling undertaken of SSCs associated with the construction phase identified maximum concentrations of 30 mg/l during dredging at West Hoyle Bank. However, it should be noted that this value is equivalent to background levels. It is unlikely that these SSCs will affect the development of eggs and larvae and they are only expected to be present in the immediate vicinity of the release site with dispersion continuing over successive tides.

Eggs and larvae of species which deposit their eggs near or on the seabed are most likely to be affected by SSCs and associated deposition. This includes sandeel and herring. While sandeel spawning grounds were identified within the Proposed Development, sandeel and their eggs are likely to be tolerant to some level of sediment deposition due to the nature of re-suspension and deposition within their natural high energy preferred habitat and spawning environment within the Irish Sea (MarineSpace Ltd *et al.*, 2013). Sandeel prefer coarse to medium sands for spawning (Wright *et al.,* 2000), with 65% of the PSA samples collected within the Proposed Development being characterised as unsuitable or sub-prime for spawning using the Latto *et al.* (2013) methodology (see volume 3, appendix I for further information on this analysis). Sandeel are sensitive to changes in spawning habitat and show reduced selection or avoidance of gravel and fine sediment habitats (Holland *et al.,* 2005). Therefore, increased SSCs in areas of suitable or prime spawning habitat within the Proposed Development may cause avoidance behaviour until the fine sediments are dissipated by the current. However, modelled deposition levels for fine sediments are expected to be highly localised, with finer mud particles dispersed with residual currents. For example, modelling of sedimentation during drilling suggested that mean sedimentation was contained within a 500 m radius of the drill site and limited to <0.1 mm (see volume 3, appendix H for further information). Therefore, effects on sandeel spawning populations due to this impact are predicted to be limited.

Herring are a pelagic species, which lay matts of demersal eggs on the seabed (this is discussed in greater detail in section 7.12.9). They are known to prefer gravelly and coarse sand environments for this spawning, which includes areas around the southeast and north-east of the Isle of Man (Coull *et al*., 1998). Kiørboe *et al.* (1981) reported that embryonic development of herring eggs was unimpaired by SSCs of up to 300 mg/l for one day. The authors suggested that harmful effects of increased SSCs are most likely to occur when oxygen tension is reduced, which is often the case when organic matter and reducing agents are released from the sediments (Kiørboe *et al.,* 1981). Further, Messieh *et al.* (1981) demonstrated that although substantial egg mortality could occur due to a thin film of sediment encasing the eggs, no deleterious effect on hatching was observed in SSCs of up to 7,000 mg/l. Their results suggest that herring eggs may be tolerant to high SSC levels, although the size at hatching tended to be higher in lower SSCs (Messieh *et al.,* 1981). Detrimental effects may occur if eggs are smothered and the deposited sediment is not removed by the currents (Birklund and Wijsmam, 2005), however this would be expected to occur quickly in this case (i.e. within a couple of tidal cycles), given the low levels of deposition expected. Furthermore, the results of the PSA conducted on the sediment samples collected within the Proposed Development demonstrated that the area is largely unsuitable spawning habitat for herring. There was only one sampling site (1.3% of the total number of samples) classified as 'suitable' habitat under the Reach *et al.* (2013) methodology and there were four samples (5.3% of the total) classified as 'sub-prime' spawning habitat. In addition, there were no spawning grounds overlapping with the Proposed Development, with the closest identified around the Isle of Man, and with nationally significant spawning grounds located out with the regional fish and shellfish ecology study area entirely (Coull *et al.,* 1998). Overall, it is unlikely that herring populations will be largely affected by this impact.

Adult marine fish species are more mobile than many of the other fish and shellfish IEFs identified in this assessment, and therefore would be likely to show greater avoidance behaviour within areas affected by increased SSC (Emu, 2004). Avoidance of turbid water is a common response behaviour to elevated SSCs (Collin and Hart, 2015). For example, avoidance behaviour was observed in adult herring and cod exposed to sediment plumes as low as 2 mg/l (Westerberg *et al.,* 1996). It is proposed that this increased mobility makes these species less susceptible to physiological effects of this impact. Conversely, due to the reduced mobility and higher dependence on specific nursery habitats, juvenile fish are likely to be less able to avoid habitat disturbances due to increased SSCs and associated deposition. This has been well researched for juvenile salmonids (Bisson and Bilby, 1982; Berli *et al.,* 2014). Juvenile fish are likely to occur throughout the regional fish and shellfish ecology study area, with nursery habitats present inshore and offshore depending on species (a complete account of all species with spawning and nursery grounds overlapping the Proposed Development and within the regional fish and shellfish ecology study area is available in volume 3, RPS Group (2024aappendix I).

Temporary increases in SSCs occur regularly in the north Irish Sea, linked heavily to interannual changes in meteorological conditions and the frequency of spring storms (White *et al*., 2003). Seasonal variation in SSCs is also typical for the area, with an increase of up to a factor of 2.7 in winter compared to summer levels (Bowers *et al.,* 2010). Further, juvenile fish typically inhabit inshore areas, where SSCs are typically higher. As the fish and shellfish assemblage in proximity to the Proposed Development is characteristic of the regional fish and shellfish ecology study area, it is likely that juveniles are acclimatised to these natural fluctuations in SSCs. Therefore, it is proposed that most juvenile fish within the regional fish and shellfish ecology study area will be largely unaffected by the relatively low-level temporary increases in SSC resulting from the construction phase. These concentrations are likely to be within the range of natural variability (generally at background levels of 30 mg/l). Recoverability, in terms of fish returning to the affected area, is highly dependent on the recovery of the area to pre-disturbance conditions, the availability of alternative suitable habitat, and the ecological plasticity of that species (Wenger *et al.,* 2017). As a result, there will be little to no impact on mobile species, such as pelagic fish and elasmobranch IEFs.

Overall, all marine fish IEFs, except herring, are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be low.

Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, high recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be medium. Despite the relatively large distance of the spawning grounds and primary habitat from the Proposed Development, the sensitivity of this receptor is still considered to be medium as a precautionary measure.

Shellfish

Many shellfish species have a high tolerance to increases in SSC and are reported to be insensitive to increases in turbidity (Wilber and Clarke, 2001). This includes shellfish IEFs, such as brown crab which has been assessed in the MarESA as being tolerant to increase in SSCs, smothering, and increase in turbidity, with very low, low, and no sensitivity to each of these impacts, respectively (Neal and Wilson, 2008). This is due to their mobility, allowing brown crab to escape from sediment deposition and avoid areas of increased SSCs, as they rely on good visibility to forage (Neal and Wilson, 2008). Non-mobile shellfish IEFs, such as common cockle, have also been assessed in the MarESA as being tolerant and not sensitive to increased SSCs and turbidity (Tyler-Walters, 2007). This is because this species naturally inhabits sedimentary and turbid environments and is therefore considered to be tolerant to these impacts (Navarro and Widdows, 1997; Tyler-Walters, 2007). The common cockle also has intermediate tolerance to smothering of up to 5 cm of deposited sediment, with a high recovery rate, and an overall low sensitivity to smothering (Tyler-Walters, 2007). For example, in laboratory and field conditions, individuals have been observed to burrow quickly to the surface if smothered by 2 to 5 cm of sediment (Jackson and James, 1979; Richardson *et al.,* 1993).

Historic common cockle beds are present within the Dee Estuary, which have been subject to previous closures and are not managed under the Dee Estuary Cockle Fishery Order (2008) Management Plan (NRW, 2024). Given the low sensitivities of common cockle to increased SSCs, turbidity, and smothering (Tyler-Walters, 2007), it is not likely that this impact will affect the cockle beds of the Dee Estuary.

Norway lobster, European lobster, and other larger crustaceans, such as spiny lobster, are classed as equilibrium species, meaning that they can only recolonise an area once the original substrate has recovered to baseline conditions (Newell *et al.,* 1998). Egg bearing (e.g. ‘berried’) Norway lobster and European lobster are potentially more vulnerable to increased SSCs as the eggs they carry attached to their bodies required regular aeration. However, the MarESA for Norway lobster states that this species is tolerant and not sensitive to increased SSCs, smothering, and increased turbidity (Sabatini and Hill, 2008). This is because they inhabit large burrows, which can penetrate 20 – 30 cm into the sediment and be over a metre long (Rice and Chapman, 1971), which would not be affected by this impact. Similarly, they are mobile species, thus are able to move to more suitable conditions if necessary, during periods of increased SSCs during the construction phase, which are not expected to be continuous and will only affect a small area at any one time (see ‘magnitude of impact’ above). Further, spawning and nursery grounds for Norway lobster are located to the north of the Proposed Development, but do not directly overlap, therefore are unlikely to be impacted by increased SSCs and associated deposition. There is no MarESA available for European lobster, however this species inhabits unsheltered seabeds, rocky crevices, and in excavated burrows (Dybern, 1973), and is also highly mobile. Therefore, it is likely that any impact to this species will be low.

Increased SSCs are unlikely to impact spiny lobster directly, as they prefer dens in shaded, sub-vertical substratum, which reduces siltation rate (Gristina *et al.,* 2009). Increased SSCs may indirectly affect spiny lobster due to reduced foraging success, however as they have been recorded remaining in shelters without food for up to a week (Groeneveld *et al.,* 2013), it is likely they are tolerant to reduced foraging ability until SSCs return to baseline conditions. The MarESA for this species is a medium resistance, and medium sensitivity to changes in suspended solids (Gibson-Hall, *et al.,* 2020). As spiny lobster are large and mobile species, light smothering (<5 cm) is unlikely to impact them, with high resistance and no sensitivity to this impact concluded in the MarESA (Gibson-Hall *et al.,* 2020). Heavier sediment deposition (>5 cm) could obstruct the entrance to their shelters or smother potential prey, with low resistance and high sensitivity to this impact concluded in the MarESA (Gibson-Hall *et al.,* 2020). However, modelled deposition levels for fine sediments are expected to be highly localised, with finer mud particles dispersed with residual currents. Thus heavier deposition is not likely to impact this species. Overall, it is likely that any impact to spiny lobster will be low.

Both king and queen scallop have the potential to be adversely impacted by burial during sediment deposition. Hendrick *et al.* (2016) demonstrated that queen scallop had some ability to emerge from burial of up to 2 cm, but mortality occurred after several days of burial and under sediments over 5 cm. The MDS modelling of sediment plume movement and deposition depths have shown this is unlikely to occur in this case (see 'magnitude of impact' above). King scallop appear to be more tolerant to burial than queen scallop, with high levels of emergence and low mortality recorded in coarse to medium grain sizes and depths of <3 cm (Szostek *et al.,* 2013). Emergence decreased and mortality increased in king scallops buried under fine sediment of increasing depths (up to 5 cm) (Szostek *et al.,* 2013). Within this study, king scallop also demonstrated increased clapping rate (a method of clearing unwanted particles by clapping their shell) at SSCs of <100 mg/l and up to 700 mg/l (Szostek *et al.,* 2013). King and queen scallop are both more mobile than many other shellfish species and are likely able to avoid active construction activities causing increases in SSC. It has been proposed that scallops may be able to visually detect the size and speed of moving particles to identify preferrable feeding conditions (Speiser and Johnsen, 2008), thus supporting the notion that they will display avoidance behaviour. Queen scallop are believed to be more mobile that king scallop, although this is yet to be quantified (Howarth and Stewart, 2014). King and queen scallop both have high intensity spawning grounds within the eastern Irish Sea and are important commercial species within the region. However, given the relatively low level of SSCs and deposition modelled (generally within background levels), their avoidance behaviour, and the large area available alternatively for spawning, this impact is unlikely to affect king and queen scallop populations in the short or long term. Similarly, king scallop has been assessed as having high tolerance, high recoverability, and low sensitivity to increased SSCs, smothering, and increase in turbidity in the MarESA (Marshall and Wilson, 2008), although no assessment is currently available for queen scallop.

Overall, all shellfish IEFs are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be low.

Diadromous Fish

The diadromous fish IEFs are expected to have some tolerance to naturally high SSCs, given their migration routes typically require them to travel through estuarine habitats, which have background SSCs that are considerably higher than in offshore areas. As the construction activities will only produce temporary and short-lived increases in SSC, with levels well below those experienced in estuarine environments, it is predicted that diadromous fish IEFs will only temporarily affected at most (if they are affected at all, based on the timing of the construction phase and their migratory seasons). Any adverse effects on these species are likely to be short term behavioural effects, such as temporary slightly erratic alarmed swimming behaviour (Chiasson, 2011), or avoidance behaviour, which has been recorded in diadromous species such as Coho salmon *Oncorhynchus kisutch*, Arctic grayling *Thymallus arcticus*, and rainbow trout *O. mykiss* (Newcombe and Jensen, 1996). While these species are not present within the regional fish and shellfish ecology study area, they share similar life histories and habitats to the diadromous fish IEFs identified as part of this assessment. Avoidance behaviour can occur at very low levels of suspended sediment (Wenger *et al.,* 2017), and studies on Coho salmon have illustrated that avoidance behaviour ceases post-disturbance or if the fish becomes acclimated (Berg, 1983; Berg and Northcote, 1985).

Overall, this impact is not expected to create any significant barrier to migration to rivers or estuaries used by these diadromous species within the regional fish and shellfish ecology study area. Diadromous fish IEFs in the regional fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptors is therefore, considered to be low. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the sensitivity of the freshwater pearl mussel IEF is also considered to be low.

Significance of Effect

Marine Fish

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.12.12.2 Decommissioning Phase

Activities in the decommissioning phase, such as removal of foundations, cables, and cable crossing protection, may lead to increases in SSCs and associated sediment deposition.

Magnitude of Impact

All Species

Based on the MDS (Table 7.22), the removal of foundations, cables, and cable crossing protection would result in increased SSCs and associated deposition within the Proposed Development. It is assumed that the increases in SSCs and associated sediment deposition generated in the decommissioning phase would be of a lower extent than that of the construction phase. This is due to the absence of seabed preparation activities, drilling, and depositing of drill cuttings, which account for additional increases in SSCs and associated deposition in the construction phase.

The impact is predicted to be of local spatial extent, short term duration (for the individual decommissioning activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of Receptor

All Species

The sensitivities of all fish and shellfish IEFs (marine fish, shellfish, and demersal species) presented in the assessment of this impact in the construction phase equally apply in the decommissioning phase (low to medium).

Significance of Effect

Marine Fish

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

Marine Mammals and Marine Turtles

7.12.13 Underwater Noise and Marine Mammals and Marine Turtles

Elevated underwater noise generated during various activities in the construction, operation and maintenance, and decommissioning of the Proposed Development is a key impact for marine mammals and marine turtles and forms the majority of impacts assessed in this section. Therefore, a brief overview on underwater noise and marine mammals and marine turtles is provided in the following paragraphs.

7.12.13.1 General Overview

Marine mammals, particularly cetaceans, are able to generate and detect sound, and are dependent on sound for many aspects of their lives (Au, *et al.,* 1974; Bailey *et al.,* 2010). This includes foraging and prey identification, avoiding predators, navigation, and communication. Anthropogenic increases in underwater noise may consequently impact marine mammals (Parsons *et al.,* 2008; Bailey *et al.,* 2010).

Richardson *et al.* (1995), describes four zones of influence of underwater noise on marine mammals, which vary with the distance from the source. These include audibility (detection of the sound), masking (interference with detection of sounds and communication), responsiveness (behavioural or physiological response to the sound) and injury/hearing loss (tissue damage in the ear) (Richardson *et al.,* 1995). This assessment of impacts relating to underwater noise in this section consider the zones of auditory injury and disturbance (i.e. responsiveness). There is insufficient scientific evidence to properly evaluate masking and no relevant threshold criteria to enable a quantitative assessment. The relevant thresholds for onset of effects, and the evidence base from which they are derived, are given below.

While marine turtles are also capable of detecting sound, there is limited information on auditory criteria for them, and the effect of underwater noise is therefore inferred from documented effects to other vertebrates. Bone conducted hearing is the most likely mechanism for auditory reception in marine turtles and, since high frequencies are attenuated by bone, the range of hearing are limited to low frequencies only. For example, the hearing range of leatherback turtle has been recorded as between 50 Hz and 1,200 Hz with maximum sensitivity between 100 Hz and 400 Hz (Piniak, 2012).

7.12.13.2 Marine Mammals

Auditory Injury

As discussed for fish and shellfish in section 7.12.11 above, auditory injury in marine mammals can occur either as a TTS, where an animal's auditory system can recover, or PTS, where there is no hearing recovery in the animal. The 'onset' of TTS is deemed to be where there is a temporary elevation in the hearing threshold by 6dB and is "*the minimum threshold shift clearly larger than any day to day or session to session variation in a subject's normal hearing ability*", and which "*is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions*" (Southall *et al*., 2007). Since it is considered unethical to conduct experiments measuring PTS in animals, the onset of PTS was extrapolated from early studies on TTS growth rates in chinchillas and is conservatively considered to occur where there is 40dB of TTS (Southall *et al.,* 2007).

Potential auditory injury is assessed in terms of PTS due to the irreversible nature of the effect, unlike TTS which is temporary and reversible. Animals (particularly highly mobile species) exposed to sound levels that could induce TTS are likely to respond by moving away from (fleeing) the ensonified area and therefore avoiding potential injury. It is considered there is a behavioural response (disturbance) that overlaps with potential TTS ranges. Since derived thresholds for the onset of TTS are based on the smallest measurable shift in hearing, TTS thresholds are likely to be very precautionary and could result in overestimates of TTS ranges.

Noise propagation models can be constructed to allow the received noise level at different distances from the source to be calculated. To determine the consequence of these received levels on any marine mammals which might experience such noise emissions, it is necessary to relate the levels to known or estimated impact thresholds. The injury criteria proposed by Southall *et al*. (2019) are based on a combination of linear (i.e. un-weighted) SPLs and mammal hearing weighted SELs. The hearing weighting function is designed to represent the bandwidth for each group within which acoustic exposures can have auditory effects. The categories include:

- Low Frequency (LF) cetaceans (minke whale);
- High Frequency (HF) cetaceans (bottlenose dolphin, common dolphin, Risso's dolphin);
- Very High Frequency (VHF) cetaceans (harbour porpoise); and
- Phocid Carnivores in Waters (PCW) (grey seal and harbour seal).
- these weightings have been used in this assessment, and are shown in Figure 7.8.

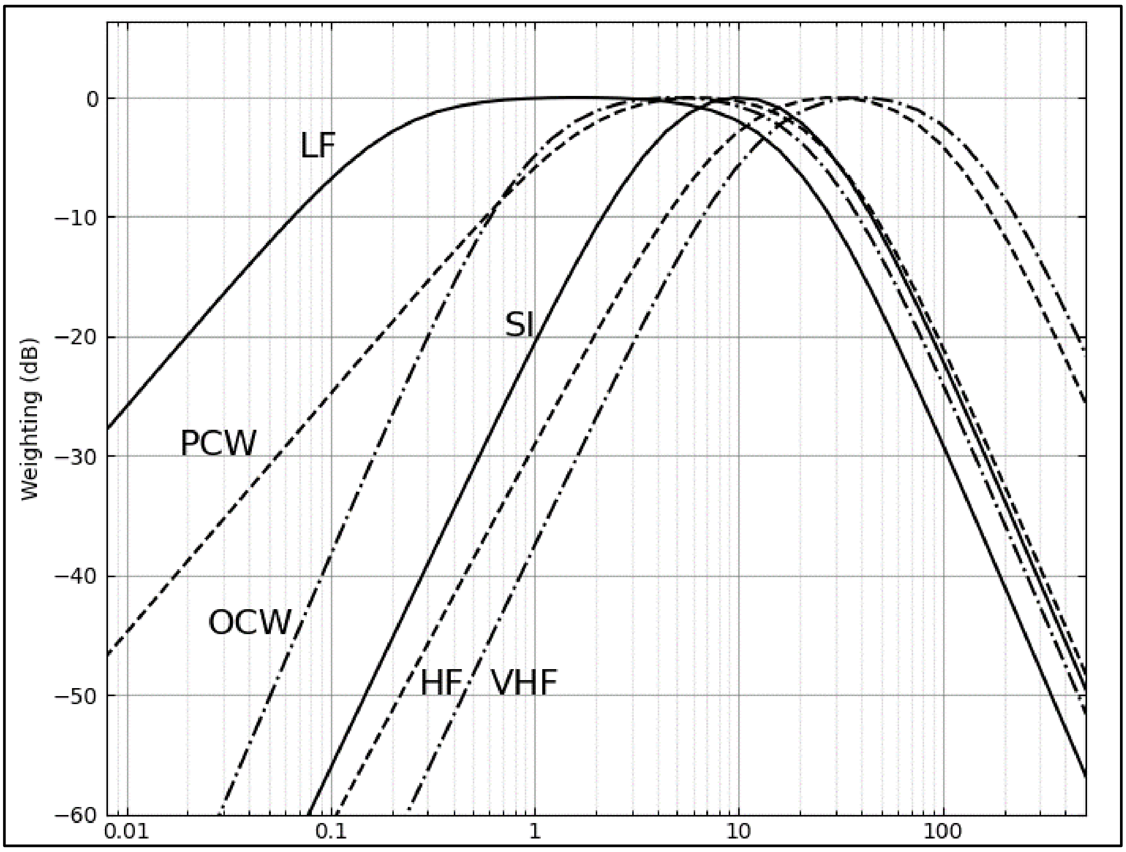


Figure 7.8: Hearing Weighting Functions For Marine Mammals (Source: Southall *et al.,* 2019) (SI = Sirenians, OCW = Other Marine Carnivores In Water)

Southall *et al.* (2019) also present injury criteria for two different types of underwater noise:

- **Impulsive sound**: which are typically transient, brief (less than 1 second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay (American National Standards Institute (ANSI) 1986; National Institute for Occupational Safety and Health (NIOSH) 1998; ANSI 2005). This category includes sound sources such as seismic surveys, impact piling and underwater explosions
- **Non-impulsive sound**: which can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent and typically do not have a high peak sound pressure with rapid rise/decay time that impulsive sounds do (ANSI 1995; NIOSH 1998). This category includes sound sources such as continuous running machinery, drilling, sonar and vessels.

The criteria for impulsive and non-impulsive sound have been adopted for this assessment, given the nature of the sound source used during construction activities. The relevant criteria for the onset of both PTS and TTS proposed by Southall *et al.* (2019) are summarised in Table 7.48. These injury thresholds are based on both SPLpk (i.e. un-weighted) and marine mammal hearing-weighted SEL as per the latest guidance (Southall *et al.,* 2019).

Table 7.48: Summary Of PTS And TTS Onset Thresholds For Marine Mammals (Source: Southall *et al.,* 2019)

Hearing Group	Parameter	PTS Onset Threshold		TTS Onset Threshold	
		Impulsive	Non-impulsive	Impulsive	Non-impulsive
LF	SPL_{pk}, unweighted	219	-	213	-
	SEL, LF weighted	183	199	168	179
HF	SPL_{pk}, unweighted	230	-	224	-
	SEL, HF weighted	185	198	170	178
VHF	SPL_{pk}, unweighted	202	-	196	-
	SEL, VHF weighted	155	173	140	153
PCW	SPL_{pk}, unweighted	218	-	212	-
	SEL, PCW weighted	185	201	170	181

To calculate distances using the SEL_{cum} metric, the underwater noise modelling assessment made a simplistic assumption that an animal would be exposed over the duration of the piling activity and that there would be no breaks in activity during this time. It was assumed that an animal would swim away from the sound source at the onset of activity at a constant rate and subsequently, conservative species-specific swim speeds were incorporated into the model. As a marine mammal swims away from the sound source, the noise it experiences will become progressively more attenuated; the cumulative SEL is derived by logarithmically adding the SEL to which the mammal is exposed as it travels away from the source. This calculation was used to estimate the approximate minimum start distance for a marine mammal in order for it to be exposed to sufficient sound energy to result in the onset of potential injury. It should be noted that the sound exposure calculations are based on the simplistic assumption that the animal will continue to swim away at a fairly constant relative speed. The real-world situation is more complex, and the animal is likely to move in a more complex manner.

The swim speeds of marine mammals used in this assessment are summarised in Table 7.49.

Table 7.49: Swim Speeds Assumed For Exposure Modelling

Species	Hearing Group	Swim Speed (m/s)	Reference
Harbour porpoise	VHF	1.5	Otani *et al.,* 2000
Bottlenose dolphin	HF	1.52	Bailey and Thompson, 2010
Common Dolphin	HF	1.52	
Risso’s dolphin	HF	1.52	
Minke whale	LF	2.3	Boisseau *et al.,* 2021
Grey seal	PCW	1.8	Thompson, 2015
Harbor seal	PCW	1.8	

In addition, the assumptions and limitations of underwater noise modelling (e.g. equal energy rule, reduced sound levels near the surface, conservative swim speeds, and use of impulsive sound thresholds at large ranges) also lead to an overestimation of ranges. Notably, Hastie *et al.* (2019) reported that during piling operations, there were range dependent changes in signal characteristics with received sound losing its impulsive characteristics at ranges of several kilometres, especially beyond 10 km. As such, TTS is not considered to be a useful predictor of the effects of underwater sound on marine mammals where ranges exceed more than 10 km and therefore, where this is the case (i.e. piling and UXO clearance), TTS is not included in the final assessment of significance for injury. Ranges for TTS were modelled for completeness for all noise-related impacts and are presented in this chapter and in volume 3, Underwater Noise Technical Report (RPS Group and Seiche, 2024)volume 3, appendix J.

Behavioural Disturbance

Beyond the area in which injury may occur, the effect on marine mammal behaviour is the most important measure of impact. Significant (i.e. non-trivial) disturbance may occur when there is a risk of animals incurring sustained or chronic disruption of behaviour or when animals are displaced from an area, with subsequent redistribution being significantly different from that occurring due to natural variation.

To consider the possibility of significant disturbance resulting from the Proposed Development, it is therefore necessary to consider the likelihood that the sound could cause non-trivial disturbance, the likelihood that the sensitive receptors will be exposed to that sound and whether the number of animals exposed are likely to be significant at the population level. Assessing this is however a very difficult task due to the complex and variable nature of sound propagation, the variability of documented animal responses to similar levels of sound, and the availability of population estimates, and regional density estimates for all marine mammal species.

Southall *et al.* (2007) recommended that the only currently feasible way to assess whether a specific sound could cause disturbance is to compare the circumstances of the situation with empirical studies. JNCC (2010a) guidance indicates that a score of five or more on the Southall *et al.* (2007) behavioural response severity scale could be significant. The more severe the response on the scale, the lower the amount of time that the animals will tolerate it before there could be significant adverse effects on life functions, which would constitute a disturbance. The US National Marine Fisheries Service (NMFS) (NMFS, 2005) define strong disturbance in all marine mammals as Level B harassment and suggest a threshold of 160 dB re 1 µPa (rms) for impulsive noise. This threshold meets the criteria defined by the JNCC (2010a) as a ‘non-trivial’ (i.e. significant) disturbance and is equivalent to the Southall *et al*. (2007) severity score of five or more on the behavioural response scale. Beyond this threshold the behavioural responses are likely to become less severe (e.g. minor changes in speed, direction and/or dive profile, modification of vocal behaviour and minor changes in respiratory rate (Southall *et al.,* 2007)). The NMFS guidelines suggest a precautionary level of 140 dB re 1 µPa (rms) to indicate the onset of low-level marine mammal disturbance effects for all mammal groups for impulsive sound, although this is not considered likely to lead to a ‘significant’ disturbance response (NMFS, 2005). For continuous noise, the NMFS (2005) guidance sets the marine mammal level B harassment of 120 dB re 1 µPa (rms). This value sits approximately mid-way between the range of values identified in Southall *et al.* (2007) for continuous sound but is lower than the value at which the majority of mammals responded at a response score of six (i.e. once the received rms sound pressure level is greater than 140 dB re 1 µPa). Considering the paucity and high-level variation of data relating to onset of behavioural effects due to continuous sound, it is recommended that any ranges predicted using this number are viewed as probabilistic and potentially over precautionary.

To demonstrate the variation in behavioural responses of marine mammals, Graham *et al.* (2017) used empirical evidence collected during piling at the Beatrice OWF (Moray Firth, Scotland) to demonstrate that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the source. The study showed a 100% probability of disturbance at an (un-weighted) SEL of 180 dB re 1 µPa^{2}s, 50% at 155 dB re 1 µPa^{2}s and dropping to approximately 0% at an SEL of 120 dB re 1 µPa^{2}s. The dose response thresholds tie in with the NMFS (2005) criteria since a mild behavioural response is suggested to occur at a threshold of 140 dB re 1 µPa (rms) which is equivalent of 130 dB 1 µPa^{2}s where a small response (approximately 10% of animals) would occur according to the dose response. In addition, Graham *et al.* (2019) demonstrated that the response of harbour porpoise to piling diminished over the piling phase. For a given received sound level or at a given distance from the source, there were more detections of animals at the last piling location compared to the first piling location (Graham *et al.,* 2019). Dose response is an accepted approach to understanding the behavioural effects from piling and has been applied at other UK offshore projects, such as Seagreen OWF (Seagreen Wind Energy Ltd, 2012) and Hornsea Project Three (GoBe, 2018).

Similarly, a telemetry study undertaken of tagged harbour seal during pile driving at the Lincs OWF (The Wash, England) found that there was a proportional response at different received sound levels (Russell *et al.,* 2016). Dividing the study area into a 25 km^2 grid, the authors modelled Single-strike Sound Exposure Levels (SELss) and matched these to corresponding densities of harbour seal in the same grids during non-piling versus piling periods. The authors reported a significant decrease in usage (abundance) during piling at predicted received SEL levels of between 142 dB and 151 dB re 1μPa^{2}s (Russell *et al.,* 2016). More recently, the effects of piling sounds on harbour seal was investigated using tracking data from 24 individuals (Whyte *et al.,* 2020). Predicted SEL_{cum} experienced by each seal were compared to different auditory weighting functions and thresholds for TTS and PTS. The study used predictions of seal density during pile driving made by Russell *et al.* (2016) compared to distance from the OWF and predicted SELss by multiple approaches. Predicted seal density significantly decreased within 25 km or SELss (averaged across depths and pile installations) above 145 dB re 1 Ipa^2 (Whyte *et al.,* 2020).

This assessment adopts a conservative approach and uses the NMFS (2005) Level B harassment threshold of 160 dB re 1 μPa (rms) for impulsive sound. This is defined as having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild (NMFS, 2005). This is similar to the JNCC (2010a) description of non-trivial disturbance and has therefore been used as the basis for onset of behavioural change in this assessment. It is important to understand that exposure to sound levels in excess of the behavioural change threshold stated above does not necessarily imply that the sound will result in significant disturbance. As noted previously, it is also necessary to assess the likelihood that the sensitive receptors will be exposed to that sound and whether the numbers exposed are likely to be significant at the population level. For the assessment of disturbance to all marine mammals (except harbour porpoise), underwater noise effects were modelled using the NMFS (2005) criteria (Table 7.50).

Table 7.50:Disturbance Criteria For Marine Mammals Used In The Assessment (Source: NMFS, 2005)

Effect	Non-Impulsive Threshold	Impulsive Threshold (Other than Piling)
Mild disturbance (all marine mammals)	-	140 dB re 1µ Pa (rms)
Strong disturbance (all marine mammals)	120 dB re 1µ Pa (rms)	160 dB re 1µ Pa (rms)

A recent position statement from NRW (2023) presents a number of disturbance criteria specifically for assessing the impacts on harbour porpoise, which are summarised in Table 7.51 below. Given that the Proposed Development lies in Welsh waters, separate disturbance calculations have been undertaken for harbour porpoise based on the guidance summarised in Table 7.51.

Table 7.51:Disturbance Criteria For Harbour Porpoise From NRW (2023) Guidance

Source	Recommended Criteria
Piling	Dose-response curves, where available. Where these are not available, the recommended disturbance criteria for piling align with those for seismic surveys (see next row).
Seismic surveys	143 dB SEL_{ss} (Tougaard, 2021); 145 dB SEL_{ss} (Lucke *et al.* 2009); or 140 dB SEL_{ss} (ASCOBANS, 2014)
Geophysical surveys (SBP and sonar)	160 dB SPL_{rms} level B harassment (NMFS, 2005)
UXO	140 dB SEL (W_{vhf}) (Southall *et al.,* 2019)
Continuous noise	120 dB SPL_{rms} (NMFS 2005)

When applying these criteria, it is possible to provide quantification of the magnitude of effects with respect to the spatial extent of disturbance and subsequently the number of animals potentially disturbed (based on availably density information). Caution, however, should be taken when using this approach, as there are significant challenges for developing a comprehensive set of empirically derived criteria for such a diverse group of animals (Southall *et al.,* 2021). Extensive data gaps have been identified (such as measurements of the effects of elevated noise on baleen whales) which mean that extrapolation from other species has been necessary. Sounds that disturb one species may, however, be irrelevant or inaudible to other species since there are broad differences in hearing across the frequency spectrum for different marine mammal hearing groups. Variance in responses even within a species are well documented to be context and sound-type specific (Ellison *et al*., 2012). In addition, the potential interacting and additive effects of multiple stressors (e.g. reduction in prey, noise and disturbance, contamination, etc.) is likely to influence the severity of responses (Lacy *et al.,* 2017).

For these reasons, neither a threshold approach nor a dose-response function was provided in the original guidance (Southall *et al.,* 2007) and subsequently the recent recommendations by Southall *et al.* (2021) also steer away from a single overarching approach. Instead, Southall *et al.* (2021) propose a framework for developing probabilistic response functions for future studies. The authors suggest different contexts for characterising marine mammal responses for both free-ranging and captive animals with distinctions made by sound sources (i.e. active sonar, seismic surveys, continuous/industrial sound and pile driving). Three parallel categories have been proposed within which a severity score from an acute (discrete) exposure can be allocated:

- Survival – defence, resting, social interactions and navigation.
- Reproduction – mating and parenting behaviours.
- Foraging – search, pursuit, capture and consumption.

Even where responses to these categories could be assigned, based on acute exposure, there is still limited understanding of how longer term (chronic) exposure could create impacts at the population level. To explore this, Southall *et al.* (2021) reported observations from long term whale watching studies and suggested that there were differences in the ability of marine mammals to compensate for long term disturbance which related to their breeding strategy. Mysticetes (i.e. baleen whales, such as minke whale) and grey seal are capital breeders, accumulating energy in their feeding grounds and transferring this to calves in their breeding ground. Grey seal often make long foraging trips from haul-out sites. Other marine mammals, such as harbour seal, bottlenose dolphin, and harbour porpoise are income breeders, meaning that they balance the costs of pregnancy and lactation by increased food intake, rather than depending on fat stores. In contrast to grey seal, harbour seal feed throughout the pupping season, and make shorter foraging trips from haul-outs sites. These different reproductive strategies can impact the energetic consequences of disturbance, and cause variation in an individual's vulnerability to disturbance (Harwood *et al.,* 2020).

In addition, the ability to compensate for chronic noise exposure will also depend on a range of ecological factors. These include the relative importance of the disturbed area and prey availability within their wider home range, the distance to and quality of other suitable sites, the relative risk of predation or competition in other areas, individual exposure history, and the presence of concurrent disturbances in other areas of their range (Gill *et al.,* 2001). For example, animals may be able to compensate for short-term disturbances by feeding in other areas, which would reduce the risk of longer-term population consequences. For harbour porpoise, foraging behaviour (intensity) and diet (largely target prey size) inform their vulnerability to disturbance, and if animals can find suitable high energy-density prey they may be capable of recovering from some lost foraging opportunities due to disturbance (Booth, 2020). Christiansen and Lusseau (2015) studied the effect of whale watching on minke whale in Faxafoi Bay, Iceland and found no significant long-term effects on vital rates, although years with low sandeel density led to increased exposure to whale watching as whales were forced to move into disturbed areas to forage. However, odontocetes (i.e. toothed whales, such as dolphins and harbour porpoise), may be more vulnerable to whale watching compared to baleen whales due to their more localised, and often, coastal home ranges. For example, Bejder *et al.* (2006) documented a decrease in local abundance of bottlenose dolphin which was associated with an increase in whale watching in a tourist area compared to a control area. If, however, there is no suitable habitat nearby, animals may be forced to remain in an area despite the disturbance, regardless of whether or not it could affect survival or reproductive success (Gill *et al*., 2001).

The marine mammal species considered in this assessment vary biologically and therefore have different ecological requirements that may affect their sensitivity to disturbance. In summation, Southall *et al.* (2021) clearly highlight the caveats associated with simple, one-size-fits-all, threshold approaches that could lead to errors in disturbance assessments. Recognising this inherent uncertainty in the quantification of effects the assessment has adopted a precautionary approach at all stages of assessment including:

- Conservative assumptions in the marine mammal baseline (e.g. use of seasonal density peaks, offshore and inshore densities)
- Conservative assumptions in the MDS for the project parameters (Table 7.23)
- Conservative assumptions in the underwater noise modelling (see volume 3, Underwater Noise Technical Report (RPS Group and Seiche, 2024)volume 3, appendix J).

Relevant assumptions have been described throughout this chapter and demonstrate that such layering of conservatism is likely to lead to a very precautionary assessment.

7.12.13.3 Marine Turtles

Auditory Injury

The relevant criteria for injury are considered those contained in the recent ‘Sound Exposure Guidelines for Fishes and Sea Turtles’, by Popper *et al.* (2014). These guidelines set out criteria for injury due to different sources of noise. Where insufficient data exist to determine a quantitative guideline value, the risk is categorised in relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (i.e. in the tens of metres), “intermediate” (i.e. in the hundreds of metres) or “far” (i.e. in the thousands of metres). It should be noted that these qualitative criteria cannot differentiate between exposures to different noise levels and therefore all sources of noise, no matter how noisy, would theoretically elicit the same assessment result.

The injury criteria used in this noise assessment for impulsive piling are given in Table 7.52, where both peak and SEL criteria are unweighted. Physiological effects relating to injury comprise of the following (Popper *et al.,* 2014; Popper and Hawkins, 2016):

- **Mortality and potential mortal injury**: either immediate mortality or tissue and/or physiological damage that is sufficiently severe (e.g. a barotrauma) that death occurs sometime later due to decreased fitness. Mortality has a direct effect upon animal populations, especially if it affects individuals close to maturity.
- **Recoverable injury**: Tissue and other physical damage or physiological effects, that are recoverable but which may place animals at lower levels of fitness, may render them more open to predation, impaired feeding and growth, or lack of breeding success, until recovery takes place.
- **TTS**: Short term changes in hearing sensitivity may, or may not, reduce fitness and survival. Impairment of hearing may affect the ability of animals to capture prey and avoid predators, and also cause deterioration in communication between individuals; affecting growth, survival, and reproductive success. After termination of a sound that causes TTS, normal hearing ability returns over a period that is variable, depending on many factors, including the intensity and duration of sound exposure.

Table 7.52: Criteria For The Onset Of Injury To Marine Turtles Due To Impulsive And Non-Impulsive Sound Sources (Source: Popper *et al.,* 2014)

Sound Source	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Impulsive Piling	SEL, dB re 1 μPa$_2$s	210	(Near) High (Intermediate) Low (Far) Low	(Near) High (Intermediate) Low (Far) Low
	Peak, dB re 1 μPa	>207		
Non-impulsive Sound	-	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
Explosives (e.g. UXO)	Peak, dB re 1 μPa	229 – 234	(Near) High (Intermediate) High (Far) Low	(Near) High (Intermediate) High (Far) Low

It should be noted that there are no thresholds in Popper *et al*. (2014) in relation to noise from high frequency sonar (>10 kHz). This is because the hearing range of marine turtle species falls well below the frequency range of high frequency sonar systems. Consequently, the effects of noise from high frequency sonar surveys on marine turtles has not been conducted as part of this study, due to the frequency of the source being beyond the range of hearing and also due to the lack of any suitable thresholds.

As above for marine mammals, it was assumed that marine turtles would swim away from the sound source at the onset of activity at a constant rate. Therefore, a conservative swim speed of 0.5 m/s (Popper *et al.,* 2014) was incorporated into the model.

Behavioural Disturbance

As above for injury, the most recent criteria for disturbance to marine turtles are considered to be those detailed in Popper *et al.* (2014). The risk of behavioural effects is categorised in relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (i.e. in the tens of metres), “intermediate” (i.e. in the hundreds of metres) or “far” (i.e. in the thousands of metres), as shown in Table 7.53. It is important to note that these criteria are qualitative rather than quantitative. Consequently, a source of noise of a particular type (e.g. piling) would result in the same predicted impact, no matter the level of noise produced or the propagation characteristics.

Table 7.53: Criteria For The Onset Of Behavioural Effects In Marine Turtles For Various Sound Sources (Source: Popper *et al.,* 2014)

Sound Source	Relative Risk of Behavioural Effects
Impulsive Piling	(Near) High (Intermediate) Moderate (Far) Low
Explosives (e.g. UXO)	(Near) High (Intermediate) High (Far) Low
Non-impulsive Sound	(Near) High (Intermediate) Moderate (Far) Low

7.12.14 Injury, Disturbance, and Displacement from Underwater Noise Generated during Piling

7.12.14.1 Construction Phase

Magnitude of Impact

The MDS for this impact is based on the piling of up to four jacket foundations for the new Douglas platform with a maximum hammer energy of 3,000 kJ (Table 7.23). This will require a total of eight piles, with a maximum of 100 minutes of piling each. Therefore, there will be a total of 800 minutes of piling required, which equates to just under 13.5 hours. The magnitude of impact is based on the underwater noise modelling presented in)volume 3, appendix J. The piling injury ranges are based on a comparison to the relevant impulsive sound thresholds, and disturbance range are based on application of a dose-response curve, as described in section 7.12.13.

Auditory Injury

During impact piling the interaction with the seafloor and the water column is complex. In these cases, a combination of dispersion (i.e. where the waveform shape elongates), and multiple reflections from the sea surface and bottom and molecular absorption of high frequency energy, the sound will lose its impulsive shape after some distance (generally in order of several kilometres).

Southall (2021) discusses this aspect in detail, and notes that "…*when onset criteria levels were applied to relatively high-intensity impulsive sources (e.g. pile driving), TTS onset was predicted in some instances at ranges of tens of kilometres from the sources. In reality, acoustic propagation over such ranges transforms impulsive characteristics in time and frequency. Changes to received signals include less rapid signal onset, longer total duration, reduced crest factor, reduced kurtosis, and narrower bandwidth (reduced high-frequency content). A better means of accounting for these changes can avoid overly precautionary conclusions, although how to do so is proving vexing*". The point is reenforced later in the discussion which points out that "…*it should be recognized that the use of impulsive exposure criteria for receivers at greater ranges (tens of kilometres) is almost certainly an overly precautionary interpretation of existing criteria*".

Consequently, caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres from the sources.

The marine mammal PTS injury ranges due to impact piling with and without the use of an ADD for 30 minutes prior to the commencement of piling are shown in Table 7.54. As stated in section 7.11, the use of an ADD is an embedded mitigation measure. With 30 minutes of ADD activation, the threshold for PTS was not exceeded for any marine mammal hearing group (Table 7.54). For marine turtles, the SEL_{cum} threshold for mortality due to impact pile driving was also not exceeded (Table 7.55).

Table 7.54: Auditory Injury Ranges Based On The Cumulative SEL Metric For Marine Mammals Due To Impact Pile Driving Of The Platform Jackets, With And Without The Use Of An ADD (N/E = Threshold Not Exceeded)

Hearing Group	Threshold (Weighted SEL)	Range (m)	
		Without ADD	With 30 mins ADD
LF	PTS – 183 dB re 1 µPa^{2}s	1,000	N/E
	TTS – 168 dB re 1 µPa^{2}s	35,300	31,400
HF	PTS – 185 dB re 1 µPa^{2}s	N/E	N/E
	TTS – 170 dB re 1 µPa^{2}s	N/E	N/E
VHF	PTS – 155 dB re 1 µPa^{2}s	20	N/E
	TTS – 140 dB re 1 µPa^{2}s	8,660	5,960

Hearing Group	Threshold (Weighted SEL)	Range (m)	
		Without ADD	**With 30 mins ADD**
PCW	PTS – 185 dB re 1 µPa²s	N/E	N/E
	TTS – 170 dB re 1 µPa²s	3,710	585

Table 7.55: Injury Ranges For Marine Turtles Based On The Cumulative SEL Metric Due To Impact Pile Driving Based On The Cumulative SEL Metric (N/E = Threshold Not Exceeded)

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m)
Marine turtles	Mortality	210	N/E

The injury ranges for marine mammals based on peak pressure are summarised in Table 7.56 for both the first strike the animal experiences, and the phase of piling with the maximum sound energy. These ranges represent the potential zone for instantaneous injury. The injury ranges are therefore highly dependent upon the hammer energy, but independent of piling duration. It is assumed that, although the piling phase with the highest sound energy has larger injury ranges, the animal would have moved out of the ranges at the time those hammer energies are used. It is important to understand that a pile is a large and distributed source and therefore reporting injury ranges that are smaller than the physical size of the pile based on a point source sound level assumption (i.e. assumption of an infinitesimally small source size) could result in an overestimation of injury range. Harbour porpoise (VHF group) had the largest PTS injury range of 490 m for the maximum SPL (Table 7.56).

Table 7.56: Summary Of Peak Pressure Injury Ranges For Marine Mammals And Marine Turtles Due To The Phase Of Impact Piling Resulting In The Maximum Peak Sound Pressure Level, And Due To The First Hammer Strike

Hearing Group	Threshold (Unweighted Peak)	Range (m)	
		Max Peak Experienced	**First Hammer Strike**
LF	PTS – 219 dB re 1 µPa (pk)	180	45
	TTS – 213 dB re 1 µPa (pk)	184	77
HF	PTS – 230 dB re 1 µPa (pk)	41	17
	TTS – 224 dB re 1 µPa (pk)	69	29
VHF	PTS – 202 dB re 1 µPa (pk)	490	204
	TTS – 196 dB re 1 µPa (pk)	836	349
PCW	PTS – 218 dB re 1 µPa (pk)	118	49
	TTS – 212 dB re 1 µPa (pk)	201	84
Marine turtles	Mortality – 207 dB re 1 µPa (pk)	314	131

There is a possibility that multiple pin piles will need to be installed in a single 24-hour period. The potential SEL_{cum} injury ranges for marine mammals due to impact pile driving of pin piles are modelled as following the same piling schedule, but with continuous installation for 24 hours (this is an overestimation as the vessel will need to reposition). For injury the MDS considers a maximum of two adjacent piles at the same platform (Table 7.23). It is assumed that the marine mammal or marine turtle will swim away from the pile installation and not return to the area within the 24-hour period. As the piling schedule, and therefore the hammer energies, remain unchanged, the injury ranges due to the peak metric will be the same as those for the single pile case (Table

7.56). The results for the consecutive piling are shown in Table 7.57 for marine mammals and Table 7.58 for marine turtles. The PTS threshold was not exceeded for any marine mammal hearing group after 30 minutes of ADD activation. The highest TTS threshold after 30 minutes of ADD activation was 42,800 m for the LF hearing group (minke whale). For marine turtles, the SEL_{cum} threshold for mortality due to consecutive piling was not exceeded.

Table 7.57: Marine Mammal Injury Ranges For Consecutive Pin Pile Installation Based On The Cumulative SEL Metric (N/E = Threshold Not Exceeded)

Hearing Group	Threshold (Weighted SEL)	Range (m)	
		Without ADD	**With 30 min ADD**
LF	PTS – 183 dB re 1 µPa^{2}s	1,905	N/E
	TTS – 168 dB re 1 µPa^{2}s	46,900	42,800
HF	PTS – 185 dB re 1 µPa^{2}s	N/E	N/E
	TTS – 170 dB re 1 µPa^{2}s	N/E	N/E
VHF	PTS – 155 dB re 1 µPa^{2}s	22	N/E
	TTS – 140 dB re 1 µPa^{2}s	11,700	8,960
PCW	PTS – 185 dB re 1 µPa^{2}s	N/E	N/E
	TTS – 170 dB re 1 µPa^{2}s	6,280	3,050

Table 7.58: Marine Turtle Ranges For Consecutive Pin Pile Installation Based On The Cumulative SEL Metric (N/E = Threshold Not Exceeded)

Hearing Group	Response	Threshold (SEL, dB re 1 µPa^{2}s)	Range (m)
Marine turtles	Mortality	210	N/E

Overall, the embedded mitigation measure of ADD activation for 30 minutes resulted in no PTS injury thresholds being exceeded for marine mammals (Table 7.54 and Table 7.57). ADDs are commonly used to mitigate harm to marine mammals from offshore developments and are recommended by the JNCC (2010a) guidance for piling, particularly in periods of low visibility. There are a range of ADDs with different sound source characteristics available (McGarry *et al.,* 2020), and a suitable device will be consulted upon and decided post-submission of the ES. The selected device will be deployed from the piling vessel and activated for a determined duration to allow individuals sufficient time to flee from the source, whilst also minimising the addition sound introduced into the environment. Furthermore, the PTS injury ranges based on the SPL_{pk} thresholds are all within 500 m (Table 7.56). As per the JNCC (2010a) guidance, a standard 500 m mitigation zone will be applied as part of the MMMP, which is also an embedded mitigation measure (see Table 7.32).

Harbour Porpoise

Activation of an ADD for 30 minutes is an embedded mitigation measure for this impact (Table 7.32). As a VHF species, PTS ranges for single or consecutive pin piling were not exceeded with the activation of an ADD for 30 minutes (see Table 7.54 and Table 7.57). Further, PTS ranges for the first hammer strike (204 m) and maximum hammer energy (490 m) were within the standard mitigation zone of 500 m (Table 7.56). As stated in Table 7.32, a standard 500 m mitigation zone will be applied as part of the MMMP (JNCC, 2010a), which is an embedded mitigation measure applicable to this impact.

The population densities provided in Table 7.17 were used to assess the number of animals with the potential to be injured by the different piling scenarios modelled above. For harbour porpoise, the maximum injury range occurred for the maximum SPL_{pk} (490 m; Table 7.56). Only up to one harbour porpoise was assessed as potentially being impacted by this scenario, which corresponded to 0.0001% of the reference population for the Celtic and Irish Seas MU.

Harbour porpoise typically live between 12 years and 24 years and give birth once a year (Fisher and Harrison, 1970). The duration of the construction phase is up to two years, although only eight piles will be installed in this period (as defined in Table 7.23). Depending on the piling schedule, it could potentially overlap with a maximum of two breeding cycles. The duration of the effect in the context of the life cycle of harbour porpoise is classified as medium term, as the risk (albeit very small) is meaningful in the context of the lifespan of this species.

Overall, this impact is predicted to be of local spatial extent with respect to the ranges over which PTS could occur, medium term duration, intermittent throughout the construction phase and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. PTS could affect a small number of animals leading to measurable changes at an individual level, but this is unlikely to affect the wider population. The magnitude is therefore considered to be low.

Bottlenose Dolphin, Common Dolphin, and Risso's Dolphin

As HF species, PTS ranges for single or consecutive pin piling were not exceeded with or without the activation of an ADD for 30 minutes (see Table 7.54 and Table 7.57). Further, PTS ranges for the first hammer strike (17 m) and maximum hammer energy (41 m) were well within the standard mitigation zone of 500 m (Table 7.56) (JNCC, 2010a).

The population densities provided in Table 7.17 were used to assess the number of animals with the potential to be injured by the different piling scenarios modelled above. For the dolphin species, the maximum injury range occurred for the maximum SPL_{pk} (41 m; Table 7.56). For three species, only up to one animal was assessed as potentially being impacted by this scenario. For bottlenose dolphin, this corresponded to which corresponded to 0.00001% of the reference population for the Irish Sea MU. For common dolphin and Risso's dolphin, this corresponded to 0.0000001% and 0.000001% of the reference population of the Celtic and Irish Seas MU, respectively.

Overall, this impact is predicted to be of local spatial extent with respect to the ranges over which PTS could occur, medium term duration, intermittent throughout the construction phase and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since injury will be fully mitigated via the embedded mitigation there is no residual risk of injury. The magnitude of impact is therefore considered to be negligible.

Minke Whale

As LF species, PTS ranges for single or consecutive pin piling were not exceeded with the activation of an ADD for 30 minutes (see Table 7.54 and Table 7.57). Further, PTS ranges for the first hammer strike (45 m) and maximum hammer energy (180 m) were well within the standard mitigation zone of 500 m (Table 7.56) (JNCC, 2010a).

The population densities provided in Table 7.17 were used to assess the number of animals with the potential to be injured by the different piling scenarios modelled above. For minke whale, the maximum injury range occurred for consecutive piling without the use of an ADD (1,905 m; Table 7.57). Only up to one minke whale was assessed as potentially being impacted by this scenario, which corresponded to 0.001% of the reference population for the Celtic and Greater North Seas MU.

Minke whale typically live up to 60 years and have a gestation period of approximately ten months. Females may give birth to one calf every one to two years and calves are weaned over five to ten months. Therefore, the two-year construction phase could potentially overlap with key breeding/nursing cycles, although only eight piles will be installed. For an individual female, the risk (albeit small) could interrupt at least one key breeding period with additional risk to mother calf pairs during nursing. This is meaningful in the context of the lifetime of an individual and therefore is classed as medium term.

Overall, this impact is predicted to be of local spatial extent with respect to the ranges over which PTS could occur, medium term duration, intermittent throughout the construction phase and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. PTS could affect a small number of animals leading to measurable changes at an individual level, but this is unlikely to affect the wider population. The magnitude of impact is therefore considered to be low.

<u>Grey Seal and Harbour Seal</u>

For grey seal and harbour seal (PCW hearing group), PTS ranges for single or consecutive pin piling were not exceeded with or without the activation of an ADD for 30 minutes (see Table 7.54 and Table 7.57). Further, PTS ranges for the first hammer strike (49 m) and maximum hammer energy (118 m) were well within the standard mitigation zone of 500 m (Table 7.56) (JNCC, 2010a).

The population densities provided in Table 7.17 were used to assess the number of animals with the potential to be injured by the different piling scenarios modelled above. For both species, the maximum injury range occurred for the maximum SPL_{pk} (118 m; Table 7.56). Only up to one grey seal or harbour seal was assessed as potentially being impacted by this scenario. For grey seal, this corresponded to 0.0002% of the reference populations at the relevant Mus (see Table 7.17) and 0.0000003% of the OSPAR Region III population. For harbour seal, this corresponded to 0.00002% of the reference populations at the relevant Mus (Wales, NW England, and Northern Ireland).

Both seal species typically live between 20 years to 30 years with gestation lasting between ten months to 11 months (SCOS, 2021), thus the duration of piling (albeit intermittent over the two-year construction phase) could potentially overlap with up to two breeding cycles. Considering the above, the duration of the effect in the context of life cycle of harbour seal and grey seal is classified as medium term.

Overall, this impact is predicted to be of local spatial extent, medium term duration, intermittent throughout the construction phase and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since injury will be fully mitigated via the embedded mitigation there is no residual risk of injury. The magnitude of impact is therefore considered to be negligible.

<u>Marine Turtles</u>

Use of an ADD is not applicable to marine turtles, and therefore, was not modelled. However, the threshold for mortality for single and consecutive piling was not exceeded for (Table 7.55 and Table 7.58). Further, mortality ranges for the first hammer strike (131 m) and maximum hammer energy (314 m) were well within the standard mitigation zone of 500 m (Table 7.56) (JNCC, 2010a).

Injury ranges to marine turtles due to piling activities were not presented in the underwater noise modelling assessment ()volume 3, appendix J). As per the criteria by Popper *et al.* (2014) (Table 7.52), insufficient data exist to determine a quantitative guideline value for PTS. Instead, the available criteria for recoverably injury and TTS provide relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (i.e. in the tens of metres), “intermediate” (i.e. in the hundreds of metres) or “far” (i.e. in the thousands of metres). As such, only an assessment on the mortality threshold of marine turtles could be conducted (Table 7.55 and Table 7.58). However, the marine turtle populations within the regional marine mammal and marine turtle study area are likely to be lower than those of the marine mammal IEFs, and this study area does not represent important habitat for reproduction and nesting. Therefore, the two-year construction phase will not overlap with key reproductive events in their life cycles. Considering this, the duration of the effect in the context of life cycle of marine turtles is classified as short term.

Overall, this impact is predicted to be of local spatial extent, short term duration, intermittent throughout the construction phase and, although the impact itself is reversible (i.e. the elevation in underwater sound only occurs during piling), mortality is permanent. It is predicted that the impact will affect the receptor directly. Since the mortality thresholds for single and consecutive piling were not exceeded, the magnitude of impact is **negligible.**

Behavioural Disturbance

All Species

For the assessment of behavioural disturbance as a result of piling at the new Douglas platform, a dose-response approach has been applied for all species.

Empirical evidence from monitoring at OWFs during construction suggests that pile driving is unlikely to lead to 100% avoidance of all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al.,* 2011). This was demonstrated at Horns Rev OWF, where 100% avoidance occurred in harbour porpoise at up to 4.8 km from the piles, whilst at greater distances (10 km plus) the proportion of animals displaced reduced to <50% (Brandt *et al.,* 2011). Similarly, Graham *et al*. (2019) used empirical evidence collected during piling at the Beatrice OWF to demonstrate that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the sound source. For harbour porpoise, in line with current guidance for assessing behavioural disturbance to this species (NRW, 2023), the dose-response curve was applied as shown by Graham *et al*. (2017) where the probability of response approaches zero at approximately 120 dB SEL_{ss}. In the absence of species-specific data for other cetacean species the same dose response curve was assumed to apply to all cetacean IEFs in this assessment (Figure 7.9).

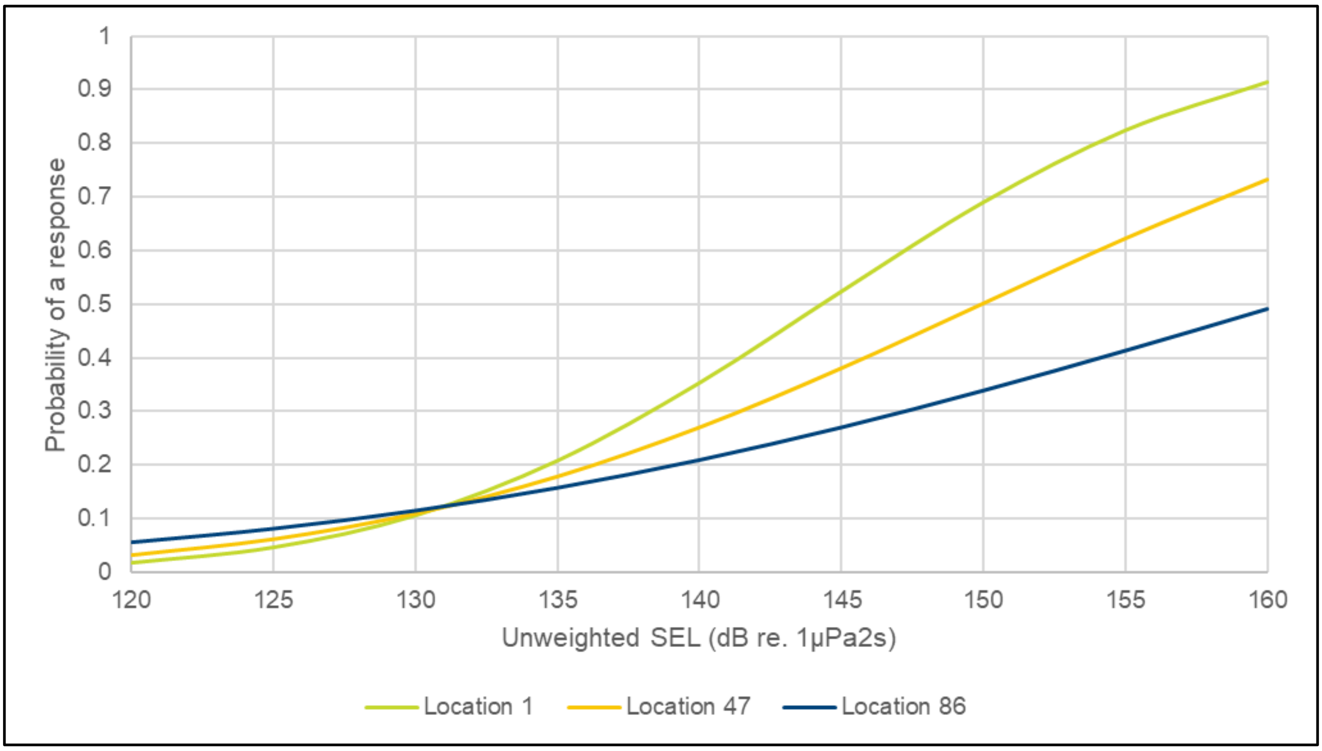


Figure 7.9: The Probability Of A Harbour Porpoise Response (24 hr) In Relation To The Partial Contribution Of Unweighted Received SEL_{ss} For The First Location Piled (Green), The Middle Location (yellow) And The Final Location (blue); Reproduced From Graham *et al*. (2019)

Similarly, a telemetry study undertaken by Russell *et al*. (2016) investigating the behaviour of tagged harbour seal during pile driving at the Lincs Offshore Wind Farm (The Wash) found that there was a proportional response at different received sound levels. Dividing the study area into a 5 km x 5 km grid, the authors modelled SEL_{ss} levels and matched these to corresponding densities of harbour seal in the same grids during non-piling versus piling periods to show change in usage. The study found that there was a significant decrease in usage (abundance) during piling at predicted received SEL levels of between 142 dB and 151 dB re 1µPa^{2}s.

More recently, a study by Whyte *et al. (*2020) used tracking data from 24 harbour seal to estimate the effects of pile driving sounds on this species. Predicted SEL_{cum} experienced by each seal were compared to different auditory weighting functions and thresholds for TTS and PTS. The study used predictions of seal density during pile driving made by Russel*l et al*. (2016) compared to distance from the wind farm and predicted SEL_{ss} by multiple approaches. Predicted seal density significantly decreased within 25 km or SEL_{ss} (averaged across depths and pile installations) above 145 dB re 1 lPa^2. Predictions of seal density, and changes in seal density, during piling were provided in Whyte *et al.* (2020), averaged across all water depths and piling events. A dose response curve derived from this study (Figure 7.10) was therefore applied to the seal assessment to determine the number of animals that may potentially respond behaviourally to received sound levels during piling. Unweighted SEL_{ss} contours were plotted in 5 dB isopleths in decreasing increments from 180 dB to 120 dB re. 1 µPa^{2}s using the highest modelled received sound level.

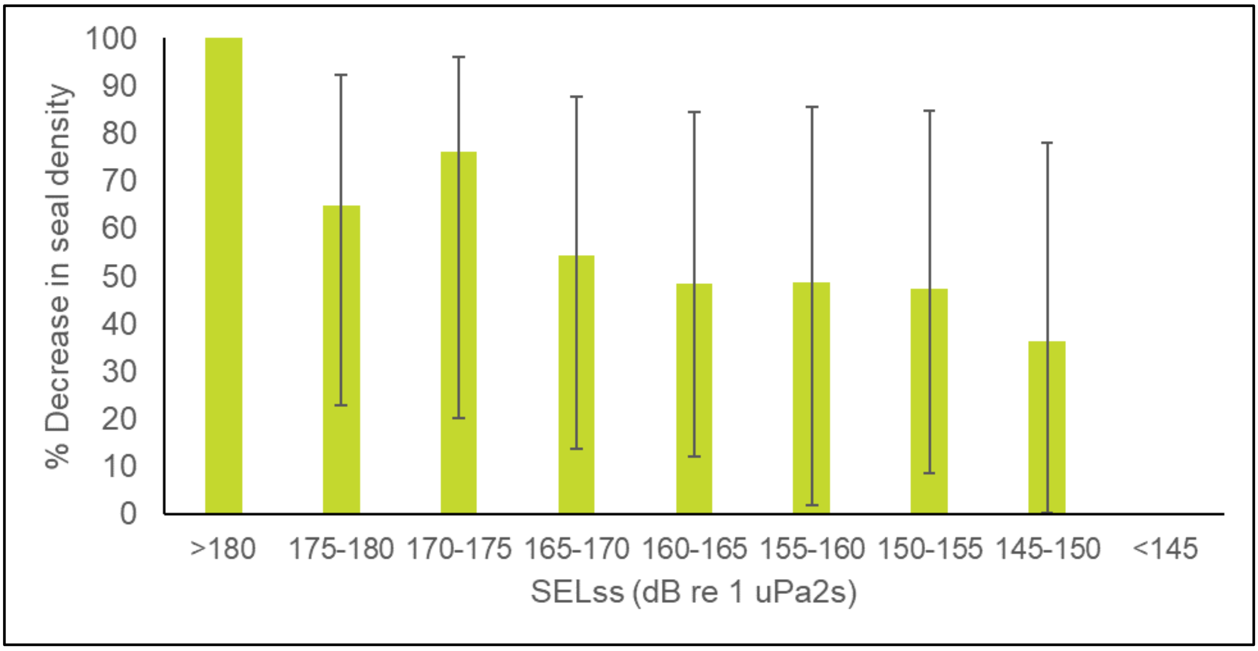


Figure 7.10: Predicted Decrease In Seal Density As A Function Of Estimated Sound Exposure Level, (Error Bars Show 95% CI) (From Whyte *et al.*, 2020)

To adopt the most precautionary approach, the dose-response contours were plotted in Geographical Information System (GIS) for the modelled piling location (Figure 7.11). The areas within each 5 dB isopleth were calculated from the spatial GIS map and a proportional expected response, derived from the dose response curve for each isopleth area, was used to calculate the number of animals potentially disturbed. These numbers were subsequently summed across all isopleths to estimate the total number of animals disturbed during piling. The number of animals predicted to respond was based on species-specific densities as agreed with statutory consultees (Table 7.17).

Using the dose-response approach as per NRW guidance (NRW, 2023) for harbour porpoise based on the SCANS-III Block F density estimate of 0.086 animals per km^2, 158 animals have the potential to be disturbed, representing 0.25% of the reference population of the Celtic and Irish Sea MU (Table 7.59). When this is based upon the recent SCANS-IV Block CS-E density estimate (0.5153 animals per km^2), this is equivalent to 945 animals or 1.51% of the reference population. The large increase in harbour porpoise density between SCANS-III Block F (0.086 animals per km^2) and SCANS-IV Block CS-E (0.5153 animals per km^2) is unlikely to represent a long-term increase, given the short timeframe over which the increase has occurred and the 'snap-shot' nature of the SCANS surveys. For these reasons, these two density estimates have been considered as the lower and upper limits, with actual density likely sitting within this range.

For bottlenose dolphin, 20 animals (6.51% of the Irish Sea MU population) were predicted to be disturbed. However, this increased to 65 animals (21.91%) for the density estimates for Cardigan Bay (0.035 animals per km^2) derived from Lohrengel *et al.* (2018). It should be noted that the densities derived from Lohrengel *et al.* (2018) are more precautionary, and the prediction of 20 bottlenose dolphin is more realistic. Similarly, for grey seal, 125 animals were predicted to be disturbed using the average densities from Carter *et al.* (2022) overlaid on the Proposed Development marine mammal and marine turtle study area. In contrast, if the maximum densities were used, this value increased to 1,084 animals. It should be noted that the value of 125 grey seal is more realistic. A similar trend was also observed for harbour seal (Table 7.59).

For all other marine mammal IEFs, the number of animals with the potential to be disturbed was predicted to be <100 and represented <0.5% of their respective reference populations (Table 7.59).

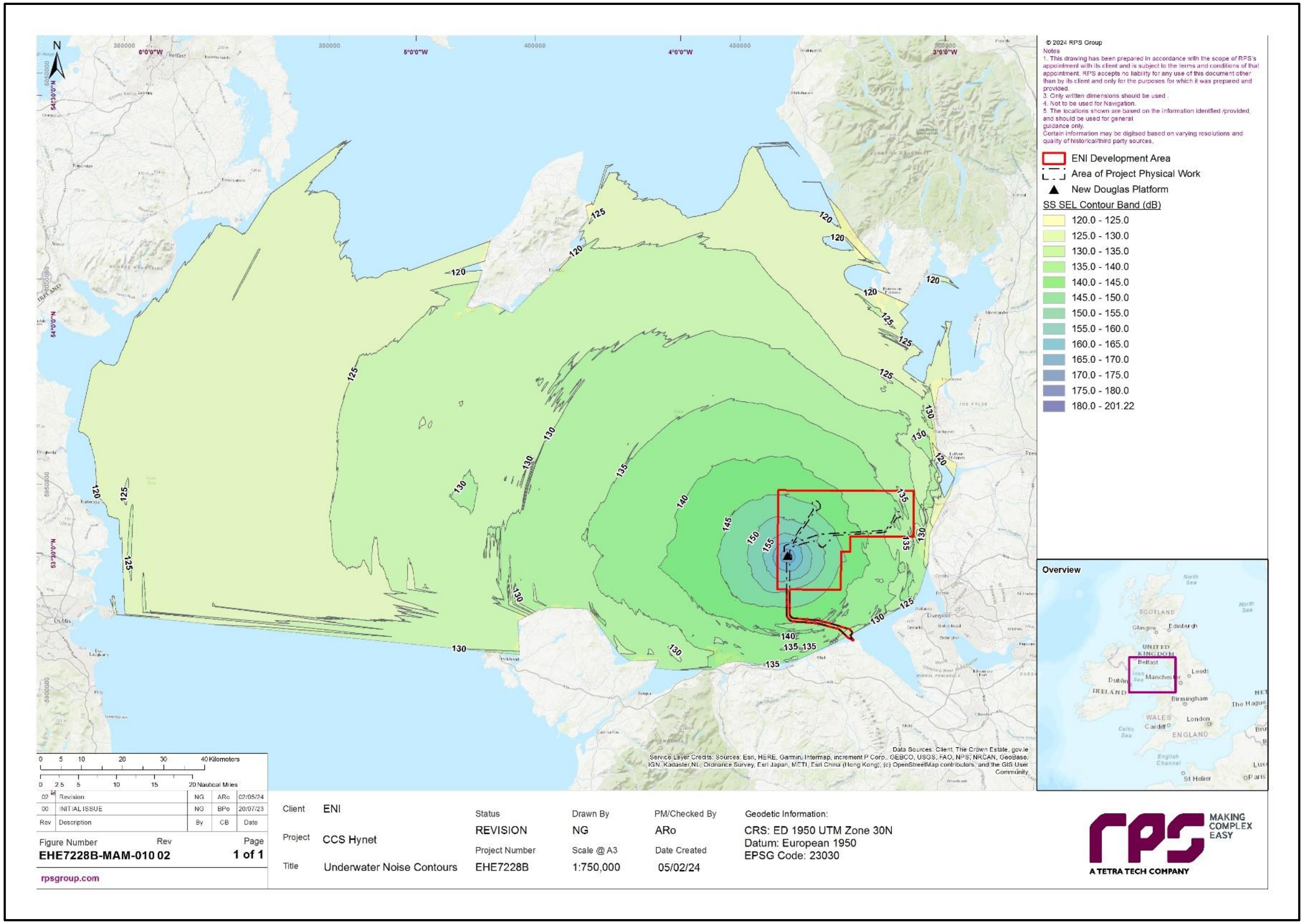


Figure 7.11: Maximum Adverse Piling Scenario At The Greatest Spatial Extent, Showing SEL_{ss} Noise Contours In 5 dB Isopleths

Table 7.59: Potential Number Of Animals Predicted To Be Disturbed Within Weighted SEL_{ss} Noise Contours As A Result Of Piling. Densities Derived From The Sources Presented In Table 7.17

Species	Density (animals per km^2)	New Douglas Platform Pile Installation		
		Number of Animals (based on dose-response)	% Reference Population (MU)	% OSPAR III Region
Harbour porpoise	0.086	158	0.25	N/A
	0.515	945	1.51	N/A
Bottlenose dolphin	0.010	20	6.51	N/A
	0.035	65	21.91	N/A
Common dolphin	0.027	50	0.05	N/A
Risso's dolphin	0.0313	58	0.47	N/A
Minke whale	0.009	17	0.08	N/A
Grey seal	0.467	125	0.92	0.21
	4.06	1,084	7.99	1.78
Harbour seal	0.0049	2	0.09	N/A
	0.593	159	11.1	

As only eight piles will be installed throughout the 2-year construction phase with an expected maximum total piling duration of 800 minutes (approximately 3.5 hours), behavioural disturbance will be short term and intermittent over the construction phase. As animals are expected to recover quickly after disturbance, only a minor alteration to the distribution of individuals within the regional marine mammal and marine turtle study area is possible. Regardless of the small scale of the response, behavioural disturbance associated with piling will be reduced by tertiary mitigation summarised in Table 7.32 and described in volume 4: Marine Mammal Mitigation Plan. Similarly, primary measures employed to mitigate injury (Table 7.32) are also expected to reduce disturbance due to piling. Overall, the impact of piling leading to behavioural effects is predicted to be of local spatial extent, short term duration, and intermittent over the construction phase. Further, the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Therefore, for all marine mammal IEFs, the magnitude of impact is considered to be low.

As there are no population densities available for marine turtles (Table 7.17), a qualitative assessment was not possible. However, the marine turtle populations within the regional marine mammal and marine turtle study area are likely to be lower than those of the marine mammal IEFs, and this study area does not represent important habitat for reproduction and nesting. As marine turtles are not as sensitive to underwater noise as marine mammals, the magnitude of impact is not likely to be higher than that presented for the marine mammal IEFs. Therefore, a low magnitude of impact can be extrapolated from that presented above for the marine mammal IEFs.

Sensitivity of Receptor

Auditory Injury

<u>Harbour Porpoise</u>

It has been reported that hearing impairment due to exposure to piling noise is likely to occur where the source frequencies overlap the range of peak sensitivity for the receptor species rather than across the whole frequency hearing spectrum (Kastelein *et al*., 2013). This study demonstrated that harbour porpoise hearing around 125 kHz (the key frequency for echolocation) was not affected by simulated piling sound (broadband spectrum). Rather, a measurable threshold shift in hearing was induced between frequencies of 4 kHz to 8 kHz, although the magnitude of the shift was relatively small (2.3 dB to 3.6 dB at 4 kHz to 8 kHz). This relatively small shift was due to most of the energy from the simulated piling occurring in lower frequencies, which generate lower received SELs (Kastelein *et al.,* 2013). More recently, the authors confirmed that sensitivity declined sharply above 125 kHz (Kastelein *et al.,* 2017), providing further information to confirm the hearing range and sensitivities of harbour porpoise.

In addition to sound frequency, the duty cycle of fatiguing sounds is also likely to affect the magnitude of a hearing shift in harbour porpoise. For example, it has been suggested that hearing may recover to some extent during inter-pulse intervals, and that fatiguing sound is an important parameter in determining the magnitude of TTS (Kastelein *et al*., 2014). Similarly, Finneran (2015) highlights that whilst a threshold shift can accumulate across multiple exposures, the resulting shift will be less than the shift from a single, continuous exposure with the same total SEL. Again, this suggests that the ranges predicted by the underwater noise model using the SEL_{cum} metric are likely to be overestimates.

When assessing sensitivity to injury, a clear distinction between PTS and TTS must be made. TTS is temporary and reversible hearing damage, and therefore it is anticipated that any animals experiencing TTS would recover after they are no longer exposed to elevated noise levels (i.e. they may have moved beyond the injury zone or piling has ceased). The implication of animals experiencing TTS, leading to potential displacement, is not fully understood, but it is likely that aversive responses to anthropogenic noise could temporarily affect life functions, such as communication, foraging, mating, and predator detection. However, acute effects are less likely due to the reversibility of TTS. Further, in order to minimise exposure to sound, some cetaceans are able to undertake some self-mitigation measures, such as changing the orientation of the head to reduce sound levels reaching the ears. They may also be able to suppress hearing sensitivity by one or more neurophysiological auditory response control mechanisms in the middle ear, inner ear, and/or central nervous system. Self-mitigation has been reported for harbour porpoise by Nachtigall *et al.* (2017), who demonstrated a change in hearing levels when exposed to a loud warning sound. Kastelein *et al.* (2020) highlighted the lack of reproducibility of TTS in a harbour porpoise after exposure to repeated airgun sounds, suggesting that these discrepancies may be due to self-mitigation. The characteristics of the sound that the animal is exposed and the shift in hearing experienced will influence the degree and speed of hearing recovery. Following exposure to a sound source of 75 db re 1 µPa (SEL) over 120 minutes found that harbour porpoise recovery to the pre-exposure threshold was estimated to be complete within 48 minutes after exposure (e.g. the higher the hearing threshold shift, the longer the recovery) (Sea Mammal Research Company (SEAMARCO), 2011). Scientific understanding of this is limited to the results of controlled exposure studies on small numbers of captive animals (reviewed in Finneran, 2015). Therefore, extrapolating these results to the natural environment should be treated with caution as it is not possible to exactly replicate natural environmental conditions in captive studies. Furthermore, the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response. Overall, since TTS is reversible, harbour porpoise is assessed as having high tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of harbour porpoise to TTS is therefore considered to be low.

On the contrary, PTS is permanent and irreversible hearing damage. Thus, it is expected that harbour porpoise is sensitive to PTS as it would affect key life functions (e.g. communication, predator detection, foraging, mating, and maternal fitness) and could lead to a chronic and/or acute health problems (Erbe *et al.,* 2018). Due to a lack of empirical data, it is challenging to equate onset of PTS with biologically significant responses, however a potential consequence is a deterioration in health, which could potentially lead to reduced birth rate in females and mortality of individuals (Costa, 2012). The assessment of sensitivity takes into account the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication. Although a threshold shift may occur outside of the most sensitive hearing range, the occurrence of PTS in harbour porpoise, due to the species reliance on hearing, could be detrimental to an individual’s capacity for survival and reproduction. Since PTS is irreversible, harbour porpoise is assessed as high vulnerability, low recoverability, low tolerance, and international value. The sensitivity of harbour porpoise to PTS is therefore considered to be high.

Bottlenose Dolphin, Common Dolphin, and Risso's Dolphin

PTS would induce a biological effect that could impact the health and vital rates of these dolphin species (Erbe *et al*., 2018), which are all classed as HF cetaceans (Southall *et al*., 2019). As described for harbour porpoise above, there are frequency-specific differences in the onset and growth of a sound-induced threshold shift in relation to the characteristics of the sound source and hearing sensitivity of the receiving species. For example, Finneran and Schlundt (2013) demonstrated that exposure of two captive bottlenose dolphin to an impulsive sound source between 3 kHz and 80 kHz increased susceptibility to auditory fatigue between frequencies of 10 kHz. to 30 kHz. The SEL_{cum} threshold incorporates hearing sensitivities of marine mammals and the magnitude of effects for HF species are considerably smaller compared to the VHF species (e.g. harbour porpoise) and LF species (e.g. minke whale). This highlights that species such as bottlenose dolphin, common dolphin and Risso's dolphin are less sensitive to the frequency components of the piling sound signal. Self-mitigation has also been reported for bottlenose dolphin by Nachtigall *et al.* (2017), who demonstrated that a change in hearing levels when exposed to a loud warning sound. The assessment of sensitivity considered the irreversibility of the effects (as noted for harbour porpoise above) and importance of sound for echolocation, foraging and communication in small, toothed cetaceans.

Although there are no species-specific recovery rates for these dolphin species to TTS available, there is no evidence to suggest that recovery rates will be significantly different to those for harbour porpoise. Therefore, the hearing of these dolphin species will recover once they are no longer exposed to elevated noise levels (i.e. they may have moved beyond the injury zone or piling has ceased). Given that bottlenose dolphin, common dolphin, and Risso's dolphin would be able to tolerate TTS without any impact on reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased, these species are of medium vulnerability, high tolerance, high recoverability and international value. The sensitivity of these receptors to TTS is therefore considered to be low.

The assessment of sensitivity provided below takes into account the uncertainty surrounding the effects of PTS on survival and reproduction and the importance of sound for echolocation, foraging and communication. Bottlenose dolphin, short-beaked dolphin and Risso's dolphin are deemed to have low tolerance to PTS, low recoverability, high vulnerability, and international value. Therefore, the sensitivity of these receptors to PTS is considered to be high.

Minke Whale

Unlike dolphins and harbour porpoise, minke whale do not echolocate. However, they can produce and hear sounds, via a skull vibration enabled bone conduction mechanism and are likely to do so for communication (Cranford and Krysl, 2015). Although empirical evidence on minke whale hearing is limited, however it has been indicated that their hearing is likely to operate at similar frequencies to those of anthropogenic noise sources (Tubelli, *et al.,* 2012). Minke whale are baleen whales, which have an estimated functional hearing range between 17 Hz and 35 kHz, and it is likely that they rely on LF hearing (Ketten and Mountain, 2009). More recently, a best frequency range of between 30 Hz to 7.5 kHz or between 100 Hz to 25 kHz (depending on stimulation location) was predicted for the middle ear transfer function in minke whale (i.e. a measure of the transmission of acoustic energy from the external ear to the cochlea) (Tubelli, *et al.,* 2012). Similarly, a strong reaction to a 15 kHz ADD was recorded in a controlled exposure study on free-ranging minke whale in Iceland, suggesting that this frequency is the likely upper limit of their hearing sensitivity (Boisseau *et al.,* 2021). As described for harbour porpoise above, there are likely to be frequency-specific differences in the onset and growth of a sound-induced threshold shift in relation to the characteristics of the sound source and hearing sensitivity of the receiving species.

The assessment of sensitivity provided below considers the uncertainty surrounding the effects of PTS on minke whale survival and reproduction and the importance of sound for communication. Given that any effects of PTS will be irreversible (i.e. as noted for harbour porpoise above), minke whale are deemed to be of high vulnerability, low recoverability, low tolerance, and of international value. Therefore, the sensitivity of minke whale to PTS is considered to be high.

Although there are no species-specific recovery rates for minke whale to TTS available, there is no evidence to suggest that recovery rates will be significantly different to those for harbour porpoise. Furthermore, minke whale exhibit a temporal distribution in UK and Irish waters, with most sightings in continental shelf waters occurring between May and September. SCANS III surveys were carried out during summer months, and therefore density values, and subsequent predicted numbers to be affected for minke whale will be overly conservative for piling activities occurring during winter months. Given that minke whale would be able to tolerate the effect of TTS without any impact on reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased, minke whale are considered to be of medium vulnerability, high tolerance, high recoverability and of international value. Therefore, the sensitivity of minke whale to TTS is considered to be low.

Grey Seal and Harbour Seal

Seals are less reliant on hearing for foraging than cetacean species but may rely on sound for communication and predator avoidance (Deecke *et al*., 2002). They use their vibrissae (i.e. whiskers) to detect swimming fish (Schulte-Pelkum *et al.,* 2007), however, in certain conditions, they may also listen to sounds produced by fish in order to forage. Therefore, a reduction in fitness, reproductive output and longevity are potential ecological consequences of a sound induced threshold shift (Kastelein *et al.,* 2018a). Based on calculations of SEL of tagged harbour seal during the construction of the Lincs OWF (Greater Wash, England), at least half of the tagged seals would have received sound levels from pile driving that exceeded auditory injury thresholds (e.g. PTS) for pinnipeds (Hastie, *et al.,* 2015). However, as population estimates indicated that the relevant population trend is increasing and therefore, these predicted levels of PTS were not sufficient to cause a decrease in the population trajectory (although it should be noted that there are many other ecological factors that will influence the population health) (Hastie *et al.,* 2015). The authors noted that due to lack of data on effects of sound on seal hearing, the exposure criteria used are intentionally conservative and therefore predicted numbers of individuals likely to be affected by PTS would also have been highly conservative (Hastie *et al.,* 2015). However, despite the uncertainty surrounding PTS in seals, they rely on hearing much less than cetaceans and therefore would likely exhibit some tolerance (i.e. the effect is unlikely to cause a change in either reproduction or survival rates). In addition, it has been proposed that seals may be able to self-mitigate (i.e. reduce their hearing sensitivity in the presence of loud sounds) (Kastelein *et al.,* 2018a), as has been observed in odontocetes (Nachtigall *et al.,* 2018). However, it is not clear how long odontocetes can self-mitigate, or if seals can do this as well (Kastelein, *et al.,* 2018a). Seals may also be able to reduce their exposure to underwater noise by swimming near the water's surface, where SPLs are often lower (Kastelein *et al.,* 2018b).

Recently, Reichmuth *et al.* (2019) reported the first confirmed case of PTS following a known acoustic exposure event in a seal. The study included evaluation of the underwater hearing sensitivity of a trained harbour seal before and immediately following exposure to 4.1 kHz tonal fatiguing stimulus, and rather than the expected pattern of TTS onset and growth, an abrupt threshold shift of >47 dB was observed half an octave above the exposure frequency (Reichmuth *et al.*, 2019). Hearing at 4.1 kHz recovered within 48 hours, however, there was a PTS of at least 8 dB at 5.8 kHz, and hearing loss was evident for more than ten years (Reichmuth *et al.*, 2019).

Although the evidence from Hastie *et al.* (2015) suggests a lower sensitivity of pinnipeds to PTS, based on uncertainties and the results of Reichmuth *et al.* (2019), a precautionary approach has been taken in the assessment of sensitivity to PTS. Harbour seal and grey seal are deemed to have a low tolerance to PTS, low recoverability, high vulnerability, and of international value. Therefore, the sensitivity of these receptors to PTS is considered to be high.

A study measuring recovery rates of harbour seal following exposure to a sound source of 193 dB re 1 $\mu Pa^2 s$ (SEL_{cum}) over 360 minutes found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure (Kastelein *et al.,* 2018a). This is similar to recovery rates found in SEAMARCO (2011), which showed that for small TTS values, recovery in seals was very fast (around 30 mins); the higher the hearing threshold shift, the longer the recovery. Therefore, in most cases, reduced hearing for such a short time probably has little effect on the total foraging period of a seal. However, if hearing is impaired for longer periods (hours or days) the impact is likely to be ecologically significant (SEAMARCO, 2011). These results indicate that harbour seal (and therefore grey seal, using harbour seal as a proxy) are less vulnerable to TTS than harbour porpoise for the noise bands tested. It is also expected that seals would move beyond the injury range prior to the onset of TTS. Thus, grey seal and harbour seal are likely to be able to tolerate the effect of TTS without any impact on both reproduction and survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased. Grey seal and harbour seal are considered to be of medium vulnerability, high tolerance, high recoverability and international value. Therefore, the sensitivity of these receptors to TTS is considered to be low.

<u>Marine Turtles</u>

Marine turtles are known to migrate through and feed within the regional marine mammal study area during the summer months. Therefore, they have the potential to be within the range of underwater noise impacts due to piling and would be sensitive to these impacts during that time of the year.

Marine turtles are able to detect LF sound (Ridgeway *et al.,* 1969; Bartol and Ketten, 2006; Lavender *et al.,* 2012; Martin *et al.,* 2012; Piniak *et al.,* 2012, 2016). Elevated underwater noise generated during piling has the potential to cause tissue damage and mortality in marine turtles (Nelms *et al.,* 2016). Studies have shown that marine turtles display avoidance and startle responses when exposed to impulse sounds (Lenhardt, 1994; McCauley *et al.,* 2000). These responses include increased swim speeds and altered dive durations, although the effects of these responses are largely unknown for marine turtles (reviewed in Nelms *et al.,* 2016). These responses may lead to physical injury and mortality as a result of decompression sickness and strandings, as is observed for marine mammals (Gordon *et al.,* 2003; Wright *et al.,* 2007; Mann *et al.,* 2010; Jepson *et al.,* 2013). Furthermore, García-Párraga *et al.* (2014) recorded decompression sickness in loggerhead sea turtles, although the study was not in relation to impacts of underwater noise. Although marine turtles use sound for predator avoidance (Piniak *et al.,* 2016), reliance on hearing for survival and reproduction is expected to be lower than in cetaceans and therefore animals would exhibit some tolerance (i.e. the effect is unlikely to cause a change in either reproduction or survival rates).

Overall, marine turtles are deemed to be of low tolerance to PTS, medium vulnerability, low recoverability, and international value. Therefore, the sensitivity of marine turtles to PTS has been considered, conservatively, to be high.

Whilst recovery rates from recoverable injury and TTS for marine turtles are unknown, it is expected that individuals would move beyond the injury range prior to the onset of impairment. Given that marine turtles likely to be able to tolerate the effect without any impact on reproduction or survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased, they are deemed to be of medium tolerance, medium vulnerability, high recoverability, and international value. Therefore, the sensitivity of marine turtles to recoverable injury and TTS is considered to be low.

Behavioural Disturbance

<u>Harbour Porpoise</u>

As a small cetacean species, harbour porpoise has a high metabolic requirement and is vulnerable to heat loss through radiation and conduction. They must forage frequently to build sufficient fat reserves for insulation. For example, a study on six non-lactating harbour porpoise and found that they require between 4% and 9.5% of their body weight in fish per day (Kastelein *et al.*, 1997). Wild harbour porpoise have been reported to forage almost continuously day and night to achieve their required calorific intake (Wisniewska *et al.*, 2016) and therefore they are vulnerable to starvation if their foraging is interrupted. Although there were no site-specific marine mammal surveys conducted for the Proposed Development, harbour porpoise were sighted year round in site-specific surveys of OWFs that overlap with the Proposed Development (Gwynt y Môr OWF and Awel y

Môr OWF) (CMACS, 2005b; Goddard *et al.,* 2017; 2018; Goulding *et al.,* 2019; Sinclair *et al.,* 2021), and could therefore be vulnerable to piling throughout the year.

The variance in behavioural responses to increased underwater noise is well documented and is context specific. Factors such as the activity state of the receiving animal, the nature and novelty of the sound (i.e. previous exposure history), and the spatial relation between sound source and receiving animal are important in determining the likelihood of a behavioural response and therefore their sensitivity (Ellison *et al*., 2012).

Recently, Kastelein *et al.* (2022) studied the effects of six piling sounds (average in the pool of up to 135 dB re 1 μPa^{2}s) on one harbour porpoise under experimental conditions. The harbour porpoise was subjected to test periods of 15 minutes, where it was exposed to piling sounds. Behaviours was observed to return to normal immediately after each test period in which the harbour porpoise responded to the sound by behavioural reaction (e.g. changing her respiration rate, moving away from the sound source) (Kastelein *et al.,* 2022). At-sea measurements reported by Brandt *et al.* (2012) observed reduced porpoise acoustic activity within a 2.6 km range from a piling site 24 hours to 72 hours after sounds stopped, although shorter return times were recorded after application of sound abatement methods such as air bubble screens (for approximately six hours). The discrepancy between times required for harbour porpoise to return to the affected area in the pool (Kastelein *et al.,* 2022) versus at sea (Brandt *et al.,* 2012) are likely to relate to the SEL experienced by the animal, which depends on their distance from the piling location at sea (Kastelein *et al.,* 2022). The frequency content of sounds is an important factor determining the response of harbour porpoise to piling, and the high-frequency part of the spectrum of impulsive pile driving has a relatively large effect on their behaviour (Kastelein *et al.,* 2022).

Empirical evidence from monitoring at OWFs during construction suggests that pile driving is unlikely to lead to 100% avoidance of all individuals exposed, and that there will be a proportional decrease in avoidance at greater distances from the pile driving source (Brandt *et al*., 2011). This was demonstrated at Horns Rev OWF, where 100% avoidance occurred in harbour porpoises at up to 4.8 km from the piles, whilst at greater distances (10 km plus) the proportion of animals displaced reduced to <50% (Brandt *et al.,* 2011). Furthermore, recent results from the Beatrice OWF suggest that harbour porpoise may adapt to increased noise disturbance over the course of the piling phase, thereby showing a degree of tolerance and behavioural adaptation (Graham *et al.,* 2019). The authors also demonstrated that the probability of occurrence of harbour porpoise (measured as porpoise positive minutes) increased exponentially moving further away from the noise source. Similarly, a study of seven OWFs constructed in the German Bight also showed that harbour porpoise detections declined several hours before the start of pling within the vicinity of the construction site (up to 2 km) and were reduced for about one to two hours post-piling, whilst at the maximum effect distances (from 17 km out to approximately 33 km) avoidance only occurred during the hours of piling (Brandt *et al*., 2018). Harbour porpoise detections during piling were found at sound levels exceeding 143 dB re 1 μPa^{2}s and at lower received levels (i.e. at greater distances from the source) there was little evident decline in porpoise detections (Brandt *et al.,* 2018). These studies demonstrate the dose-response relationship between received noise levels and declines in porpoise detections although noting that the extent to which responses could occur will be context-specific such that, particularly at lower received levels (i.e. 130 dB -140 dB re 1 μPa2s), detectable responses may not be apparent from region to region.

As presented in section 7.12.13, Southall *et al.* (2021) build on the earlier work presented in Southall et al. (2007) and the expanding literature in this area to introduce a concept of a behavioural response severity spectrum. This spectrum has a progressive severity of possible responses within three response categories: survival, feeding, and reproduction. For example, between seven and nine on the spectrum, where sensitivity is highest, displacement is likely to occur resulting in movement of animals to areas with an increased risk of predation and/or with sub-optimal feeding grounds (Southall *et al.,* 2021). A failure of vocal mechanisms to compensate for sound can result in interruption of key reproductive behaviour including mating and socialising, causing a reduction in an individual’s fitness leading to potential breeding failure and impact on survival rates.

There are limitations of the single step-threshold approach for strong disturbance and mild disturbance as it does not account for inter- or intra-specific variance or context-based variance. Acknowledging these limitations, harbour porpoise within an area modelled as ‘strong disturbance’ would be most sensitive to behavioural effects and therefore may have a response score of seven or above according to Southall *et al*. (2021). The potential severity of effects reduces towards the lower end of the spectrum, where there may be some detectable responses that could result in effects on the short-term health of animals. However, these are less likely to impact an animals' survival rate. For example, mild disturbance (score four to six on the spectrum) could lead to effects such as changes in swimming speed and direction, minor disruptions in communication, interruptions in foraging, or disruption of parental attendance/nursing behaviour (Southall *et al.,* 2021).

Although harbour porpoise may be able to avoid the disturbed area and forage elsewhere, the reproductive success of some individuals could potentially be affected. As mentioned above, it is anticipated that there would be some adaptability to the elevated sound levels from piling and therefore survival rates are not likely to be affected. Due to uncertainties associated with the effects of behavioural disturbance on vital rates of harbour porpoise, the assessment is highly conservative as it assumes the same level of sensitivity for both strong and mild disturbance, noting that for the latter the sensitivity is likely to be lower.

Harbour porpoise is deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability, and international value. Therefore, the sensitivity of harbour porpoise to behavioural disturbance is considered to be medium.

Bottlenose Dolphin, Common Dolphin, and Risso's Dolphin

Bottlenose dolphin, common dolphin and Risso's dolphin have larger body sizes and lower metabolic rates than harbour porpoise. Therefore, they have a lower necessity to forage frequently and are thought to be less vulnerable to disturbance than harbour porpoise. Common dolphin exhibit seasonal shifts around the UK and Ireland. Individuals move onto continental waters in the summer (coinciding with the mating/calving period) and come back to inshore waters during winter. As they tend to move towards the Celtic Shelf and into the western English Channel and St. George's Channel, probability of presence within Proposed Development is low. There were no site-specific marine mammal surveys undertaken for the Proposed Development, but these dolphin species were recorded sporadically in results of site-specific surveys of OWFs that overlap with the Proposed Development (Gwynt y Môr OWF and Awel y Môr OWF) (CMACS, 2005b; Goddard et al., 2017; 2018; Goulding et al., 2019; Sinclair et al., 2021). Bottlenose dolphin is largely coastally distributed in relation to the regional marine mammal study area and are more abundant during summer and autumn compared to late winter and early spring months (Baines and Evans, 2012). Risso's dolphin are mostly common in Manx territorial waters and there is a potential for these species to be present in the vicinity of the Proposed Development in the summer months (for more details see volume 3, RPS Group (2024a)volume 3, appendix I). Overall, due to their distribution and seasonality these species are unlikely to be disturbed year-round as a result of piling. Additionally, these is no indication that waters within the Proposed Development are important for foraging or breeding for these species.

There is limited information regarding the specific sensitivities of HF cetaceans to disturbance from piling sound as most studies focus on harbour porpoise. A study of the response of bottlenose dolphin to piling sound during harbour construction works at the Nigg Energy Park (north-east Scotland) found that there was a weak but measurable response to impact and vibration piling with animals reducing the amount of time they spent in the vicinity of the construction works (Graham *et al.,* 2017). Fernandez-Betelu *et al.* (2021) investigated dolphin detections during impact piling at the Beatrice OWF and Moray OWF and found surprising results at small temporal scales. The reported an increase in dolphin detections on the southern Moray coast on days with impulsive sound compared to days without with predicted maximum received levels in coastal areas of 128 dB re 1μPa^{2}s and 141 dB re 1μPa^{2}s, respectively. The authors warned that caution must be exercised in interpreting these results as increased click changes do not necessarily equate to larger group sizes but may be due to a modification in behaviour (e.g. an increase in vocalisations during piling) (Fernandez-Betelu *et al*., 2021). The results of this study suggest that impulsive sound generated during piling at the OWFs did not cause any displacement of bottlenose dolphin from their population range.

Due to the low abundance of these three dolphin species in the vicinity of the Proposed Development, they may be able to avoid the disturbed area. Whilst there may some impacts on reproduction in closer proximity to the source (i.e. within the area of 'strong disturbance'), these are unlikely to impact on survival rates as some tolerance is expected to build up over the course of the piling. It is anticipated that animals would return to previous activities once the impact had ceased.

As above for harbour porpoise, the severity spectrum presented by Southall *et al*. (2021) applies across all marine mammals considered in this assessment. Therefore, it is expected that, as described for harbour porpoise, strong disturbance in the near field could result in displacement whilst mild disturbance over greater ranges would result in other, less severe behavioural responses.

Overall, bottlenose dolphin, common dolphin, and Risso's dolphin are deemed to have some tolerance to behavioural disturbance, low vulnerability, high recoverability and international value. Therefore, the sensitivity of these receptors to behavioural disturbance is considered to be medium.

Minke Whale

Minke whale have a seasonal occurrence within the Proposed Development marine mammal study area. Although sandeel are thought to be the key prey resource for minke whale within the North Sea, the distribution of minke whale seems to mirror the distribution of herring in Manx and Irish waters (Howe, 2018b). Disturbance from areas that are important for herring could have implications on the health and survival of disturbed minke whales, due to their reliance on herring in the area. Herring habitat in the vicinity of the Proposed Development is described in volume 3, RPS Group (2024a)volume 3, appendix I. The majority of the Proposed Development was considered as unsuitable sediment for herring spawning, although significant spawning areas were identified around the Isle of Man. The displacement of minke whale could lead to reduced foraging for disturbed individuals particularly since minke whale maximise their energy storage whilst on feeding grounds by exploiting prey herded by other species (Christiansen *et al*., 2013a). The presence of whale watching boats within an important feeding ground for minke whale in Iceland has been demonstrated to lead to a reduction in foraging activity (Christiansen *et al.,* 2013b). As a capital breeder, such a reduction could lead to reduced reproductive success since female body condition is known to affect foetal growth (Christiansen *et al.,* 2014). However, it is worth noting that the study was conducted in Faxafloi Bay (Iceland) where baseline noise levels are lower in comparison to the eastern Irish Sea. In addition, a subsequent study conducted by Christiansen and Lusseau (2015) in the same study area found no significant long-term effects of disturbance from whale watching on vital rates since whales moved into disturbed areas when sandeel numbers were lower across their wider foraging area.

As expected for all marine mammal species in this assessment, strong disturbances in the nearfield could result in displacement whilst mild disturbance over larger ranges would result in other, less severe behavioural responses (Southall *et al.,* 2021). The Proposed Development is situated in region of relatively high levels of existing sound disturbance due to shipping, fishing, and other vessel activity. Therefore, minke whale that occur within the Proposed Development are subject to underwater noise from existing activities and may be desensitised (to some extent) to increased noise levels, particularly in the far field where mild disturbance could occur.

Overall, minke whale is deemed to have some tolerance to behavioural disturbance, low vulnerability, high recoverability, and international value. The sensitivity of minke whale to behavioural disturbance is therefore, considered to be medium.

Grey Seal and Harbour Seal

Seals could potentially experience mild disturbance; however this constitutes only slight changes in behaviour (such as changes in swimming speed or direction), and is unlikely to result in population-level effects. Although there are likely to be alternative foraging sites for both seal species, barrier effects as a result of installation of the new Douglas platform could either prevent seals from travelling to forage from haul-out sites or force seals to travel greater distances than usual during periods of piling. Strong disturbance could result in displacement of seals from an area.

Hastie *et al.* (2021) measured the relative influence of perceived risk of different sound sources (e.g. silence, pile driving, and a tidal turbine) and prey patch quality (low density versus high density), in grey seal in an experimental pool environment. Their results showed that foraging success was highest under silence, but under tidal turbine and pile driving treatments success was similar at the high-density prey patch but significantly reduced under the low-density prey patch. Therefore, avoidance rates were dependent on the quality of the prey patch as well as the perceived risk from the anthropogenic sound and therefore it can be anticipated such decisions are consistent with a risk/profit balancing approach (Hastie *et al.,* 2021).

There are several empirical studies on seal behaviour during installation of OWFs, which can be extrapolated for this assessment. For example, Russell *et al.* (2016) studied movements of tagged harbour seal during piling at the Lincs OWF (Greater Wash, England) and reported significant avoidance of the OWF. Seal abundance significantly reduced up to 25 km from the piling activity and there was a 19% to 23% decrease in usage within this range (Russell *et al.,* 2016). However, the displacement was limited to pile driving activity only, with harbour seal returning rapidly to baseline levels of activity within two hours of cessation of the piling (Russell *et al.,* 2016). Aarts *et al*. (2018) tracked grey seal during construction of the Luchterduinen OWF and Gemini OWF (The Netherlands) and reported diverse reactions to piling, ranging from altered surfacing and diving behaviour, changes in swimming direction, or coming to a halt. In some cases, however, no apparent changes in diving behaviour or movement were observed (Aarts *et al*., 2018). Similar to the conclusions drawn by Hastie *et al.* (2021) the study at the Luchterduinen and Gemini OWFs suggested grey seal were balancing risk with profit. Whilst approximately half of the tracked grey seal were absent from the pile-driving area altogether, this may be because animals were drawn to other more profitable areas as opposed to active avoidance of the sound, although a small sample size (n=36 animals) means that no firm conclusions could be reached (Aarts *et al.,* 2018). It was notable that, in some cases, grey seal exposed to pile-driving at distances shorter than 30 km returned to the same area on subsequent trips. This suggests that the incentive to go to the area was stronger than potential deterrence effect of underwater noise from pile driving in some seals.

Behavioural changes and subsequent barrier effects could impact the ability of grey and harbour seals to accumulate the energy reserves required for both reproduction and lactation (Sparling *et al.,* 2006). To maximise energy for reproduction, female seals exhibit clear increases in foraging effort (including increased diving) in the run up to the breeding season. Further, during the third trimester of pregnancy, grey seal accumulates reserves of subcutaneous blubber which they use for milk production during lactation (Hall *et al*., 2001). Therefore, grey seal forging at sea may be most vulnerable during this period, as this energy storage is extremely important for offspring survival and female fitness (Mellish *et al.,* 1999; Hall *et al.,* 2001). Consequently, reproduction rates and probability of survival could be impacted by any potential exclusion from foraging grounds during this time.

Seals may also be vulnerable to disturbance during the lactation period, however the extent of which this may occur will depend on their breeding strategy. In particular, behavioural changes could impact harbour seal during lactating periods between June and August, when females spend much of their time in the water with their pups, and foraging is more restricted than during other periods (Bowen *et al.,* 1999). Effects of behavioural disturbance may include reduced fecundity, reduced fitness, and reduced reproductive success. Although harbour seal may be able to avoid the disturbed area to forage elsewhere, there may carry an energetic cost by having to move greater distances to forage, and therefore there may be a potential effect on reproductive success of some individuals. Conversely, the lactation period for grey seal (a capital breeder) is shorter (lasting around 17 days; Sparling *et al.,* 2006). During this time, females fast and remain mostly on shore. Furthermore, as female grey seal do not forage often during this lactation period, it is expected that they may exhibit some tolerance to disturbance as they would not spend as much time in sea, where they can be affected by underwater noise. It should be noted, however, that female grey seal return to the water post-lactation and must forage extensively to build up lost energy reserves.

Overall, grey seal and harbour seal are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore, considered to be medium.

Marine Turtles

Very limited data exists on sea turtle behavioural responses to noise (Nelms *et al.,* 2016), therefore the data which exist for fish have been used as a proxy. Various studies have examined the effect of the sound pressure component of impulsive noise (including piling operations and seismic airgun surveys) on the behaviour of different fish species. For example, an observable behavioural response was recorded for cod between SPL_{pk} 140 to 161 dB re 1 µPa and between SPL_{pk} 144 dB to 156 dB re 1 µPa for sole (Mueller-Blenkle *et al.,* 2010). In rockfish, a startle or 'C-turn' behavioural response was recorded at peak pressure levels, starting at around 200 dB re 1 µPa, although this was less common with larger-bodied individuals (Pearson *et al.,* 1992). McCauley *et al.* (2000) reported a that fish generally moved to the bottom of the cage during periods of high-level exposure in laboratory experiments (greater than rms levels of around 156 to 161 dB re 1 µPa; approximately equivalent to SPL_{pk} levels of around 168 to 173 dB re 1 µPa). These studies align with the criteria for onset of behavioural effects in marine turtles, which state that at 'far' distances from the sound source (thousands of metres) there is likely a low risk of onset of behavioural effects from impulsive piling and at 'intermediate' distances there is likely a moderate risk of onset of behavioural effects from impulsive piling (Table 7.53).

Marine turtles are known to migrate through and feed within the regional marine mammal study area during the summer, which is, therefore, considered to be the most sensitive time of year. However, piling activities are unlikely to result in barrier effects to migration for these species, as the disturbance ranges stated above in the 'Magnitude of Impact' section will likely constitute a small area in the context of the wider available habitat in the Irish Sea. Furthermore, marine turtles do not nest on beaches within the UK and Ireland, therefore their sensitivity to disturbance in this respect will be low. Offshore waters of the Irish Sea could potentially host important feeding grounds for marine turtles (NPWS, 2019), but as previously stated, the area disturbed during piling will likely constitute a very small proportion of available habitat in the context of the wider region. Thus, it is anticipated that marine turtles could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased.

Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of marine turtles to behavioural disturbance is therefore, considered to be low.

Significance of Effect

Auditory Injury

Harbour Porpoise

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this results in a 'minor or moderate' significance of effect. Whilst there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS this is unlikely to affect the international value of the species. Only a very minor loss or detrimental alteration to the harbour porpoise populations will occur due to this impact (see Table 7.27). Therefore, it has been concluded that the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Bottlenose Dolphin, Common Dolphin, and Risso's Dolphin

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Minke Whale

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this results in a 'minor or moderate' significance of effect. Whilst there may be some residual effect with a small number of animals potentially exposed to sound levels that could elicit PTS this is unlikely to affect the international value of the species. Only a very minor loss or detrimental alteration to the minke whale populations will occur due to this impact (see Table 7.27). Therefore, it has been concluded that the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Grey Seal and Harbour Seal

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtles

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance

All Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtles

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. As per Table 7.31, this results in a 'negligible or minor' significance of effect. Given that the effects of this impact are reversible and are not predicted to affect marine turtle reproductive cycles or a population, only a very minor loss or detrimental alteration to these species at a population level is possible (Table 7.27). Therefore, it has been concluded that the effect will be of **negligible adverse** significance, which is **not significant** in EIA terms.

7.12.15 Injury, Disturbance, and Displacement from Underwater Noise Generated during UXO Clearance

7.12.15.1 Construction Phase

UXO clearance prior to the construction of the Proposed Development may result in detonation (high order) of a UXO. This activity has the potential to generate some of the highest peak sound pressures of all anthropogenic underwater noise sources (von Benda-Beckman *et al.,* 2015), and are considered a high energy, impulsive sound source. The potential effects of UXO clearance will depend on sound source characteristics, the receptor species, distance from the sound source, and sound attenuation within the environment.

Further detail on underwater noise modelling of UXO clearance is provided in volume 3, appendix J. For UXO detonation, underwater noise modelling was undertaken following the methodology described in Soloway and Dahl (2014), which provides a simple relationship between distance from an explosion and the weight of the charge but does not account for bottom topography or sediment characteristics. Since the charge is assumed to be freely standing in mid-water, unlike a UXO which would be resting on the seabed and could potentially be buried, degraded or subject to other significant attenuation, this estimation of the source level can be considered conservative. Additionally, the explosive material is likely to have deteriorated over time, so maximum sound levels are likely to be over-estimates of true sound levels. In order to compare to the marine mammal hearing weighted thresholds, it is necessary to apply the frequency dependent weighting functions at each distance from the source. This was accomplished by determining a transfer function between unweighted and weighted SEL values at various distances based on an assumed spectrum shape and taking into account molecular absorption at various ranges.

Recent controlled experiments showed low-order deflagration to result in a substantial reduction in acoustic output over traditional high order methods, with SPL_{pk} and SEL_{cum} being typically significantly lower for the deflagration of the same size munition, and with the acoustic output being proportional to the size of the shaped charge, rather than the size of the UXO itself (Robinson *et al.,* 2020).

Magnitude of Impact

Potential effects of high order UXO clearance include mortality, physical injury, or auditory injury. As the duration of impact (elevated sound) for each UXO detonation is very short (seconds), behavioural effects are considered to be negligible in this context. TTS is presented as a temporary auditory injury but also represents a threshold for the onset of a moving away response. Specific underwater noise modelling for the Proposed Development was undertaken using published and peer-reviewed criteria to determine PTS and TTS ranges. As an embedded mitigation measure, a MMMP will be developed in order to reduce the potential to experience injury.

The MDS assumes a maximum UXO size is of be 907 kg, with a maximum of one detonation in 24 hours (Table 7.23) A low order clearance donor charge of 0.08 kg is assumed whilst low-yield donor charges are multiples of 0.75 kg (up to four required for the largest UXO size of 907 kg). For donor charges for high-order clearance activities, charge weights of 1.2 kg (the most common) and 3.5 kg (single barracuda blast charge) have been included.

The clearance activities will be tide- and weather-dependent, with full details of the UXO clearance timeline not available at this stage. There is an assumption of up to 500 g NEQ clearance shot for neutralisation of residual explosive material at each location (Table 7.23).

Auditory Injury (PTS)

All Species

PTS ranges for low order and low yield UXO clearance activities are presented in Table 7.60, donor charges used in high order UXO clearance presented in Table 7.61, and high order clearance of UXO presented in Table 7.62. The number of animals predicted to experience PTS due to low order disposal is presented in Table 7.63, donor charges in Table 7.64, and high order clearance in Table 7.65.

There is a small risk that a low order clearance could result in high order detonation of UXO, and, as such, the underwater noise modelling considered both high order and low order techniques. As previously described in section 7.12.13, underwater noise is unlikely to be impulsive in character once it has propagated more than a few kilometres. The NMFS (2018) guidance suggested an estimate of 3 km for transition from impulsive to continuous (although this was not subsequently presented in the later guidance (Southall *et al.,* 2019)). Hastie *et al.* (2019) suggested that some measures of impulsiveness (for seismic airguns and pile-driving) change markedly within approximately 10 km of the source. Therefore, caution should be used when interpreting any results with predicted injury ranges in the order of tens of kilometres as the PTS ranges are likely to be significantly lower than what has been predicted.

A high order explosion of the maximum UXO size (907 kg) yielded the largest PTS ranges for all species, with the greatest injury range (15.37 km; SPL_{pk}) seen for the VHF hearing group (i.e. harbour porpoise) (Table 7.62). However, this injury range is reduced to 8.05 km for more common 130 kg charge in harbour porpoise (SPL_{pk}). Conservatively, the number of harbour porpoise that could be potentially injured, based on the densities provided in Table 7.17, was estimated as 64 animals for high order explosion of a 907 kg UXO (Table 7.65), based on the SCANS-III Block F density estimate, equating to 0.10% of the Celtic and Irish Seas MU. For the SCANS-IV Block CS-E density estimate, this would be expected to affect up to 383 animals (Approximately 0.61% of the Celtic and Irish Seas MU). Predicted numbers were much smaller for the 130 kg and 25 kg UXOs with up to 18 and six animals potentially experiencing PTS respectively, based on the SCANS-III Block F density estimate (Table 7.65). For the SCANS-IV Block CS-E density estimate, the corresponding numbers of animals affected would be 105 (130 kg) and 35 (25 kg). For low order techniques, the largest range of 2,290 m was predicted from the 4 x 0.75 kg low-yield charges (Table 7.60), which could injure up to two harbour porpoise based on the SCANS-III Block F density estimate, or up to nine animals based on the SCANS-IV Block CS-E estimate (Table 7.63).

The maximum PTS range estimated for bottlenose dolphin, common dolphin and Risso's dolphin (HF hearing group) using the SPL_{pk} metric was 890 m for the high order detonation of a 907 kg UXO (Table 7.62). This was reduced to 464 m for 130 kg and 268 m for 25 kg. Using the population densities provided in Table 7.17, it was calculated that up to one animal could potentially be injured by any of the three high order detonation sizes (Table 7.65). With reference to the wider populations of these species, this equated to very small proportions of the relevant Mus (<0.00007% for bottlenose dolphin, 0.0000004% for short-beaked common dolphin and 0.000006% for Risso's dolphin). For low order techniques, the injury ranges were considerably lower with a maximum of 133 m estimated (Table 7.60) with no more than one animal of any species likely to be present within this range (Table 7.63).

The maximum PTS range estimated for minke whale using the SEL_{cum} metric was 4.22 km for the detonation of a charge size of 907kg, but this was reduced to 1.71 km for 130 kg and 775 m for 25 kg (Table 7.62). Conservatively, the number of minke whale that could be potentially injured, based on the densities provided in Table 7.17, was estimated as up to one animal for high order explosion of a 907 kg UXO (Table 7.65) equating to 0.000005% of the population of the Celtic and Greater North Seas MU. For low order techniques, the maximum range predicted was up to 406 m (Table 7.60) with no more than one animal of any species likely to be present within this range (Table 7.63).

The maximum PTS range estimated for grey seal and harbour seal using the SPL_{pk} metric was 3.02 km for the detonation of charge size of 907 kg, but this was reduced to 1.58 km for 130 kg and 910 m for 25 kg (Table 7.62). Conservatively, the number of grey seal that could potentially be injured, based on the densities provided in Table 7.17, was estimated as up to 115 animals for high order explosion of a 907 kg UXO, 32 animals for 130 kg, and up to one animal for 25 kg (Table 7.65). For the 907 kg UXO, this equates to 0.001% of the population of the relevant MUs for grey seal within the regional marine mammal and marine turtle study area. This also equates to 0.02% of the population of grey seal within OSPAR Region III. Although the modelled PTS ranges were the same for both grey seal and harbour seal, up to two harbour seal could potentially be injured during a high order explosion of a 907 kg UXO, using the densities provided in Table 7.17. This equates to 0.0001% of the harbour seal population within the relevant Mus in the regional marine mammal and marine turtle study area. For low order techniques, the maximum range predicted was up to 449 m (Table 7.60) and there would be up to three grey seal and one harbour seal potentially injured within this range (Table 7.63).

Table 7.60: Potential PTS Ranges For Low Order And Low Yield UXO Clearance Activities

Charge Size (kg)	Hearing Group	PTS Range (m)	
		SPL_{pk}	SEL_{cum}
0.08 kg low order donor charge	LF	122	47
	HF	40	2
	VHF	685	190
	PCW	135	9
0.5 kg clearance shot	LF	223	115
	HF	73	4
	VHF	1,265	421
	PCW	247	22
2 x 0.75 kg low-yield charge	LF	322	196
	HF	105	7
	VHF	1,820	650
	PCW	357	38
4 x 0.75 kg low-yield charge	LF	406	275

Charge Size (kg)	Hearing Group	PTS Range (m)	
		SPL_{pk}	SEL_{cum}
	HF	133	10
	VHF	2,290	840
	PCW	449	53

Table 7.61: Potential PTS Ranges For Donor Charges Used In High Order UXO Clearance Activities

Charge Size (kg)	Hearing Group	PTS Range (m)	
		SPL_{pk}	SEL_{cum}
1.2 kg donor charge for high order UXO disposal	LF	299	176
	HF	98	6
	VHF	1,690	596
	PCW	331	34
3.5kg donor blast-fragmentation charge for high order UXO disposal	LF	427	297
	HF	140	10
	VHF	2,415	885
	PCW	473	57

Table 7.62: Potential PTS Ranges For High Order Clearance Of UXOs

Charge Size (kg)	Hearing Group	PTS Range (m)	
		SPL_{pk}	SEL_{cum}
25 kg UXO – high order explosion	LF	825	775
	HF	268	27
	VHF	4,645	1,645
	PCW	910	147
130 kg UXO – high order explosion	LF	1,425	1,705
	HF	464	61
	VHF	8,045	2,520
	PCW	1,580	323
907 kg UXO – high order explosion	LF	2,720	4,215
	HF	890	151
	VHF	15,370	3,820
	PCW	3,015	800

Table 7.63: Number Of Animals With The Potential To Experience PTS Due To Low Order And Low Yield UXO Clearance Activities

Threshold	Estimated Number of Animals with the Potential to be Affected						
	Harbour porpoise	Bottlenose dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
0.08kg low-order donor charge							
SPL_{pk}	<1	<1	<1	<1	<1	<1	<1
SEL	<1	<1	<1	<1	<1	<1	<1
0.5kg clearing shot							
SPL_{pk}	<1 to 3	<1	<1	<1	<1	<1	<1
SEL	<1	<1	<1	<1	<1	<1	<1
2 x 0.75kg low-yield charge							
SPL_{pk}	<1 to 6	<1	<1	<1	<1	2	<1
SEL	<1	<1	<1	<1	<1	<1	<1
4 x 0.75kg low-yield charge							
SPLpk	2 to 9	<1	<1	<1	<1	3	<1
SEL	<1 to 2	<1	<1	<1	<1	<1	<1

Table 7.64: Number Of Animals With The Potential To Experience PTS Due To High Order UXO Clearance Activities

Threshold	Estimated Number of Animals with the Potential to be Affected						
	Harbour porpoise	Bottlenose dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
1.2kg donor charge for high-order UXO disposal							
SPL_{pk}	<1 to 5	<1	<1	<1	<1	2	<1
SEL	<1	<1	<1	<1	<1	<1	<1
3.5kg donor blast-fragmentation charge for high-order UXO disposal							
SPL_{pk}	2 to 10	<1	<1	<1	<1	3	<1
SEL	<1 to 2	<1	<1	<1	<1	<1	<1

Table 7.65: Number Of Animals With The Potential To Experience PTS Due To High Order Clearance Of UXOs

Threshold	Estimated Number of Animals with the Potential to be Affected						
	Harbour porpoise	Bottlenose dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
25kg UXO – high order explosion							
SPL_{pk}	6 to 35	<1	<1	<1	<1	<1	<1
SEL	<1 to 5	<1	<1	<1	<1	<1	<1
130kg UXO – high order explosion							
SPL_{pk}	18 to 105	<1	<1	<1	<1	32	<1
SEL	2 to 11	<1	<1	<1	<1	2	<1
907kg UXO – high order explosion							

Threshold	Estimated Number of Animals with the Potential to be Affected						
	Harbour porpoise	Bottlenose dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
SPL_{pk}	64 to 383	<1	<1	<1	<1	115	2
SEL	4 to 24	<1	<1	<1	< 1	9	<1

For the purposes of this assessment, the MDS assumes clearance of a maximum UXO size of 907 kg by either low order or high order techniques. However, clearance of 130 kg UXOs is considered more likely. Embedded mitigation, such as using low order techniques where possible (primary mitigation) will reduce the risk of injury (Table 7.32). It must be noted, however, that low order techniques are not always possible and are dependent upon the individual situations surrounding each UXO.

With primary measures in place the assessment found that there would be a residual risk of injury over a range of 2.29 km that would require further mitigation (Table 7.60). Where low order/low yield measures are not possible there is a maximum risk of injury (predicted for harbour porpoise) out to 15 km for a 907 kg UXO and 8.05 km for a 130 kg UXO (Table 7.62). Therefore, adopting standard industry practice (JNCC, 2010b), tertiary mitigation will be applied as part of a MMMP (Table 7.32).

The harbour porpoise injury ranges (for both low order and high order clearance) are considerably larger than the standard 1,000 m mitigation zone recommended for UXO clearance (JNCC, 2010b) and there are often difficulties in detecting marine mammals (particularly harbour porpoise) over such large ranges (McGarry *et al.,* 2017, 2020). The MMMP will also include the use of ADDs to deter animals from the ZoI. The efficacy of such deterrence will depend upon the device selected and reported ranges of effective deterrence vary. In addition to the ADD, deterrence can also be achieved through soft start charges, the application of which will be discussed and agreed with consultees post-submission of the ES, once more information on the size and type of UXOs are known. Details of appropriate tertiary mitigation as set out in the draft MMMP will be discussed and agreed with consultees post-consent when further details of the size and type of potential UXOs are understood.

Adopting a precautionary approach, and assuming application of mitigation, the assessment considered the magnitude for a high order detonation. The magnitude of impact is predicted to be of local to regional spatial extent (depending on species), very short-term duration (for each UXO detonation), and intermittent throughout the construction phase. Although the impact itself is reversible (i.e. the elevation in underwater noise only occurs during the UXO detonation activity), the effect of PTS on sensitive receptors is permanent. It is predicted that the impact will affect the receptor directly. With tertiary mitigation applied (i.e. MMMP), it is anticipated that for most species, individuals would be deterred from the ZoI and therefore the risk of PTS would be reduced. For all marine mammal IEFs except harbour porpoise, the magnitude of impact is therefore considered to be negligible.

For harbour porpoise, as the ranges of effect are large, there is considered to be a residual risk of PTS to a small number of individuals. Therefore, the magnitude of impact is considered to be low. Whilst it is difficult to quantify this residual risk (due to uncertainties over the predicted ranges of effect and the potential ranges over which deterrence measures are effective), it is anticipated that there would be some measurable changes at an individual level but that this would not manifest to population-level effects due to the small proportion of the Celtic and Irish Sea MU potentially affected (0.01%).

Injury ranges to marine turtles due to UXO clearance activities were not presented in the underwater noise modelling assessment (volume 3, appendix J). As per the criteria by Popper *et al.* (2014) (Table 7.52), insufficient data exist to determine a quantitative guideline value for PTS as a result of UXO clearance activities. Instead, the available criteria provide relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. in the tens of metres), "intermediate" (i.e. in the hundreds of metres) or "far" (i.e. in the thousands of metres). As such, no assessment of the impact of UXO clearance on the marine turtles IEF could be conducted. However, the marine turtle populations within the regional marine mammal and marine turtle study area are likely to be lower than those of the marine mammal IEFs, and this study area does not represent important habitat for reproduction and nesting. As marine turtles are not as sensitive to underwater noise as harbour porpoise, a negligible magnitude of impact can be extrapolated from that presented for all marine mammal IEFs except harbour porpoise.

Behavioural Disturbance (TTS as a Proxy)

All Species

A second threshold assessed in the underwater noise modelling was the onset of TTS, whereby the resulting effect would be a potential temporary loss in hearing. Whilst similar ecological functions would be inhibited in the short term due to TTS, these are reversible on recovery of the animal's hearing and therefore not considered likely to lead to any long-term effects on the individual. The onset of TTS also corresponds to a moving away or 'fleeing response' as this is the threshold at which animals are likely to move away from the ensonified area. Thus, the onset of TTS also reflects the threshold at which behavioural displacement could occur.

As previously described in section 7.12.13, underwater noise is unlikely to be impulsive in character once it has propagated more than a few kilometres. It is particularly important when interpreting results for TTS with ranges of up to 34.37 km as these are likely to be significantly lower than predicted (34.37 km was the maximum TTS value modelled for any marine mammal hearing group; see Table 7.68).

As above for PTS, the assessment of TTS considered low order and low yield UXO clearance activities (Table 7.66), donor charges for high order UXO disposal (Table 7.67) and high order explosions (Table 7.68). The largest ranges using SPL_{pk} were predicted for clearance of the 907 kg UXO with potential TTS/moving away response over a maximum distance of 28.32 km for the VHF hearing group (i.e. harbour porpoise) (Table 7.68). However, a larger range of 34.36 km was predicted for the LF hearing group (i.e. minke whale) using the SEL_{cum} threshold (Table 7.68).

Table 7.66: Potential TTS Ranges For Low Order And Low Yield UXO Clearance Activities

Charge Size (kg)	Hearing Group	TTS Range (m)	
		SPL_{pk}	SEL_{cum}
0.08 kg low order donor charge	LF	224	655
	HF	73	23
	VHF	1,265	1,500
	PCW	247	124
0.5 kg clearance shot	LF	411	1,585
	HF	134	56
	VHF	2,325	2,435
	PCW	455	301
2 x 0.75 kg low-yield charge	LF	593	2,665
	HF	194	95
	VHF	3,350	3,120
	PCW	660	504
4 x 0.75 kg low-yield charge	LF	750	3,670
	HF	244	131
	VHF	4,220	3,600
	PCW	830	695

Table 7.67: Potential TTS Ranges For Donor Charges Used In High Order UXO Clearance Activities

Charge Size (kg)	Hearing Group	TTS Range (m)	
		SPL_{pk}	SEL_{cum}
1.2 kg donor charge for high-order UXO disposal	LF	551	2,400
	HF	180	85
	VHF	3,110	2,975
	PCW	610	454
3.5kg donor blast-fragmentation charge for high-order UXO disposal	LF	790	3,940
	HF	257	141
	VHF	4,445	3,715
	PCW	875	745

Table 7.68: Potential TTS Ranges For High Order Clearance Of UXOs

Charge Size (kg)	Hearing Group	TTS Range (m)	
		SPL_{pk}	SEL_{cum}
25 kg UXO – high order explosion	LF	1,515	9,325
	HF	494	343
	VHF	8,555	5,290
	PCW	1,680	1,760
130 kg UXO – high order explosion	LF	2,625	17,755
	HF	855	680
	VHF	14,825	6,830
	PCW	2,905	3,360
907 kg UXO – high order explosion	LF	5,015	34,365
	HF	1,635	1,380
	VHF	28,320	8,925
	PCW	5,550	6,470

The number of animals that would potentially experience TTS/fleeing due to low order and low yield UXO clearance activities is presented in Table 7.69, donor charges for high order UXO disposal in Table 7.70, and high order explosions in Table 7.71. The highest number of animals affected, based on high order detonation of a 907 kg UXO, was found for grey seal where up to 534 animals could experience TTS (Table 7.71). This equated to 0.45% of the relevant MU populations and 0.1% of the OSPAR Region III population (based on SEL_{cum}). For harbour porpoise, between 217 animals and 1,299 animals could potentially be affected by the high order detonation of a 907 kg UXO (based on SPL_{pk} with lower densities from SCANS-III and higher densities from SCANS-IV). This equated to 0.35% to 2.08% of the population of the Celtic and Irish Seas MU. For minke whale and harbour seal, up to 34 and eight individuals, respectively, could potentially experience TTS/fleeing due to the high order detonation of a 907 kg UXO (both based on SEL_{cum}) (Table 7.71). This equated to 0.17% and 0.05% of the populations of the relevant minke whale and harbour seal MUs, respectively.

For the three dolphin species, the number of animals predicted to experience TTS/fleeing was very small with no more than one animal for all UXO clearance activities (Table 7.69 to Table 7.71). For all species, behavioural disturbance associated with UXO clearance will be reduced by tertiary mitigation summarised in Table 7.32 and described in volume 4: Marine Mammal Mitigation Plan. Similarly, primary measures employed to mitigate injury, including the use of low-order detonation where appropriate (Table 7.32) are also expected to reduce disturbance due to UXO clearance.

Table 7.69: Number Of Animals With The Potential To Experience TTS Due To Low Order And Low Yield UXO Clearance Activities

Threshold	Estimated Number of Animals with the Potential to be Affected						
	Harbour porpoise	Bottlenose dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
0.08kg low-order donor charge							
SPL_{pk}	<1 to 3	<1	<1	<1	<1	<1	<1
SEL	<1 to 4	<1	<1	<1	<1	<1	<1
0.5kg clearing shot							
SPL_{pk}	2 to 9	<1	<1	<1	<1	3	<1
SEL	2 to 10	<1	<1	<1	<1	2	<1
2 x 0.75kg low-yield charge							
SPL_{pk}	4 to 19	<1	<1	<1	<1	6	<1
SEL	3 to 16	<1	<1	<1	<1	4	<1
4 x 0.75kg low-yield charge							
SPL_{pk}	5 to 29	<1	<1	<1	<1	4	<1
SEL	4 to 21	<1	<1	<1	<1	7	<1

Table 7.70: Number Of Animals With The Potential To Experience TTS Due To High Order UXO Clearance Activities

Threshold	Estimated Number of Animals with the Potential to be Affected						
	Harbour porpoise	Bottlenose dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
1.2kg donor charge for high-order UXO disposal							
SPL_{pk}	3 to 16	<1	<1	<1	<1	5	<1
SEL	3 to 15	<1	<1	<1	<1	3	<1
3.5kg donor blast-fragmentation charge for high-order UXO disposal							
SPL_{pk}	6 to 32	<1	<1	<1	<1	10	<1
SEL	4 to 23	<1	<1	<1	<1	7	<1

Table 7.71: Number Of Animals With The Potential To Experience TTS Due To High Order Clearance Of UXOs

Threshold	Estimated Number of Animals with the Potential to be Affected						
	Harbour porpoise	Bottlenose dolphin	Common Dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
25kg UXO – high order explosion							
SPL_{pk}	20 to 119	<1	<1	<1	<1	36	<1
SEL	8 to 46	<1	<1	<1	3	40	<1
130kg UXO – high order explosion							
SPL_{pk}	60 to 356	<1	<1	<1	<1	107	2
SEL	4 to 19	<1	<1	<1	8	145	3
907kg UXO – high order explosion							
SPL_{pk}	217 to 1,299	<1	<1	<1	< 1	393	6
SEL	22 to 129	<1	<1	<1	34	534	8

As per the recent NRW (2023) guidance (Table 7.51), updated disturbance range to harbour porpoise due to UXO clearance were modelled using the 140 dB SEL (W_{vhf}) metric (Southall *et al.,* 2019; NRW, 2023). These disturbance distances are presented in Table 7.72, with the highest value of 8.92 km reported for the high order disposal of a 907 kg UXO. The number of animals with the potential to be disturbed has been calculated using the densities for this species as set out in Table 7.17. Disposal of the maximum UXO size of 907 kg has the potential to disturb between 22 and 129 harbour porpoise (based on the SCANS-III estimate of 0.086 animals per km^2 and SCANS-IV estimate of 0.515 animals per km^2, respectively), which equates to 0.03% and 0.21%, respectively, of the population of the Celtic and Irish Seas MU. This is considerably lower than the 217 to 1,299 animals potentially affected by the high order detonation of a 907 kg UXO (based on SPL_{pk}) that was modelled using guidance prior to NRW (2023) (see Table 7.71).

Table 7.72: Potential Disturbance Ranges To Harbour Porpoise And Numbers Of Animals Potentially Affected (Based On New Guidance From NRW (2023))

Charge Weight (kg)	Disturbance Range (m)	Number of Animals
Low order and low-yield donor charge configurations		
0.08	1,500	<1 to 4
0.5	2,435	2 to 10
2 x 0.75 kg	3,120	3 to 16
4 x 0.75 kg	3,600	4 to 21
High-order donor charge options		
1.2	2,975	3 to 15
3.5	3,715	4 to 23
Potential UXOs (high order disposal)		
25	5,290	8 to 46
130	6,830	13 to 76
907	8,925	22 to 129

Overall, application of tertiary mitigation (i.e. MMMP) to reduce the risk of PTS will also to some extent reduce the risk of TTS/fleeing, although notably the ranges for the latter are much larger. However, such effects, are reversible and therefore animals are anticipated to fully recover. It is, however, recognised that where tertiary mitigation applies, deterrence measures (i.e. ADD and soft start charges) by their nature would contribute to, rather than reduce, the moving away response.

Adopting a precautionary approach, and with the embedded mitigation adopted, the assessment considered the magnitude of a high order detonation. The magnitude of TTS resulting from a high order detonation is predicted to be of regional spatial extent, short-term duration, and intermittent throughout the construction phase. Both the impact itself (i.e. the increased underwater noise during a detonation event) and effect of TTS are reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **negligible** for all IEFs. This includes marine turtles, as although they were not concluded in the underwater noise modelling for this impact, the magnitude of effect can be extrapolated from that of the marine mammal IEFs (as per the reasoning provided above for 'Auditory Injury (PTS)').

Sensitivity of Receptor

Auditory Injury (PTS)

<u>Harbour Porpoise</u>

The main acoustical property during the detonation of explosives is a short shock wave, comprising a sharp rise in pressure followed by an exponential decay with a time constant of a few hundred microseconds (volume 3, appendix J). In shallow water, the interactions of the shock and acoustic waves create a complex pattern, which was investigated further by Von Benda-Beckmann *et al*. (2015). Due to their high sensitivity to underwater noise, harbour porpoise are the most studied species in the scientific literature. Von Benda-Beckmann *et al*. (2015) reported the impact of explosives on harbour porpoise within the southern North Sea. They investigated the potential for injury to occur as an ear trauma caused by the blast wave at a peak overpressure of 172 kPa (190 dB re. 1 μPa). They measured SEL and peak overpressure at distances up to 2 km from the explosions of seven aerial bombs (charge mass of 263 kg and 121 kg) detonated at approximately 26 m to 28 m depth, on a sandy substrate. The potential for noise-induced PTS to occur was based on a threshold of 190 dB re. 1 μPa^{2}s (PTS 'very likely to occur') and an onset threshold of 179 dB re. 1 μPa^{2}s (SEL) (PTS 'increasingly likely to occur') (criteria defined by Lucke *et al*., 2009). Their results suggested that 500 m was the largest distance at which a risk of ear trauma could occur and that noise-induced PTS was likely to occur further than the 2 km range that was measured during the study as the SEL recorded at this distance was 191 dB re. 1 μPa^{2}s (i.e. 1 dB above the 'very likely to occur' threshold).

Von Benda-Beckmann *et al*. (2015) also modelled possible ranges for 210 explosions that had been logged by the Royal Netherland Navy and the Royal Netherlands Meteorological Institute in 2010 and 2011. Using the empirical measurements of SEL out to 2 km to validate their model, the study found that the effect distances ranged between hundreds of metres to just over 10 km (for charges ranging from 10 kg up to 1,000 kg) (Von Benda-Beckmann *et al.,* 2015). Near the surface, where porpoises are known to spend a considerable amount of time (e.g. 55% based on Teilmann *et al.,* 2007) the SELs were predicted to be lower with effect distances for the onset of PTS just below 5 km (Von Benda-Beckmann *et al.,* 2015). However, whilst the model could provide a reasonable estimate of the SEL within 2 km (since the empirical measurements were made out to this point), estimates above this distance required further validation since the uncorrected model systematically overestimated SEL. More recently, Salomons *et al.* (2021) analysed the sound measurements performed near two UXO detonations (charge masses of 140 kg and 325 kg). From the weighted SEL values and threshold levels from Southall *et al.* (2019), a PTS effect range of 2.5 to 4 km was derived (Salomons *et al.,* 2021). When comparing the experimental data and model predictions, Salomons *et al.* (2021) concluded that harbour porpoise are at risk of PTS at distances of several kilometres from large explosives; between 2 km and 6 km based on 140 kg and 325 kg charge masses, respectively. In addition, 24 harbour porpoise were found dead along the coastline following clearance of ground mines in the Baltic Sea in 2019 (Siebert *et al.,* 2022). Post-mortem examination found that the cause of death was associated with a blast injury in ten of these animals, however the charge masses of the explosives are unknown (Siebert *et al*., 2022).

The use of low order UXO disposal methods has been shown to offer a substantial reduction in acoustic output over traditional high-order detonations, with the SPL_{pk} and SEL_{cum} observed being typically >20 dB lower for the deflagration of the same sized munition (a reduction factor of just over ten in SPL_{pk} and 100 in acoustic energy) (Robinson *et al.,* 2020). This study also demonstrated that the acoustic output depends on the size of the shaped charge, rather than the size of the UXO itself (Robinson *et al.,* 2020). Considering this, the use of low order techniques offers the potential for greatly reduced acoustic sound exposure of marine mammals and marine turtles.

The sensitivity of harbour porpoise to injury from impulsive underwater noise has been described previously for piling (section 7.12.14) and is not repeated here. Overall, harbour porpoise are deemed to have limited tolerance to PTS, high vulnerability, low recoverability, and international value. The sensitivity of harbour porpoise to PTS is therefore considered to be high.

<u>All other Marine Mammal and Marine Turtle IEFs</u>

In comparison to harbour porpoise, however, less is known about the sensitivity of bottlenose dolphin, common dolphin, Risso's dolphin, minke whale, grey seal, harbour seal, and marine turtles to explosive detonation. One study measured the effect of clearance of relatively small explosives (35 kg charge) at an important feeding area for a resident community of bottlenose dolphin in Portugal (Santos *et al.,* 2010). The authors measured acoustic pressure levels in excess of 170 dB re 1 µPa and no adverse effects in the behaviour or appearance of the dolphins, despite pressure levels being 60 dB higher than ambient sound (Santos *et al.,* 2010). Besides this, there is little published literature for these dolphin species and the assessment is highly precautionary as a result. In addition, evidence of severe blast injuries was recorded in the ears of two humpback whales *Megaptera novaeangliae* which died following a 5,000 kg explosion in Newfoundland, Canada (Ketten *et al.*, 1993). As humpback whale and minke whale are both baleen whales, it is possible that similar injuries would occur for minke whale.

The sensitivity of these IEFs to injury from impulsive underwater noise has been described previously for piling (section 7.12.14) and is not repeated here. Overall, these receptors are deemed to have limited tolerance to PTS, high vulnerability, low recoverability, and international value. The sensitivity of these receptors to PTS is therefore considered to be high.

Behavioural Disturbance (TTS as a Proxy)

Underwater noise generated during UXO clearance has the potential to cause behavioural disturbance. However, there are no agreed thresholds for the onset of a behavioural response generated as a result of an explosion. Southall *et al.* (2007) recommend that the use of TTS onset as an auditory effect may be most appropriate for single pulses (such as UXO detonation) and therefore it has been applied to inform the assessment.

As TTS is temporary and reversible, it is anticipated that any animals experiencing it would recover after they have moved beyond the injury zone are no longer exposed to elevated sound levels. The implication of animals experiencing TTS, leading to potential displacement, is not fully understood, but it is likely that aversive responses to anthropogenic sound could temporarily affect life functions as described in section 7.12.14 for PTS. Therefore, in this respect animals exposed to TTS-inducing sound levels have similar susceptibility as those exposed to levels that could induce PTS. It is important to note, however, given that TTS is only temporary hearing impairment, it is less likely to lead to acute effects and will largely depend on recoverability. The degree and speed of hearing recovery will depend on the characteristics of the sound the animal is exposed to, and on the degree of shift in hearing experienced.

Harbour Porpoise

The recovery rates of harbour porpoise exposed to a sound source of 75 db re 1 μPa (SEL) over 120 minutes were investigated by SEAMARCO (2011). The results suggested that recovery to the pre-exposure threshold was estimated to be complete within 48 minutes following exposure (the higher the hearing threshold shift, the longer the recovery) (SEAMARCO, 2011).

Kastelein *et al.* (2021) reported that the susceptibility to TTS depends on the frequency of the fatiguing sound causing the shift and the greatest TTS depends on the SPL (and related SEL). In this study, TTS occurrence in a captive harbour porpoise was measured at a range of frequencies typical of high amplitude anthropogenic sounds. The results indicated that the greatest shift in mean TTS occurred at 0.5 kHz with hearing always recovering within 60 minutes after the fatiguing sound stopped (Kastelein *et al.,* 2021). Currently, scientific understanding of the biological effects of TTS is limited to the results of controlled exposure studies on small numbers of captive animals (reviewed in Finneran, 2015), such as the study by Kastelein *et al.* (2021). Caution must be taken when extrapolating these results to how animals may respond in the natural environment as it is not possible to exactly replicate natural environmental conditions, and the small number of test subjects would not account for intraspecific differences (i.e. differences between individuals) or interspecific differences (i.e. extrapolating to other species) in response.

The sensitivity of harbour porpoise to TTS and behavioural disturbance has been described previously for piling (section 7.12.14) and is not repeated here. Overall, since TTS is reversible, harbour porpoise is assessed as having some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of harbour porpoise to behavioural disturbance (with TTS as a proxy) is therefore considered to be low.

Grey Seal and Harbour Seal

One study on harbour seal found that recovery from TTS to the pre-exposure baseline was estimated to be complete within 72 minutes following exposure to a sound source of 193 dB re1 μPa^{2}s (SELcum) over 360 minutes (Kastelein *et al.,* 2018a). SEAMARCO (2011) also demonstrated similar results, which showed that recovery in seals was very fast (around 30 minutes) for small TTS values. The authors demonstrated a linear relationship between TTS values and recovery time – the higher the hearing threshold shift, the longer the recovery (SEAMARCO, 2011). Kastelein *et al*. (2019) also demonstrated rapid recovery from TTS in two harbour seals. The greatest TTS, measured at 22.4 kHz 1 to 4 minutes after cessation of the sound, was 17 dB, but dropped to 3 dB in 1 hour, and hearing recovered fully within 2 hours. The authors noted that harbour seal appears equally susceptible to TTS between 2.5 kHz and 16 kHz (Kastelein *et al.,* 2019).

Based on these results, reduced hearing for a short time is unlikely to largely effect the total foraging period of harbour seal (and therefore grey seal, using harbour seal as a proxy). However, the impact is likely to be ecologically significant if hearing is impaired for longer periods (e.g. hours or days) (SEAMARCO, 2011). Nonetheless, these studies indicate that seal species are less vulnerable to TTS than harbour porpoise for the noise bands tested. In addition, it is expected that animals would move beyond the injury range prior to the onset of TTS. The assessment considered that both grey seal and harbour seal are likely to be able to tolerate the effect without any impact on both reproduction and survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased.

The sensitivity of grey seal and harbour seal to TTS and behavioural disturbance has been described previously for piling (section 7.12.14) and is not repeated here. Overall, since TTS is reversible, grey seal and harbour seal are assessed as having some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance (with TTS as a proxy) is therefore considered to be low.

All other Marine Mammal IEFs

Whilst there are no available species-specific recovery rates for bottlenose dolphin, common dolphin, Risso's dolphin, and minke whale to TTS, there is no evidence to suggest that recovery will be significantly different to the recovery rates presented for harbour porpoise, harbour seal, and grey seal. Therefore, it is anticipated that affected animals can recover their hearing after they are no longer exposed to elevated sound levels.

For example, Finneran *et al.* (2000) exposed two captive bottlenose dolphins to sounds that simulated distant underwater explosions and measured their behavioural and auditory responses. The animals were exposed to an intense sound once per day and no auditory shift (i.e. TTS) greater than 6 dB in response to levels up to 221 dB re 1 µPa p-p (peak-peak) was observed. Behavioural shifts, such as delaying approach to the test station and avoiding the 'start' station, were recorded at 196 dB and 209 dB re 1 µPa p-p for the two bottlenose dolphins and continued at higher levels (Finneran *et al.,* 2000). Nowacek *et al.* (2007) discussed several caveats to this study, for example, the signals used in Finneran *et al.* (2000) were distant and the study measured masked-hearing signals. Furthermore, the bottlenose dolphins used in the experiment were also trained and rewarded for tolerating high levels of noise and subsequently, it can be anticipated that behavioural disruption would likely be observed at lower levels in other contexts.

Furthermore, Boisseau *et al.* (2021) demonstrated that minke whales in Iceland avoided a 15 kHz ADD with a source level of 198 dB re 1 µPa re 1 m (rms) and clearly reacted to signals at the likely upper limit of their hearing sensitivity.

It can be anticipated that these IEFs would be able to tolerate the effect without any impact on reproduction or survival rates with ability to return to previous behavioural states or activities once the impacts had ceased. The sensitivity of these IEFs to TTS and behavioural disturbance has been described previously for piling (section 7.12.14) and is not repeated here. Overall, since TTS is reversible, these receptors are assessed as having some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance (with TTS as a proxy) is therefore considered to be low.

Significance of Effect

Auditory Injury (PTS)

<u>All Species</u>

Overall, for all IEFs except harbour porpoise, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Overall, for harbour porpoise, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance (TTS as a Proxy)

<u>All Species</u>

Overall, for all IEFs, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. As per Table 7.31, this results in a 'negligible or minor' significance of effect. Given that the effects of this impact are reversible and are not predicted to affect a significant percentage of the relevant MU populations, only a very minor loss or detrimental alteration to these species at a population level is possible (Table 7.27). Therefore, it has been concluded that the effect will be of **negligible adverse** significance, which is **not significant** in EIA terms.

7.12.16 Injury, Disturbance, and Displacement from Underwater Noise Generated during Geophysical and Seismic Site Investigation Surveys

Seismic and site investigation surveys during the construction and operation and maintenance phases have the potential to cause direct or indirect effects (including injury or disturbance). A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious and behavioural effects as a result of these surveys, using the latest criteria (volume 3, appendix J). This underwater noise modelling is drawn upon in the assessment below.

Sonar-based survey types will be used for the geophysical surveys to be conducted within the Proposed Development. These include MBES and SBP technology. The equipment likely to be used can typically work at a range of signal frequencies, depending on the distance to the bottom and the required resolution. The signal is highly directional, acts like a beam and is emitted in pulses. Sonar-based sources are considered as continuous (non-impulsive) because they generally compromise a single (or multiple discrete) frequency as opposed to a broadband signal with high kurtosis, high peak pressures and rapid rise times. In addition, seismic site investigation surveys will be conducted using VSP technology.

While marine turtles could potentially be affected by geophysical and seismic site investigation surveys, there is a lack of scientific understanding or legislation to thoroughly assess their sensitivity (revied by Nelms *et al.,* 2016). In addition, only three countries (6% of total) which allow seismic testing to be conducted in their waters have developed mandatory mitigation guidelines which include marine turtles. These countries are Brazil, Canada, and the USA (only within the Gulf of Mexico) (Nelms *et al.,* 2016). Additionally, the UK's guidelines on seismic surveys (JNCC, 2017) make a generalised statement acknowledging that *"…other protected fauna, for example turtles, will occur in waters where these guidelines may be used*" and that *"…whilst the appropriate mitigation may require further investigation, the soft-start procedures for marine mammals would also be appropriate for marine turtles…*". However, no mandatory mitigation measures for marine turtles are included by JNCC (2017). Furthermore, there are no thresholds in Popper *et al.* (2014) in relation to HF sonar (>10 kHz) for marine turtles. Thus, marine turtles were not included in the underwater noise modelling for this impact (see volume 3, appendix J).

7.12.16.1 Construction Phase

Magnitude of Impact

Auditory Injury

Marine Mammal IEFs

Potential impacts of site investigation surveys will depend on the characteristic of the source, survey design, frequency bands and water depth. Sonar-based survey equipment has very strong directivity which effectively means that there is only potential for injury when an animal is directly beneath the sound source. Once the animal moves outside of the main beam, there is no potential for injury. The same is true in many cases for TTS where an animal is only exposed to enough energy to cause TTS when inside the direct beam of the sonar. For this reason, many of the TTS and PTS ranges are similar (i.e. limited by the depth of the water). Any shallower waters surveyed would result in shorter injury ranges due to these directivity effects therefore these values represent a worst-case assessment.

The modelling results for MBES and SBP activity are presented in Table 7.73. The highest PTS ranges were 345 m for MBES and 335 for SBP, both for the VHF hearing group (i.e. harbour porpoise). Similarly, the highest TTS ranges of 495 m (MBES) and 655 m (SBP) were also modelled for the VHF hearing group. These PTS ranges are well in line with the standard 500 m mitigation zone that will be applied as part of the MMMP, which is an embedded mitigation measure applicable to this impact (Table 7.32).

Table 7.73: Potential Impact Ranges For Marine Mammals During The Geophysical Surveys Based On Comparison To Southall *et al.* (2019) SEL Thresholds For Non-Impulsive Sound (N/E = Threshold Not Exceeded)

Survey type	Hearing group	Range (m)	
MBES	LF	N/E	40
	HF	105	290
	VHF	345	485
	PCW	5	80
SBP	LF	45	50
	HF	50	260
	VHF	335	655
	PCW	40	50

The modelling results for VSP are presented in Table 7.74. Neither the SEL nor peak PTS threshold was exceeded for the HF hearing group (i.e. dolphin species). The highest PTS injury range (444 m) was modelled for the LF hearing group (i.e. minke whale) against the SEL threshold. This is in line with the standard 500 m mitigation zone will be applied as part of the MMMP, which is an embedded mitigation measure applicable to this impact (Table 7.32).

Table 7.74: Potential Impact Ranges For Marine Mammals During The VSP Survey Based On Comparison To Southall *et al.* (2019) SEL And Peak Thresholds (N/E = Threshold Not Exceeded)

Species Group	Threshold (Weighted SEL)	Range (m)	
LF	PTS – 183 dB re 1 µPa²s	444	13
	TTS – 168 dB re 1 µPa²s	2,941	38
HF	PTS – 185 dB re 1 µPa²s	N/E	N/E
	TTS – 170 dB re 1 µPa²s	4	6
VHF	PTS – 155 dB re 1 µPa²s	235	124
	TTS – 140 dB re 1 µPa²s	1,138	225
PCW	PTS – 185 dB re 1 µPa²s	11	16
	TTS – 170 dB re 1 µPa²s	38	44

The number of animals with the potential to be injured within the modelled ranges for PTS were estimated using the most up to date species-specific density estimates (Table 7.17). These results are presented in Table 7.75. For all species except grey seal, there was less than one animal with the potential to be disturbed due to the MBES and SBP survey activities. For grey seal, 16 individuals could potentially be disturbed from MBES and 18 from SBP (Table 7.75). Across all species, a larger number of animals had the potential to be disturbed by VSP site investigation surveys. Again, the species with the highest number of animals with the potential to be disturbed was grey seal, where 2,155 individuals could potentially experience mild disturbance, and 9 could experience strong disturbance. For all other species, there was less than one animal with the potential to experience strong disturbance from VSP.

Table 7.75: Estimated Number Of Animals With The Potential To Be Disturbed From Geophysical And Seismic Site Investigation Surveys

Activity	Estimated Number of Animals with the Potential to be Disturbed					
	Bottlenose dolphin	Common dolphin	Risso's dolphin	Minke whale	Grey seal	Harbour seal
Geophysical activities – 120 dB SPL_{rms}						
MBES	<1	<1	<1	<1	16	<1
SBP	<1	<1	<1	<1	18	<1
Seismic						
VSP (mild) – 140 dB SPL_{rms}	19	15	17	5	2,155	32
VSP (strong) – 160 dB SPL_{rms}	<1	<1	<1	<1	9	<1

As per Table 7.51, recent guidance from NRW (2023) was used to estimate the number of harbour porpoise with the potential to be disturbed from site investigation surveys. These results are presented in Table 7.76, and indicate that less than one individual has the potential to be disturbed from MBES and SBP surveys. For VSP, the highest number of individuals with the potential to be disturbed at the SCANS-III density estimate of 0.086 animals per km^2 is 33, and at the SCANS-IV estimate of 0.515 animals per km^2 this is 196, calculated using the 140 dB SEL_{ss} threshold (Tougaard, 2021). Overall, the results presented in Table 7.75 and Table 7.76 suggest that a low number of individuals could be disturbed due to MBES and SBP, and experience strong VSP disturbance. Therefore, it is not likely that these activities will impact these species at a population level.

Table 7.76: Estimated Number Of Harbour Porpoise With The Potential To Be Disturbed From Geophysical And Seismic Site Investigation Surveys Using The Latest NRW (2023) Guidance

Activity	Threshold	Number of Harbour Porpoise
Geophysical activities		
MBES	160 dB SPL_{rms}	<1
SBP		<1
Seismic		
VSP	140 dB SEL_{ss}	33 to 196
	143 dB SEL_{ss}	16 to 92
	145 dB SEL_{ss}	7 to 41

Overall, site investigation surveys are considered short term as they will take place over a period of several months. Embedded mitigation for injury during geophysical surveys will involve the use of MMOs and PAM to ensure that the risk of injury over the 500 m mitigation zone is reduced in line with JNCC guidance (JNCC, 2017) (Table 7.32). The largest PTS range was predicted as 444 m (for LF hearing group in response to VSP; Table 7.74) and it is considered that standard industry measures will be effective at reducing the risk of injury over this distance. MBES surveys in shallow waters (<200m) are not typically subject to the requirements of mitigation (JNCC, 2017). Requirements for mitigation will be agreed with the consultees post submission of the ES and prior to any shallow geophysical or seismic survey effort.

Overall, with embedded mitigation applied where required, the impact of geophysical and seismic site investigation surveys leading to PTS is predicted to be of very limited spatial extent, short-term duration (during individual surveys), intermittent over the construction phase, and whilst the impact itself will occur during the construction phase only, the effect of PTS will be permanent. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be negligible**.**

Behavioural Disturbance

Marine Mammal IEFs

For all marine mammal hearing groups except harbour porpoise, the maximum disturbance ranges were 1,100 m and 1,180 m for MBES and SBP, respectively (Table 7.77). For harbour porpoise, these ranges were 490 m (MBES) and 430 m (SBP). Table 7.77 also presents the disturbance ranges for VSP, which range from 5 km to 11 km for the different harbour porpoise SEL_{ss} thresholds. For all other hearing groups, mild disturbance (measured against a threshold of 140 dB re 1 µPa (rms)) occurred to 13 km, and strong disturbance (160 dB re 1 µPa (rms)) occurred to 800 m.

Table 7.77: Potential Disturbance Ranges For Marine Mammals Due To MBES, SBP, And VSP, Based On Comparison To NMFS (2005) And Southall *et al.* (2019) Thresholds

Survey type	Threshold	Disturbance Range (m)
MBES	All hearing groups – 120 dB SPL_{rms}	1,100
	Harbour porpoise – 160 dB SPL_{rms}	490
SBP	All hearing groups – 120 dB SPL_{rms}	1,180
	Harbour porpoise – 160 dB SPL_{rms}[10]	430
VSP	Mild (all hearing groups) – 140 dB re 1 µPa (rms)	13,000
	Strong (all hearing groups) – 160 dB re 1 µPa (rms)	800
	Harbour porpoise – 143 dB SEL_{ss}	7,500
	Harbour porpoise – 140 dB SEL_{ss}	11,000
	Harbour porpoise – 145 dB SEL_{ss}	5,000

With impulsive sound sources, there is an understanding of the difference between strong and mild disturbance, whereas for non-impulsive (continuous) sound sources (i.e. MBES and SBP), there is only a single available threshold (120 dB re 1 µPa (rms)) (NMFS, 2005). This threshold has been classed as the distance beyond which no animals would be disturbed. Given that ranges for disturbance from MBES and SBP for all hearing groups (except harbour porpoise) are presented up to the 120 dB re 1 µPa (rms) threshold, and there is no distinction between mild and strong disturbance, it can be assumed that not all animals found within those ranges presented within Table 7.77 would be disturbed. There is also likely to be a proportional response (i.e. not all animals will be disturbed to the same extent), although there is no dose-response curve available to apply in the context of non-impulsive sound sources. Individual life history and context will also influence the likelihood of an individual to exhibit an aversive response to noise. These impacts will not be continuous over the construction phase, instead carried out over a shorter number of days within the period, during the individual survey events. Therefore, given the limited quantitative information available, as described above, any simplified calculation would likely lead to an unrealistic overestimation of the number of animals likely to be disturbed. As such, this value has not been quantified. However, the MBES and SBP surveys will be very short in duration (up to several months), intermittent, and animals are expected to recover quickly after cessation of the activities. This could result in only a minor alteration to the distribution of marine mammals within the regional marine mammal and marine turtle study area. Behavioural disturbance associated with geophysical and seismic site investigation surveys will be reduced by tertiary mitigation summarised in Table 7.32 and described in volume 4: Marine Mammal Mitigation Plan. Similarly, primary measures employed to mitigate injury (Table 7.32) are also expected to reduce disturbance.

Overall, the impact of site investigation surveys leading to behavioural effects is predicted to be of local spatial extent, short term duration, and intermittent over the construction phase. Further, the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Therefore, for all IEFs, the magnitude of impact is considered to be low.

Sensitivity of Receptor

Auditory Injury

Marine Mammal IEFs

The sensitivity of all marine mammal IEFs to auditory injury in general has been described previously in greater detail for piling (section 7.12.14) and is not repeated here. Sills *et al.* (2020) evaluated TTS onset levels for impulsive noise in seals following exposure to underwater noise from a seismic air gun and found transient shifts in hearing thresholds at 400 Hz were apparent following exposure to four to ten consecutive pulses (SEL_{cum} 191 – 195 dB re 1 μPa^{2}s; 167 – 171 dB re 1 μPa^{2}s with frequency weighting for PCW).

Modelling has been used to compare potential effects of a non-impulsive sound source (Marine Vibroseis (MV)) and impulsive seismic sources (air gun) on marine mammals (Matthews *et al.,* 2021). The results of this study demonstrated that few marine mammals could be expected to be exposed to potentially injurious sound levels for either source type, but fewer were predicted for MV arrays than air gun arrays. The estimated number of animals exposed to sound levels was also found to be dependent on the selection of evaluation criteria, with more behavioural disturbance predicted for MV arrays compared to air gun arrays when using SPL but the opposite when using frequency-weighted sound fields and a multiple-step, probabilistic, threshold function. Overall, Matthews *et al.* (2021) demonstrated the importance of using both SPL_{pk} and SEL threshold metrics, as they relate to different characteristics of both impulsive and continuous sound (e.g. SPL_{pk} measures acute exposure to high-amplitude sounds whilst SEL looks at accumulative exposure over a set duration).

Ruppel *et al.* (2022) categorised marine acoustic sources into four tiers based on their potential to injure marine mammals using physical criteria about the sources (e.g. source level, transmission frequency, directionality, beamwidth, and pulse repetition rate). Those in Tier Four were considered unlikely to result in ‘incidental take’ (i.e. loss of individuals) of marine mammals and therefore termed “*de minimis”*, and included most high resolution geophysical sources (e.g. MBES, SBP). They also suggested that surveys that simultaneously deploy multiple, non-impulsive de minimis sources are unlikely to result in incidental take of marine mammals.

Overall, marine mammals IEFs are deemed have limited tolerance to PTS, high vulnerability, low recoverability and international value. The sensitivity of the receptors to PTS from elevated underwater noise during site investigation surveys is therefore, considered to be high.

While TTS as a result of this impact could occur, marine mammal IEFs are likely to be able to tolerate the effect of TTS without any impact on both reproduction and survival rates and would be able to return to previous behavioural states or activities once the impacts had ceased. Thus, marine mammals IEFs are considered of medium vulnerability, high tolerance, high recoverability and international value. Therefore, the sensitivity of these receptors to TTS from elevated underwater noise during site investigation surveys is considered to be low.

Behavioural Disturbance

Marine Mammal IEFs

The hearing and vocal ranges of many marine mammals overlap with the transmission frequencies of many commercial sonar systems (approximately 12 – 1,800 kHz) (Richardson *et al.,* 1995). Whilst there are many HF sonar systems with peak frequencies well above marine mammal hearing ranges, it is possible that relatively high levels of sound are also produced as sidebands at lower frequencies (Hayes and Gough, 1992) so may elicit behavioural responses in marine mammals. For example, fine-scale data from harbour porpoises showed different responses to noise exposure when exposed to airgun pulses at ranges of 420 – 690 m with noise level estimates of 135 –147 dB re 1 μPa^2s (SEL) (van Beest, *et al.,* 2018). Two individuals used shorter and shallower dives (compared to their natural behaviour) immediately after exposure, whilst one individual displayed rapid and directed movements away from the exposure site. This noise-induced behavioural change typically lasted for eight hours or less, with natural behaviour resumed after 24 hours (van Beest *et al.,* 2018). Stone and Tasker (2006) present results from 201 seismic surveys in the UK and adjacent waters and demonstrated that cetaceans (including bottlenose dolphin and minke whale) can be disturbed by seismic exploration. Small odontocetes showed the strongest lateral spatial avoidance by moving out of the area, whilst baleen whales and killer whales (*Orcinus orca*) showed more localised spatial avoidance, by orienting away from the vessel and increasing distance from source but not leaving the area completely (Stone and Tasker, 2006).

Hermannsen *et. Al.* (2015) investigated the source characteristics and propagation of broadband pulses from a small airgun (10 Hz up to 120 kHz). They confirmed that there are substantial medium-to-high frequency components in airgun pulses, indicating that small odontocetes and seals may be affected by even a single airgun (Hermannsen *et al.,* 2015). However, these findings indicate that in the context of exposure to sonar-like sound sources (e.g. MBES, SBP), marine mammals may exhibit subtle behavioural responses but factors such as species, behavioural context, location, and prey availability may be as important or even more important than the acoustic signals themselves (Ruppel *et. Al.,* 2022). MacGillivray *et al.* (2014) compared sound level above hearing threshold as a function of horizontal distance, for seven acoustic sources including air guns, SBP, MBES and SSS. Weighting sounds according to hearing sensitivity allows assessment of relative exposure risks, and whilst this analysis did not directly relate to potential for behavioural responses, it allowed comparison of modelled acoustic sources. Modelling indicated that odontocetes were most likely to hear sounds from Mid Frequency (MF) sources (e.g. fisheries, communication, and hydrographic systems), baleen whales from LF sources (SBP and airguns), and pinnipeds from both MF and LF sources. Modelled sensation levels for all species were lowest for the HF sources (e.g. SSS and MBES), which operate at the upper limits of the audible spectrum (MacGillivray *et al.,* 2014). Hastie *et al.* (2014) carried out behavioural response tests on grey seals exposed to two HF sonar systems (200 kHz and 375 kHz). Results showed that both systems had significant effects on seal behaviour. When the 200 kHz sonar was active, seals spent significantly more time hauled out and, although they remained swimming during operation of the 375 kHz sonar, they were distributed further from the sonar (Hastie *et al.,* 2014).

Largely, research has focused on the effects of multi-array seismic surveys on marine mammals, and therefore evidence for behavioural responses to sonar-like sources (e.g. MBES, SBPs) is less widely available. Multi-array impulsive sound sources are broadband in character (i.e. produce sound across a wide range of frequencies), unlike sonar-like sources which typically produce more tonal sound either at a discrete frequency or a range of discrete frequencies. However, findings from studies of multi-array impulsive sources may be useful in supporting predictions of behavioural responses of marine mammals to geophysical survey sources in general, given the overlap of parameters that typically characterise sound sources (i.e. transmission frequency; source level; pulse duration) (see MacGillivray *et al.,* 2014; Ruppel *et al*., 2022). Although evidence on the impact of MBES on melon-headed whale (or similar species) behaviour is limited, a 12 kHz MBES has been deemed to be the most plausible trigger for an extreme behavioural response in melon-headed whale (*Peponocephala electra)* (Southall *et al.,* 2013). This exposure resulted in a mass group stranding of melon-headed whale in a shallow lagoon in Madagascar in 2008, which is an area where such open-ocean species would not usually frequent (Southall *et al*., 2013). Whilst an unequivocal cause and effect relationship between

MBES and the strandings cannot be concluded, the authors state that intermittent, repeated sounds of this nature could present a salient and potential aversive stimulus and suggests potential for such behavioural responses (or indirect injury) from MBES should be considered in environmental assessments (Southall *et al.,* 2013). However, a study on the effect of MBES surveys on Cuvier's beaked whale (*Ziphius cavirostris*) in California, USA, reported that vocalisation rate was the only behaviour that changed during exposure to MBES (Kates Varghese *et al*. 2020). The results indicated that there was not a consistent change in foraging behaviour and individuals did not leave the range or stop foraging during the MBES activity (Kates Varghese *et al*. 2020). Similarly, tagged short-finned pilot whale (*Globicephala macrorhynchus)* that were exposed to a Single-Beam Echosounder (SBES), did not change their foraging behaviour, but variance in directionality of movement was observed (Quick *et al.,* 2014). This suggests that individuals increased their vigilance while the SBES was active, although the authors acknowledged that the range of behaviours exhibited could not be directly attributed to SBES operation, and that changes in behaviour were unlikely to be biologically significant (Quick *et al.,* 2014). In a study by Cholewiak *et. Al.* (2017) fewer beaked whale vocalisations were recorded when an SBES source was actively transmitting, suggesting that animals either move away from the area or reduce their foraging activity (although the findings were not statistically significant).

Temporary displacement or change in harbour porpoise echolocation behaviour was recorded in response to a 3D seismic survey in the North Sea (Sarnocińska *et al.,* 2020). No general displacement was detected at 15 km from any seismic activity but decreases in echolocation signals were detected up to 8 to 12 km from the active airguns (Sarnocińska *et al.,* 2020). Based on other studies (Dyndo *et al.,* 2015; Tougaard *et al.,* 2015) harbour porpoise disturbance ranges due to airgun noise are predicted to be smaller than to pile driving noise at the same energy. This is because the perceived noise level of the airgun pulses is predicted to be lower than for pile driving noise due to less energy at the higher frequencies where porpoise hearing is better (Sarnocinska *et al.,* 2020). Similarly, Thompson *et al.* (2013) found acoustic detections of harbour porpoise in a 2,000 km^2 North Sea study area decreased significantly during a commercial 2D seismic survey, but this effect was small in relation to natural variation. Animals were typically detected again at affected sites within a few hours, and the level of response declined through the ten-day survey suggesting exposure led to some tolerance of the activity (Thompson *et al.,* 2013). This suggests that prolonged seismic survey noise did not cause broader-scale displacement into suboptimal or higher-risk habitat. Likewise, no evidence of prolonged or large-scale displacement of humpback whale, sperm whale (*Physeter macrocephalus),* and Atlantic spotted dolphin (*Stenella frontalis*) due to seismic exploration was recorded during a ten-month study off Angola (Weir, 2008).

Aside from displacement or avoidance, other behavioural responses to seismic surveys have been demonstrated (reviewed in Wright and Consentino, 2015). These behavioural responses include cessation of singing (Melcón *et al*., 2012) and alteration of dive and respiration patterns which may lead to energetic burdens on the animals (Gordon *et al*., 2003). It is possible that these behavioural responses may lead to greater effects than expected, such as strandings (Cox *et al.,* 2006; Tyack *et al.,* 2006) or disruptions to migration (Heide-Jørgensen *et al.,* 2013). However, such extreme responses are highly context-dependent and variable, depending on factors such as the activity of the animal at the time (Robertson *et al*., 2013), prior experience to exposure (Andersen *et al.,* 2012), extent or type of disturbance (Melcón *et al*., 2012), environment in which they inhabit (Heide-Jørgensen *et al*., 2013) and the type of survey (as discussed in above for 'Auditory Injury').

It is expected that, to some extent, marine mammals will be able to adapt their behaviour to reduce impacts on survival and reproduction rates and tolerate elevated levels of underwater noise during site investigation surveys. Marine mammals are deemed to have some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance from elevated underwater noise during site investigation surveys is therefore considered to be medium.

Significance of Effect

Auditory Injury

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.16.2 Operation and Maintenance

Magnitude of Impact

Auditory Injury

Marine Mammal IEFs

Routine geophysical site investigation surveys and/or asset integrity surveys are expected to occur annually over the 25-year operations and maintenance phase (Table 7.23).

An overview of potential impacts from elevated underwater noise due to site investigation surveys are described above for the construction phase and have not been reiterated here. Overall, with embedded mitigation applied where required, this impact is predicted to be of very limited spatial extent, short-term duration (during individual surveys), intermittent over the operations and maintenance phase, and whilst the impact itself will occur during this phase, the effect of PTS will be permanent. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be negligible.

Behavioural Disturbance

Marine Mammal IEFs

An overview of potential impacts from elevated underwater noise due to site investigation surveys are described above for the construction phase and have not been reiterated here. Overall, this impact is predicted to be of local spatial extent, short term duration, and intermittent over the operations and maintenance phase. Further, the effect of behavioural disturbance is of high reversibility (with animals returning to baseline levels soon after surveys have ceased). It is predicted that the impact will affect the receptor directly. Therefore, for all IEFs, the magnitude of impact is considered to be low.

Sensitivity of Receptor

Auditory Injury

All Species

The sensitivity of all marine mammal IEFs to auditory injury from underwater noise has been described previously for piling (section 7.12.14) and for site investigation surveys in the construction phase. This information is not repeated here, as the sensitivity of marine mammal IEFs during the operations and maintenance phase is not expected to differ from that of construction phase. Overall, all marine mammal IEFs are deemed to have limited tolerance to auditory injury, high vulnerability, low recoverability, and international value. The sensitivity of these receptors to auditory injury is therefore considered to be **high**.

Since TTS is reversible, all marine mammal and marine turtle IEFs are assessed as having high tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to TTS is therefore considered to be low.

Behavioural Disturbance

Marine Mammal IEFs

The sensitivity of marine mammals during the operations and maintenance phase is not expected to differ from the construction phase. The sensitivity of marine mammals to behavioural disturbance as a result of this impact is as described above for the construction phase. All marine mammals are deemed have some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance from is therefore considered to be medium.

Significance of Effect

Auditory Injury

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.17 Injury, Disturbance, and Displacement from Vessel Activity and other Noise Producing Activities

The impact of vessel use during the construction, operation and maintenance, and decommissioning phases of the Proposed Development have the potential to cause injury, behavioural disturbances, and associated displacement of marine mammals. Noise producing activities (e.g. seabed preparation, drilling, and rock placement over the cables) could additionally result in disturbances to marine mammals within the development area.

The impacts from elevated underwater noise due to vessel use and other activities is based on a vessel and/or activity basis, considering the maximum injury/disturbance range as assessed in volume 3, Underwater Noise Technical Report (RPS Group and Seiche, 2024)volume 3, appendix J. However, several activities could be potentially occurring at the same time and therefore ranges of effects may extend from several vessels/locations where the activity is carried out and potentially overlap.

7.12.17.1 Construction Phase

Magnitude of Impact

Auditory Injury

All Species

During the construction phase of the Proposed Development, the increased levels of vessel activity will contribute to total underwater noise levels. The MDS for construction activities is up to a total of 236 construction vessels round trips (Table 7.23). These include heavy lift vessels, tug/anchor handlers, survey vessels, cable lay and installation vessels, and support vessels. Full details are provided in the MDS (Table 7.23). While this will result in an increase in vessel presence, movement will be limited to within the Proposed Development and are likely to follow existing shipping routes while travelling to and from ports. The MDS also accounts for other noise producing activities in the construction phase, such cable laying, cable trenching/cutting, and the use of jack-up rigs (Table 7.23).

Baseline levels of vessel traffic in the eastern Irish Sea are already high, largely due to ferry routes. For example, in 2019, there were 1,912 commercial ferry crossings between Liverpool or Heysham and the Isle of Man, 1,696 crossings between Liverpool and Belfast, 1,087 between Heysham and Warrenpoint (Northern Ireland), and 604 crossings between Heysham and Dublin (Energie Baden-Württemberg (EnBW) and British Petroleum (BP), 2023a). Vessels and construction activities will be temporary and transitory, as opposed to permanent and fixed. In this respect, vessel and construction activity noise is unlikely to differ significantly to that of vessel traffic already in the area.

A detailed underwater noise modelling assessment has been carried out to investigate the potential for injurious effects due to increase underwater noise (non-impulsive sound), using the latest criteria (see volume 3, appendix J). A conservative assumption has been made that all individuals will respond to increased vessel noise. The exposure metrics for different species and flee speeds (as detailed in Table 7.49) were employed. In reality, the distance over which effects may occur will, however, vary according to the species, the ambient sound levels, hearing ability, and behavioural response differences.

The underwater noise modelling results indicate that the threshold for PTS was not exceeded for any species for all vessels and activities. The threshold for TTS was also not exceeded for all species except harbour porpoise (in the VHF hearing group) (Table 7.78). Therefore, there is a negligible risk of PTS occurring to marine mammals as a result of elevated underwater sound due to vessel use, and cable laying, trenching, and jack-up rig activities. These activities were not modelled for marine turtles. However, given that thresholds were not exceeded for all marine mammal hearing groups (except TTS for VHF), the same result has been extrapolated for marine turtles.

Table 7.78: Estimated PTS And TTS Ranges (m) From Different Vessel Types And Activities For The Marine Mammal Hearing Groups (N/E = Threshold Not Exceeded)

Noise Source	Range (m)							
	LF		HF		VHF		PCW	
	PTS	TTS	PTS	TTS	PTS	TTS	PTS	TTS
Vessels								
Anchor handling vessel	N/E	N/E	N/E	N/E	N/E	700	N/E	N/E
Main installation vessel, construction vessel	N/E	N/E	N/E	N/E	N/E	1,440	N/E	N/E
Survey vessel, crew transfer vessels, and support vessels	N/E	N/E	N/E	N/E	N/E	6,740	N/E	N/E

Noise Source	Range (m)							
	LF		HF		VHF		PCW	
	PTS	TTS	PTS	TTS	PTS	TTS	PTS	TTS
Miscellaneous small vessel (e.g. tugs, vessels carrying Remotely Operated Vehicles (ROVs), dive boats, guard vessels)	N/E	N/E	N/E	N/E	N/E	700	N/E	N/E
Activities								
Cable trenching/cutting	N/E	N/E	N/E	N/E	N/E	5,000	N/E	N/E
Cable laying	N/E	N/E	N/E	N/E	N/E	1,440	N/E	N/E
Jack-up rig	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E

Overall, for all IEFs, the likelihood of auditory injury is extremely low and the maximum duration of the construction phase is up to two years. Therefore, this impact is predicted to be of limited spatial extent, medium term duration, intermittent and, although the impact itself is reversible (i.e. the elevation in underwater noise only occurs during the activities), the effect of PTS is permanent. It is predicted that the impact will affect the receptor directly. Since the PTS threshold was not predicted to be exceeded for any activities or hearing groups, the magnitude of impact is considered to be negligible.

Behavioural Disturbance

All Species

Behavioural disturbance is only likely to occur if vessel sound and activities exceed the background ambient noise levels. As discussed above for auditory injury, vessel traffic within the Proposed Development is already high, indicating high background ambient noise levels.

As above for auditory injury, a detailed underwater noise modelling assessment has been carried out to investigate the potential for behavioural disturbance due to increase underwater noise (non-impulsive sound), using the latest criteria (see volume 3, appendix J). A conservative assumption has been made that all individuals will respond to increased vessel noise. The exposure metrics for different species and flee speeds (as detailed in Table 7.49) were employed. In reality, the distance over which effects may occur will, however, vary according to the species, the ambient sound levels, hearing ability, and behavioural response differences. It should be borne in mind that there is a considerable degree of uncertainty and variability in the onset of disturbance and therefore any disturbance ranges should be treated as potentially over precautionary.

Based on the results of the underwater noise modelling, the estimated behavioural disturbance ranges for all hearing groups are presented in Table 7.79. The greatest behavioural disturbance range was from survey vessels, crew transfer vessels, and support vessels, with an estimated range of 20 km. Disturbance ranges for other vessels and activities varied from 6.3 to 16 km, with the threshold of disturbance not exceeded for jack-up rig activities.

Table 7.79: Estimated Behavioural Disturbance Ranges (km) From Different Vessel Types And Activities For All Marine Mammal Hearing Groups (N/E = Threshold Not Exceeded)

Noise Source	Disturbance Range (km)
Vessels	
Anchor handling vessel	6.3

Noise Source	Disturbance Range (km)
Main installation vessel, construction vessel	7.5
Survey vessel, crew transfer vessels, and support vessels	20
Miscellaneous small vessel (e.g. tugs, vessels carrying ROVs, dive boats, guard vessels)	6.3
Activities	
Cable trenching/cutting	16
Cable laying	7.5
Jack-up rig	N/E

With impulsive sound sources, there is an understanding of the difference between strong and mild disturbance, whereas for non-impulsive (continuous) sound sources, there is only a single available threshold (120 dB re 1 μPa (rms)) (NMFS, 2005). This threshold has been classed as the distance beyond which no animals would be disturbed. Given that ranges for disturbance for vessels are presented up to the 120 dB re 1 μPa (rms) threshold, and there is no distinction between mild and strong disturbance, it can be assumed that not all animals found within those ranges presented within Table 7.79 would be disturbed. There is also likely to be a proportional response (i.e. not all animals will be disturbed to the same extent), although there is no dose-response curve available to apply in the context of non-impulsive sound sources. Individual life history and context will also influence the likelihood of an individual to exhibit an aversive response to noise. These impacts will not be continuous over the construction phase, instead carried out over a shorter number of days within the period. Therefore, given the limited quantitative information available, as described above, any simplified calculation would likely lead to an unrealistic overestimation of the number of animals likely to be disturbed. As such, this value has not been quantified.

The impact is predicted to be of local spatial extent, medium-term duration, intermittent and reversible (i.e. increased underwater noise only occurs during the vessel presence and activities). Similarly, the effect of behavioural disturbance is reversible as receptors are expected to recover within days, even hours. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be **low.**

Sensitivity of Receptor

Increased vessel movements during the construction phase of the Proposed Development have the potential to result in a range of effects on marine mammals and marine turtles including injury due to elevated underwater noise, avoidance behaviour or displacement, and masking of vocalisations or changes in vocalisation rate.

Auditory Injury

<u>All Species</u>

The sensitivity of all marine mammal and marine turtle IEFs to auditory injury from underwater noise has been described previously for piling (section 7.12.14) and is not repeated here. Overall, all marine mammal and marine turtle IEFs are deemed to have limited tolerance to PTS, high vulnerability, low recoverability, and international value. The sensitivity of these receptors to auditory injury is therefore considered to be high.

Since TTS is reversible, all marine mammal and marine turtle IEFs are assessed as having high tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to TTS is therefore considered to be low.

Behavioural Disturbance

Cetacean IEFs

Disturbance levels will be dependent on individual species hearing ranges and background sound levels within the Proposed Development. Species sensitivity to underwater noise produced by vessels is related to species activity at the time of disturbance (International Whaling Commission (IWC), 2006; Senior *et al*., 2008), and the level of response is dependent on vessel type and behaviour (e.g. heading, speed) (Oakley *et al*., 2017; Hermannsen *et al*., 2019).

Cetaceans can both be attracted to and disturbed by vessels. For example, resting dolphins are likely to avoid vessels, foraging dolphins will ignore them, and socialising dolphins may approach vessels (Richardson *et al*., 1995). Species such common dolphin are regularly sighted near vessels and may also approach vessels (e.g. bow-riding). However, dolphins are also known to show aversive behaviours to vessel presence, including increased swimming speed, greater time travelling, less time resting or socialising, avoidance, increased group cohesion, and/or longer dive duration (Miller *et al*., 2008; Marley *et al.,* 2017; Toro *et al*., 2021). Other marine mammals, however, may show higher avoidance of vessels in comparison to dolphins. For example, a study by Meza *et al.* (2020) in the Istanbul Strait (Turkey) found increased foraging in bottlenose dolphin and common dolphin behavioural budgets, but a decrease in time spent foraging by harbour porpoise when exposed to purse seine vessels. In addition, a study of the vessel traffic associated with the construction of subsea gas pipeline in north-west Ireland demonstrated that bottlenose dolphin was positively correlated with overall vessel numbers and the number of construction vessels, but minke whale and grey seal were displaced by high levels of vessel traffic (Anderwald *et al.,* 2013). However, the authors suggested that minke whale and grey seal were avoiding the area due to noise rather than vessel presence. It was, however, unclear whether the bottlenose dolphins were attracted to the vessels themselves or to particularly high prey concentrations within the study area at the time (Anderwald *et al.,* 2013).

A reduction and/or simplification of dolphin vocalisations has been linked to vessel presence and noise. For example, Fouda *et al.* (2018) investigated the effect of concurrent ambient sound levels on social whistle calls produced by bottlenose dolphins in the western North Atlantic. The results demonstrated increases in ship sounds (both within and below the dolphin call bandwidth) resulted in simplified vocal calls, with higher dolphin whistle frequencies and a reduction in whistle contour complexity (Fouda *et al.,* 2018). This sound-induced simplified vocal calls may result in reduced information content and decrease effective communication, parent–offspring proximity, or group cohesion. Similarly, an upward shift in whistle frequency related to vessel presence has also been observed in bottlenose dolphin Walvis Bay, Namibia (Heiler, 2016).

Reactions of marine mammals to noise generate by vessels are often linked to changes in the engine and propeller speed (Richardson *et al.,* 1995). For example, Watkins (1986) reported avoidance behaviour in baleen whales from loud or rapidly changing sound sources, particularly where a boat approached an animal. Disturbance in small cetaceans, (dolphins and porpoises) is likely to be associated with small, fast-moving vessels as these species are more sensitive to HF sound, whilst baleen whales (e.g. minke whale) are likely to be more sensitive to slower moving vessels which emit LF sound. A study in the Moray Firth found that transit of vessels (moving motorised boats) resulted in a nearly 50% reduction of the likelihood of recording bottlenose dolphin prey capture buzzes (Pirotta *et al.,* 2015). The authors also suggested that vessel presence, not just vessel sound, resulted in disturbance of bottlenose dolphins (Pirotta *et al.,* 2015). Similarly, Richardson (2012) investigated the effect of disturbance on bottlenose dolphin community structure in Cardigan Bay, Wales, and found that group size was significantly smaller in areas of high vessel traffic.

As stated, harbour porpoise are VHF cetaceans and are particularly sensitive to high frequency sound. Therefore, they are likely to avoid vessels. Wisniewska *et al*. (2018) studied the temporary change in foraging rates of harbour porpoise in response to vessel sound in coastal waters with high traffic rates. Their results demonstrated that occasional high sound levels coincided with vigorous fluking, bottom diving, interrupted foraging, and even cessation of echolocation, leading to significantly fewer prey capture attempts at received levels greater than 96 dB re 1 µPa (16 kHz third-octave) (Wisniewska *et al*., 2018). Another study in the wider UK found that the occurrence of harbour porpoise declined significantly when the number of vessels in a 5 km^2

area exceeded 20,000 ships per year (approximately 80 ships per day or 18 ships per km^2) (Heinänen and Skov, 2015). Recently, Benhemma-Le Gall *et al.* (2021) compared harbour porpoise occurrence and foraging activity between two OWFs in the Moray Firth. Their results suggested that increased vessel activity (and other construction activities) led to a decrease in harbour porpoise acoustic detections and activity at distances of up to 4 km.

There is, however, evidence of habituation to boat traffic (Vella, 2002) and therefore a slight increase from the existing levels of traffic in the vicinity of the Proposed Development may not result in high levels of disturbance. The Liverpool Bay area already has a high level of anthropogenic activities as a baseline. For example, Lusseau *et al.* (2011) undertook a modelling study on the interaction between bottlenose dolphins and vessels associated with OWF development in the Moray Firth. Their results predicted that increased vessel movements did not have an adverse effect on the local population of bottlenose dolphin, although it did note that foraging may be disrupted by disturbance from vessels, which was also suggested by Benhemma-Le Gall *et al*. (2021).

The presence of vessels in foraging grounds could also result in reduced foraging success. Christiansen *et al*. (2013b) found that the presence of whale-watching boats within an important feeding ground in Iceland led to a reduction in minke whale foraging activity. As minke whale is a capital breeder, this could lead to reduced reproductive success since female body condition is known to affect foetal growth (Christiansen *et al.,* 2014). However, it is worth noting that the study was conducted in Faxafloi Bay (Iceland) where baseline sound levels (compared to the Irish Sea) are very low (McGarry *et al*., 2017). In addition, a subsequent study conducted by Christiansen and Lusseau (2015) in the same study area found no significant long-term effects of disturbance from whale-watching on minke whale vital rates since animals moved into disturbed areas when sandeel numbers were lower across their wider foraging area. A study (albeit on grey seals) by Hastie *et al.* (2021) demonstrated how foraging context is important when interpreting avoidance behaviour and should be considered when predicting the effects of anthropogenic activities. The authors state that avoidance rates depend on the perceived risk (e.g. silence, pile driving noise, operational noise from tidal turbines) versus the quality of the prey patch and highlight that sound exposure in different prey patch qualities may result in markedly different avoidance behaviour (Hastie *et al.,* 2021). Given the existing levels of vessel activity in the Proposed Development shipping and navigation study area (see volume 2, chapter 9) it is expected that cetaceans could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased.

Vessel movements involved in the construction phase, however, are unlikely to result in barrier effects to migration for these receptors as disturbance ranges will likely constitute a small area in the context of the wider available habitat in the Irish Sea. Overall, the cetacean IEFs are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be medium.

<u>Grey Seal and Harbour Seal</u>

Seals are particularly sensitive to disturbances in regions where vessel traffic overlaps with productive coastal waters (Robards *et al*., 2016). Common reactions to approaching vessels includes increased alertness (Henry and Hammill, 2001), head raising (Niemi*, et al.,* 2013) and flushing off haul-out sites into the sea (Jansen *et al.,* 2015; Andersen *et al*., 2012; Blundell and Pendleton, 2015; Johnson and Acevedo-Gutiérrez, 2007), although it should be noted that the studies listed focussed on vessel presence rather than vessel sound. Recently however, Mikkelsen *et al.* (2019) investigated the behaviour of a tagged grey seal to vessel noise, and reported changes in diving behaviour, switching rapidly from a dive ascent to descent.

In a study of harbour seal in Alaska, haul out probability was adversely affected by vessels, with cruise ships having the strongest effect (Blundell and Pendleton, 2015). Harbour seal have been shown to be alerted and move away when a boat approaches (Andersen *et al.,* 2012; Blundell and Pendleton, 2015), but this response varies by season. When disturbed, hauled-out seals typically flush into the water, which could be detrimental during pupping season (Terhune and Almon, 1983; Johnson and Acevedo-Gutiérrez, 2007). Recently, Pérez Tadeo *et al.* (2021) assessed the responses of grey seal to ecotourism during breeding and pupping seasons at White Strand Beach, south-west Ireland. They found that vessels approaching within 500 m of the beach showed strong influence on the proportion of grey seal entering the water and an increase in vigilance and decrease in resting behaviour (Pérez Tadeo *et al.*, 2021). Similarly, a study on harbour seal showed avoidance behaviour or alert reactions when vessels approached within 100 m of a haul-out (Paterson *et al.,* 2005). This disturbance to seal haul-outs could have adverse consequences during the pupping season, due to trade-offs between feeding and nursing. Andersen *et al.* (2012), reported that harbour seal exhibit weaker and shorter lasting responses to disturbance during the breeding season and appear more reluctant to flee and return to the haul-out site after being disturbed (likely attributed to a trade-off between moving away and nursing, rather than habituation).

Furthermore, the presence of vessels in foraging grounds could result in reduced foraging success, particularly in harbour seals given reduced foraging ranges (approximately 50 km from haul-outs) when compared to grey seals (approximately 100 – 150 km from haul-outs) (SCOS, 2021). However, seals can be curious and have been recorded approaching tour boats that regularly visit an area and may habituate to sounds from tour vessels (Bonner, 1982). Mikkelsen *et al.* (2019) used long term sound and movement tagging data to study reaction of grey seals to vessel noise in the North Sea. They found that grey seal were exposed to audible vessel noise 2.2% – 20.5% of their time when in water and that high vessel noise coincided with interruption of functional behaviours such as resting (Mikkelsen *et al.,* 2019). A study on grey seals by Hastie *et al.* (2021) demonstrated how foraging context is important when interpreting avoidance behaviour and should be considered when predicting the effects of anthropogenic activities. The authors state that avoidance rates depend on the perceived risk (e.g. silence, pile driving noise, operational noise from tidal turbines) versus the quality of the prey patch and highlight that sound exposure in different prey patch qualities may result in markedly different avoidance behaviour (Hastie *et al.,* 2021). Given the existing levels of vessel activity in the Proposed Development shipping and navigation study area (see volume 2, chapter 9) it is expected that seals could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased.

Vessel movements involved in the construction phase, however, are unlikely to result in barrier effects to migration for these receptors as disturbance ranges will likely constitute a small area in the context of the wider available habitat in the Irish Sea. Overall, grey and harbour seal are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be medium.

<u>Marine Turtle IEFs</u>

Marine turtles are known to migrate through and feed within the regional marine mammal study area during the summer, which is, therefore, considered to be the most sensitive time of year. Vessel movements involved in the construction phase, however, are unlikely to result in barrier effects to migration for these receptors as disturbance ranges will likely constitute a small area in the context of the wider available habitat in the Irish Sea.

Although there is little published data on the behavioural response of marine turtles to vessels, responses are expected to consist of changes in swimming speed or direction, and diving behaviour. However, similar to marine mammals, direct displacement from the Proposed Development marine mammal study area is unlikely. As marine turtles do not nest on beaches in the UK and Ireland, their sensitivity to disturbance in this respect will be low. Offshore waters of the Irish Sea could potentially host important feeding grounds for sea turtles (NPWS, 2019), but the area of likely disturbance as a result of this impact will constitute a very small proportion of available habitat in the context of the wider region.

Given existing baseline levels of traffic within Liverpool Bay, vessels involved in the construction phase are unlikely to increase the risk of disturbance and therefore it is expected that marine turtles could tolerate the effects of disturbance without any impact on reproduction and survival rates and would return to previous activities once the impact had ceased. Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Auditory Injury

All Species

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEF

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.17.2 Operation and Maintenance Phase

Magnitude of Impact

Auditory Injury

Vessel traffic associated with operation and maintenance activities will result in up to 750 return trips by vessels to and from the Proposed Development over the 25-year lifetime of the Proposed Development (Table 7.23). Over a 25-year period this equates to just 2.5 vessel return trips per month. Vessel presence within the Proposed Development at any one time will be lower during the operation and maintenance than in the construction phase, but will be of a longer duration, over the whole 25-year lifetime of the Proposed Development.

An overview of potential impacts from elevated underwater noise due to vessel use and other activities are described above for the construction phase and have not been reiterated here. The impact is predicted to be of limited spatial extent, long term duration, intermittent, and although the impact itself is reversible (i.e. the elevation in underwater noise only occurs during the activities), the effect of PTS (if it were to occur) is permanent. It is predicted that the impact will affect the receptor directly. Since the PTS threshold was not predicted to be exceeded for any activities or species, the magnitude of impact is considered to be negligible.

Behavioural Disturbance

Vessel activities within the operation and maintenance phase include cable maintenance (Table 7.23). An overview of potential impacts from elevated underwater noise due to vessel use and other activities are described above for the construction phase and have not been reiterated here. The impact is predicted to be of local spatial extent, long-term duration, intermittent and reversible (i.e. the elevation in underwater noise only occurs during the activities). Similarly, the effects of behavioural disturbance are reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of Receptor

Auditory Injury

<u>All Species</u>

The sensitivity of all marine mammal and marine turtle IEFs to auditory injury from underwater noise has been described previously for piling (section 7.12.14) and is not repeated here. The sensitivity of marine mammal and marine turtle IEFs during the operations and maintenance phase is not expected to differ from the construction phase. Overall, all marine mammal and marine turtle IEFs are deemed to have limited tolerance to auditory injury, high vulnerability, low recoverability, and international value. The sensitivity of these receptors to auditory injury is therefore considered to be high.

Since TTS is reversible, all marine mammal and marine turtle IEFs are assessed as having high tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to TTS is therefore considered to be low.

Behavioural Disturbance

<u>Marine Mammal IEFs</u>

The sensitivity of marine mammals during the operations and maintenance phase is not expected to differ from the construction phase. The sensitivity of marine mammals to behavioural disturbance as a result of this impact is as described above for the construction phase. All marine mammals are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be medium.

<u>Marine Turtle IEFs</u>

The sensitivity of marine turtles during the operations and maintenance phase is not expected to differ from the construction phase. The sensitivity of marine turtles to behavioural disturbance as a result of this impact is as described above for the construction phase. All marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Auditory Injury

<u>All Species</u>

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance

<u>Marine Mammal IEFs</u>

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

<u>Marine Turtle IEF</u>

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.17.3 Decommissioning Phase

Magnitude of Impact

Auditory Injury

Vessel traffic associated with decommissioning activities will result in up to 128 return trips by vessels to and from the Proposed Development (Table 7.23). Vessel presence within the Proposed Development during the decommissioning will be equal to or lower than that of the construction phase at any one time.

An overview of potential impacts from elevated underwater noise due to vessel use and other activities are described above for the construction phase and have not been reiterated here. The impact is predicted to be of limited spatial extent, long term duration, intermittent, and although the impact itself is reversible (i.e. the elevation in underwater noise only occurs during the activities), the effect of PTS (if it were to occur) is permanent. It is predicted that the impact will affect the receptor directly. Since the PTS threshold was not predicted to be exceeded for any activities or species, the magnitude of impact is considered to be **negligible.**

Behavioural Disturbance

Vessel activities within the decommissioning phase include cable and foundation removal (Table 7.23). An overview of potential impacts from elevated underwater noise due to vessel use and other activities are described above for the construction phase and have not been reiterated here. The impact is predicted to be of local spatial extent, long-term duration, intermittent and reversible (i.e. the elevation in underwater noise only occurs during the activities). Similarly, the effects of behavioural disturbance are reversible as receptors are expected to recover within hours/days. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of Receptor

Auditory Injury

<u>All Species</u>

The sensitivity of all marine mammal and marine turtle IEFs to auditory injury from underwater noise has been described previously for piling (section 7.12.14) and is not repeated here. The sensitivity of marine mammal and marine turtle IEFs during the decommissioning phase is not expected to differ from the construction phase. Overall, all marine mammal and marine turtle IEFs are deemed to have limited tolerance to auditory injury, high vulnerability, low recoverability, and international value. The sensitivity of these receptors to auditory injury is therefore considered to be high.

Since TTS is reversible, all marine mammal and marine turtle IEFs are assessed as having high tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to TTS is therefore considered to be low.

Behavioural Disturbance

<u>Marine Mammal IEFs</u>

The sensitivity of marine mammals during the decommissioning phase is not expected to differ from the construction phase. The sensitivity of marine mammals to behavioural disturbance as a result of this impact is as described above for the construction phase. All marine mammals are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be medium.

Marine Turtle IEFs

The sensitivity of marine turtles during the decommissioning phase is not expected to differ from the construction phase. The sensitivity of marine turtles to behavioural disturbance as a result of this impact is as described above for the construction phase. All marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Auditory Injury

All Species

Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEF

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.18 Injury due to Collision with Marine Vessels

7.12.18.1 Construction Phase

Increases in marine vessel traffic during the construction phase of the Proposed Development could result in increased collisions risk for marine mammals and marine turtles within the Proposed Development and the surrounding Liverpool Bay.

Magnitude of Impact

All Species IEFs

Vessel traffic associated with construction activities will result in up to 236 return trips by vessels to and from the Proposed Development (Table 7.23). Increased vessel traffic in the construction phase is discussed in greater detail in section 7.12.17 above.

Collision with vessels has the potential to result in fatal and non-fatal injuries for marine mammals and marine turtles (Laist *et al.,* 2001; Hazel *et al.,* 2007; Vanderlaan and Taggart, 2007; Cates *et al.,* 2017; Schoeman *et al.,* 2020). Evidence of fatal collisions has been gathered from carcasses washed up on beaches, caught on vessel bows, and from floating carcasses (Laist *et al*., 2001; Foley *et al.,* 2019; Peltier *et al.,* 2019). Fatal injuries include propeller cuts, bruising, oedema, internal bleeding, and fractures (Jensen and Silber, 2003; Douglas *et al.,* 2008). However, fatalities are often not reported, particularly for marine turtles and smaller marine mammals (Authier *et al.,* 2014; Schoeman *et al.,* 2020). Evidence of non-fatal injuries has been gathered from individuals showing scars and gashes characteristic of collision with propellers (Wells *et al.,* 2008; Luksenburg, 2014). The New York State Marine Mammal and Sea Turtle Stranding Program reported that 10.6% of stranded marine turtles displayed evidence of propeller wounds (Gerle and DiGiovanni, 1998).

Whilst there are a range of vessels likely to be involved in the construction of the Proposed Development, those travelling at higher speeds pose a greater risk of injury due to the potential for stronger impact (Hazel *et al.,* 2007; Work *et al.,* 2010; Schoeman *et al.,* 2020). Vessels travelling at 7 m/s (14 knots) or faster are the most likely to cause death or a serious injury for marine mammals (Laist *et al.,* 2001). Vanderlaan and Taggart (2007) demonstrated the probability of lethal injury for large whales decreased to <50% when large vessels were travelling at 10 knots, and this probability was even lower for small vessels (3 – 6 m length) travelling at 10 knots. However, for marine turtles, vessel operators cannot rely on turtles to actively avoid vessels at speeds above 1.1 m/s (2.2 knots) (Hazel *et al.,* 2007). Work *et al.* (2010) demonstrated that the probability of lethal injury in loggerhead turtle was reduced when small vessels were travelling at 7.5 knots of less. It is likely that a proportion of the vessels associated with the construction phase will be stationary or slow moving throughout the Proposed Development for significant periods of time. Most vessels involved in the construction phase are likely to be travelling at lower speeds than 14 knots, which is suitable for the marine mammal IEFs within the regional marine mammal study area. Lower speeds of 10 knots would be required if a large whale, such as a humpback or fin whale (*Balaenoptera physalus*) was detected during vessel transit. These species are rare within the regional marine mammal study area, but there have been sporadic and isolated sightings in the past. As marine turtles are also infrequently recorded within the regional marine mammal study area, lower speeds would also be required upon sighting. Furthermore, marine turtles are not as easily detected as marine mammals, as they do not produce blows, breach the water, or produce sound detectable by a hydrophone. All vessels will be required to follow an EMP, which outlines instructions for vessel operation including advice to not deliberately approach marine mammals or turtles and to avoid sudden changes in speed or direction. With the EMP in place, the risk of collision is likely to be reduced for marine mammals, and to marine turtles, but to a lower extent.

Many of the vessels involved in the construction phase will be relatively small, such as tugs, ROVs, crew transfer vessels, dive boats, barges, and Rigid Inflatable Boats (RIBs). These smaller vessels will have good manoeuvrability and would be able to avoid any detected marine mammals or turtles (Schoeman *et al.,* 2020). Larger vessels with lower manoeuvrability would need larger distances to avoid an animal, however, would have more time to react as they would be travelling at slower speeds. Additionally, the sound emitted from these vessels could deter marine mammals and potentially marine turtles from the potential ZoI. Finally, the vessel movements will likely follow existing shipping routes, and will be contained within the Proposed Development.

Overall, with the measures to reduce the risk of collision in place (e.g. the EMP), this impact is predicted to be limited and localised spatial extent, medium term duration, intermittent, and of medium to low reversibility (depending on the extent of injuries). It is predicted that this impact will affect the receptor directly. Therefore, the magnitude of impact is conservatively considered to be low.

Sensitivity of Receptor

The majority of scientific publications on vessel collisions focus on large vessels and large, slow swimming baleen whales (Knowlton and Kraus, 2001; Nowacek *et al.,* 2004; Douglas *et al.,* 2008; Van der Hoop *et al.,* 2012). However, a recent review found that smaller whales, dolphins, porpoises, and marine turtles are also affected, but reporting is scarcer (Schoeman *et al.,* 2020).

Marine Mammal IEFs

In general, marine mammals are able to detect and avoid vessels, however, they do not always move out of the path of an approaching vessel (Schoeman *et al.,* 2020). Behaviours such as resting, foraging, nursing, and socialising could distract marine mammals from detecting the risk posed by vessels (Dukas, 2002). As discussed in the 'Magnitude of Impact' section above, vessel collisions can pose a serious risk to marine mammals, and result in serious and fatal injuries.

Harbour porpoise are the most common cetacean in UK and Irish waters, and within the regional marine mammal study area. They are a small, highly mobile species, and have been demonstrated to display avoidance behaviour to vessels (Polacheck and Thorpe, 1990; Camphuysen and Siemensma, 2011).

Furthermore, the most recent report by the UK Cetacean Strandings Investigation Programme detailed that only four out of 53 stranded harbour porpoise in 2015 had died from physical trauma of unknown origin, which could have been due to vessel strikes (UK Cetacean Strandings Investigation Programme, 2015). However, the physical trauma of unknown origin could also be due to undiagnosed bycatch or bottlenose dolphin attacks (IAMMWG *et al.,* 2015). Similarly, the programme only identified five harbour porpoise out of 1,041 strandings had injuries consistent with a fatal impact from vessel strikes between 2000 and 2010 (Jepson, 2005; Deaville and Jepson, 2011). Of these 1,041 stranded harbour porpoise, 48 died of acute physical trauma of unknown origin (Jepson, 2005; Deaville and Jepson, 2011). Overall, it is likely that harbour porpoise will largely be able to avoid vessel collisions within the Proposed Development.

As discussed in the preceding paragraphs, large, slow swimming baleen whales are likely to be the most vulnerable to vessel collisions. Minke whale are baleen whales and the largest marine mammal IEF identified in this assessment, however they are significantly smaller than other baleen whales, such as humpbacks and fin whales. Information on vessel collisions with minke whale is scarce, however there have been various reports of lethal collisions around the UK, including one in Easter Ross, Scotland, one in Shoebury, England (Groves, 2016), and two in Norfolk, England (Aldred, 2013). Similarly, out of 110 fatally stranded minke whale in Scotland between 1992 and 2002, two were killed by vessel strikes (Pierce *et al.,* 2004).

Vessel strikes can result in lethal or non-lethal injuries to dolphins (Schoeman *et al.,* 2020). For example, Dwyer *et al.* (2013) reported short-term survival of a bottlenose dolphin in New Zealand which suffered multiple propeller wounds, including penetration to the bone. Van Waerbeek *et al.* (2007) reported that bottlenose dolphin may receive a moderate impact from collisions, however these may be sustainable at species level because many strikes are nonlethal. However, the proportion of dolphins colliding with vessels is poorly understood. For example, a long-term photo-identification monitoring of 277 resident bottlenose dolphins present in Maui Nui, Hawai'I, reported that only one individual exhibited marks indicative of vessel interactions (Olson *et al.,* 2022). Reports of vessel collisions with other dolphin IEFs identified in this assessment are rare. For example, a common dolphin with deep propeller injuries below the dorsal fin was found dead on a Cornwall beach in 2022 (Morwood, 2022). Additionally, blunt trauma and spinal cord injuries likely due to a vessel collision were determined as the cause of death of a common dolphin in New Zealand (Martinez and Stockin, 2013). Similarly, one individual in a pod of 14 Risso's dolphin observed in the Ionian Sea had injuries indicative of vessel strikes behind the dorsal fin (Menniti and Vella, 2022).

In pinnipeds, trauma ascribed to collisions with vessels has been identified in <2% of both live stranded (Goldstein *et al*., 1999) and dead stranded seals in the USA (Swails, 2005). Furthermore, a study in the Moray Firth, Scotland, demonstrated that seals utilise the same areas as vessels during trips between haul-outs and foraging sites but tended to remain over 20 m from vessels with only three instances over 2,241 days of seal activity resulted in passes at <20 m (Onoufriou *et al.,* 2016). Furthermore, a study on strandings data of harbour seal in the Salish Sea reported 27 cases of fatal propellor strikes between 2002 and 2019 (Olson *et al.,* 2021).

Although the potential for injury due to collision with construction vessels is relatively low, the consequences of collision risk could be fatal. All marine mammal IEFs would be highly vulnerable to a collision, and the effect could potentially cause a change in both reproduction and survival of individuals. However, it is likely that marine mammals will avoid vessels, minimising collision risk. On the basis that not all collisions are lethal, there is considered to be a medium potential for recovery.

Overall, all marine mammal IEFs are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Unlike marine mammals, marine turtles are less likely to be able to identify the direction of the source of vessel noise and avoid approaching vessels (Hazel, 2009). Furthermore, their smaller size in comparison to marine mammals, lack of blow, minimal time spent surfacing, and the inability to detect them using a hydrophone result in marine turtles being more difficult to detect from vessels. Marine turtles appear to be at a higher risk of vessel collision during nesting and breeding seasons (National Oceanic and Atmospheric Administration

(NOAA) Fisheries, 2023), however these occur in their tropical and subtropical habitats, far from the regional marine mammal study area.

Sightings and strandings of marine turtles within the regional marine mammal study area are not particularly common, with minimal information available on these species in UK and Irish waters. In 2021, there were 15 reported strandings of dead marine turtles in the UK and Ireland, with one stranded leatherback turtle in Rosyth, Scotland, with injuries indicative of a propeller strike. However, it is not known if these injuries were the cause of death of if they were inflicted upon the carcass post-mortem (Penrose *et al.,* 2022). In the past five years, only one other fatally stranded turtle with propeller injuries indicative of vessel collision has been reported: a leatherback which was found in Cornwall in 2018 (Penrose and Gander, 2019). Again, it is unknown whether these propeller wounds occurred pre- or post-mortem.

Marine turtles are known to migrate through and feed within the regional marine mammal study area during the summer (albeit it in relatively low numbers), as the offshore waters of the Irish Sea could potentially host important feeding grounds for them (NPWS, 2019). However, as marine turtles do not nest on beaches within the UK and Ireland and are more likely to be present further offshore, the potential for injury due to collision with construction vessels is relatively low. However, the consequences of a potential collision risk could be fatal; all marine turtle IEFs would be highly vulnerable to a collision, and the effect could potentially cause a change in both reproduction and survival of individuals. However, on the basis that not all collisions are lethal, there is considered to be a medium potential for recovery.

Overall, marine turtle IEFs are deemed to have low tolerance, medium recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.18.2 Operation and Maintenance Phase

Increases in marine vessel traffic during the operation and maintenance phase of the Proposed Development could result in increased collisions risk for marine mammals within the Proposed Development and the surrounding Liverpool Bay.

Magnitude of Impact

All Species

Vessel traffic associated with operation and maintenance activities will result in up to 750 return trips by vessels to and from the Proposed Development over the 25-year lifetime of the Proposed Development (Table 7.23). Vessel presence within the Proposed Development at any one time will be lower during the operation and maintenance than in the construction phase, but will be of a longer duration, over the whole 25-year lifetime of the Proposed Development. An overview of the potential for vessel collision is provided within this section for the construction phase and has not been reiterated here.

Overall, with the measures to reduce the risk of collision in place (e.g. the EMP), and the lower volume of vessel traffic associated with the operation and maintenance phase, this impact is predicted to be limited and localised spatial extent, long term duration, intermittent, and of medium to low reversibility (depending on the extent of injuries). It is predicted that this impact will affect the receptor directly. Therefore, the magnitude of impact is conservatively considered to **be low.**

Sensitivity of Receptor

All Species

The sensitivities of marine mammal and turtle IEFs presented in the assessment of this impact in the construction phase equally apply in the operation and maintenance phase (medium).

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.18.3 Decommissioning Phase

Increases in marine vessel traffic during the decommissioning phase of the Proposed Development could result in increased collisions risk for marine mammals within the Proposed Development and the surrounding Liverpool Bay.

Magnitude of Impact

All Species

Vessel traffic associated with decommissioning activities will result in up to 128 return trips by vessels to and from the Proposed Development (Table 7.23). Vessel presence within the Proposed Development during the decommissioning will be equal to or lower than that of the construction phase at any one time. An overview of the potential for vessel collision is provided within this section for the construction phase and has not been reiterated here.

Overall, with the measures to reduce the risk of collision in place (e.g. the EMP), this impact is predicted to be limited and localised spatial extent, medium duration, intermittent, and of medium to low reversibility (depending on the extent of injuries). It is predicted that this impact will affect the receptor directly. Therefore, the magnitude of impact is conservatively considered to be low.

Sensitivity of Receptor

All Species

The sensitivities of marine mammal and turtle IEFs presented in the assessment of this impact in the construction phase equally apply in the decommissioning phase (medium).

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.19 Effects on Marine Mammals and Marine Turtles due to changes in Prey Availability

7.12.19.1 Construction Phase

There is potential for changes in prey abundance resulting from construction activities to have a direct impact on the foraging abilities of marine mammals and marine turtles within the Proposed Development and surrounding vicinity.

Magnitude of Impact

All Species

The key prey species for marine mammals include gadoids (e.g. cod, haddock, poor cod, and whiting), forage fish (e.g. herring, sprat, sandeel, mackerel), cephalopods, and flatfish (e.g. dab, flounder, plaice, and sole). These species have been identified as IEFs of varying importance within the regional fish and shellfish ecology study area (Table 7.13), which largely overlaps with the regional marine mammal study area. Consequently, adverse effects on fish and shellfish species within the regional marine mammal study area may have indirect effects on marine mammals.

Key prey for marine turtles includes pelagic invertebrates such as jellyfish, salps, and squid, various smaller fish and crustaceans, and floating seaweed. These prey species are not considered IEFs within the regional marine mammal study area and are also unlikely to be affected by the Proposed Development.

Potential impacts on prey species during the construction phase have been assessed the appropriate MDSs for these receptors. Impacts in the construction phase are:

- temporary subtidal habitat loss and/or disturbance (section 7.12.9);
- long-term subtidal habitat loss (section 7.12.10);
- underwater noise (section 7.12.11); and
- increased SSCs and associated deposition (7.12.12).

No significant adverse effects were predicted to occur to the prey species of marine mammals or marine turtles due to activities within the construction phase. Therefore, changes in prey availability are predicted to be of local spatial extent, medium duration, intermittent, and high reversibility. Therefore, the magnitude of this impact is considered **low**.

Sensitivity of Receptor

Marine Mammal IEFs

Although foraging strategies vary between species, marine mammals often exploit a range of prey species depending on season and availability and can cover extensive distances to forage. Although site-fidelity is observed, such as the resident population of bottlenose dolphin in Cardigan Bay and seals returning to the same haul-outs to breed, marine mammals are largely unconfined to one location. They can move freely to exploit prey resources and have large home ranges. For example, grey seal in the English Channel have been recorded undertaking foraging trips of up to 350 km (Vincent, *et al.,* 2016), and up to 2,100 km in the North Sea (McConnell, *et al.,* 1999). As the impacts to prey species will be largely localised within the Proposed Development and may be intermittent or not affect the entire area at any one time, only a small area will potentially be affected in comparison to available foraging habitat within the regional marine mammal study area.

Furthermore, the fish and shellfish communities present within the Proposed Development are characteristic of the regional marine mammal study area. Therefore, it can be assumed that there will be similar prey species available within the wider area. However, there may be an energetic cost associated with increased foraging distances for harbour porpoise and harbour seal. Harbour porpoise have a high surface area to volume ratio and live in cold, high latitude waters (Rojano-Doñate, *et al.,* 2018). Therefore, they have a high metabolic rate in order to maintain optimal body temperature (Rojano-Doñate, *et al.,* 2018). They meet their high metabolic demands by undertaking continuous shallow foraging dives (Wisniewska *et al.,* 2016, 2018; McDonald, *et al.,* 2021). Harbour seal are not observed foraging as far offshore as grey seal, and typically remain within 50 km of their haul-out sites (SCOS, 2021). Despite this, if harbour porpoise and harbour seal do have to travel further for alternative foraging grounds, the impacts to prey species are predicted to be short-term and reversible (i.e. increased underwater noise would occur during noise producing activities). Harbour porpoise were observed to resume normal activity levels a few days after cessation of piling at two Danish offshore wind farms (Tougaard *et al.,* 2003, 2005). A similar response was observed in harbour seal, with no significant displacement recorded during the construction of multiple wind projects in The Wash, England, and displacement limited to piling activities. Within two hours of cessation of piling, harbour seal distribution had returned to non-piling conditions (Russell *et al.,* 2016). It is likely that during construction marine mammals may temporarily shift their foraging efforts to other areas within the regional marine mammal study area due to disturbances to benthic habitat and associated resources (Fiorentino and Wieting, 2014). Therefore, it is expected that all marine mammal IEFs would be able to tolerate the effect without any impact on reproduction and survival rates and would be able to return to previous activities once the impact had ceased.

However, minke whale is potentially vulnerable to impacts to Irish Sea herring stocks. There are two known herring stocks in Irish Waters, and minke whale distribution appears to mirror these stocks in Manx Waters, thus within the Proposed Development marine mammal study area. The Manx herring stock spawns on the east coast of the Isle of Man in September and October (Bowers, 1969), with minke whale regularly observed on the east coast during these months. The Manx herring stock and the Mourne herring stock overlap on the west coast of the Isle of Man during the summer (Bowers, 1980). Although significantly higher minke whale sighting rates often occur in habitats associated with sandeel presence, an area of high occupancy coincided with high densities of sprat during spring (Anderwald, *et al.,* 2012). Hence, their ability to switch between different prey according to their seasonal availability and the low energetic cost of swimming (Blix and Folkow, 1995) indicates that minke whale would be able to respond to temporal changes in pelagic prey concentrations.

Overall, all marine mammals, except for minke whale, are deemed to be able to tolerate changes in prey availability, have high recoverability and high international value. The sensitivity of the receptor is therefore, considered to be low.

For minke whale, due to their reliance on herring as a primary food source in the Irish Sea, they are deemed to have some tolerance to changes in prey availability, have high recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Diet varies across the six species of marine turtles with the potential to be present within the regional marine mammal study area. Leatherback turtle is the most frequently seen marine turtle in UK and Irish waters, and they predominantly prey on soft and gelatinous pelagic invertebrates, such as jellyfish, salps, and cephalopods (Dodge *et al.,* 2011). This species undertakes extensive migrations in order to forage in different areas (Eckert *et al.,* 2006; Caut *et al.,* 2009), thus is likely to be able to tolerate unexpected changes in prey availability, although they are unlikely to occur for these species as a result of the construction of the Proposed Development. Other species, such as green, hawksbill, Kemp's ridley, loggerhead, and olive ridley sea turtles are rarer in Uk and Irish waters but could potentially be present. Clyde-Brockway *et al.* (2022) analysed diet composition of green and hawksbill sea turtles using stable isotope analysis and concluded that these species forage at multiple tropic levels and their diet was influenced by the availability of prey within the environment.

Green turtle diet was also shown to vary with season and foraging grounds (Carrión-Cortez *et al.,* 2010), suggesting tolerance to availability of prey species. Similarly, species such as Kemp's ridley sea turtle and loggerhead sea turtle consume a wide range of shellfish, particularly crustaceans (Burke *et al.,* 1994; Donaton *et al.,* 2019).

It is likely that construction will not impact prey species for marine turtles. In the unlikely event that these prey species are impacted, marine turtles will be able to exploit other species or forage elsewhere in the regional marine mammal study area. Therefore, it is expected that marine turtles would be able to tolerate the effect without any impact on reproduction and survival rates and would be able to return to previous activities once the impact had ceased.

Overall, all marine turtles are deemed to be able to tolerate changes in prey availability (which are also highly unlikely to occur due to the Proposed Development), have high recoverability and high international value. The sensitivity of the receptor is therefore, considered to be low.

Significance of Effect

Marine Mammal IEFs

Overall, for all marine mammal IEFs except minke whale, the magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Overall, for minke whale, the magnitude of the impacts is deemed to be low, and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.12.19.2 Operation and Maintenance Phase

There is potential for changes in prey abundance resulting from operation and maintenance activities to have a direct impact on the foraging abilities of marine mammals and marine turtles within the Proposed Development and surrounding vicinity.

Magnitude of Impact

All Species

Potential impacts on prey species during the operation and maintenance phase have been assessed using the appropriate MDSs for these receptors. These impacts are temporary subtidal habitat loss and/or disturbance (section 7.12.9) and long-term subtidal habitat loss (section 7.12.10).

No significant adverse effects were predicted to occur to the prey species of marine mammals or marine turtles due to activities within the operation and maintenance phase. Therefore, changes in prey availability are predicted to be of local spatial extent, long-term duration, continuous, and high reversibility. Therefore, the magnitude of impact is considered low.

Sensitivity of Receptor

All Species

The sensitivities of all marine mammal and marine turtle IEFs presented in the assessment of this impact in the construction phase equally apply in the operation and maintenance phase (low to medium).

Significance of Effect

Marine Mammal IEFs

Overall, for all marine mammal IEFs except minke whale, the magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Overall, for minke whale, the magnitude of the impacts is deemed to be low, and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms

7.12.19.3 Decommissioning Phase

There is potential for changes in prey abundance resulting from decommissioning activities to have a direct impact on the foraging abilities of marine mammals and marine turtles within the Proposed Development and surrounding vicinity.

Magnitude of Impact

All Species

Potential impacts on prey species during the construction phase have been assessed using the appropriate MDSs for these receptors. Impacts in the decommissioning phase are:

- temporary subtidal habitat loss and/or disturbance (section 7.12.9);
- long-term subtidal habitat loss (section 7.12.10);
- underwater noise (section 7.12.11); and
- increased SSCs and associated deposition (7.12.12).

No significant adverse effects were predicted to occur to the prey species of marine mammals or marine turtles due to activities within the decommissioning phase. Therefore, changes in prey availability are predicted to be of local spatial extent, long-term duration, continuous, and high reversibility. Therefore, the magnitude of impact is considered to be **low**.

Sensitivity of Receptor

All Species

The sensitivities of all marine mammal and marine turtle IEFs presented in the assessment of this impact in the construction phase equally apply in the decommissioning phase (low to medium).

Significance of Effect

Marine Mammal IEFs

Overall, for all marine mammal IEFs except minke whale, the magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Overall, for minke whale, the magnitude of the impacts is deemed to be low, and the sensitivity of the receptor is considered to be medium. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impacts is deemed to be low for all species, and the sensitivity of the receptor is considered to be low. There would be no change to the international value of these species. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13 Cumulative Effects Assessment

7.13.1 Methodology

The Cumulative Effects Assessment (CEA) investigated the impact associated with the Proposed Development with other plans, projects, and activities. The plans, projects, and activities were selected as relevant to the CEA are based upon the results of a screening exercise (for full details see volume 3, appendix F). The plans, projects, and activities have been individually considered for screening in or out of this chapter's CEA based upon data confidence, effect-receptor pathways, and the spatial/temporal scales involved.

The marine biodiversity CEA methodology has followed the methodology set out in volume 1, chapter 5. As part of the assessment, all plans, projects, and activities considered alongside the Proposed Development have been allocated into 'tiers' reflecting their current stage within the planning and development process. The tiered approach to the CEA is as follows:

- Tier 1:
  - under construction;
  - permitted application;
  - submitted application; and
  - those currently operational that were not operational when baseline data were collected, and/or those that are operational but have an ongoing impact.
- Tier 2:
  - the scoping report has been submitted and is in the public domain.
- Tier 3:
  - the scoping report has not been submitted and is not in the public domain;
  - identified in the relevant development plan for the Proposed Development; and
  - identified in other plans or programmes.
- Tier 4:
  - no publicly available information.

This tiered approach has been adopted to provide a clear assessment of the Proposed Development alongside other projects, plans and activities. The specific plans, projects, and activities scoped into the CEA, are outlined in for each topic below in their respective sections.

As outlined in volume 1, chapter 3, the construction phase of the Proposed Development is anticipated to start in 2024, to enable operation to commence during 2026/2027. Although a two-year construction phase is anticipated, at this stage, indicative timelines for construction activities do continue into 2026. For example, the installation of a jacket, topside, and piling for the new Douglas platform is currently anticipated to take place over 29 days in April 2026. Therefore, as a precaution, plans, projects, and activities with a construction phase commencing in 2026 are included in the CEA, although it should be noted that cumulative effects will be of a lesser extent due to the reduced temporal overlap.

7.13.2 Benthic Subtidal and Intertidal Ecology

The CEA study area for this topic was defined as the study area used for Physical Processes (Figure 7.12). All plans, projects, and activities identified within this area were assessed and sorted into tiers using the methodology described in section 7.13.1 above.

The specific plans, projects, and activities scoped into the CEA for benthic subtidal and intertidal ecology are outlined in Table 7.80 and in Figure 7.12.

For benthic subtidal and intertidal ecology, a number of the impacts considered for the Proposed Development alone (Table 7.21) have not been considered within the CEA due to their localised and temporally restricted nature. These impacts include:

- Increased temperature impacting benthic communities (section 7.12.5).
- Impacts resulting from the release of sediment bound contaminants (section 7.12.7).
- Accidental pollution to the surrounding area (section 7.12.8).

7.13.2.1 Maximum Design Scenario

The MDS presented in Table 7.81 has been selected as those with the potential to result in the greatest effect on benthic subtidal and intertidal receptors. The potential cumulative effects presented and assessed in this section were based on the PDE provided in volume 1, chapter 3, as well as the information available on other plans, projects, and activities. Effects of adverse significance are not expected to arise should another a different development scenario to that assessed here be taken forward to the final design scheme.

Table 7.80: List Of Other Plans, Projects, And Activities Considered Within The CEA For Benthic Subtidal And Intertidal Ecology

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
Tier 1						
Offshore Renewables						
Burbo Bank Extension OWF cable repair and remediation	Operational (with ongoing activities)	0.00	Export cable repair and remediation activities over the 25-year lifetime of the Burbo Bank Extension OWF.	N/a	2017–- 2042	These activities overlap spatially with the Proposed Development and temporally with the construction and operation and maintenance phases of the Proposed Development.
Awel y Môr OWF	Consented	1.10	Proposed renewable energy project, 10.50 km off the coast of North Wales, of up to 1.1 GW. Proposed for a maximum of 50 turbines, associated transmission assets, and cabling (including and interlink cable with Gwynt y Môr OWF).	2026 – 2030	2030 – 2055	This project will overlap with all three phases of the Proposed Development.
Mona OWF Suction Bucket Trails	Consented	5.60	The works proposed within this Marine Licence Application consist of trialling suction bucket foundations	2023 to June 2024	N/A	The suction bucket trials may overlap with early construction activities of the Proposed Development.

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
			to assess the install viability within the Mona OWF Array Area, which is predominantly within Welsh waters.			
Deposits and Removal						
Burbo Bank Extension OWF Disposal Site IS153	Operational (with ongoing activities)	0.50	Deposit of substances at sea, construction works, removal of sediment, and disposal of inert material during drilling for the Burbo Bank Extension OWF.	N/a	2017–- 2042	These activities overlap with the construction and operation and maintenance phases of the Proposed Development.
Hilbre Swash	Operational (with ongoing activities)	0.00	Licence to extract up to 12 million tonnes of aggregate (mainly sand) over 15 years.	N/a	2015 – 2029	Aggregate extraction activities within this project will overlap temporally with the construction and operation and maintenance phases of the Proposed Development. This project also spatially overlaps with the Proposed Development.
Mostyn Energy Park Expansion	Submitted	2.30	Extension of the Mostyn Energy Park at the Port of Mostyn. Requires construction of a	2023 to 2025	2025 to 2030	Activities will overlap with the construction and operation and maintenance phases of

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
			360 m quay, reclamation of 3.5 ha area, capital dredging of new berth pockets and re-dredging of approach channel. Use of dredged material for fill material for reclamation, disposal of dredged material at Mostyn Deep. Maintenance dredging of new and existing berths, approach channel and harbour area.			the Proposed Development.
Tier 2						
Offshore Renewables						
Mona OWF	Pre-application	5.53	Proposed renewable energy project, 28.20 km off the coast of North Wales, of up to 350 MW.	2026–- 2028	2029–- 2089	This project will overlap with all three phases of the Proposed Development.
Cables and Pipelines						
Morgan and Morecambe OWF Transmission Assets	Pre-application	3.00	The transmission assets for the Morgan and Morecambe OWF	2028–- 2029	2030–- 2065	This project will overlap with the operations and maintenance and decommissioning phases of the Proposed Development.

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
Tier 3						
Cables and Pipelines						
MaresConnect – Wales – Ireland Interconnector Cable	Planning application not yet submitted	10.00	A proposed 750 MW subsea and underground electricity interconnector system, linking the electricity grids in the UK and Ireland.	2025	2027–- 2037	This project will overlap with the construction and operations and maintenance phases of the Proposed Development.
Tier 4						
Offshore Renewables						
Removal of a meteorological mast at Gwynt y Môr OWF	Issued (variation to an existing marine licence)	0.00	A seabed survey and removal of topside lattice structures, monopiles, and scour protection.	N/a	Licence issued for 2022–- 2027	Although no information on the timeline of this project is available, the Marine License is issued for between 2022 and 2027. Therefore, this activity will overlap with the operations and maintenance phase of the Proposed Development. This project also spatially overlaps with the Proposed Development.

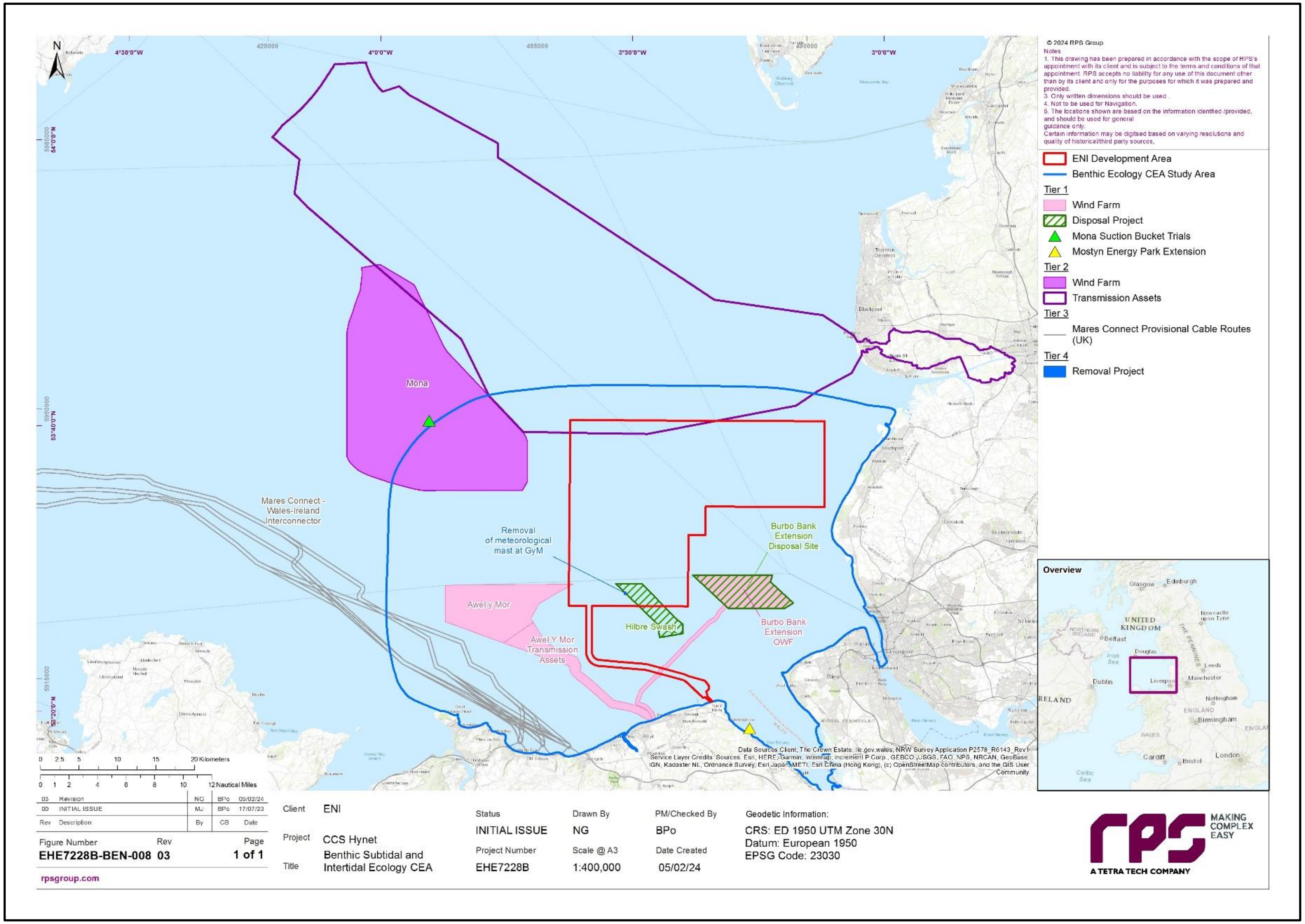


Figure 7.12: Plans, Projects, And Activities Screened Into The CEA For Benthic Subtidal And Intertidal Ecology

Table 7.81: MDS Considered For The Assessment Of Potential Cumulative Effects On Benthic Subtidal And Intertidal Ecology

Potential Cumulative Effect	Phase	MDS	Justification
Temporary subtidal habitat loss and/or disturbance	C	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Burbo Bank Extension OWF cable repair and remediation; and • Awel y Môr OWF. Deposits and Removal: • Burbo Bank Extension OWF Disposal Site IS153; • Hilbre Swash; and • Mostyn Energy Park Expansion. **Tier 2:** Offshore Renewables: • Mona OWF. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable. **Tier 4:** Offshore Renewables: • Removal of a meteorological mast at Gwynt y Môr OWF.	These projects involve activities which will result in temporary subtidal habitat loss and/or disturbance which may contribute to the impact upon a habitat that the Proposed Development will also affect.
	O	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Burbo Bank Extension OWF cable repair and remediation; and • Awel y Môr OWF. Deposits and Removal:	

Potential Cumulative Effect	Phase	MDS	Justification
		• Burbo Bank Extension OWF Disposal Site IS153; and • Hilbre Swash. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable. **Tier 4:** Offshore Renewables: • Removal of a meteorological mast at Gwynt y Môr OWF.	
	D	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	
Increased SSCs and associated deposition	C	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities:	These projects involve activities which may impact the tidal/wave regime and sediment

Potential Cumulative Effect	Phase	MDS	Justification
		Tier 1: Offshore Renewables: • Burbo Bank Extension OWF cable repair and remediation; • Awel y Môr OWF; and • Mona OWF Suction Bucket Trails. Deposits and Removal: • Burbo Bank Extension OWF Disposal Site IS153; • Mostyn Energy Park Expansion; and • Hilbre Swash. **Tier 2:** Offshore Renewables: • Mona OWF. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable. **Tier 4:** Offshore Renewables: • Removal of a meteorological mast at Gwynt y Môr OWF.	transport during their temporal overall with the Proposed Development.
	D	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	

Potential Cumulative Effect	Phase	MDS	Justification
Long-term subtidal habitat loss	C and O	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. Deposits and Removals: • Mostyn Energy Park Expansion. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable.	These projects involve the installation of hard structures on the seabed which will cause long-term subtidal habitat loss within the CEA benthic ecology study area.
	D	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	
Introduction of artificial habitat and colonisation of hard structures	O	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities:	These projects involve the installation of hard structures on the seabed which may be

Potential Cumulative Effect	Phase	MDS	Justification
		Tier 1: Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable.	colonised by new communities within the CEA benthic ecology study area.
Increased risk of introduction and spread of INNS	C	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF; and • Mona OWF Suction Bucket Trails. Deposits and Removals: • Mostyn Energy Park Expansion. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable.	These projects involve the installation of hard structures on the seabed which may be colonised by INNS within the CEA benthic ecology study area.

Potential Cumulative Effect	Phase	MDS	Justification
	O	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. Deposits and Removals: • Mostyn Energy Park Expansion. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable.	
	D	The MDS is as described for the Proposed Development (Table 7.21) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	

7.13.3 Temporary Habitat Loss and/or Disturbance

There is the potential for cumulative temporary habitat loss and/or disturbance as a result of activities associated with the Proposed Development and other plans, projects, and activities. Activities include cable burial, jack-up vessel use, anchor placements, seabed preparation, dredging, aggregate extraction, cables and pipelines laying, and remedial work. For the purposes of this ES, this additive impact has been assessed within the benthic subtidal and intertidal ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.81.

7.13.3.1 Tier 1

Construction Phase

Magnitude of Impact

Subtidal Habitats and Species

Predicted cumulative temporary habitat loss and/or disturbance from each of the Tier 1 plans, projects, and activities during the construction phase of the Proposed Development are presented in Table 7.82 together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented. For all the Tier 1 plans, projects, and activities during the construction phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 18.97 km^2 (including the values for the Proposed Development provided in Table 7.21).

The construction phase of the Proposed Development is between 2024 and 2026, while that of Awel y Môr OWF is currently anticipated as 2026 to 2030 (Table 7.88). Therefore, there may be some overlap between the construction phases of both projects, however it should be noted that it any cumulative impacts will be of a lesser extent than if the two projects overlapped for a longer period of time (i.e. over multiple years).

For the aggregate extraction at the Hilbre Swash site, the overall licenced area for this site is 21.79 km^2. However, the Crown Estate reports that, in 2021, only 3.97% of the total area of seabed licenced to be dredged in the North West region was actively dredged (The Crown Estate and MPA Marine Aggregates, 2021). For the purposes of this assessment, the MDS assumes that a precautionary 5% of the total licensed area of Hilbre Swash will be actively dredged during this period. It is unlikely that the whole site will be active at once, therefore the impact associated with aggregate extraction at this site will be spread over the full length of the 15-year licence therefore resulting in longer-term low-level disturbance.

Dredging activities associated with the Mostyn Energy Park Expansion have been estimated to result in temporary subtidal habitat loss of 3.16 ha (31,600 m^2), with recolonisation expected to occur over a short period of time (although any indication on this time period was not provided in the Environmental Statement for this project (ABPmer, 2022)).

Table 7.82: Cumulative Temporary Habitat Loss And/Or Disturbance For The Construction Phase Of Tier 1 Plans, Projects, And Activities Identified

Project	Predicted Temporary Habitat Loss and/or Disturbance (km^2)	Cause of Temporary Habitat Loss and/or Disturbance	Source
Proposed Development	**1.91**	**See Table 7.21**	**Table 7.21**
Offshore Renewables			
Burbo Bank Extension OWF Cable Repair and Remediation	0.03	Cable repair and remediation activities.	EnBW and BP (2023b)
Awel y Môr OWF	15.91	Jack-up events, anchoring, cable installation, and seabed preparation.	RWE Renewables UK (2021a)
Deposits and Removals			
Hilbre Swash	1.09	Aggregate extraction (mainly sand). The values provided in the preceding column represent the area of the project as no values specific to this impact were available.	EnBW and BP (2023b)
Burbo Bank Extension OWF Disposal Site IS153	Not available	Dredging and disposal	-
Mostyn Energy Park Expansion	0.03	Removal of seabed material during dredging	ABPmer (2022)
Total	**18.97**		

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of local spatial extent (given the low disturbance footprints), short term duration (over the two-year construction phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

The Tier 1 projects will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 1 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 1 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 1 assessment.

As the Fylde MCZ IEF is not in the vicinity of any of the Tier 1 projects, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 1 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operations and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

Predicted cumulative temporary habitat loss and/or disturbance from each of the Tier 1 plans, projects, and activities during the operations and maintenance phase of the Proposed Development are presented in Table 7.83, together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented. For all the Tier 1 plans, projects, and activities during the operations and maintenance phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 1.49 km^2 (including the values for the Proposed Development provided in Table 7.21).

Table 7.83: Cumulative Temporary Habitat Loss And/Or Disturbance For The Operations And Maintenance Phase Of Tier 1 Plans, Projects, And Activities Identified

Project	Predicted Temporary Habitat Loss and/or Disturbance (km^2)	Cause of Temporary Habitat Loss and/or Disturbance	Source
Proposed Development	**0.07**	**See Table 7.21**	**Table 7.21**
Offshore Renewables			
Burbo Bank Extension OWF Cable Repair and Remediation	0.03	Cable repair and remediation activities.	EnBW and BP (2023b)
Awel y Môr OWF	0.30	Cable repair and remediation activities and jack-up activities for platform and turbine maintenance.	RWE Renewables UK (2021a)
Deposits and Removals			
Hilbre Swash	1.09	Aggregate extraction (mainly sand). The values provided in the preceding column represent the area of the project as no values specific to this impact were available.	EnBW and BP (2023b)
Burbo Bank Extension OWF Disposal Site IS153	Not available	Dredging and disposal	-
Total	**1.49**		

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of local spatial extent (given the low disturbance footprints), long-term duration (over the operations and maintenance phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact was deemed to be low, and the sensitivity of the receptor was considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

Subtidal Habitats and Species

The only Tier 1 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development was Awel y Môr OWF. There were no values provided for the footprint of temporary habitat loss and/or disturbance for this project, however they will not exceed that of the construction phase (15.91 km^2) and are likely to be lower in reality, due to the absence of seabed preparation (RWE Renewables UK, 2021a). Similarly, these values are also not available for the Proposed Development (Table 7.21) but are also likely to be similar to that of the construction phase (1.91 km^2). Therefore, the cumulative temporary habitat loss and/or disturbance is estimated at 17.82 km^2, and it should be noted that this value is likely to be higher than reality.

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of local spatial extent (given the low potential disturbance footprints), short-term duration (over the decommissioning phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact was deemed to be low, and the sensitivity of the receptor was considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.3.2 Tier 2

Construction Phase

Magnitude of Impact

Subtidal Habitats and Species

The only Tier 2 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the construction phase of the Proposed Development was Mona OWF.

Within the MDS for this project, up to 131.07 km^2 of temporary habitat loss and/or disturbance was predicted to occur (EnBW and BP, 2023b).

Therefore, the cumulative temporary habitat loss and/or disturbance is estimated at 132.98 km^2 (including the values for the Proposed Development provided in Table 7.21).

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of regional spatial extent (given the larger disturbance footprints than for the Tier 1 assessment), short term duration (over the two-year construction phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

The Tier 2 project will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 2 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 2 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 2 assessment.

As the Fylde MCZ IEF is not in the vicinity of any the Tier 2 project mentioned above, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this assessment for the construction phase.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact was deemed to be low, and the sensitivity of the receptor was considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

There were two Tier 2 projects identified in the CEA with the potential for cumulative temporary habitat loss and/or disturbance in the operations and maintenance phase: Mona OWF and Morgan and Morecambe OWF Transmission Assets. The construction phases of these two projects also overlap with the operation and maintenance phase of the Proposed Development. Predicted cumulative temporary habitat loss and/or disturbance from each of the Tier 2 plans, projects, and activities during the operations and maintenance phase of the Proposed Development are presented in Table 7.84 together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented. For all the Tier 2 plans, projects, and activities during the operations and maintenance phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 148.75 km^2 (including the values for the Proposed Development provided in Table 7.21).

At the time of writing, there was no publicly available information to quantify the footprint of temporary habitat loss and/or disturbance due to the Morgan and Morecambe OWF Transmission Assets. Therefore, these values are not included in the total calculation presented in the paragraph above. As the transmission assets only involves cables, it is likely that the disturbance footprint of temporary habitat loss and/or disturbance will be of a lower extent to that presented for Mona OWF (which includes offshore export cables).

Table 7.84: Cumulative Temporary Habitat Loss And/Or Disturbance For The Operations And Maintenance Phase Of Tier 2 Plans, Projects, And Activities Identified

Project	Predicted Temporary Habitat Loss and/or Disturbance (km^2)	Cause of Temporary Habitat Loss and/or Disturbance	Source
Proposed Development	**0.07**	**See Table 7.21**	**Table 7.21**
Offshore Renewables			
Mona OWF	Construction: 131.07 Operation and maintenance: 17.61	Jack-up events and cable repair and remediation.	EnBW and BP (2023b)
Cables and Pipelines			
Morgan and Morecambe OWF Transmission Assets	Not available	Only the Scoping Report is currently available for this project, so no footprint of disturbance is available. However, the construction and operations and maintenance phases of this project overlap with the operations and maintenance phase of the Proposed Development. Therefore, activities such as jack-up events, anchoring, seabed preparation, cable laying, and cable maintenance will result in temporary habitat loss and/or disturbance.	-
Total	**148.75**		

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of regional spatial extent (given the larger disturbance footprints than for the Tier 1 assessment), long-term duration (over the operations and maintenance phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Designated Sites

As the Fylde MCZ IEF overlaps with the Morgan and Morecambe OWF Transmission Assets, the information provided above for 'Subtidal Habitats and Species IEFs' is also applicable. Thus, the cumulative impact on the Fylde MCZ IEF is predicted to be of local spatial extent (given the lower disturbance footprints than in the construction phase), long-term duration (over the operations and maintenance phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs and the Fylde MCZ IEF are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs and the Fylde MCZ IEF are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs and the Fylde MCZ IEF, the magnitude of impact was deemed to be low, and the sensitivity of the receptor was considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

Subtidal Habitats and Species

There were two Tier 2 projects identified in the CEA with the potential for cumulative temporary habitat loss and/or disturbance in the decommissioning phase of the Proposed Development: Mona OWF and Morgan and Morecambe OWF Transmission Assets. The operations and maintenance phases of these two projects will overlap with the decommissioning phase of the Proposed Development, therefore the footprint of temporary habitat loss and/or disturbance for these projects is as above for the operations and maintenance phase (at least 17.61 km^2; Table 7.84).

The total predicted footprint of temporary subtidal habitat loss and/or disturbance is not available for the decommissioning phase of the Proposed Development (Table 7.21) but is likely to be similar to that of the construction phase (1.91 km^2). Therefore, the cumulative temporary habitat loss and/or disturbance is estimated at 19.52 km^2.

It should be noted that this is likely to be lower than reality due to the absence of publicly available information to quantify the footprint of temporary habitat loss and/or disturbance due to the Morgan and Morecambe OWF Transmission Assets. Therefore, these values are not included in the total calculation presented in the paragraph above.

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of local spatial extent (given the lower disturbance footprints than in the operation and maintenance phase), short term duration (over the decommissioning phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Designated Sites

As the Fylde MCZ IEF overlaps with the Morgan and Morecambe OWF Transmission Assets, the information provided above for 'Subtidal Habitats and Species IEFs' is also applicable. Thus, the cumulative impact on the Fylde MCZ IEF is predicted to be of local spatial extent (given the lower disturbance footprints than in the construction phase), short term duration (over the decommissioning phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs and the Fylde MCZ IEF are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs and the Fylde MCZ IEF are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs and the Fylde MCZ IEF, the magnitude of impact was deemed to be low, and the sensitivity of the receptor was considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.3.3 Tier 3

Construction and Operation and Maintenance Phases

Magnitude of Impact

Subtidal Habitats and Species

The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the construction and operation and maintenance phases of the Proposed Development was the MaresConnect interconnector cable. There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on benthic ecology receptors. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023).

The activities associated with the MaresConnect interconnector cable which are likely to result in temporary habitat loss and/or disturbance are similar to those expected for the installation of cables for the Proposed Development. Construction is planned to occur in 2025 and the project is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage. The construction activities are likely to involve cable installation such as jet trenching, and the installation of cable protection. Operation and maintenance activities are likely to involve the repair and reburial of cables.

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of local spatial extent, short term duration (for the individual construction and operation and maintenance activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

The Tier 3 project will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to its distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 3 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 3 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 3 assessment.

As the Fylde MCZ IEF is does not overlap with the MaresConnect Interconnector Cable, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 3 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact was deemed to be low, and the sensitivity of the receptor was considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development.

7.13.3.4 Tier 4

Construction and Operation and Maintenance Phases

Magnitude of Impact

Subtidal Habitats and Species

The only Tier 4 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the construction and operation and maintenance phases of the Proposed Development was the removal of a meteorological mast at Gwynt y Môr OWF. There is, however, currently no information on the impact that this project will have on benthic ecology receptors.

The activities associated with this project which are likely to result in temporary habitat loss and/or disturbance are anchoring and the use of jack-up vessels for the removal of topside lattice structures, monopiles, and scour protection. There is no timeline for these works currently publicly available, however the marine license was issued for 2022 – 2027. Therefore, while these activities may overlap with the entire construction phase of the Proposed Development, they should be completed shortly after the operation and maintenance phase of the Proposed Development begins (within 2026).

The cumulative impact on the subtidal habitats and species IEFs is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

The Tier 4 project will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to its distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 4 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 4 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 4 assessment.

As the Fylde MCZ IEF is does not overlap with Tier 4 project, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 4 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.1).

The subtidal habitats and species IEFs are deemed to be of medium vulnerability, high recoverability, and local to national value. The sensitivity of these receptors is therefore, considered to be medium.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact was deemed to be low, and the sensitivity of the receptor was considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development.

7.13.4 Increased SSCs and Associated Deposition

There is the potential for cumulative increased SSCs and associated deposition as a result of activities associated with the Proposed Development and other plans, projects, and activities. Activities include seabed preparation, dredging, aggregate extraction, and cables and pipelines laying. For the purposes of this ES, this additive impact has been assessed within the benthic subtidal and intertidal ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.81.

7.13.4.1 Tier 1

Construction Phase

Magnitude of Impact

All Benthic Subtidal and Intertidal IEFs

There is potential for cumulative impacts with six Tier 1 projects in the construction phase:

- Burbo Bank Extension OWF cable repair and remediation;
- Awel y Môr OWF
- Mona OWF Suction Bucket Trials;
- Mostyn Energy Park Expansion;
- Hilbre Swash; and
- Burbo Bank Extension OWF Disposal Site IS153.

The construction phase of the Proposed Development coincides with construction activities of the Awel y Môr OWF, such as seabed preparation, drilling, cable installation, and HDD. However, in the Preliminary Environmental Information Report (PEIR) for Awel y Môr, this impact has been determined as localised within one tidal excursion, short-term, intermittent, and reversible upon benthic subtidal and intertidal receptors (RWE Renewables UK, 2021a). The Awel y Môr Offshore Wind Farm also involves the installation of an interlink cable with the Gywnt y Môr Offshore Wind Farm, with the magnitude of suspended sediments likely being of a similar magnitude to offshore export cable installation. Thus, again it can be expected a cumulative effect that may arise would do so within the natural variability of background levels, and only occur if cable installation operations occurred simultaneously. Furthermore, the construction phase of the Proposed Development is between 2024 and 2026, while that of Awel y Môr OWF is currently anticipated as 2026 to 2030 (Table 7.88). Therefore, there may be some overlap between the construction phases of both projects, however it should be noted that it any cumulative impacts will be of a lesser extent than if the two projects overlapped for a longer period of time (i.e. over multiple years).

The construction phase of the Proposed Development also coincides with cable repair and maintenance activities at the Burbo Bank Extension OWF and disposal at site IS153. However, as this only involves intermittent maintenance and disposal work, this impact has been determined as of limited spatial extent, short-term, intermittent, and reversible upon benthic subtidal and intertidal receptors.

The construction phase of the Proposed Development also encompasses aggregate extraction the Hilbre Swash licensed area, located within the Proposed Development. Resultant plumes from the disposal of dredged material and extraction of aggregate would be advected on the tidal current running in parallel and not coincide with the Proposed Development.

As part of the Mona Offshore Wind Farm application, a series of suction bucket foundation trials were consented to, to validate the suitability of foundation and optimise design. These works occur within the Mona Array Area at up to 30 locations, using a variety of parameters to best inform final design. At each location, the trial may be undertaken up to 3 times and once all activities at the site are complete the full removal of foundation would occur before moving to the next location to repeat (MarineSpace Ltd., 2023). Although the trials of foundation installation and subsequent removal may mobilise sediment within the Mona Array Area, the small scale nature associated with the installation/removal of one foundation at a time would be expected to produce a small plume with much of the sediment suspended settling in the vicinity of the structures. This, paired with the fact that the Mona Array Area is largely advected on tidal currents and situated approximately 5.60 km north west of the Proposed Development (at its closest point), indicate that if an overlap in SSC or deposition did occur between the projects, that it would do so at background levels. The Mona OWF suction bucket trials have only been assessed for this impact, as the WFD Compliance Assessment concluded that an assessment on ecological impacts was not required, given the low potential for impact.

The construction phase of the Proposed Development is expected to coincide with the construction and operation and maintenance phases of the Mostyn Energy Park Extension and associated maintenance dredging activities. This development, within the Dee Estuary, involves the construction of a 360 m length of new quay wall, the infilling of a 3.5 ha area behind the new quay wall (requiring 600,000 m^3 of infill material, 500,000 m^3 of which will be sourced from dredging activity arisings) (ABPmer, 2022). Alongside the new quay wall a dredged berth pocket will be required to a depth of -11 m CD (400,000 m^3), whilst re-dredging of the existing berth pocket along the existing quay wall to -9 m CD will be required (400,000 m^3) (ABPmer, 2022). The largest dredging operation will take the form of the re-dredging of the main navigation channel to a depth of -4 m CD (3,000,000 m^3) (ABPmer, 2022). Both seabed preparation and cable installation activities produce SSC plumes that extend into the Dee Estuary and overlap with the location of construction activities and dredging at the Port of Mostyn Energy Park Expansion, however, they do so at background levels i.e. < 3 mg/l. It can therefore be judged that although a cumulative impact may arise, the change in SSC would be of negligible significance and recoverable.

The largest overlap in SSC would occur if the disposal of dredged material within the Mostyn Deep disposal site occurred simultaneously with cable installation activities or seabed preparation across West Hoyle Bank, however even in this case, overlapping plumes in the vicinity of West Hoyle Bank and within the Dee Estuary would be of limited magnitude due to the decreases in SSC and deposition observed with distance from respective works. Noting also that sediment plumes would be traversing in parallel and not towards one another as they are advected on the same tidal current. Maximum SSC values in the area of overlap can be up to 100 mg/l for both plumes combined, however, the more representative average plumes are expected to have SSC values of negligible difference to background levels when they coincide. Likewise, sedimentation over the bank can be considered minor and the overall cumulative impact between the disposal of dredged material and the Proposed Development can be considered to be negligible, of local extent and short-term duration. The cumulative impact relating to overlap between operation and maintenance activities from the Mostyn Energy Park Extension and construction activities related to the Proposed Development are expected to be of a similar magnitude to the dredging/disposal activities described above, only of a smaller scale in line with reduced dredge volumes associated with maintenance works rather than construction works.

The cumulative impact on the benthic subtidal and intertidal IEFs is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

<u>Subtidal Habitats and Species</u>

The sensitivity of the subtidal habitats and species IEFs and are as previously described for the construction phase of the Proposed Development alone (see section 7.12.2).

The ‘Subtidal sands and gravels’ IEF is deemed to be of low vulnerability, medium to high recoverability, and national value. Therefore, the sensitivity of this receptor to this impact is considered to be low.

Overall, the ‘Mud habitats in deep water’ IEF and Ross worm IEF are deemed to be of low to no vulnerability, high recoverability, and national value. Therefore, the sensitivity of these receptors to this impact is considered to be negligible.

Overall, the ‘Subtidal mixed muddy sediment’ IEF is deemed to be of medium vulnerability, medium recoverability, and national value. Therefore, the sensitivity of this receptor to this impact is considered to be medium.

<u>Intertidal Habitats and Species</u>

The sensitivity of the intertidal habitats and species IEFs and are as previously described for the construction phase of the Proposed Development alone (see section 7.12.2).

Overall, the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF is deemed to be of low vulnerability, high recoverability, and international value. Therefore, the sensitivity of this receptor to this impact is considered to be low.

<u>Designated Sites</u>

As detailed in Table 7.10, the sensitivities presented for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF in the preceding section is applicable to the Dee Estuary/Aber Dyfrdwy SAC IEF. Thus, the Dee Estuary/Aber Dyfrdwy SAC IEF is deemed to be of low vulnerability, high recoverability, and international value. The sensitivity of the receptor is therefore, considered to be low.

The Fylde MCZ IEF is deemed to be of low vulnerability, medium to high recoverability, and national value. The sensitivity of the receptor is therefore, considered to be low.

Significance of Effect

<u>Subtidal Habitats and Species</u>

Overall, for the ‘Subtidal sands and gravels IEF’, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the ‘Mud habitats in deep water’ IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the cumulative effect is considered be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the ‘Subtidal mixed muddy sediment’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

<u>Intertidal Habitats and Species</u>

Overall, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

<u>Designated Sites</u>

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

<u>All IEFs</u>

The decommissioning phase of the Proposed Development coincides with operation and maintenance and decommissioning activities of the Awel y Môr OWF, such as cable maintenance, cable removal, and foundation removal. However, in the PEIR for Awel y Môr, this impact has been determined as localised within one tidal excursion, short-term, intermittent, and reversible upon benthic subtidal and intertidal receptors (RWE Renewables UK, 2021a).

The cumulative impact on the benthic subtidal and intertidal IEFs is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the construction phase and is not repeated here for brevity.

Significance of Effect

<u>Subtidal Habitats and Species</u>

Overall, for the ‘Subtidal sands and gravels IEF’, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the ‘Mud habitats in deep water’ IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the cumulative effect is considered be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the ‘Subtidal mixed muddy sediment’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

<u>Intertidal Habitats and Species</u>

Overall, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.4.2 Tier 2

Construction Phase

Magnitude of Impact

All IEFs

There is the potential for cumulative impacts with one Tier 2 project in the construction phase: Mona OWF. Construction activities may result in increased SSC. For the Mona OWF, modelling suggested that average SSCs during the course of the construction activities was expected to be <300 mg/l with a plume envelope width of approximately 20 km, which corresponds to the local tidal excursion (EnBW and BP, 2023b). Sediments deposited on slack tide in the north-east of the Mona Array Area are expected to be resuspended on subsequent tides. Typically, this plume concentration will be <10 mg/l, and this reduces as distance from the site increases due to natural sediment dispersal. Three days after installation of foundations, sediment concentrations are expected to reduce, with sedimentation and resuspension occurring dependent on the current speed and tidal cycle. Peak concentrations in a resuspension event at this point are likely to reach a maximum of <30mg/l, compared to average concentrations of a maximum of 3mg/l in the area normally (EnBW and BP, 2023b).

The increased SSCs from construction activities in the Mona OWF would be of limited spatial extent and intermittent in frequency and unlikely to interact with sediment plumes from the Proposed Development. As described in section 7.12.2, modelling for the Proposed Development suggested that material was retained in the sediment cell and would be subsequently assimilated into the existing sediment transport regime.

The cumulative effect is predicted to be of local spatial extent, short term duration (over the two-year construction phase), intermittent (due to the construction activities), and high reversibility. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Subtidal Habitats and Species

Overall, for the ‘Subtidal sands and gravels IEF’, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the ‘Mud habitats in deep water’ IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the cumulative effect is considered be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the ‘Subtidal mixed muddy sediment’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

All IEFs

There is potential for cumulative impacts with two Tier 2 projects in the decommissioning phase: Mona OWF and the Morgan and Morecambe OWF Transmission Assets. In the decommissioning phase of the Proposed Development, infrastructure removal could result in increased SSCs. The decommissioning phase of the Proposed Development will coincide with the operations and maintenance phases of these two Tier 2 projects. During their operations and maintenance phases, cable repair and reburial has the potential to result in increased SSCs. These activities would be of limited spatial extent, intermittent in frequency, and unlikely to interact with sediment plumes from the Proposed Development. As described in section 7.12.2, increased SSCs in the decommissioning phase of the Proposed Development are expected to be similar or lower to those of the construction phase, which was assessed as having a low magnitude of impact.

The construction phase of the Morgan and Morecambe OWF Transmission Assets will also coincide with the decommissioning phase of the Proposed Development. At the time of writing, there was no publicly available information to quantify the increased SSCs and associated deposition due to the Morgan and Morecambe OWF Transmission Assets. As the transmission assets only involves cables, it is likely sedimentation will be of a lower extent to that of Mona OWF (which includes offshore export cables).

Overall, the cumulative effect is predicted to be of local spatial extent, short term duration (over the two-year decommissioning phase), intermittent (due to the individual activities), and high reversibility. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Subtidal Habitats and Species

Overall, for the ‘Subtidal sands and gravels IEF’, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the ‘Mud habitats in deep water’ IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the cumulative effect is considered be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the ‘Subtidal mixed muddy sediment’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, for the 'Mudflats and sandflats not covered by seawater at low tide' IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.4.3 Tier 3

Construction and Operation and Maintenance Phases

Magnitude of Impact

All IEFs

The only Tier 3 project which has been identified in the CEA with the potential to result in increased SSCs and associate deposition during the construction and operation and maintenance phases of the Proposed Development was the MaresConnect interconnector cable. There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on benthic ecology receptors. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023).

The activities associated with the MaresConnect interconnector cable which are likely to result in increased SSCs and associated deposition are similar to those expected for the installation of cables for the Proposed Development. Construction is planned to occur in 2025 and the project is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage. The construction activities are likely to involve cable installation such as jet trenching, and the installation of cable protection. Operation and maintenance activities are likely to involve the repair and reburial of cables.

The cumulative impact is predicted to be of local spatial extent, short term duration (for the individual construction and operation and maintenance activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Subtidal Habitats and Species

Overall, for the 'Subtidal sands and gravels IEF', the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the 'Mud habitats in deep water' IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the cumulative effect is considered be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the 'Subtidal mixed muddy sediment' IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative increased SSCs and associated deposition during the decommissioning phases of the Proposed Development.

7.13.4.4 Tier 4

Construction and Operation and Maintenance Phases

Magnitude of Impact

All IEFs

The only Tier 4 project which has been identified in the CEA with the potential to result in cumulative increased SSCs and associated deposition during the construction and operation and maintenance phases of the Proposed Development was the removal of a meteorological mast at Gwynt y Môr OWF. There is, however, currently no information on the impact that this project will have on benthic ecology receptors.

The activities associated with this project which are likely to result in increased SSCs and associated deposition are anchoring and the use of jack-up vessels for the removal of topside lattice structures, monopiles, and scour protection. There is no timeline for these works currently publicly available, however the marine license was issued for 2022 – 2027. Therefore, while these activities may overlap with the entire construction phase of the Proposed Development, they should be completed shortly after the operation and maintenance phase of the Proposed Development begins (within 2026).

The cumulative impact is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Subtidal Habitats and Species

Overall, for the ‘Subtidal sands and gravels IEF’, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the ‘Mud habitats in deep water’ IEF and Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. Therefore, the cumulative effect is considered be of **negligible adverse** significance, which is **not significant** in EIA terms.

Overall, for the ‘Subtidal mixed muddy sediment’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Intertidal Habitats and Species

Overall, for the ‘Mudflats and sandflats not covered by seawater at low tide’ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Designated Sites

Overall, for the Dee Estuary/Aber Dyfrdwy SAC and Fylde MCZ IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative increased SSCs and associated deposition during the decommissioning phases of the Proposed Development.

7.13.5 Long-Term Subtidal Habitat Loss

Long-term subtidal habitat loss may result from the physical presence of foundations, cable crossing protection, and rock placement. For the purposes of this ES, this additive impact has been assessed within the benthic subtidal and intertidal ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the CEA for this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.81.

7.13.5.1 Tier 1

Construction and Operation and Maintenance Phases

Magnitude of Impact

Subtidal Habitats and Species

There is the potential for cumulative impacts with two Tier 1 projects in the construction and operation and maintenance phases: Awel y Môr OWF and the Mostyn Energy Park Expansion. The MDS for Awel y Môr OWF assumes up to 1.61 km^2 of long-term subtidal habitat loss due to the footprint of turbines, foundations, meteorological mast, and cable protection (RWE Renewables UK, 2021a). ~~Therefore, there is potential for a total of up to 1.67 km^2 of long-term subtidal habitat loss (including the values assumed in the MDS for the Proposed Development; Table 7.21).~~The MDS for this impact for the Mostyn Energy Park Expansion accounts for a footprint of long-term habitat loss of up to 3.49 ha (34,900 m^2) (ABPmer, 2022). Therefore, there is potential for a total of up to 1.71 km^2 of long-term subtidal habitat loss as a result of the Proposed Development and the Tier 1 projects.

The potential for secondary scour as a result of infrastructure placed on the seabed was not assessed for the Mostyn Energy Park Expansion or Awel y Môr OWF. However, the assessment for the Awel y Môr OWF concluded that the use of correctly designed scour protection at foundations and sufficiently buried cables would prevent primary scouring and have no significant effects on the benthic environment (RWE Renewables, 2021a). Any changes to seabed morphology were predicted to be highly local, and physical processes such as tidal flows and sediment transport limited to within 1 km of the Awel y Môr Array Area (RWE Renewables, 2021a). Therefore, it is not expected that impacts from the presence of Awel y Môr project infrastructure will accumulate with the highly local changes to seabed morphology and subtidal habitats due to the presence of cable crossings under the scope of the Proposed Development.

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprint of disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude is considered to be low.

Intertidal Habitats and Species

The Tier 1 projects will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 1 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 1 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 1 assessment.

As the Fylde MCZ IEF is does not overlap with the Awel y Môr OWF, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 1 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.3).

Overall, all IEFs except Ross worm are deemed to be of high vulnerability, low recoverability, and national to international value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

The Ross worm IEF is deemed to be of high vulnerability, medium recoverability, and local value. Therefore, the sensitivity of the receptor to this impact is considered to be medium.

Significance of Effect

Overall, for all IEFs except Ross worm, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a ‘Minor to moderate’ significance. Given the low disturbance footprint and that only one project was identified in the Tier 1 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

Subtidal Habitats and Species

There is the potential for cumulative impacts with one Tier 1 project in the decommissioning phase: Awel y Môr OWF. The MDS for Awel y Môr OWF assumes up to 1.61 km^2 of long-term subtidal habitat loss due to the removal of infrastructure installed in the construction phase (RWE Renewables UK, 2021a). Therefore, there is potential for a total of up to 1.67 km^2 of long-term subtidal habitat loss (including the footprint of infrastructure that will be removed from the Proposed Development; Table 7.21).

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprint of disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.3).

Overall, all IEFs except Ross worm are deemed to be of high vulnerability, low recoverability, and national to international value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

The Ross worm IEF is deemed to be of high vulnerability, medium recoverability, and local value. Therefore, the sensitivity of the receptor to this impact is considered to be medium.

Significance of Effect

Overall, for all IEFs except Ross worm, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a ‘Minor to moderate’ significance. Given the low disturbance footprint and that only one project was identified in the Tier 1 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.5.2 Tier 2

Construction and Operation and Maintenance Phases

Magnitude of Impact

<u>Subtidal Habitats and Species</u>

Both construction and operations and maintenance phases of the Proposed Development may interact cumulatively one Tier 2 project: the Mona OWF. They also coincide with the operations and maintenance phase of the Morgan and Morecambe OWF Transmission Assets. Predicted cumulative long-term subtidal habitat loss from both Tier 2 plans, projects, and activities during the construction and operation and maintenance phases of the Proposed Development are presented in

Table 7.85 together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented.

For both the Tier 2 plans, projects, and activities during the construction and operations and maintenance phases of the Proposed Development, the cumulative long-term subtidal habitat loss is estimated at 2.42 km^2 (including the values for the Proposed Development provided in Table 7.21). There was no publicly available figure of predicted long-term subtidal habitat loss available for the Morgan and Morecambe OWF Transmission Assets, however given the nature of this project, these are likely to be similar or lower than those presented for the Mona OWF in

Table 7.85.

Table 7.85: Cumulative Long-Term Subtidal Habitat Loss For The Construction And Operation And Maintenance Phases Of Tier 2 Plans, Projects, And Activities Identified

Project	Predicted Long-Term Subtidal Habitat Loss (km^2)	Cause of Long-Term Subtidal Habitat Loss	Source
Proposed Development	**0.06**	**See Table 7.21**	**See Table 7.21**
Offshore Renewables			
Mona OWF	2.36	Presence of foundations and cable, cable crossing, and scour protection.	EnBW and BP (2023b)
Cables and Pipelines			
Morgan and Morecambe OWF Transmission Assets	Not available	Only the Scoping Report is currently available for this project, so no footprint of disturbance is available. However, installation of foundations and cable, cable corssing, and scour protection will result in long-term subtidal habitat loss.	-
Total	**2.42**		

The PEIR for Mona OWF included an assessment on changes in physical processes, which included scour effects as a result of installed infrastructure. The impact of secondary scour, and potential long term habitat loss and disturbance was not included (EnBW and BP, 2023b). However, any changes caused by the addition of project infrastructure at the Mona OWF to the water column and seabed will have largely localised impacts to physical processes, with changes to tidal currents and sediment transport being limited to the immediate vicinity of installations (EnBw and BP, 2023b). Extrapolating from this, it is considered unlikely that secondary scour will occur as a result of infrastructure associated with the Mona OWF. Similar information is not currently available in the Scoping Report for the Morgan and Morecambe OWF Transmission Assets.

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprints for disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Intertidal Habitats and Species

The Tier 2 projects will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 2 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 2 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 2 assessment.

As the Fylde MCZ IEF overlaps with the Morgan and Morecambe OWF Transmission Assets, the information provided above for 'Subtidal Habitats and Species IEFs' is also applicable. Thus, the cumulative impact on the Fylde MCZ IEF is predicted to be of local spatial extent (given the low footprints for disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Overall, for all IEFs except Ross worm, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only three projects were identified in the Tier 2 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

Subtidal Habitats and Species

The decommissioning phase of the Proposed Development may interact cumulatively with the operations and maintenance phases of two Tier 2 projects: Mona OWF, and Morgan and Morecambe OWF Transmission Assets. Predicted cumulative long-term subtidal habitat loss from each of the Tier 2 plans, projects, and activities during their operation and maintenance phases are presented in

Table 7.85, together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented. This is estimated as 2.36 km^2. This impact is likely to be of a lower extent than in the construction and operation and maintenance phase, as the MDS for the Proposed Development assumes that all infrastructure will be removed (with only some rock placement remaining *in situ*).

There was no publicly available figure of predicted long-term subtidal habitat loss available for the Morgan and Morecambe OWF Transmission Assets, however given the nature of this project, these are likely to be similar or lower than that presented for Mona OWF in

Table 7.85.

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprints for disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Designated Sites

As the Fylde MCZ IEF overlaps with the Morgan and Morecambe OWF Transmission Assets, the information provided above for 'Subtidal Habitats and Species IEFs' is also applicable. Thus, the cumulative impact on the Fylde MCZ IEF is predicted to be of local spatial extent (given the low footprints for disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Overall, for all IEFs except Ross worm, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only three projects were identified in the Tier 2 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.5.3 Tier 3

Construction and Operation and Maintenance Phases

Magnitude of Impact

Subtidal Habitats and Species

There was one Tier 3 project identified in the CEA with the potential to result in cumulative long-term subtidal habitat loss during the construction and operation and maintenance phases of the Proposed Development: The MaresConnect interconnector cable. However, there is currently no information on the impact that this project will have on benthic ecology. A planning application is predicted to be submitted in 2024 which will identify these impacts (MaresConnect, 2023).

Cable protection associated with the MaresConnect interconnector cable is likely to result in long-term subtidal habitat loss, similar to those expected for the cables of the Tier 1 and 2 projects. Construction is likely to occur in 2025 and the protection is anticipated to become operational in 2027 (MaresConnect 2023), although it should be noted that these timeframes are only indicative at this stage.

The cumulative effect is predicted to be of regional spatial extent (as the cable runs between Wales and Ireland), long-term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Intertidal Habitats and Species

The MaresConnect interconnector cable will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to its distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 3 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 3 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 3 assessment.

As the Fylde MCZ IEF is does not overlap with the MaresConnect interconnector cable, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 3 assessment.

Sensitivity of the Receptor

The sensitivity of the receptor is as presented above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Overall, for all IEFs except Ross worm, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only one project was identified in the Tier 3 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

For the Ross worm IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative long-term subtidal habitat loss during the decommissioning phases of the Proposed Development.

7.13.5.4 Tier 4

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative long-term subtidal habitat loss during the construction, operations and maintenance, and decommissioning phases of the Proposed Development.

7.13.6 Introduction of Artificial Habitat and Colonisation of Hard Structures

The introduction of hard substrate into areas of predominantly soft sediments has the potential to alter community composition and biodiversity within the CEA benthic ecology study area. For the purposes of this ES, this additive impact has been assessed within the benthic subtidal and intertidal ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the CEA for this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.81.

7.13.6.1 Tier 1

Operation and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

There is potential for cumulative impacts with one Tier 1 project in the operation and maintenance phase: Awel y Môr OWF. The MDS for Awel y Môr OWF assumes up to 1.48 km^2 of introduced hard substrate (RWE Renewables UK, 2021a). Therefore, there is potential for a total of up to 1.54 km^2 of long-term subtidal habitat loss (including the values assumed in the MDS for the Proposed Development; Table 7.21).

As presented for the Tier 1 assessment above in section 7.13.5, the potential for secondary scour as a result of infrastructure placed on the seabed was not assessed for the Awel y Môr OWF. However, the assessment concluded that the use of correctly designed scour protection at foundations and sufficiently buried cables would prevent primary scouring and have no significant effects on the benthic environment (RWE Renewables, 2021a). Any changes to seabed morphology were predicted to be highly local, and changes to physical processes such as tidal flows and sediment transport limited to within 1 km of the Awel y Môr Array Area (RWE Renewables, 2021a). Therefore, it is not expected that impacts from the presence of Awel y Môr project infrastructure will accumulate with the highly local changes to seabed morphology and subtidal habitats due to the presence of cable crossings under the scope of the Proposed Development. Therefore, it is not expected that any cumulative secondary scour will prevent colonisation of hard structures associated with the Tier 1 projects.

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprint of disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude is considered to be low.

Intertidal Habitats and Species

The Tier 1 project will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 1 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 1 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 1 assessment.

As the Fylde MCZ IEF is does not overlap with the Awel y Môr OWF, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 1 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.4).

Overall, the subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to national value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

Significance of Effect

Overall, for all subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only one project was identified in the Tier 1 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.6.2 Tier 2

Operation and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

The operations and maintenance phase of the Proposed Development may interact cumulatively with those of two Tier 2 projects, Mona OWF, and Morgan and Morecambe OWF Transmission Assets. The Morgan and Morecambe OWF Transmission Assets construction phase will also overlap with the operation and maintenance phase of the Proposed Development. Predicted cumulative introduced hard substrate from both of the Tier 2 plans, projects, and activities during their operation and maintenance phases are presented in Table 7.86 together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented.

For both the Tier 2 plans, projects, and activities during operations and maintenance phases of the Proposed Development, the cumulative introduced hard substrate is estimated at 2.90 km^2 (including the values for the Proposed Development provided in Table 7.21). There was no publicly available figure available for the Morgan and Morecambe OWF Transmission Assets, however given the nature of this project, these are likely to be similar or lower than those presented for Mona OWF in Table 7.86.

Table 7.86: Cumulative Introduced Hard Substrate For The Operation And Maintenance Phases Of Tier 2 Plans, Projects, And Activities Identified

Project	Predicted Introduced Hard Substrate (km^2)	Reason for Introduction of Hard Substrate	Source
Proposed Development	**0.06**	**See Table 7.21**	**See Table 7.21**
Offshore Renewables			
Mona OWF	2.85	Presence of foundations and protection for cables, cable crossing, and scour.	EnBW and BP (2023b)
Cables and Pipelines			
Morgan and Morecambe OWF Transmission Assets	Not available	Only the Scoping Report is currently available for this project, so no footprint of disturbance is available. However, installation of foundations and protection for cables, cable crossing, and scour will result in long-term subtidal habitat loss.	-
Total	**2.90**		

As presented for the Tier 2 assessment above in section 7.13.5, the potential for secondary scour as a result of infrastructure placed on the seabed was not assessed in the PEIR for the Mona OWF and information was not available in the Scoping Report for the Morgan and Morecambe OWF Transmission Assets. The PEIR for Mona OWF, however, included an assessment on changes in physical processes, which included primary scour effects as a result of installed infrastructure (EnBW and BP, 2023b). Any changes caused by the addition of project infrastructure at the Mona OWF to the water column and seabed will have largely localised impacts to physical processes, with changes to tidal currents and sediment transport being limited to the immediate vicinity of installations (EnBw and BP, 2023b). Extrapolating from this, it is considered unlikely that secondary scour will occur as a result of infrastructure associated with the Mona OWF. Therefore, it is not expected that impacts from the presence of project infrastructure associated with the Tier 2 projects will accumulate with the highly local changes to seabed morphology and subtidal habitats due to the presence of cable crossings under the scope of the Proposed Development. Therefore, it is not expected that any cumulative secondary scour will prevent colonisation of hard structures associated with the Tier 1 projects.

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprints for disturbance), long-term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

<u>Intertidal Habitats and Species</u>

The Tier 2 projects will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 2 assessment.

<u>Designated Sites</u>

As above for the intertidal habitats and species IEF, there are no Tier 2 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 2 assessment.

As the Fylde MCZ IEF overlaps with the Morgan and Morecambe OWF Transmission Assets, the information provided above for 'Subtidal Habitats and Species IEFs' is also applicable. Thus, the cumulative impact on the Fylde MCZ IEF is predicted to be of local spatial extent (given the low footprints for disturbance), long-term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.4).

Overall, the subtidal habitats and species IEFs and Fylde MCZ IEF are deemed to be of high vulnerability, low recoverability, and local to international value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

Significance of Effect

Overall, for the subtidal habitats and species IEFs and Fylde MCZ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only one project was identified in the Tier 3 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.6.3 Tier 3

Operation and Maintenance Phase

Magnitude of Impact

<u>Subtidal Habitats and Species</u>

There is the potential for cumulative impacts with one Tier 3 project in the operation and maintenance phase: The MaresConnect interconnector cable. However, there is currently no information on the impact that this project will have on benthic ecology. A planning application is predicted to be submitted in 2024 which will identify these impacts (MaresConnect, 2023).

Cable protection associated with the MaresConnect interconnector cable will represent introduction of hard substrates, similar to that expected for the cables of the Tier 1 and 2 projects. Construction is likely to occur in 2025 and the protection is anticipated to become operational in 2027 (MaresConnect 2023), although it should be noted that these timeframes are only indicative at this stage.

The cumulative effect is predicted to be of regional spatial extent (as the cable runs between Wales and Ireland), long-term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Intertidal Habitats and Species

The MaresConnect interconnector cable will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to its distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 3 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 3 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 3 assessment.

As the Fylde MCZ IEF is does not overlap with the MaresConnect interconnector cable, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 3 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.4).

Overall, the subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to national value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a ‘Minor to moderate’ significance. Given the low disturbance footprint and that only one project was identified in the Tier 3 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.7 Increased Risk of Introduction and Spread of INNS

Cumulative increased risk of introduction or spread of INNS may result from the physical presence of introduced hard substrate and increased vessel activity in the region associated with other project activities. For the purposes of this ES, this additive impact has been assessed within the benthic subtidal and intertidal ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the CEA for this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.81.

7.13.7.1 Tier 1

Construction Phase

Magnitude of Impact

Subtidal Habitats and Species

There is the potential for cumulative impacts with three Tier 1 projects in the construction phase: Awel y Môr OWF, Mona OWF suction bucket trials, and the Mostyn Energy Park Expansion. The MDS for Awel y Môr OWF assumes up to 1.61 km^2 of introduced hard substrate (RWE Renewables UK, 2021a). Therefore, there is potential for a total of up to 1.67 km^2 of hard substrate to be colonised by INNS (including the values assumed in the MDS for the Proposed Development; Table 7.21). There will be no hard substrates installed at the latter two Tier 1 projects, and they are only considered cumulatively due to the potential for increased vessel presence associated with them. The MDS for Awel y Môr OWF includes up to 99 vessels over the construction phase, with up to 35 on-site at one time (RWE Renewables UK, 2021c). There will be up to 236 vessel round trips in the construction phase of the Proposed Development (Table 7.21). Values on the number of vessels associated with the Mona OWF suction bucket trials and the Mostyn Energy Park Expansion were not provided in their respective documentation (ABPmer, 2022, MarineSpace Ltd., 2023), but these are unlikely to be larger than those provided for the Awel y Môr OWF or the Proposed Development, given their smaller scale.

Overall, the cumulative effect is predicted to be of local spatial extent (due to low footprint of introduced hard substrate), long term duration, intermittent (in terms of invasions), and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

The Tier 1 projects will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 1 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 1 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 1 assessment.

As the Fylde MCZ IEF is does not overlap with the Awel y Môr OWF, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 1 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.6).

Overall, all subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to national value. The sensitivity of these IEFs is therefore, considered to be high.

Significance of Effect

Overall, for all subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a ‘Minor to moderate’ significance. Given the low disturbance footprint and that only one project was identified in the Tier 1 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

There is potential for cumulative impacts with two Tier 1 projects in the operation and maintenance phase: Awel y Môr OWF and the Mostyn Energy Park Expansion. The MDS for Awel y Môr OWF assumes up to 1.61 km^2 of introduced hard substrate to be present within this phase (RWE Renewables UK, 2021a). Therefore, there is potential for a total of up to 1.67 km^2 of hard substrate to be colonised by INNS (including the values assumed in the MDS for the Proposed Development; Table 7.21). Furthermore, the MDS for Awel y Môr OWF includes up to 1,232 vessel return trips annually over the 25-year operation and maintenance phase (30,800 total) (RWE Renewables UK, 2021a). There will be up to 750 vessel round trips over the operation and maintenance phase of the Proposed Development (Table 7.21). Values on the number of vessels associated with Mostyn Energy Park Expansion were not provided (ABPmer, 2022), but these are unlikely to be larger than those provided for the Awel y Môr OWF or the Proposed Development, given their smaller scale. Further, there will be no hard substrate installed as a result of the Mostyn Energy Park Expansion, therefore, this project is likely to represent a lower risk of introduction and spread of INNS than the Proposed Development or the Awel y Môr OWF.

Overall, the cumulative effect is predicted to be of local spatial extent (due to low footprint of introduced hard substrate), long term duration, intermittent (in terms of invasions), and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.6).

Overall, all subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to national value. The sensitivity of these IEFs is therefore, considered to be high.

Significance of Effect

Overall, for all subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a ‘Minor to moderate’ significance. Given the low disturbance footprint and that only one project was identified in the Tier 1 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

Subtidal Habitats and Species

There is the potential for cumulative impacts with one Tier 1 project in the decommissioning phase: Awel y Môr OWF. The decommissioning phase of the Proposed Development overlaps with the operation and maintenance phase of Awel y Môr OWF. Therefore, the 1.61 km^2 of hard substrate introduced in the Awel y Môr OWF operation and maintenance phase is applicable to this impact (RWE Renewables UK, 2021a). Furthermore, the MDS for Awel y Môr OWF includes up to 1,232 vessel return trips annually within the operation and maintenance phase (30,800 total) (RWE Renewables UK, 2021a). Therefore, there will be up to 2,464 vessel return trips potentially overlapping with the two-year decommissioning phase of the Proposed Development. This will be in addition to up to 128 vessel round trips associated with the decommissioning of the Proposed Development (Table 7.21).

Overall, the cumulative effect is predicted to be of local spatial extent (due to low footprint of introduced hard substrate), short-term duration (over the two-year decommissioning phase), intermittent (in terms of invasions), and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.6).

Overall, all subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to national value. The sensitivity of these IEFs is therefore, considered to be high.

Significance of Effect

Overall, for all subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only one project was identified in the Tier 1 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.7.2 Tier 2

Construction Phase

Magnitude of Impact

Subtidal Habitats and Species

The construction phase of the Proposed Development may interact cumulatively with that of one Tier 2 project: the Mona OWF.

The MDS for the Mona OWF assumes up to 2.85 km^2 of introduced hard substrate (EnBW and BP, 2023b). Therefore, there is potential for a total of up to 2.91 km^2 of hard substrate to be colonised by INNS (including the values assumed in the MDS for the Proposed Development; Table 7.21). Furthermore, the MDS for Mona OWF includes up to 2,004 vessel round trips over the construction phase (EnBW and BP, 2023b). There will be up to 236 vessel round trips in the construction phase of the Proposed Development (Table 7.21).

Overall, the cumulative effect is predicted to be of local spatial extent (due to low footprint of introduced hard substrate), long term duration, intermittent (in terms of invasions), and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Intertidal Habitats and Species

The Mona OWF will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to its distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further for the construction phase.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 2 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further for the construction phase.

As the Fylde MCZ IEF is does not overlap with the Awel y Môr OWF, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further for the construction phase.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.6).

Overall, all subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to national value. The sensitivity of these IEFs is therefore, considered to be high.

Significance of Effect

Overall, for all subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only one project was identified in the Tier 2 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

The operations and maintenance phase of the Proposed Development may interact cumulatively with those of two Tier 2 projects, Mona OWF, and Morgan and Morecambe OWF Transmission Assets. The Morgan and Morecambe OWF Transmission Assets construction phase will also overlap with the operation and maintenance phase of the Proposed Development. Predicted cumulative impacts from both Tier 2 plans, projects, and activities during their operation and maintenance phases are presented in Table 7.87 together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented.

For both the Tier 2 plans, projects, and activities during operations and maintenance phases of the Proposed Development, the cumulative introduced hard substrate is estimated at 2.90 km^2 (including the values for the Proposed Development provided in Table 7.21). There was no publicly available figure available for the Morgan and Morecambe OWF Transmission Assets, however given the nature of this project, these are likely to be similar or lower than those presented for the Mona OWF Table 7.87.

Overall, the cumulative effect is predicted to be of local spatial extent (due to low footprint of introduced hard substrate), long term duration, intermittent (in terms of invasions), and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Table 7.87: Cumulative Introduced Hard Substrate And Vessel Return Trips For The Operation And Maintenance Phases Of Tier 2 Plans, Projects, And Activities Identified

Project	Predicted Introduced Hard Substrate (km^2) and Vessel Traffic	Reason for Impact	Source
Offshore Renewables			
Mona OWF	2.85 km^2 of introduced hard substrate and up to 82,285 vessel return trips over then entire operation and maintenance phase	Presence of foundations and protection for cables, cable crossing, and scour. Vessel traffic can also pose a risk of introduction of INNS through ballast water or attached to hulls.	EnBW and BP (2023b)
Cables and Pipelines			

Project	Predicted Introduced Hard Substrate (km^2) and Vessel Traffic	Reason for Impact	Source
Morgan and Morecambe OWF Transmission Assets	Not available	Only the Scoping Report is currently available for this project, so no footprint of disturbance is available. However, installation of foundations and protection for cables, cable crossing, and scour will result in potential habitat for colonisation by INNS. Increased vessel traffic will also provide a vector for INNS transport.	-

Intertidal Habitats and Species

The Tier 2 projects will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to their distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 2 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 2 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 2 assessment.

As the Fylde MCZ IEF overlaps with the Morgan and Morecambe OWF Transmission Assets, the information provided above for 'Subtidal Habitats and Species IEFs' is also applicable. Thus, the cumulative impact on the Fylde MCZ IEF is predicted to be of local spatial extent (due to low footprint of introduced hard substrate), long term duration, intermittent (in terms of invasions), and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.6).

Overall, the subtidal habitats and species IEFs and Fylde MCZ IEF are deemed to be of high vulnerability, low recoverability, and local to international value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

Significance of Effect

Overall, for the subtidal habitats and species IEFs and Fylde MCZ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only two projects were identified in the Tier 2 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

Magnitude of Impact

Subtidal Habitats and Species

The decommissioning phase of the Proposed Development may interact cumulatively with the operations and maintenance phases of two Tier 2 projects: Mona OWF, and Morgan and Morecambe OWF Transmission Assets. For the Mona OWF, up to 2.85 km^2 of hard substrate will be present within its operation and maintenance phase, which could potentially be colonised by INNS (EnBW and BP, 2023b). There was no publicly available figure available for the Morgan and Morecambe OWF Transmission Assets, however given the nature of this project, these are likely to be similar or lower than that presented for the Mona OWF. During the decommissioning phase of the Proposed Development, the MDS assumes that all infrastructure will be removed, although some rock placement will remain *in situ.* The MDS for Mona OWF includes up to 2,351 vessel return trips per year during its operation and maintenance phase (EnBW and BP, 2023b). This means that up to 4,702 of these may occur during the two-year decommissioning phase of the Proposed Development. This will be in addition to up to 128 vessel round trips associated with the decommissioning of the Proposed Development (Table 7.21).

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprints for disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Designated Sites

As the Fylde MCZ IEF overlaps with the Morgan and Morecambe OWF Transmission Assets, the information provided above for 'Subtidal Habitats and Species IEFs' is also applicable. Thus, the cumulative impact on the Fylde MCZ IEF is predicted to be of local spatial extent (given the low footprints for disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.6).

Overall, the subtidal habitats and species IEFs and Fylde MCZ IEF are deemed to be of high vulnerability, low recoverability, and local to international value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

Significance of Effect

Overall, for the subtidal habitats and species IEFs and Fylde MCZ IEF, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only two projects were identified in the Tier 2 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.7.3 Tier 3

Construction and Operation and Maintenance Phase

Magnitude of Impact

Subtidal Habitats and Species

There is the potential for cumulative impacts with one Tier 3 project in the both the construction and operation and maintenance phases: The MaresConnect interconnector cable. However, there is currently no information on the impact that this project will have on benthic ecology. A planning application is predicted to be submitted in 2024 which will identify these impacts (MaresConnect, 2023).

Cable protection associated with the MaresConnect interconnector cable will represent introduction of hard substrates that could be colonised by INNS, similar to that expected for the cables of the Tier 1 and 2 projects. Increased vessel traffic during the construction and operation and maintenance phase of this project could also provide additional vectors for transmission of INNS. Construction of the MaresConnect interconnector cable is likely to occur in 2025 and the protection is anticipated to become operational in 2027 (MaresConnect 2023), although it should be noted that these timeframes are only indicative at this stage.

The cumulative effect is predicted to be of regional spatial extent (as the cable runs between Wales and Ireland), long-term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Intertidal Habitats and Species

The MaresConnect interconnector cable will not cumulatively interact with this impact in the intertidal zone of the Proposed Development due to its distance from the landfall (Figure 7.12). Therefore, the intertidal habitats and species IEF has not been considered further in this Tier 3 assessment.

Designated Sites

As above for the intertidal habitats and species IEF, there are no Tier 3 projects that cumulatively overlap with the Dee Estuary/Aber Dyfrdwy SAC IEF due to their distance from the landfall. Therefore, the Dee Estuary/Aber Dyfrdwy SAC IEF has not been considered further in this Tier 3 assessment.

As the Fylde MCZ IEF is does not overlap with the MaresConnect interconnector cable, cumulative effects due to this impact will not occur. Therefore, the Fylde MCZ IEF has not been considered further in this Tier 3 assessment.

Sensitivity of the Receptor

The sensitivity of the subtidal habitats and species IEFs are as previously described for the construction phase of the Proposed Development alone (see section 7.12.6).

Overall, the subtidal habitats and species IEFs are deemed to be of high vulnerability, low recoverability, and local to international value. Therefore, the sensitivity of these receptors to this impact is considered to be high.

Significance of Effect

Overall, for the subtidal habitats and species IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'Minor to moderate' significance. Given the low disturbance footprint and that only one project was identified in the Tier 3 assessment, the cumulative effect is considered be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.7.4 Tier 4

There were no Tier 4 plans, projects, or activities identified within the CEA for the construction, operation and maintenance, and decommissioning phases of this impact.

7.13.8 Conclusion

Overall, there were no significant cumulative effects identified for any tiers in the CEA for benthic subtidal and intertidal ecology.

7.13.9 Fish and Shellfish Ecology

The CEA study area for this topic was defined by a 50 km buffer around the Proposed Development (Figure 7.13). For the impact of underwater noise during the construction phase, a larger buffer of 100 km was used to account for a greater ZoI associated with underwater noise (especially piling). All plans, projects, and activities identified within this area were assessed and sorted into tiers using the methodology described in section 7.13.1 above.

The specific plans, projects, and activities scoped into the CEA for fish and shellfish ecology are outlined in Table 7.88 and in Figure 7.13.

7.13.9.1 Maximum Design Scenario

The MDS presented in Table 7.89 has been selected as those with the potential to result in the greatest effect on fish and shellfish receptors. The potential cumulative effects presented and assessed in this section were based on the PDE provided in volume 1, chapter 3, as well as the information available on other plans, projects, and activities. Effects of adverse significance are not expected to arise should another a different development scenario to that assessed here be taken forward to the final design scheme.

Table 7.88: List Of Other Plans, Projects, And Activities Considered Within The CEA For Fish And Shellfish Ecology

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
Tier 1						
Offshore Renewables						
Burbo Bank Extension OWF cable repair and remediation	Operational (with ongoing activities)	0.00	Export cable repair and remediation activities over the 25-year lifetime of the Burbo Bank Extension OWF.	N/a	2017–- 2042	These activities overlap spatially with the Proposed Development and temporally with the construction and operation and maintenance phases of the Proposed Development.
Awel y Môr OWF	Consented	1.10	Proposed renewable energy project, 10.50 km off the coast of North Wales, of up to 1.1 GW. Proposed for a maximum of 50 turbines, associated transmission assets, and cabling (including and interlink cable with Gwynt y Môr OWF).	2026 – 2030	2030 – 2055	This project will overlap with all three phases of the Proposed Development.
Mona OWF Suction Bucket Trails	Consented	5.60	The works proposed within this Marine Licence	2023 to June 2024	N/A	The suction bucket trials may overlap with early construction activities of the

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
			Application consist of trialling suction bucket foundations to assess the install viability within the Mona OWF Array Area, which is predominantly within Welsh waters.			Proposed Development.
Deposits and Removal						
Burbo Bank Extension OWF Disposal Site IS153	Operational (with ongoing activities)	0.50	Deposit of substances at sea, construction works, removal of sediment, and disposal of inert material during drilling for the Burbo Bank Extension OWF.	N/a	2017–- 2042	These activities overlap with the construction and operation and maintenance phases of the Proposed Development.
Hilbre Swash	Operational (with ongoing activities)	0.00	Licence to extract up to 12 million tonnes of aggregate (mainly sand) over 15 years.	N/a	2015 – 2029	Aggregate extraction activities within this project will overlap temporally with the construction and operation and maintenance phases of the Proposed Development. This project also spatially overlaps with the Proposed Development.

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
Mostyn Energy Park Expansion	Submitted	2.30	Extension of the Mostyn Energy Park at the Port of Mostyn. Requires construction of a 360 m quay, reclamation of 3.5 ha area, capital dredging of new berth pockets and re-dredging of approach channel. Use of dredged material for fill material for reclamation, disposal of dredged material at Mostyn Deep. Maintenance dredging of new and existing berths, approach channel and harbour area.	2023 to 2025	2025 to 2030	Activities will overlap with the construction and operation and maintenance phases of the Proposed Development.
Tier 2						
Offshore Renewables						
Mona OWF	Pre-application	5.53	Proposed renewable energy project, 28.20 km off the coast of North Wales, of up to 350 MW.	2026–- 2028	2029–- 2089	This project will overlap with all three phases of the Proposed Development.

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
Morgan OWF Generation Assets	Pre-application	7.53	The generation assets for the Morgan OWF, which has a capacity of 1.5 GW.	2026–- 2028	2029–- 2089	Temporally, the construction, operations and maintenance, and decommissioning phases of this project will overlap with the construction and operations and maintenance phases of the Proposed Development.
Morecambe OWF Generation Assets	Pre-application	30.00	The generation assets for the Morgan OWF, which has a capacity of 480 MW.	2026–- 2028	2029–- 2089	This project will overlap with all three phases of the Proposed Development.
Mooir Vannin OWF	Pre-application	63.00	OWF off the coast of the Isle of Man, with up to 100 turbines and a capacity for 100 MW.	2030 – 2032	2032 - 2067	The construction and operation and maintenance phases of this project will overlap with the operation and maintenance phase of the Proposed Development.
Cables and Pipelines						
Morgan and Morecambe OWF Transmission Assets	Pre-application	3.00	The transmission assets for the Morgan and Morecambe OWF	2028–- 2029	2030–- 2065	This project will overlap with the operations and maintenance and decommissioning phases of the

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation and Maintenance Period (if applicable)	Overlap with the Proposed Development
						Proposed Development.
Tier 3						
Cables and Pipelines						
MaresConnect – Wales – Ireland Interconnector Cable	Planning application not yet submitted	10.00	A proposed 750 MW subsea and underground electricity interconnector system, linking the electricity grids in the UK and Ireland.	2025	2027–- 2037	This project will overlap with the construction and operations and maintenance phases of the Proposed Development.
Tier 4						
Offshore Renewables						
Removal of a meteorological mast at Gwynt y Môr OWF	Issued (variation to an existing marine licence)	0.00	A seabed survey and removal of topside lattice structures, monopiles, and scour protection.	N/a	Licence issued for 2022–-2027	Although no information on the timeline of this project is available, the Marine License is issued for between 2022 – 2027. Therefore, this activity will overlap with the operations and maintenance phase of the Proposed Development. This project also spatially overlaps with the Proposed Development.

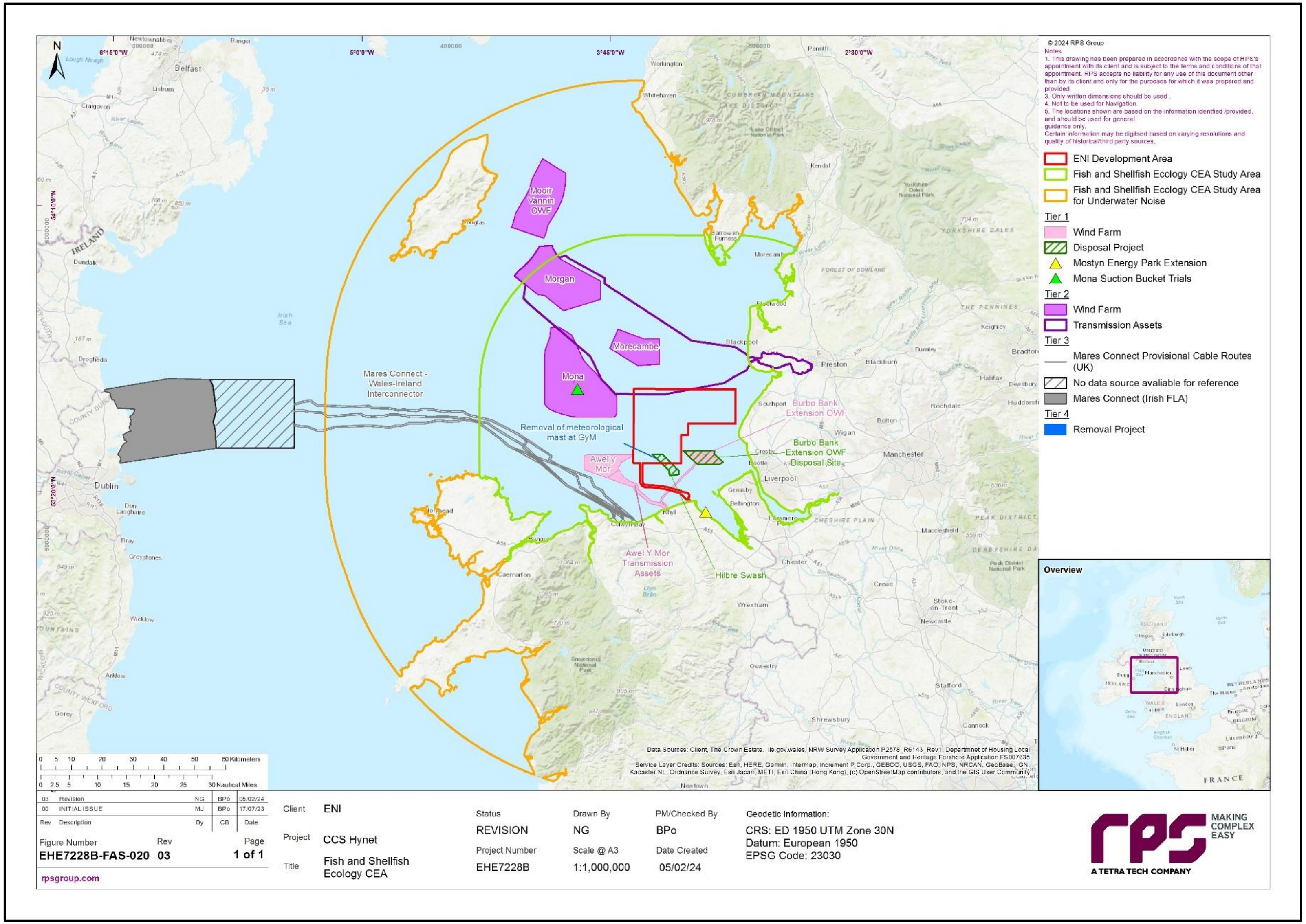


Figure 7.13: Plans, Projects, And Activities Screened Into The CEA For Fish And Shellfish Ecology

Table 7.89: MDS Considered For The Assessment Of Potential Cumulative Effects On Fish And Shellfish Ecology

Potential Cumulative Effect	Phase	MDS	Justification
Temporary subtidal habitat loss and/or disturbance	C	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Burbo Bank Extension OWF cable repair and remediation; • Awel y Môr OWF. Deposits and Removal: • Burbo Bank Extension OWF Disposal Site IS153; • Hilbre Swash; and • Mostyn Energy Park Expansion. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable **Tier 4:** Offshore Renewables: • Removal of a meteorological mast at Gwynt y Môr OWF.	These projects involve activities which will result in temporary subtidal habitat loss and/or disturbance which may contribute to the impact upon a habitat that the Proposed Development will also affect.
	O	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Burbo Bank Extension OWF cable repair and remediation; and	

Potential Cumulative Effect	Phase	MDS	Justification
		• Awel y Môr OWF. Deposits and Removal: • Burbo Bank Extension OWF Disposal Site IS153; and • Hilbre Swash. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable. **Tier 4:** Offshore Renewables: Removal of a meteorological mast at Gwynt y Môr OWF.	
	D	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets. Cables and Pipelines:	

Potential Cumulative Effect	Phase	MDS	Justification
		• Morgan and Morecambe OWF Transmission Assets.	
Increased SSCs and associated deposition	C	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Burbo Bank Extension OWF cable repair and remediation; and • Awel y Môr OWF; and • Mona OWF Suction Bucket Trails. Deposits and Removal: • Burbo Bank Extension OWF Disposal Site IS153; • Hilbre Swash; and • Mostyn Energy Park Expansion. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable **Tier 4:** Offshore Renewables: • Removal of a meteorological mast at Gwynt y Môr OWF.	These projects involve activities which may impact the tidal/wave regime and sediment transport during their temporal overall with the Proposed Development.
	D	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables:	

Potential Cumulative Effect	Phase	MDS	Justification
		• Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	
Long-term subtidal habitat loss	C and O	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. Deposits and Removals: • Mostyn Energy Park Expansion. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable.	These projects involve the installation of hard structures on the seabed which will cause long-term subtidal habitat loss within the CEA fish and shellfish ecology study area.
	D	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:**	

Potential Cumulative Effect	Phase	MDS	Justification
		Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	
Underwater noise impacting fish and shellfish receptors	C	The MDS is as described for the Proposed Development (Table 7.22) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; and • Morecambe OWF Generation Assets.	These projects all involve activities which will result in increased underwater noise which may coincide with that of construction activities for the Proposed Development. These may contribute to the impact upon fish and shellfish receptors.

7.13.10 Temporary Subtidal Habitat Loss and/or Disturbance

There is the potential for cumulative temporary habitat loss and/or disturbance as a result of activities associated with the Proposed Development and other plans, projects, and activities. Activities include cable burial, jack-up vessel use, anchor placements, seabed preparation, dredging, aggregate extraction, cables and pipelines laying, and remedial work. For the purposes of this ES, this additive impact has been assessed within the fish and shellfish ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.89.

7.13.10.1 Tier 1

Construction Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with five Tier 1 projects in the construction phase:

- Burbo Bank Extension OWF cable repair and remediation;
- Awel y Môr OWF;
- Hilbre Swash;
- Mostyn Energy Park Expansion; and
- Burbo Bank Extension OWF Disposal Site IS153.

The cumulative magnitude for this impact is as described for benthic subtidal and intertidal ecology (see section 7.13.3). For all the Tier 1 plans, projects, and activities during the construction phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 18.97 km^2 (including the values for the Proposed Development provided in Table 7.21).

The construction phase of the Proposed Development is between 2024 and 2026, while that of Awel y Môr OWF is currently anticipated as 2026 to 2030 (Table 7.88). Therefore, there may be some overlap between the construction phases of both projects, however it should be noted that it any cumulative impacts will be of a lesser extent than if the two projects overlapped for a longer period of time (i.e. over multiple years).

Dredging activities associated with the Mostyn Energy Park Expansion have been estimated to result in temporary subtidal habitat loss of 3.16 ha (31,600 m^2), with recolonisation expected to occur over a short period of time (although any indication on this time period was not provided in the Environmental Statement for this project (ABPmer, 2022)).

The cumulative impact on fish and shellfish IEFs is predicted to be of local spatial extent (given the low disturbance footprints), short term duration (over the two-year construction phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.9)

Marine Fish

Overall, most fish IEFs (such as pelagic spawners, elasmobranchs, and flatfish) are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be low.

Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be medium.

Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally generate a medium to high sensitivity. However, the sensitivity of herring to this impact is considered to be low, due to the limited suitable spawning sediments within the Proposed Development and the core herring spawning ground being located well outside and to the north-east of the regional fish and shellfish ecology study area off the coast of the Isle of Man.

Shellfish

Overall, spiny lobster are deemed to be of medium vulnerability, low to medium recoverability, and of national importance. The sensitivity of the receptor is therefore considered to be medium.

European lobster and Norway lobster are deemed to be of high vulnerability, medium to high recoverability and of local importance. The sensitivity of the receptor is therefore considered to be medium.

King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be low.

All other shellfish IEFs are deemed to be of medium vulnerability, medium recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be medium.

Diadromous Fish

Overall, diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. As such, the sensitivity of the receptor is therefore considered to be low.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the sensitivity of the freshwater pearl mussel IEF is also considered to be low.

Significance of Effect

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

<u>Diadromous Fish</u>

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Operation and Maintenance Phase

Magnitude of Impact

<u>All Species</u>

There is potential for cumulative impacts with four Tier 1 projects in the operation and maintenance phase:

- Burbo Bank Extension OWF cable repair and remediation;
- Awel y Môr OWF;
- Hilbre Swash; and
- Burbo Bank Extension OWF Disposal Site IS153.

The cumulative magnitude for this impact is as described for benthic subtidal and intertidal ecology (see section 7.13.3). For all the Tier 1 plans, projects, and activities during the operations and maintenance phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 1.49 km^2 (including the values for the Proposed Development provided in Table 7.21).

The cumulative impact on fish and shellfish IEFs is predicted to be of local spatial extent (given the low disturbance footprints), long-term duration (over the operations and maintenance phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Construction Phase and is not repeated here for brevity.

Significance of Effect

<u>Marine Fish</u>

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Decommissioning Phase

Magnitude of Impact

All Species

The only Tier 1 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development was Awel y Môr OWF. There were no values provided for the footprint of temporary habitat loss and/or disturbance for this project, however they will not exceed that of the construction phase (15.91 km^2) and are likely to be lower in reality due to the absence of seabed preparation (RWE Renewables UK, 2021a). Similarly, these values are also not available for the Proposed Development (Table 7.21) but are also likely to be similar to that of the construction phase (1.91 km^2). Therefore, the cumulative temporary habitat loss and/or disturbance is estimated at 17.82 km^2, and it should be noted that this is likely to be higher than reality.

Therefore, the cumulative impact is predicted to be of local spatial extent (given the low potential disturbance footprints, short-term duration (over the decommissioning phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the construction phase and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

7.13.10.2 Tier 2

Construction Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with three Tier 2 projects in the construction phase: Mona OWF, Morgan OWF Generation Assets, and Morecambe OWF Generation Assets. Predicted cumulative temporary habitat loss and/or disturbance from each of the Tier 2 plans, projects, and activities during the construction phase of the Proposed Development are presented in Table 7.90 together with a breakdown of the sources of these data. For all the Tier 2 plans, projects, and activities during the construction phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 223.84 km^2 (including the values for the Proposed Development provided in Table 7.21).

Table 7.90: Cumulative Temporary Habitat Loss And/Or Disturbance For The Construction Phase Of Tier 2 Plans, Projects, And Activities Identified

Project	Predicted Temporary Habitat Loss and/or Disturbance (km^2)	Cause of Temporary Habitat Loss and/or Disturbance	Source
Offshore Renewables			
Mona OWF	131.07	Jack-up events, cable installation, sand wave clearance, anchoring, and cable removal.	EnBW and BP (2023b)

Project	Predicted Temporary Habitat Loss and/or Disturbance (km^2)	Cause of Temporary Habitat Loss and/or Disturbance	Source
Morgan OWF Generation Assets	87.36	Jack-up events, cable installation, sand wave clearance, anchoring, and cable removal.	EnBW and BP (2023c)
Morecambe OWF Generations Assets	3.5	Jack-up vessel use and installation of cables, turbine and platform foundations.	Morecambe Offshore Wind Limited (2023)
Total	**221.93**		

Therefore, the cumulative impact is predicted to be of regional spatial extent (given the larger disturbance footprints than for the Tier 1 assessment), short term duration (over the two-year construction phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Operation and Maintenance Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with four Tier 2 projects in the operation and maintenance phase:

- Mona OWF;
- Morgan OWF Generation Assets;
- Morecambe OWF Generation Assets; and
- Morgan and Morecambe OWF Transmission Assets.

The operation and maintenance phase of the Proposed Development will overlap with both the construction and operation and maintenance phases of these four Tier 2 projects. Predicted cumulative temporary habitat loss and/or disturbance from each of the Tier 2 plans, projects, and activities during the operation and maintenance phase of the Proposed Development are presented in Table 7.91 together with a breakdown of the sources of these data. For all the Tier 2 plans, projects, and activities during the operation and maintenance phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 251.28 km^2 (including the values for the Proposed Development provided in Table 7.21).

At the time of writing, there was no publicly available information to quantify the footprint of temporary habitat loss and/or disturbance due to the Morgan and Morecambe OWF Transmission Assets. Therefore, these values are not included in the total calculation presented in the paragraph above. As the transmission assets only involves cables, it is likely that the disturbance footprint of temporary habitat loss and/or disturbance will be of a lower extent to that presented for Mona OWF (which includes offshore export cables).

Table 7.91: Cumulative Temporary Habitat Loss And/Or Disturbance For The Construction And Operations And Maintenance Phase Of Tier 2 Plans, Projects, And Activities Identified

Project	Predicted Temporary Habitat Loss and/or Disturbance (km^2)	Cause of Temporary Habitat Loss and/or Disturbance	Source
Offshore Renewables			
Mona OWF	Construction: 131.07 Operation and Maintenance: 17.60 km^2 over the entire phase.	Jack-up events, cable installation, sand wave clearance, anchoring, and cable removal.	EnBW and BP (2023b)
Morgan OWF Generation Assets	Construction: 87.36 Operation and Maintenance: 11.56 km^2 over the entire phase.	Jack-up events, cable installation, sand wave clearance, anchoring, and cable removal.	EnBW and BP (2023c)
Morecambe OWF Generations Assets	Construction: 3.5 Operation and Maintenance: 4,500 m^2 per year, for a 35-year life cycle. Therefore, a total of 0.16 km^2 over the entire phase.	Jack-up vessel use and installation of cables, turbine and platform foundations.	Morecambe Offshore Wind Limited (2023)

Project	Predicted Temporary Habitat Loss and/or Disturbance (km^2)	Cause of Temporary Habitat Loss and/or Disturbance	Source
Cables and Pipelines			
Morgan and Morecambe OWF Transmission Assets	Not available	Only the Scoping Report is currently available for this project, so no footprint of disturbance is available. However, the construction and operations and maintenance phases of this project overlap with the operations and maintenance phase of the Proposed Development. Therefore, activities such as jack-up events, anchoring, seabed preparation, cable laying, and cable maintenance will result in temporary habitat loss and/or disturbance.	-
Total	**251.25**		

Therefore, the cumulative impact is predicted to be of regional spatial extent (given the larger disturbance footprints than for the Tier 1 assessment), long-term duration (over the operations and maintenance phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Decommissioning Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with four Tier 2 projects in the decommissioning phase:

- Mona OWF;
- Morgan OWF Generation Assets;
- Morecambe OWF Generation Assets; and
- Morgan and Morecambe OWF Transmission Assets.

The decommissioning phase of the Proposed Development will overlap with the operation and maintenance phases of these four Tier 2 projects. Predicted cumulative temporary habitat loss and/or disturbance from each of the Tier 2 plans, projects, and activities during their operation and maintenance phases are presented in Table 7.91 together with a breakdown of the sources of these data. For all four Tier 2 plans, projects, and activities during the decommissioning phase of the Proposed Development, the cumulative temporary habitat loss and/or disturbance is estimated at 29.32 km^2. There are no values available for the decommissioning phase of the Proposed Development, however if it is assumed to be equal or lesser than the construction phase (1.91 km^2), the total cumulative temporary habitat loss and/or disturbance in this phase is 31.23 km^2.

At the time of writing, there was no publicly available information to quantify the footprint of temporary habitat loss and/or disturbance due to the Morgan and Morecambe OWF Transmission Assets. Therefore, these values are not included in the total calculation presented in the paragraph above. As the transmission assets only involves cables, it is likely that the disturbance footprint of temporary habitat loss and/or disturbance will be of a lower extent to that presented for Mona OWF (which includes offshore export cables).

Therefore, the cumulative impact is predicted to be of local spatial extent (given the smaller disturbance footprints than for the operation and maintenance phase), short-term duration (over the decommissioning phase), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

7.13.10.3 Tier 3

Construction and Operation and Maintenance Phases

Magnitude of Impact

All Species

The only Tier 3 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the construction and operation and maintenance phases of the Proposed Development was the MaresConnect interconnector cable. There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on fish and shellfish receptors. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023).

The activities associated with the MaresConnect interconnector cable which are likely to result in temporary habitat loss and/or disturbance are similar to those expected for the installation of cables for the Proposed Development. Construction is planned to occur in 2025 and the project is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage. The construction activities are likely to involve cable installation such as jet trenching, and the installation of cable protection. Operation and maintenance activities are likely to involve the repair and reburial of cables.

The cumulative impact on

predicted to be of local spatial extent, short term duration (for the individual construction and operation and maintenance activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development.

7.13.10.4 Tier 4

Construction and Operation and Maintenance Phases

Magnitude of Impact

Subtidal Habitats and Species

The only Tier 4 project which has been identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the construction and operation and maintenance phases of the Proposed Development was the removal of a meteorological mast at Gwynt y Môr OWF. There is, however, currently no information on the impact that this project will have on fish and shellfish receptors.

The activities associated with this project which are likely to result in temporary habitat loss and/or disturbance are anchoring and the use of jack-up vessels for the removal of topside lattice structures, monopiles, and scour protection. There is no timeline for these works currently publicly available, however the marine license was issued for 2022 – 2027. Therefore, while these activities may overlap with the entire construction phase of the Proposed Development, they should be completed shortly after the operation and maintenance phase of the Proposed Development begins (within 2026).

The cumulative impact is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, European lobster and Norway lobster the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms

For all other shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Decommissioning Phase

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development.

7.13.11 Increased SSCs and Associated Deposition

There is the potential for cumulative increased SSCs and associated deposition as a result of activities associated with the Proposed Development and other plans, projects, and activities. Activities include seabed preparation, dredging, aggregate extraction, and cables and pipelines laying. For the purposes of this ES, this additive impact has been assessed within the fish and shellfish ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.89.

7.13.11.1 Tier 1

Construction Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with six Tier 1 projects in the construction phase:

- Burbo Bank Extension OWF cable repair and remediation;
- Awel y Môr OWF;
- Mona OWF Suction Bucket Trials;
- Mostyn Energy Park Expansion;
- Hilbre Swash; and
- Burbo Bank Extension OWF Disposal Site IS153.

The construction phase of the Proposed Development coincides with construction activities of the Awel y Môr OWF, such as seabed preparation, drilling, cable installation, and HDD. However, in the PEIR for Awel y Môr, this impact has been determined as localised within one tidal excursion, short-term, intermittent, and reversible upon fish and shellfish receptors (RWE Renewables UK, 2021a). The Awel y Môr OWF also involves the installation of an interlink cable with the Gywnt y Môr Offshore Wind Farm, with the magnitude of suspended sediments likely being of a similar magnitude to offshore export cable installation. Thus, again it can be expected a cumulative effect that may arise would do so within the natural variability of background levels, and only occur if cable installation operations occurred simultaneously. Furthermore, the construction phase of the Proposed Development is between 2024 and 2026, while that of Awel y Môr OWF is currently anticipated as 2026 to 2030 (Table 7.88). Therefore, there may be some overlap between the construction phases of both projects, however it should be noted that it any cumulative impacts will be of a lesser extent than if the two projects overlapped for a longer period of time (i.e. over multiple years).

The construction phase of the Proposed Development also coincides with cable repair and maintenance activities at the Burbo Bank Extension OWF and disposal at site IS153. However, as this only involves intermittent maintenance and disposal work, this impact has been determined as of limited spatial extent, short-term, intermittent, and reversible upon fish and shellfish receptors.

The construction phase of the Proposed Development also encompasses aggregate extraction the Hilbre Swash licensed area, located within the Proposed Development. Resultant plumes from the disposal of dredged material and extraction of aggregate would be advected on the tidal current running in parallel and not coincide with the Proposed Development.

As part of the Mona Offshore Wind Farm application, a series of suction bucket foundation trials were consented to, to validate the suitability of foundation and optimise design. These works occur within the Mona

Array Area at up to 30 locations, using a variety of parameters to best inform final design. At each location, the trial may be undertaken up to 3 times and once all activities at the site are complete the full removal of foundation would occur before moving to the next location to repeat (MarineSpace Ltd., 2023). Although the trials of foundation installation and subsequent removal may mobilise sediment within the Mona Array Area, the small scale nature associated with the installation/removal of one foundation at a time would be expected to produce a small plume with much of the sediment suspended settling in the vicinity of the structures. This, paired with the fact that the Mona Array Area is largely advected on tidal currents and situated approximately 5.60 km north west of the Proposed Development (at its closest point), indicate that if an overlap in SSC or deposition did occur between the projects, that it would do so at background levels. The Mona OWF suction bucket trials have only been assessed for this impact, as the WFD Compliance Assessment concluded that an assessment on ecological impacts was not required, given the low potential for impact.

The construction phase of the Proposed Development is expected to coincide with the construction and operation and maintenance phases of the Mostyn Energy Park Extension and associated maintenance dredging activities. This development, within the Dee Estuary, involves the construction of a 360 m length of new quay wall, the infilling of a 3.5 ha area behind the new quay wall (requiring 600,000 m^3 of infill material, 500,000 m^3 of which will be sourced from dredging activity arisings) (ABPmer, 2022). Alongside the new quay wall a dredged berth pocket will be required to a depth of -11 m CD (400,000 m^3), whilst re-dredging of the existing berth pocket along the existing quay wall to -9 m CD will be required (400,000 m^3) (ABPmer, 2022). The largest dredging operation will take the form of the re-dredging of the main navigation channel to a depth of -4 m CD (3,000,000 m^3) (ABPmer, 2022). Both seabed preparation and cable installation activities produce SSC plumes that extend into the Dee Estuary and overlap with the location of construction activities and dredging at the Port of Mostyn Energy Park Expansion, however, they do so at background levels i.e. < 3 mg/l. It can therefore be judged that although a cumulative impact may arise, the change in SSC would be of negligible significance and recoverable.

The largest overlap in SSC would occur if the disposal of dredged material within the Mostyn Deep disposal site occurred simultaneously with cable installation activities or seabed preparation across West Hoyle Bank, however even in this case, overlapping plumes in the vicinity of West Hoyle Bank and within the Dee Estuary would be of limited magnitude due to the decreases in SSC and deposition observed with distance from respective works. Noting also that sediment plumes would be traversing in parallel and not towards one another as they are advected on the same tidal current. Maximum SSC values in the area of overlap can be up to 100 mg/l for both plumes combined, however, the more representative average plumes are expected to have SSC values of negligible difference to background levels when they coincide. Likewise, sedimentation over the bank can be considered minor and the overall cumulative impact between the disposal of dredged material and the Proposed Development can be considered to be negligible, of local extent and short-term duration. The cumulative impact relating to overlap between operation and maintenance activities from the Mostyn Energy Park Extension and construction activities related to the Proposed Development are expected to be of a similar magnitude to the dredging/disposal activities described above, only of a smaller scale in line with reduced dredge volumes associated with maintenance works rather than construction works.

Proposed Developmenti.e.The cumulative impact on the benthic subtidal and intertidal IEFs is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.12).

Marine Fish

Overall, all marine fish IEFs, except herring, are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be low.

Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, high recoverability and of national importance. Therefore, the sensitivity of this receptor is considered to be medium.

Shellfish

Overall, all shellfish IEFs are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be low.

Diadromous Fish

Overall, this impact is not expected to create any significant barrier to migration to rivers or estuaries used by these diadromous species within the CEA fish and shellfish ecology study area. Diadromous fish IEFs in the regional fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptors is therefore, considered to be low.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the sensitivity of the freshwater pearl mussel IEF is also considered to be low.

Significance of Effect

Marine Fish

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

Decommissioning Phase

Magnitude of Impact

All Species

The decommissioning phase of the Proposed Development coincides with operation and maintenance and decommissioning activities of the Awel y Môr OWF, such as cable maintenance, cable removal, and foundation removal. However, in the PEIR for Awel y Môr, this impact has been determined as localised within one tidal excursion, short-term, intermittent, and reversible upon benthic subtidal and intertidal receptors (RWE Renewables UK, 2021a).

The cumulative impact on the benthic subtidal and intertidal IEFs is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the construction phase and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms. Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.13.11.2 Tier 2

Construction Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with three Tier 2 projects in the construction phase: Mona OWF, Morgan OWF Generation Assets, and Morecambe OWF Generation Assets.

For the Mona OWF, modelling suggested that average SSCs during the course of the construction activities was expected to be <300 mg/l with a plume envelope width of approximately 20 km, which corresponds to the local tidal excursion (EnBW and BP, 2023b). Sediments deposited on slack tide in the north-east of the Mona Array Area are expected to be resuspended on subsequent tides. Typically, this plume concentration will be <10 mg/l, and this reduces as distance from the site increases due to natural sediment dispersal. Three days after installation of foundations, sediment concentrations are expected to reduce, with sedimentation and resuspension occurring dependent on the current speed and tidal cycle. Peak concentrations in a resuspension event at this point are likely to reach a maximum of <30mg/l, compared to average concentrations of a maximum of 3mg/l in the area normally (EnBW and BP, 2023b).

For the Morgan OFW Generation Assets, sedimentation one day after the cessation of the sand wave clearance activities was modelled to result in up to 0.5 mm of deposited material at the site of release. In the wider area (approximately 100 m from the release) deposited material reaches depths of typically 0.3 mm, still detectable above background levels of <0.01mm but are expected to decrease on subsequent tidal cycles (EnBW and BP, 2023c). This modelling also found that SSCs would increase by up to 50 mg/l in the area immediately surrounding piling, with a rapid reduction back to background levels of sedimentation as time and distance from the piling activity increased (EnBW and BP, 2023c).

For the Morecambe OWF Generation Assets, finer sediment is expected to exist as a passive plume, and extend to a maximum of 10 km. Other sediments are expected to settle quickly in proximity to their release, within a few hundred metres and up to approximately a kilometre from any construction activity (Morecambe Offshore Wind Limited, 2023).

The increased SSCs from construction activities in the three Tier 2 projects would be of limited spatial extent and intermittent in frequency and unlikely to interact with sediment plumes from the Proposed Development. As described in section 7.12.2, modelling for the Proposed Development suggested that material was retained in the sediment cell and would be subsequently assimilated into the existing sediment transport regime.

The cumulative effect is predicted to be of local spatial extent, short term duration (over the two-year construction phase), intermittent (due to the construction activities), and high reversibility. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

<u>Marine Fish</u>

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

<u>Shellfish</u>

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

<u>Diadromous Fish</u>

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

Decommissioning Phase

Magnitude of Impact

<u>All Species</u>

There is potential for cumulative impacts with four Tier 2 projects in the decommissioning phase:

- Mona OWF;
- Morgan OWF Generation Assets;
- Morecambe OWF Generation Assets; and
- Morgan and Morecambe OWF Transmission Assets.

The operation and maintenance phases of the first three projects will occur during the decommissioning phase of the Proposed Development. For the Morgan and Morecambe OWF Transmission Assets, both the construction and operation and maintenance phases will overlap with the decommissioning phase of the Proposed Development. During their operations and maintenance phases, cable repair and reburial has the potential to result in increased SSCs. These activities would be of limited spatial extent, intermittent in frequency, and unlikely to interact with sediment plumes from the Proposed Development. As described in section 7.12.2, increased SSCs in the decommissioning phase of the Proposed Development are expected to be similar or lower to those of the construction phase, which was assessed as having a low magnitude of impact.

At the time of writing, there was no publicly available information to quantify the increased SSCs and associated deposition due to the Morgan and Morecambe OWF Transmission Assets. As the transmission assets only involves cables, it is likely sedimentation will be of a lower extent to that of Mona OWF (which includes offshore export cables).

Overall, the cumulative effect is predicted to be of local spatial extent, short term duration (over the two-year decommissioning phase), intermittent (due to the individual activities), and high reversibility. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

7.13.11.3 Tier 3

Construction and Operation and Maintenance Phases

Magnitude of Impact

All Species

The only Tier 3 project which has been identified in the CEA with the potential to result in increased SSCs and associate deposition during the construction and operation and maintenance phases of the Proposed Development was the MaresConnect interconnector cable. There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on fish and shellfish receptors. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023).

The activities associated with the MaresConnect interconnector cable which are likely to result in increased SSCs and associated deposition are similar to those expected for the installation of cables for the Proposed Development. Construction is planned to occur in 2025 and the project is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage. The construction activities are likely to involve cable installation such as jet trenching, and the installation of cable protection. Operation and maintenance activities are likely to involve the repair and reburial of cables.

The cumulative impact is predicted to be of local spatial extent, short term duration (for the individual construction and operation and maintenance activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative increased SSCs and associated deposition during the decommissioning phases of the Proposed Development.

7.13.11.4 Tier 4

Construction and Operation and Maintenance Phases

Magnitude of Impact

All Species

The only Tier 4 project which has been identified in the CEA with the potential to result in cumulative increased SSCs and associated deposition during the construction and operation and maintenance phases of the

Proposed Development was the removal of a meteorological mast at Gwynt y Môr OWF. There is, however, currently no information on the impact that this project will have on fish and shellfish receptors.

The activities associated with this project which are likely to result in increased SSCs and associated deposition are anchoring and the use of jack-up vessels for the removal of topside lattice structures, monopiles, and scour protection. There is no timeline for these works currently publicly available, however the marine license was issued for 2022 – 2027. Therefore, while these activities may overlap with the entire construction phase of the Proposed Development, they should be completed shortly after the operation and maintenance phase of the Proposed Development begins (within 2026).

The cumulative impact is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and of high reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, for all marine fish IEFs except herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

For herring, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **negligible adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect upon the freshwater pearl mussel IEF is also considered to be **negligible adverse.**

Decommissioning Phase

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative increased SSCs and associated deposition during the decommissioning phases of the Proposed Development.

7.13.12 Long-Term Subtidal Habitat Loss

Long-term subtidal habitat loss may result from the physical presence of foundations, cable crossing protection, and rock placement. For the purposes of this ES, this additive impact has been assessed within the fish and shellfish ecology CEA study area, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the CEA for this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.89.

7.13.12.1 Tier 1

Construction and Operation and Maintenance Phases

Magnitude of Impact

All Species

There is the potential for cumulative impacts with two Tier 1 projects in the construction and operation and maintenance phases: Awel y Môr OWF and the Mostyn Energy Park Expansion. The MDS for Awel y Môr OWF assumes up to 1.61 km^2 of long-term subtidal habitat loss due to the footprint of turbines, foundations, meteorological mast, and cable protection (RWE Renewables UK, 2021a). The MDS for this impact for the Mostyn Energy Park Expansion accounts for loss of up to 34,900 m^2 of habitat (ABPmer, 2022). Therefore, there is potential for a total of up to 1.71 km^2 of long-term subtidal habitat loss (including the values assumed in the MDS for the Proposed Development; Table 7.21).

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprint of disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.10).

Marine Fish

Overall, sandeel are deemed to be of high vulnerability, high recoverability, and of regional importance. The sensitivity of sandeel is therefore considered to be medium.

Herring are deemed to be of high vulnerability, medium recoverability, and of national importance. The sensitivity of herring is therefore considered to be medium.

Overall, most marine fish IEFs in the regional fish and shellfish ecology study area (with the exception of herring and sandeel) are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be low.

Shellfish

Spiny lobster are deemed to be of high vulnerability, low recoverability, and of regional importance. The sensitivity of spiny lobster is therefore considered to be high.

Norway lobster and European lobster are deemed to be of high vulnerability, medium to high recoverability and of local importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be medium.

King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be low.

All other shellfish IEFs are deemed to be of medium vulnerability, high recoverability, and of local importance. The sensitivity of the receptor is therefore considered to be low.

Diadromous Fish

Overall, diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore considered to be low.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the sensitivity of the freshwater pearl mussel IEF is also considered to be low.

Significance of Effect

Marine Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of most marine fish IEFs (with the exception of herring and sandeel) is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring and sandeel, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'minor or moderate' significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the CEA fish and shellfish ecology study area that may be impacted by long-term subtidal habitat loss.

For Norway lobster and European lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Decommissioning Phase

Magnitude of Impact

All Species

There is the potential for cumulative impacts with one Tier 1 project in the decommissioning phase: Awel y Môr OWF. The MDS for Awel y Môr OWF assumes up to 1.61 km^2 of long-term subtidal habitat loss due to the removal of infrastructure installed in the construction phase (RWE Renewables UK, 2021a). Therefore, there is potential for a total of up to 1.67 km^2 of long-term subtidal habitat loss (including the footprint of infrastructure that will be removed from the Proposed Development; Table 7.21).

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprint of disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the construction and operation and maintenance phases and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of most marine fish IEFs (with the exception of herring and sandeel) is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring and sandeel, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a ‘minor or moderate’ significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the CEA fish and shellfish ecology study area that may be impacted by long-term subtidal habitat loss.

For Norway lobster and European lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

7.13.12.2 Tier 2

Construction and Operation and Maintenance Phases

Magnitude of Impact

All Species

The construction and operations and maintenance phases of the Proposed Development may interact cumulatively with those of three Tier 2 projects: Mona OWF, Morgan OWF Generation Assets, and Morecambe Generation Assets. They also coincide with the operations and maintenance phase of the Morgan and Morecambe OWF Transmission Assets. Predicted cumulative long-term subtidal habitat loss from all the Tier 2 plans, projects, and activities during the construction and operation and maintenance phases of the Proposed Development are presented in Table 7.92, together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented.

For both the Tier 2 plans, projects, and activities during the construction and operations and maintenance phases of the Proposed Development, the cumulative long-term subtidal habitat loss is estimated at 4.38 km^2 (including the values for the Proposed Development provided in Table 7.21). There was no publicly available figure of predicted long-term subtidal habitat loss available for the Morgan and Morecambe OWF Transmission Assets, however given the nature of this project, these are likely to be similar or lower than those presented for the Mona OWF in Table 7.92.

Table 7.92: Cumulative Long-Term Subtidal Habitat Loss For The Construction And Operation And Maintenance Phases Of Tier 2 Plans, Projects, And Activities Identified

Project	Predicted Long-Term Subtidal Habitat Loss (km^2)	Cause of Long-Term Subtidal Habitat Loss	Source
Offshore Renewables			
Mona OWF	2.36	Presence of foundations and protection for cables, cable crossing, and scour.	EnBW and BP (2023b)
Morgan OWF Generation Assets	1.52		
Morecambe OWF Generation Assets	0.45		
Cables and Pipelines			
Morgan and Morecambe OWF Transmission Assets	Not available	Only the Scoping Report is currently available for this project, so no footprint of disturbance is available. However, installation of foundations and protection for cables, cable crossing, and scour will result in long-term subtidal habitat loss.	-
Total	**4.33**		

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprint of disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of most marine fish IEFs (with the exception of herring and sandeel) is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring and sandeel, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'minor or moderate' significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the CEA fish and shellfish ecology study area that may be impacted by long-term subtidal habitat loss.

For Norway lobster and European lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Decommissioning Phase

Magnitude of Impact

All Species

The decommissioning phase of the Proposed Development may interact cumulatively with the operations and maintenance phases of four Tier 2 projects:

- Mona OWF;
- Morgan OWF Generation Assets;
- Morecambe OWF Generation Assets; and
- Morgan and Morecambe OWF Transmission Assets.

Predicted cumulative long-term subtidal habitat loss from each of the Tier 2 plans, projects, and activities during their operation and maintenance phases are presented in Table 7.92, together with a breakdown of the sources of this data and any assumptions made where necessary information was not presented. This is estimated as 4.33 km^2. This impact is likely to be of a lower extent than in the construction and operation and maintenance phase, as the MDS for the Proposed Development assumes that all infrastructure will be removed (with only some rock placement remaining *in situ*).

There was no publicly available figure of predicted long-term subtidal habitat loss available for the Morgan and Morecambe OWF Transmission Assets, however given the nature of this project, these are likely to be similar or lower than that presented for Mona OWF in Table 7.92.

Overall, the cumulative effect is predicted to be of local spatial extent (given the low footprints for disturbance), long term duration, continuous, and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of most marine fish IEFs (with the exception of herring and sandeel) is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring and sandeel, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a ‘minor or moderate’ significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the CEA fish and shellfish ecology study area that may be impacted by long-term subtidal habitat loss.

For Norway lobster and European lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

7.13.12.3 Tier 3

Construction and Operation and Maintenance Phases

Magnitude of Impact

All Species

There was one Tier 3 project identified in the CEA with the potential to result in cumulative long-term subtidal habitat loss during the construction and operation and maintenance phases of the Proposed Development: The MaresConnect interconnector cable. However, there is currently no information on the impact that this project will have on fish and shellfish ecology. A planning application is predicted to be submitted in 2024 which will identify these impacts (MaresConnect, 2023).

Cable protection associated with the MaresConnect interconnector cable is likely to result in long-term subtidal habitat loss, similar to those expected for the cables of the Tier 1 and 2 projects. Construction is likely to occur in 2025 and the protection is anticipated to become operational in 2027 (MaresConnect 2023), although it should be noted that these timeframes are only indicative at this stage.

The cumulative effect is predicted to be of regional spatial extent (as the cable runs between Wales and Ireland), long-term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of most marine fish IEFs (with the exception of herring and sandeel) is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For herring and sandeel, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Shellfish

For spiny lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this yields a 'minor or moderate' significance. The effect will be of **minor adverse** significance (which is **not significant** in EIA terms) due to the small proportion of the CEA fish and shellfish ecology study area that may be impacted by long-term subtidal habitat loss.

For Norway lobster and European lobster, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For king and queen scallop, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

For all other shellfish IEFs, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Due to the obligate life history of freshwater pearl mussel with Atlantic salmon and sea trout, the significance of the effect on the freshwater pearl mussel IEF is also considered to be **minor adverse.**

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative long-term subtidal habitat loss during the decommissioning phases of the Proposed Development.

7.13.12.4 Tier 4

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative long-term subtidal habitat loss during the construction, operations and maintenance, and decommissioning phases of the Proposed Development.

7.13.13 Underwater Noise Impacting Fish and Shellfish Receptors

Underwater noise may be generated in the construction phase of the Proposed Development during piling, UXO clearance, site investigation surveys, and various construction activities, such as cable laying. For the purposes of this ES, this additive impact has been assessed within the fish and shellfish ecology CEA study area for underwater noise, using the tiered approach outlined above in section 7.13.1. Due to the higher levels of sound associated with percussive and explosive underwater noise, this section will focus upon the impacts of piling and UXO clearance which have the greatest potential for cumulative effects.

All plans, projects, and activities screened into the CEA for this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.89.

7.13.13.1 Tier 1

Construction Phases

Magnitude of Impact

<u>All Species</u>

There is the potential for cumulative impacts with one Tier 1 project in the construction phase of the Proposed Development: Awel y Môr OWF. The construction phase of the Proposed Development is between 2024 and 2026, while that of Awel y Môr OWF is currently anticipated as 2026 to 2030 (Table 7.88). Therefore, there may be some overlap between the construction phases of both projects, however it should be noted that it any cumulative impacts will be of a lesser extent than if the two projects overlapped for a longer period of time (i.e. over multiple years). The MDS for Awel y Môr OWF assumes the instillation of monopiles for the foundations of 91 turbines and two platforms, with a maximum hammer energy of 5,000 kJ (RWE Renewables UK, 2021d). Furthermore, this MDS also encompasses HDD cofferdam piling with a maximum hammer energy of 300 kJ, clearance of up to 10 UXOs (RWE Renewables UK, 2021d).

Underwater noise modelling undertaken for the Awel y Môr OWF indicated injury and mortality to ranges of up to 1,300 m for Group 1 fish, 6,300 m for Group 2 fish, and 8,600 m for Group 3 fish, if modelled as static receptors (RWE, 2021d). In all cases, modelling the fish as fleeing receptors highly significantly reduced mortality distances, down to <100 m even for Group 3 fish. Injury distances were calculated to reach out to up to 12,000 m for Group 3 static receptors, with this again reducing to up to 120 m when fish were modelled as fleeing receptors, with similar patterns for all other groups of fish (RWE Renewables UK, 2021d). In general, all these values exceeded those modelled for the Proposed Development (see section 7.12.11).

As with the Proposed Development, embedded mitigation including soft starts will reduce the risk of injury and mortality to many fish and shellfish. With respect to behavioural effects, the Awel y Môr OWF indicated behavioural effects in the tens of kilometres, similar to those modelled for the Proposed Development (33 km; see section 7.12.11).

Overall, the cumulative impact is predicted to be of regional spatial extent, short-term duration, intermittent throughout the two-year construction phase, and high reversibility (due to TTS and recoverable injury). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.11).

Marine Fish

Overall, most marine fish IEFs, including elasmobranchs, are deemed to be of low vulnerability, high recoverability, and local to international importance. The sensitivity of these receptors is therefore, considered to be low.

Sprat (Group 4) are deemed to be of medium vulnerability, high recoverability, and regional to national importance. The sensitivity of these receptors is therefore, considered to be medium.

Cod (Group 3) and herring (Group 4) are deemed to be of high vulnerability, high recoverability, and national importance. The sensitivity of the receptor is therefore, considered to be high.

Shellfish

Overall, all shellfish IEFs identified in this assessment are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of these receptors is therefore, considered to be low.

Diadromous Fish

Overall, most diadromous fish species IEFs are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of these receptors is therefore, considered to be low.

As Group 4 species, Allis shad and twaite shad are deemed to be of high vulnerability, high recoverability, and national importance. The sensitivity of these receptors is therefore considered to be high.

Significance of Effect

Marine Fish

Overall, for most marine fish IEFs (including elasmobranchs), the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For Group 4 sprat, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be medium. The effect will, therefore be **minor adverse**, which is **not significant** in EIA terms.

For cod and herring the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be high The effect will, therefore be either minor adverse or moderate adverse according to the matrix provided in Table 7.31. Based upon the short duration of the project construction phase overlaps, particularly with respect to pile driving (approximately 13 hours of piling for the Proposed Development) and UXO clearance (a duration of days), the significance of the effect is considered **minor adverse**, which is **not significant** in EIA terms.

Shellfish

Overall, for all shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, for most diadromous IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For Group 4 diadromous IEFs (Allis and twaite shad), the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be high. The effect will, therefore, be either minor adverse or moderate adverse according to the matrix provided in Table 7.31. Based upon the short duration of the project construction phase overlaps, particularly with respect to pile driving (approximately 13 hours of piling for the

Proposed Development) and UXO clearance (a duration of days), the significance of the effect is considered **minor adverse**, which is **not significant** in EIA terms.

7.13.13.2 Tier 2

Construction Phases

Magnitude of Impact

All Species

There is potential for cumulative impacts with three Tier 2 projects in the construction phase: Mona OWF, Morgan OWF Generation Assets, and Morecambe OWF Generation Assets. The construction phase of the Proposed Development is between 2024 and 2026, while that of these three Tier 2 projects is currently anticipated as 2026 to 2028 (Table 7.88). Therefore, there may be some overlap between the construction phases of the Tier 2 projects, however it should be noted that it any cumulative impacts will be of a lesser extent than if the three projects overlapped for a longer period of time (i.e. over multiple years). Although the Mooir Vannin OWF is located within the 100 km screening buffer used to identify other plans and projects with potential cumulative impact with regards to underwater noise (63 km away), its construction phase is anticipated to be between 2030 – 2032 (Table 7.88). Therefore, it will not overlap with that of the Proposed Development (2024 - 2026) and is therefore not considered further in this Tier 2 assessment.

The MDS for the Mona OWF includes monopile and pin pile installation with a maximum hammer energy of 5,500 kJ and 2,800 kJ, respectively (EnBW and BP, 2023d). Underwater noise modelling indicated mortality ranges of up to 670 m for Groups 2 to 4 fish during maximum hammer energy, with 420 m modelled for Group 1 fish. If modelled as static receptors, mortality ranges were modelled as 780 m for Group 1 fish, 2,090 m for Group 2 and eggs and larvae, and 2,880 m for Group 3 and 4 fish (EnBW and BP, 2023d). If modelled as fleeing receptors, these values decreased to 11 m for Group 3 and 4 fish, with the threshold not exceeded for Groups 1 and 2. As static receptors, injury ranges were calculated to reach out to 1,085 m for Group 1, 4,440 for Group 2, and 4,400 for Groups 3 and 4. Again, these were reduced to 67 m for Groups 2 to 4 when modelled as fleeing receptors, with the threshold not exceeded for Group 1 (EnBW and BP, 2023d). In general, all these values exceeded those modelled for the Proposed Development (see section 7.12.11).

The MDS for the Morgan OWF Generation Assets includes monopile and pin pile installation with a maximum hammer energy of 5,500 kJ and 3,700 kJ, respectively, and clearance of up to 13 UXOs (EnBW and BP, 2023c). For the Morgan OWF Generation Assets, underwater noise modelling indicated mortality ranges of up to 745 m for Group 1 fish, 2,120 m for Group 2 fish, and 2,980 m for Group 3 and 4 fish, if modelled as static receptors (EnBW and BP, 2023c). In all cases, modelling the fish as fleeing receptors highly reduced mortality ranges, down to <100 m. As static receptors, injury distances were calculated to reach out to up to 4,760 m for Groups 2 to 4, with this again reducing to <100 m in all cases when fish were modelled as fleeing receptors, with similar patterns for all other groups of fish. In general, all these values exceeded those modelled for the Proposed Development (see section 7.12.11).

The MDS for the Morecambe OWF Generation Assets includes monopile and pin pile installation with a with a maximum hammer energy of 5,000 kJ and 2,500 kJ, respectively (Morecambe Offshore Wind Limited, 2023). For the Morecambe OWF Generation Assets, underwater noise modelling indicated mortality ranges of up to 1,600 m for Group 1 fish, 5,000 m for Group 2 fish, and 3,3000 m for Group 3 and 4 fish, if modelled as static receptors (Morecambe Offshore Wind Limited, 2023). In all cases, modelling the fish as fleeing receptors highly reduced mortality ranges, down to100 m for Group 1 fish and to 250 m for Groups 2 to 4. All these values exceeded those modelled for the Proposed Development (see section 7.12.11).

The cumulative effect is predicted to be of regional spatial extent, short-term duration (over the two-year construction phase), intermittent (in terms of noise producing activities), and high reversibility (due to TTS and recoverable injury). It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Tier 1 assessment and is not repeated here for brevity.

Significance of Effect

Marine Fish

Overall, for most marine IEFS (including elasmobranchs), the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For Group 4 sprat, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be medium. The effect will, therefore be **minor adverse**, which is **not significant** in EIA terms.

For cod and herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be high. The effect will, therefore be either minor adverse or moderate adverse according to the matrix provided in Table 7.31. Based upon the short duration of the project construction phase overlaps, particularly with respect to pile driving (approximately 13 hours of piling for the Proposed Development) and UXO clearance (a duration of days), the significance of the effect is considered **minor adverse**, which is **not significant** in EIA terms.

Shellfish

Overall, for all shellfish IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Diadromous Fish

Overall, for most diadromous IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

For Group 4 diadromous IEFs (Allis and twaite shad), the magnitude of the impact is deemed to be low, and the sensitivity of the receptors is considered to be high. The effect will, therefore be either minor adverse or moderate adverse according to the matrix provided in Table 7.31. Based upon the short duration of the project construction phase overlaps, particularly with respect to pile driving (approximately 13 hours of piling for the Proposed Development) and UXO clearance (a duration of days), the significance of the effect is considered **minor adverse**, which is **not significant** in EIA terms.

7.13.13.3 Tier 3 and 4

There were no Tier 3 or 4 plans, projects, or activities identified in the CEA with the potential to result in increased underwater noise during the construction phase of the Proposed Development.

7.13.14 Conclusion

Overall, there were no significant cumulative effects identified for any tiers in the CEA for fish and shellfish ecology.

7.13.15 Marine Mammals and Marine Turtles

The CEA study area for this topic was defined as the regional marine mammal and marine turtle study area (Figure 7.14). All plans, projects, and activities identified within this area were assessed and sorted into tiers using the methodology described in section 7.13.1 above.

The specific plans, projects, and activities scoped into the CEA for marine mammals and marine turtles are outlined in Table 7.93 and in Figure 7.14.

Effects on marine mammals and marine turtles due to changes in prey availability has been assessed for the Proposed Development alone (section 7.12.19). However, this impact has not been presented here in the CEA to avoid repetition of the CEA presented above for fish and shellfish (i.e. prey species). As there were no significant cumulative effects presented for fish and shellfish (section 7.13.14), it can be concluded that there will be no cumulative effect on marine mammals and marine turtles due to changes in prey availability.

7.13.15.1 Maximum Design Scenario

The MDS presented in Table 7.94 has been selected as those with the potential to result in the greatest effect on marine mammal and marine turtle receptors. The potential cumulative effects presented and assessed in this section were based on the PDE provided in volume 1, chapter 3, as well as the information available on other plans, projects, and activities. Effects of adverse significance are not expected to arise should another a different development scenario to that assessed here be taken forward to the final design scheme.

Table 7.93: List Of Other Plans, Projects, And Activities Considered Within The CEA For Marine Mammals And Marine Turtle

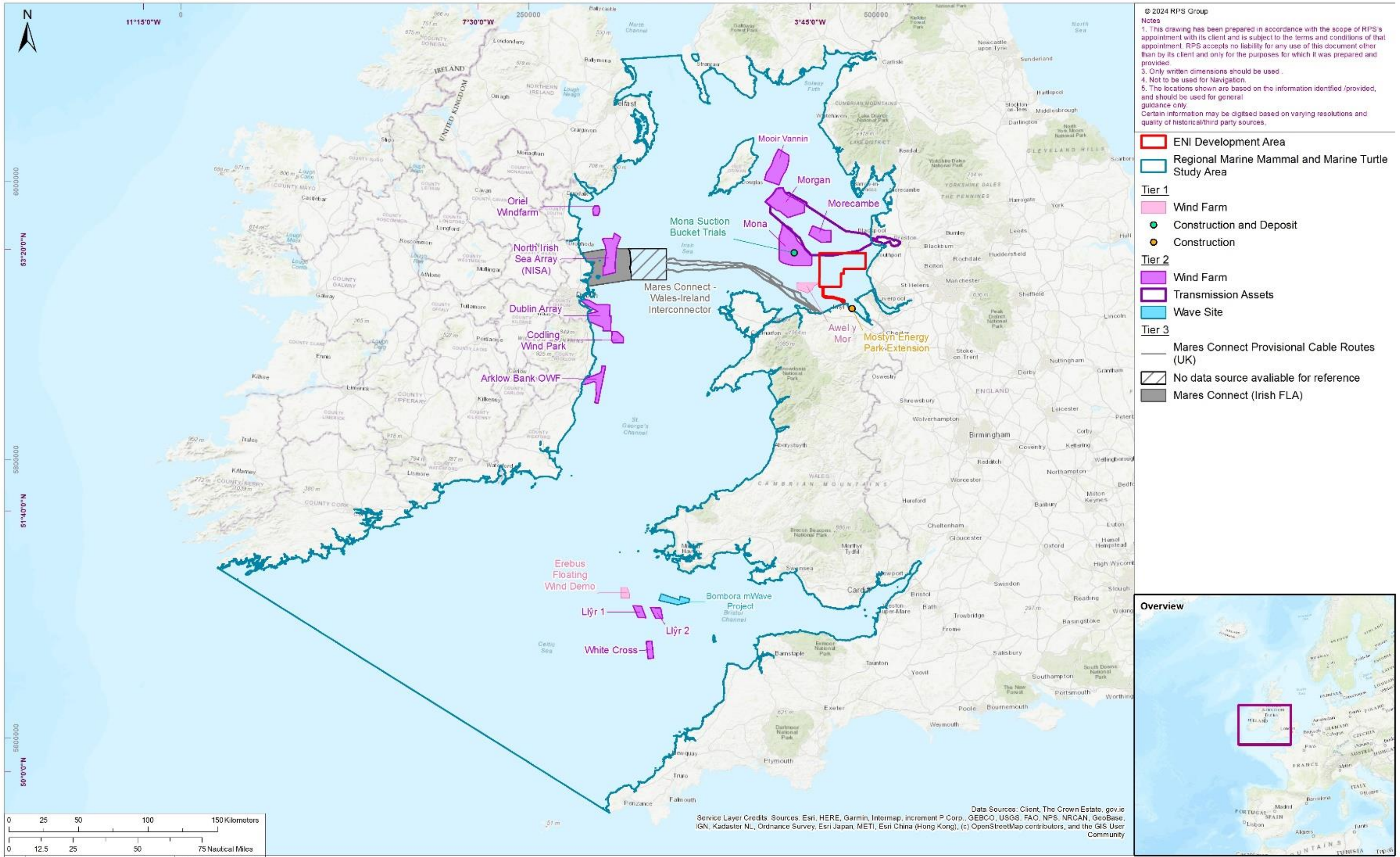
Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation Period (if applicable)	Overlap with the Proposed Development
Tier 1						
Offshore Renewables						
Awel y Môr OWF	Application submitted	1.10	Proposed renewable energy project, 10.50 km off the coast of North Wales, of up to 1.1 GW.	2026 – 2030	2030 – 2055	This project will overlap with all three phases of the Proposed Development.
Project Erebus	Application submitted	252.25	Floating energy demonstration projects.	2025	2026 - 2051	This project overlaps with the construction and operations and maintenance phases of the Proposed Development.
Construction						
Mostyn Energy Park Extension (MEPE) Project	Application submitted	4.00	Extension of quay wall at the Port of Mostyn.	Q2 2023 – Q1 2025	2025 - unknown	This project overlaps with the construction and operations and maintenance phases of the Proposed Development.
Construction and deposit						
Mona OWF Suction Bucket foundation trials	Application submitted	8.80	Trialling of suction bucket foundations to validate their viability within the Mona OWF array area.	July 2023 – July 2024	July 2023 – July 2024	This project overlaps with the construction and operations and maintenance phases of the Proposed Development.
Tier 2						

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation Period (if applicable)	Overlap with the Proposed Development
Offshore Renewables						
Mona OWF	Pre-application	5.53	Proposed renewable energy project, 28.20 km off the coast of North Wales, of up to 350 MW.	2026 - 2028	2029 - 2089	This project will overlap with all three phases of the Proposed Development.
Morgan OWF Generation Assets	Pre-application	7.53	The generation assets for the Morgan OWF, which has a capacity of 1.5 GW.	2026 - 2028	2029 - 2089	This project will overlap with all three phases of the Proposed Development.
Morecambe OWF Generation Assets	Pre-application	30.00	The generation assets for the Morgan OWF, which has a capacity of 480 MW.	2026 - 2028	2029 - 2089	This project will overlap with all three phases of the Proposed Development.
Mooir Vannin OWF	Planning	63.00	OWF located approximately 11 km east of the Manx coast, with up to 100 turbines and a capacity of 80-100 MW.	2030 – 2032	2032 - 2067	This project will overlap with all three phases of the Proposed Development.
North Irish Sea Array (NISA) OWF	Pre-application	143.68	OWF located approximately 12.5 km off the coast of Dublin, with between 34 turbines and 46 turbines.	2024 – 2026	2027 - 2059	This project will overlap with all three phases of the Proposed Development.

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation Period (if applicable)	Overlap with the Proposed Development
Codling Offshore Wind Park	Pre-application	145.46	OWF in the Irish Sea with a maximum capacity of 1.45 GW.	2025 – 2027	2028 - 2063	This project will overlap with all three phases of the Proposed Development.
Dublin Array OWF	Pre-application	151.88	OWF located approximately 10 km off the coast of Dublin and Wicklow counties, with a maximum capacity of 900 MW.	2025 – 2026	2027 - 2062	This project will overlap with all three phases of the Proposed Development.
Oriel OWF	Pre-application	161.42	OWF in the Irish Sea with a maximum capacity of 375 MW.	2025 – 2026	2026 – unknown	This project will overlap with the construction and operations and maintenance phase of the Proposed Development. It may also overlap with the decommissioning phase, but the lifespan of this project is currently not available.
Arklow Bank Wind Park Phase 2	Pre-application	164.25	OWF located approximately 15 km off the coast of Arklow, with a maximum capacity of 800 MW.	Unknown	2028 – unknown	This project will overlap with the operations and maintenance phase of the Proposed Development. It may also overlap with the construction and decommissioning phases, but these

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation Period (if applicable)	Overlap with the Proposed Development
						dates are not currently available.
Llŷr 2 Floating OWF	Pre-application	252.38	Floating offshore wind demonstration project of up to 100 MW.	2024 – 2025	2026 – 2051	This project will overlap with all three phases of the Proposed Development.
Llŷr 1 Floating OWF	Pre-application	258.08	Floating offshore wind demonstration project of up to 100 MW.	2024 – 2025	2026 – 2051	This project will overlap with all three phases of the Proposed Development.
White Cross OWF	Pre-application	276.39	Floating OWF with a capacity of up to 100MW	2025 – 2026	2026 – unknown	This project will overlap with the construction and operations and maintenance phase of the Proposed Development. It may also overlap with the decommissioning phase, but the lifespan of this project is currently not available.
Construction and Deposit						
Bombora WavePower mWave Pembrokeshire Project	Consented (EIA not publicly available)	218.42	Wave energy demonstration site off the coast of south Pembrokeshire with a capacity of 1.5 MW	2024 (installation)	2024-2025	This project will operate for 6-12 months, after which it will be removed from the seabed. This will overlap with the construction phase of the Proposed Development.
Cables and Pipelines						

Project/Plan/Activity	Status	Distance from Proposed Development (km)	Description	Construction Period (if applicable)	Operation Period (if applicable)	Overlap with the Proposed Development
Morgan and Morecambe OWF Transmission Assets	Pre-application	3.00	The transmission assets for the Morgan and Morecambe OWF	2028 - 2029	2030 - 2065	This project will overlap with the operations and maintenance and decommissioning phases of the Proposed Development.
Tier 3						
Cables and Pipelines						
MaresConnect – Wales – Ireland Interconnector Cable	Planning application not yet submitted	10.00	A proposed 750 MW subsea and underground electricity interconnector system, linking the electricity grids in the UK and Ireland.	2025	2027 - 2037	This project will overlap with the construction and operations and maintenance phases of the Proposed Development.



Rev	Description	By	CB	Date
02	REVISION	MJ	AR	07/02/24
00	INITIAL ISSUE	MJ	BPo	17/07/23

Figure Number: EHE7228B-MAM-009 | Rev: 02 | Page: 1 of 1

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Client: ENI
Project: CCS Hynet
Title: Marine Mammal and Marine Turtle CEA

Status: REVISION | Drawn By: MJ | PM/Checked By: AR
Project Number: EHE7228B | Scale @ A3: 1:2,500,000 | Date Created: 07/02/24

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Figure 7.14: Plans, Projects, And Activities Screened Into The CEA For Marine Mammals and Marine Turtles

Table 7.94: MDS Considered For The Assessment Of Potential Cumulative Effects On Marine Mammals And Marine Turtles

Potential Cumulative Effect	Phase	MDS	Justification
Injury, Disturbance, and Displacement from Underwater Noise Generated during Piling	C	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF; and • Project Erebus. Construction Projects: • Mostyn Energy Park Extension. **Tier 2:** Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; • Morecambe OWF Generation Assets; • Arklow Bank Wind Park Phase 2; • Dublin Array OWF; • NISA OWF; • Oriel OWF; • Codling Offshore Wind Park; • Llŷr 1 Floating OWF; • Llŷr 2 Floating OWF; and • White Cross OWF.	The ZoI for piling can extend over kilometres, therefore by adopting a precautionary approach, projects within the marine mammal and marine turtle CEA study area with construction phases that overlap temporally with the construction phase for the Proposed Development were included. Specifically, piling for the Proposed Development is anticipated for April 2026. Therefore, projects whose construction phase finishes in 2025 were screened in as the sequential piling could lead to a longer duration of impact.
Injury, Disturbance, and Displacement from Underwater Noise Generated during UXO Clearance	C	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF; and • Project Erebus.	The ZoI for UXO clearance can extend beyond the boundaries of a project. Therefore, projects within the marine mammal and marine turtle CEA study area whose construction phases overlap temporally with the construction phase of the Proposed Development were included. The construction phases of these projects would include pre-construction UXO clearance.

Potential Cumulative Effect	Phase	MDS	Justification
		Tier 2: Offshore Renewables: • Mona OWF; • Morgan OWF Generation Assets; • Morecambe OWF Generation Assets; • Arklow Bank Wind Park Phase 2; • Dublin Array OWF; • NISA OWF; • Oriel OWF; • Codling Offshore Wind Park; • Llŷr 1 Floating OWF; • Llŷr 2 Floating OWF; and • White Cross OWF.	
Injury, Disturbance, and Displacement from Underwater Noise Generated during Geophysical and Seismic Site Investigation Surveys	C	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; and • Morgan OWF Generation Assets.	It is anticipated that the magnitude of the impacts will be of a similar scale to that described for the Proposed Development (maximum disturbance value of 13 km for VSP; Table 7.77). Therefore, the screening exercise has screened in projects within 13 km from the Proposed Development whose construction phases (which would include pre-construction site investigation surveys) and operation and maintenance phases overlap temporally with those of the Proposed Development.
	O	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables:	

Potential Cumulative Effect	Phase	MDS	Justification
		• Mona OWF; • Morgan OWF Generation Assets; and • Mooir Vannin OWF. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	
Injury, Disturbance, and Displacement from Vessel Activity and other Noise Producing Activities	C	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. Construction and deposit: • Mona OWF Suction Bucket Trials **Tier 2:** Offshore Renewables: • Mona OWF; and • Morgan OWF Generation Assets. **Tier 3:** Cables and Pipelines: MaresConnect Wales – Ireland Interconnector Cable.	It is expected that projects contribute to increased vessel traffic and hence to the amount of noise produced in the environment during the construction, operations and maintenance, and decommissioning phases. However, given the large scale of the marine mammal and marine turtle CEA study area (Figure 7.14), only projects within the maximum disturbance range modelled for the Proposed Development have been included. As per Table 7.79, the maximum disturbance range of vessel activity and other noise producing activities was modelled at 20 km for survey vessels. Therefore, the screening exercise has screened in projects within 20 km from the Proposed Development.
	O	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; and • Morgan OWF Generation Assets.	

Potential Cumulative Effect	Phase	MDS	Justification
		Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: MaresConnect Wales – Ireland Interconnector Cable.	
	D	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; and • Morgan OWF Generation Assets. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets.	
Injury due to Collision with Marine Vessels	C	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. Construction and deposit: • Mona OWF Suction Bucket Trials **Tier 2:** Offshore Renewables: • Mona OWF; and • Morgan OWF Generation Assets.	It is expected that projects contribute to increased vessel collision risk during the construction, operations and maintenance, and decommissioning phases. However, given the large scale of the marine mammal and marine turtle CEA study area (Figure 7.14), only projects within Liverpool Bay have been included. This is because vessel use associated with projects at the extremities of the marine mammal and marine turtle CEA study area, such as those along the coast of Ireland or South West England, would not contribute to increased vessel activity in combination with that of the Proposed Development.

Potential Cumulative Effect	Phase	MDS	Justification
		Tier 3: Cables and Pipelines: MaresConnect Wales – Ireland Interconnector Cable.	
	O	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; and • Morgan OWF Generation Assets. Cables and Pipelines: • Morgan and Morecambe OWF Transmission Assets. **Tier 3:** Cables and Pipelines: • MaresConnect Wales – Ireland Interconnector Cable.	
	D	The MDS is as described for the Proposed Development (Table 7.23) and assessed cumulatively with the following plans, projects, and activities: **Tier 1:** Offshore Renewables: • Awel y Môr OWF. **Tier 2:** Offshore Renewables: • Mona OWF; and • Morgan OWF Generation Assets. Cables and Pipelines: Morgan and Morecambe OWF Transmission Assets.	

7.13.16 Injury, Disturbance, and Displacement from Underwater Noise Generated during Piling

There is the potential for cumulative increased underwater noise as a result of piling activities associated with the construction phases of the Proposed Development and other plans, projects, and activities. For the purposes of this ES, this additive impact has been assessed within the marine mammal and marine turtle CEA study area, using the tiered approach outlined above in section 7.13.1.

As for the assessment of the Proposed Development alone (section 7.12.14), the risk of injury in terms of PTS to most of the marine mammal and marine turtles due to piling is expected to be localised within close vicinity of the respective projects. It is also anticipated that standard mitigation and monitoring methods (which include soft starts and visual and acoustic monitoring as standard) will be applied during construction, thereby reducing the magnitude of impact. Therefore, there is very low potential for significant cumulative impacts for injury from increased underwater noise during pilling, and the CEA focuses on disturbance only.

As outlined in section 7.13.1, the construction phase of the Proposed Development is anticipated to start in 2024, to enable operation to commence during 2026/2027. Piling is currently anticipated to take place over 29 days in April to May 2026, although the total piling duration, based upon 100 minutes piling for each of eight pin piles, is less than 13.5 hours in total. Therefore, as a precaution, plans, projects, and activities with a construction phase commencing in 2026 are included in the CEA for this impact, although it should be noted that cumulative effects will be of a lesser extent due to the reduced temporal overlap.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.94.

7.13.16.1 Tier 1

Construction Phase

Magnitude of Impact

There is potential for cumulative impacts with one Tier 1 project in the construction phase: Project Erebus.

The piling phase of the Proposed Development (April/May 2026) overlaps with the construction phase of another Tier 1 project, Awel y Môr OWF. However, the MDS in the ES for Awel y Môr OWF assumes that there will be up to 201 days of piling over 12 months in 2028, within the project's four-year construction phase (RWE Renewables UK, 2022). Given the almost two-year gap in between piling activities at Awel y Môr OWF and the Proposed Development, the Awel y Môr OWF is not included in this Tier 1 assessment.

Similarly, the piling phase of the Tier 1 Mostyn Energy Park Extension (Q3 2023 to Q2 2024) is expected to overlap temporally with the construction phase of the Proposed Development. However, construction for Mostyn Energy Park Extension is expected to have been completed in Q1 2025, before the piling phase for the Proposed Development has commenced. Given the almost two-year gap between piling at Mostyn Energy Park Extension and piling at the Proposed Development, Mostyn Energy Park Extension has not been included in this Tier 1 assessment.

Project Erebus is anticipated to be constructed in 2025 only (Table 7.93), therefore piling should not overlap with that of the Proposed Development. However, as the construction phase finishes in 2025, Project Erebus was screened into the assessment as the sequential piling of the Proposed Development in 2026 could lead to a longer duration of impact.

Effects on harbour seal and marine turtles were not considered in the ES for Project Erebus. Given, that the CEA for piling is provided on species-by-species basis, harbour seal and marine turtles will not be considered further for the Tier 1 assessment. There were also very few data on Risso's dolphin in the Project Erebus area, and no density estimate was available (Blue Gem Wind, 2020). Therefore, this species was not included in the

Tier 1 assessment, although the spatial scale of the effects was expected to be similar to that of bottlenose dolphin (Blue Gem Wind, 2020).

Where cumulative numbers of animals potentially disturbed are presented for each species below, the calculations take into account the timelines of respective projects. Given that the construction phase of Project Erebus is anticipated to be completed prior to the commencement of piling at the Proposed Development, animals are likely to recover from the disturbance between piling events and therefore the numbers of animals potentially disturbed at respective projects are not added together.

Harbour Porpoise

Project Erebus is a demonstration scale floating OWF, composed of six to ten wind turbines and a range of foundation options, including pile driven anchors. The construction is planned to take place in 2025 with only 18 days over which piling may occur (Blue Gem Wind, 2020). occur. The number of harbour porpoise predicted to be disturbed was based on densities from site-specific surveys at Project Erebus (Blue Gem Wind, 2020; Table 7.95). It should be noted that Project Erebus is located in close proximity to the Bristol Channel Approaches/Dynesfeydd Môr Hafren SAC designated for protection of harbour porpoise. As the piling at Project Erebus is anticipated to be completed in 2025, it will contribute, temporally, to a slightly longer duration of piling within the marine mammal and marine turtle CEA study area.

Cumulatively, the piling at Project Erebus in 2025 would disturb 1,967 harbour porpoise, followed by that of the Proposed Development in 2026 which, based upon estimates derived by application of the recommended dose-response approach (NRW, 2023) would disturb up to 158 animals (Table 7.95).

Table 7.95: Number Of Harbour Porpoise Predicted To Be Disturbed As A Result Of Piling For Tier 1 Projects

Project	Maximum Number of Piles	Piling Duration	Piling Phase	Density (Animals per km^2)	Maximum Number of Animals Disturbed	Percentage of Reference Population (%)	Source
Proposed Development	8	29 days	<1 month	0.086 0.515	158 945	0.25% (Celtic and Irish Seas MU) 1.51% (Celtic and Irish Seas MU)	Section 7.12.14
Project Erebus	35	18 days	8 months	0.04	1,967	3.15% (Celtic and Irish Seas MU)	Blue Gem Wind, 2020

As harbour porpoise can travel over large distances and there is a potential for overlap of disturbance noise contours with SACs designated for this species (see Table 7.19), the cumulative effects on the designated features and conservation objectives of sites designated for harbour porpoise will be considered in RIAA.

Overall, the impact is predicted to be of regional spatial extent, short-term duration (up to 18 and 29 days of piling for both Project Erebus and the Proposed Development) and intermittent (only occurs during piling activities). Furthermore, the effect of behavioural disturbance is reversible, as animals can return to baseline levels within hours/days after piling activities have ceased. It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however this is not likely to have large-scale population effects, given the short-term cumulative duration of piling. The magnitude is therefore considered to be low.

Dolphin Species

Data collected by Lohrengel *et al.* (2018) was used to assess bottlenose dolphin disturbance for Project Erebus. Up to 310 bottlenose dolphin (2.8% of the Offshore Channel and Southwest England MU) were predicted to potentially experience disturbance (Blue Gem Wind, 2020; Table 7.96). This short-term and temporary behavioural effects (up to 18 days of piling) were considered unlikely to alter the population trajectory of bottlenose dolphin (Blue Gem Wind, 2020).

For common dolphin, Project Erebus assessed the number of animals potentially disturbed using densities from site-specific surveys and SCANS-III block D (Blue Gem Wind, 2020). Whilst up to 2,067 animals (2.01% of the population) may be behaviourally disturbed, this was not anticipated to lead to changes in the population trajectory due to the short-term nature of the impact (Table 7.96).

Cumulatively, piling at Project Erebus in 2025 would potentially affect up to 310 bottlenose dolphin, and 2,067 common dolphin. Followed by subsequent piling at the Proposed Development in 2026, up to 65 bottlenose dolphin and 33 common dolphin could potentially experience disturbance (Table 7.96). However, this is likely to be an overestimate as highly precautionary densities were used for the respective assessments.

As described above for harbour porpoise, the piling at Project Erebus is anticipated to be completed in 2025, and will contribute, temporally, to a slightly longer duration of piling within the marine mammal and marine turtle CEA study area.

Table 7.96: Number Of Dolphin Species Predicted To Be Disturbed As A Result Of Piling For Tier 1 Projects

Project	Maximum Number of Piles	Piling Duration	Piling Phase	Density (Animals per km^2)	Maximum Number of Animals Disturbed	Percentage of Reference Population	Source
Bottlenose dolphin							
Proposed Development	8	29	<1 month	0.010 0.035	20 65	6.51% (Irish Sea MU) 21.91% (Irish Sea MU)	Section 7.12.14
Project Erebus	35	18 days	8 months	0.063 (array area) 0.3743 (wider area)	310	2.8% (Offshore Channel and Southwest England MU)	Blue Gem Wind, 2020
Common Dolphin							
Proposed Development	8	29	<1 month	0.027	50	0.05% (Celtic and Greater North Seas MU)	Section 7.12.14
Project Erebus	35	18 days	8 months	1.61 (array are) 0.3743 (wider area)	2,067	2.01% (Celtic and Greater North Seas MU)	Blue Gem Wind, 2020

Cardigan Bay, and the Cardigan Bay/Bae Ceredigion SAC in particular, constitute important habitats for bottlenose dolphin, with large numbers of animals present in the summer (Table 7.19). As bottlenose dolphin can travel over large distances, there is a possibility that a small number of individuals from SAC populations may be occasionally present within the disturbance noise contours. As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in RIAA.

Overall, the impact is predicted to be of regional spatial extent, short-term duration (up to 18 and 29 days of piling for both Project Erebus and the Proposed Development) and intermittent (only occurs during piling activities). Furthermore, the effect of behavioural disturbance is reversible, as animals can return to baseline levels within hours/days after piling activities have ceased. It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however this is not likely to have large-scale population effects, given the short-term cumulative duration of piling. The magnitude is therefore considered to be low.

Minke Whale

Project Erebus assessed the number of minke whale predicted to be affected by disturbance during piling using densities from SCANS III block D (Blue Gem Wind, 2020; Hammond *et al.,* 2021). As described above for harbour porpoise, the piling at Project Erebus is anticipated to be completed in 2025, and will contribute, temporally, to a slightly longer duration of piling within the marine mammal and marine turtle CEA study area.

Cumulatively, for piling at Project Erebus in 2025, up to 55 minke whale (0.3% of the Celtic and Irish Seas MU) was assessed as having the potential to experience disturbance (Blue Gem Wind, 2020). Subsequently, piling at the Proposed Development in 2026 has been predicted to affect up to 32 minke whale (0.16% of the Celtic and Irish Seas MU population (Table 7.97).

Table 7.97: Number Of Minke Whale Predicted To Be Disturbed As A Result Of Piling For Tier 1 Projects

Project	Maximum Number of Piles	Piling Duration	Piling Phase	Density (Animals per km^2)	Maximum Number of Animals Disturbed	Percentage of Reference Population (%)	Source
Proposed Development	8	29 days	<1 month	0.009	17	0.08% (Celtic Greater North Seas MU)	Section 7.12.14
Project Erebus	35	18 days	8 months	0.0112	55	0.3% (Celtic Greater North Seas MU)	Blue Gem Wind, 2020

Overall, the impact is predicted to be of regional spatial extent, short-term duration (up to 18 and 29 days of piling for both Project Erebus and the Proposed Development) and intermittent (only occurs during piling activities). Furthermore, the effect of behavioural disturbance is reversible, as animals can return to baseline levels within hours/days after piling activities have ceased. It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however this is not likely to have large-scale population effects, given the short-term cumulative duration of piling. The magnitude is therefore considered to be low.

Grey Seal

Project Erebus used specific gridded density estimates from Carter *et al.* (2020) to assess the number of grey seal predicted to be affected by disturbance. The Wales and Southwest England MUs populations of 6,090 individuals were taken forward as the reference population to inform the assessment (Blue Gem Wind, 2020). As described above for harbour porpoise, the piling at Project Erebus is anticipated to be completed in 2025, and will contribute, temporally, to a slightly longer duration of piling within the marine mammal and marine turtle CEA study area. It should be noted that Project Erebus is located in close proximity to the Pembrokeshire Marine/Sir Benfro Forol SAC and Lundy SAC, which are designated for protection of grey seal (Table 7.19). As such the cumulative effects on the designated features and conservation objectives of designated sites will be considered in RIAA.

Cumulatively, for piling at Project Erebus in 2025, up to 18 grey seal (0.3% of the relevant MUs) was assessed as having the potential to experience disturbance (Blue Gem Wind, 2020). Subsequently, piling at the Proposed Development in 2026 has been predicted to affect up to 125 grey seal (0.92% of various seal MUs populations) (Table 7.97).

Table 7.98: Number Of Grey Seal Predicted To Be Disturbed As A Result Of Piling For Tier 1 Projects

Project	Maximum Number of Piles	Piling Duration	Piling Phase	Maximum Number of Animals Disturbed	Density (Animals per km²)	Percentage of Reference Population (%)	Source
Proposed Development	8	29 days	<1 month	125	0.467	0.92% (various seal MUs, see Table 7.17) 0.21% (OSPAR Region III)	Section 7.12.14
Project Erebus	35	18 days	8 months	18	Not available as grid cell specific	0.3% (Wales and SW England MUs)	Blue Gem Wind, 2020

Overall, the impact is predicted to be of regional spatial extent, short-term duration (up to 18 and 29 days of piling for both Project Erebus and the Proposed Development) and intermittent (only occurs during piling activities). The piling works for the Proposed Development are expected to be undertaken over a number of days, with the total active piling duration expected to be less than 13.5 hours (within the 29 days), therefore any overlap is expected to be minor. Furthermore, the effect of behavioural disturbance is reversible, as animals can return to baseline levels within hours/days after piling activities have ceased. It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas), however this is not likely to have large-scale population effects, given the short-term cumulative duration of piling. The magnitude is therefore considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.14).

Harbour porpoise and grey seal are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability, and international value. Therefore, the sensitivity of harbour porpoise to behavioural disturbance is considered to be medium.

Overall, bottlenose dolphin, common dolphin, and minke whale are deemed to have some tolerance to behavioural disturbance, low vulnerability, high recoverability and international value. Therefore, the sensitivity of these receptors to behavioural disturbance is considered to be medium.

Significance of Effect

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.16.2 Tier 2

Construction Phase

Magnitude of Impact

There is potential for cumulative impacts with eleven Tier 2 projects in the construction phase:

- Mona OWF;
- Morgan OWF Generation Assets;
- Morecambe OWF Generation Assets;
- Mooir Vannin OWF;
- Arklow Bank Wind Park Phase 2;
- Dublin Array OWF;
- NISA OWF;
- Oriel OWF;
- Codling Offshore Wind Park;
- Llŷr 1 Floating OWF;
- Llŷr 2 Floating OWF; and
- White Cross OWF.

The construction dates are unknown for Arklow Bank Wind Phase 2; however, it has been conservatively screened into the assessment in the event that a temporal overlap occurs.

For the majority of these Tier 2 projects, only a Scoping Report is available, which does not include detailed information about behavioural disturbance due to piling. However, injury and disturbance due to piling was scoped in for these projects within their respective Scoping Reports (Oriel Wind Farm Ltd., 2019; Codling Wind Park Limited, 2020; Dublin Array, 2020; SSE Renewables, 2020; Arup, 2021; Floventis Energy, 2022; White Cross, 2022; Orsted, 2023). However, PEIRs are available for the Mona OWF, Morgan OWF Generation Assets, and Morecambe OWF Generation Assets, which have been used in this assessment to provide more detailed information on this impact (EnBW and BP, 2023a, 2023e; Morecambe Offshore Wind Limited, 2023). Marine turtles have not been included in any of the three PEIRs, so are not included further in this Tier 2 assessment. The assessment on behavioural disturbance for Morecambe OWF Generation Assets only included harbour porpoise, grey seal, and harbour seal.

Temporally, the construction phases for 11 of the 12 Tier 2 projects are anticipated to occur between 2024 and 2028 (Table 7.93), although refined piling programmes are not currently available for any of the projects considered (the construction phase of Mooir Vannin OWF is expected to commence in 2030, after construction of the Proposed Development is complete). This timescale constitutes a total of four years where piling activities will occur across the marine mammal and marine turtle CEA study area. Piling will occur intermittently over the construction phase of respective projects. Therefore, although this will not result in a continuous risk of disturbance to marine mammals, it may affect multiple breeding seasons. In the context of these species' life cycles, the duration of the impact is classified as medium term, as the exposure to elevated sound levels could occur over a meaningful proportion of their lifespan.

Additionally in spatial terms, animals may be displaced from an area comparable to disturbance noise contours modelled for the Proposed Development alone (Figure 7.11). However, should concurrent piling occur with another project, considerable levels of underwater noise are likely which may potentially result in a larger area of strong disturbance.

Harbour Porpoise

Piling at the Proposed Development is predicted to potentially disturb up to 158 harbour porpoise, based upon application of the dose-response approach, in line with current guidance (NRW, 2023). Subsequently, piling Mona OWF, Morgan OWF Generation Assets, and Morecambe OWF Generation Assets could affect 587, 1,370, and 1,279 harbour porpoise, respectively (Table 7.99). Given that the construction phase for these three projects is anticipated to be between 2026 to 2028, there is potential for temporal overlap in piling activity with that of the Proposed Development (April/May 2026). The piling works for the Proposed Development are expected to be undertaken over a number of days, with the total active piling duration expected to be less than 13.5 hours, therefore any overlap is expected to be minor.

Table 7.99: Number Of Harbour Porpoise Predicted To Be Disturbed As A Result Of Piling For Tier 2 Projects

Project	Density (Animals per km^2)	Maximum Number of Animals Disturbed	Percentage of Reference Population (Celtic and Irish Seas MU)	Source
Proposed Development	0.086 0.515	158 945	0.25% 1.51%	Section 7.12.14
Mona OWF	0.097	587	0.94%	EnBW and BP (2023a)
Morgan OWF Generation Assets	0.247	1,370	2.19%	EnBW and BP (2023e)
Morecambe OWF Generation Assets	0.371	1,279	2.05%	Morecambe Offshore Wind Limited (2023)

Dolphin Species

Piling at the Proposed Development is predicted to potentially disturb up to 65 bottlenose dolphin. Subsequently, piling Mona OWF and Morgan OWF Generation Assets could affect 17 and 16 individuals, respectively (Table 7.100). For common dolphin, the Proposed Development is predicted to potentially disturb up to 33 animals. Subsequently, piling Mona OWF and Morgan OWF Generation Assets could affect 109 and 100 individuals, respectively). For Risso's dolphin, the Proposed Development is predicted to potentially disturb up to 58 animals. Subsequently, piling Mona OWF and Morgan OWF Generation Assets could affect 105 and 96 individuals, respectively.

Given that the construction phase for these three projects is anticipated to be between 2026 to 2028, there is potential for temporal overlap in piling activity with that of the Proposed Development (April/May 2026). The piling works for the Proposed Development are expected to be undertaken over a number of days, with the total active piling duration expected to be less than 13.5 hours, therefore any overlap is expected to be minor.

Table 7.100: Number Of Dolphin Species Predicted To Be Disturbed As A Result Of Piling For Tier 2 Projects

Project	Density (Animals per km^2)	Maximum Number of Animals Disturbed	Percentage of Reference Population	Source
Bottlenose Dolphin				
Proposed Development	0.010 0.035	20 65	6.51% (Irish Sea MU) 21.91% (Irish Sea MU)	Section 7.12.14
Mona OWF	0.035	17	5.69% (Irish Sea MU)	EnBW and BP (2023a)
Morgan OWF Generation Assets	0.035	16	5.28% (Irish Sea MU)	EnBW and BP (2023e)
Common Dolphin				
Proposed Development	0.027	50	0.05% (Celtic and Greater North Seas MU)	Section 7.12.14
Mona OWF	0.018	109	0.11% (Celtic and Greater North Seas MU)	EnBW and BP (2023a)
Morgan OWF Generation Assets	0.018	100	0.10% (Celtic and Greater North Seas MU)	EnBW and BP (2023e)
Risso's Dolphin				
Proposed Development	0.0313	58	0.47% (Celtic and Greater North Seas MU)	Section 7.12.14
Mona OWF Generation Assets	0.0313	189	1.54% (Celtic and Greater North Seas MU)	EnBW and BP (2023a)
Morgan OWF Generation Assets	0.0313	174	1.42% Celtic and Greater North Seas MU)	EnBW and BP (2023e)

Minke Whale

Piling at the Proposed Development is predicted to potentially disturb up to 17 minke whale. Subsequently, piling Mona OWF and Morgan OWF Generation Assets could affect 105 and 96 individuals, respectively (Table 7.101). Given that the construction phase for these three projects is anticipated to be between 2026 to 2028, there is potential for temporal overlap in piling activity with that of the Proposed Development (April/May 2026). The piling works for the Proposed Development are expected to be undertaken over a number of days, with the total active piling duration expected to be less than 13.5 hours, therefore any overlap is expected to be minor.

Table 7.101: Number Of Minke Whale Predicted To Be Disturbed As A Result Of Piling For Tier 2 Projects

Project	Density (Animals per km²)	Maximum Number of Animals Disturbed	Percentage of Reference Population (Celtic and Greater North Seas MU)	Source
Proposed Development	0.009	17	0.08%	Section 7.12.14
Mona OWF	0.0173	105	0.52%	EnBW and BP (2023a)
Morgan OWF Generation Assets	0.0173	96	0.48%	EnBW and BP (2023e)

Grey Seal and Harbour Seal

For grey seal, piling at the Proposed Development is predicted to potentially disturb up to 125 animals. Subsequently, piling Mona OWF, Morgan OWF Generation Assets, and Morecambe OWF Generation Assets could affect 92, 48, and up to one animal, respectively (Table 7.101). For harbour seal, piling at the Proposed Development is predicted to potentially disturb up to 2 animals. Subsequently, piling Mona OWF, Morgan OWF Generation Assets, and Morecambe OWF Generation Assets could each affect up to one animal (Table 7.101).

Given that the construction phase for these three projects is anticipated to be between 2026 to 2028, there is potential for temporal overlap in piling activity with that of the Proposed Development (April/May 2026). The piling works for the Proposed Development are expected to be undertaken over a number of days, with the total active piling duration expected to be less than 13.5 hours, therefore any overlap is expected to be minor.

Table 7.102: Number Of Grey And Harbour Seal Predicted To Be Disturbed As A Result Of Piling For Tier 2 Projects

Project	Density (Animals per km²)	Maximum Number of Animals Disturbed	Percentage of Reference Population	Source
Grey Seal				
Proposed Development	0.467	125	0.92% (various seal MUs, see Table 7.17) 0.21% (OSPAR Region III)	Section 7.12.14
Mona OWF	Not available as grid cell specific	92	0.68% (various seal MUs combined) 0.15% (OSPAR Region III)	EnBW and BP (2023a)
Morgan OWF Generation Assets	Not available as grid cell specific	48	0.53% (various seal MUs combined) 0.08% (OSPAR Region III)	EnBW and BP (2023e)
Morecambe OWF Generation Assets	Not available as grid cell specific	<1	0.069% (various seal MUs combined) 0.0069% (OSPAR Region III)	Morecambe Offshore Wind Limited (2023)
Harbour Seal				

Project	Density (Animals per km^2)	Maximum Number of Animals Disturbed	Percentage of Reference Population	Source
Proposed Development	0.0049	2	0.09% (various seal MUs combined)	Section 7.12.14
Mona OWF	Not available as grid cell specific	<1	0.02% (various seal MUs combined)	EnBW and BP (2023a)
Morgan OWF Generation Assets	Not available as grid cell specific	<1	0.009% (various seal MUs combined)	EnBW and BP (2023e)
Morecambe OWF Generation Assets	Not available as grid cell specific	<1	0.00021% (various seal MUs combined)	Morecambe Offshore Wind Limited (2023)

In the context of the wider habitat available within the marine mammal and marine turtle CEA study area, it is not anticipated that it will result in long-term population-level effects on any of the species.

As above for the Tier 1 assessment, the cumulative effects on the designated features and conservation objectives of designated sites relevant to the marine mammal IEFs will be included in the RIAA.

Overall, the impact is predicted to be of regional spatial extent, medium term duration, intermittent, and high reversibility (as the impact itself occurs only during piling and animals can return to baseline levels within hours/days after piling has ceased). It is predicted that the impact will affect the receptor directly. The impact could result in some measurable changes to individuals that are disturbed (i.e. interruption of feeding or breeding and/or displacement to alternative areas). There are no long-term population-level consequences of disturbance anticipated for any species, and the magnitude is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.14).

Harbour porpoise and grey seal are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability, and international value. Therefore, the sensitivity of harbour porpoise to behavioural disturbance is considered to be medium.

Overall, bottlenose dolphin, common dolphin, and minke whale are deemed to have some tolerance to behavioural disturbance, low vulnerability, high recoverability and international value. Therefore, the sensitivity of these receptors to behavioural disturbance is considered to be medium.

Significance of Effect

<u>All Species</u>

For all species, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Cumulative impacts are unlikely to affect the international value of these species in the context of their respective reference populations. The cumulative effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.16.3 Tier 3 and 4

There were no Tier 3 or 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative impacts regarding underwater noise during piling.

7.13.17 Injury, Disturbance, and Displacement from Underwater Noise Generated during UXO Clearance

There is the potential for cumulative increased underwater noise as a result of UXO clearance activities associated with the construction phases of the Proposed Development and other plans, projects, and activities. For the purposes of this ES, this additive impact has been assessed within the marine mammal and marine turtle CEA study area, using the tiered approach outlined above in section 7.13.1.

As detailed above in section 7.12.15, the duration of increased underwater noise for each UXO detonation is very short (i.e. within seconds), therefore behavioural effects are considered to be negligible in this context. TTS is presented as a metric of temporary auditory injury but also represents a threshold for the onset of a displacement or moving away response in line with recommendations from Southall *et al.* (2007).

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.94.

7.13.17.1 Tier 1

Construction Phase

Magnitude of Impact

<u>All Species</u>

There is potential for cumulative impacts with two Tier 1 projects in the construction phase: Awel y Môr OWF and Project Erebus. Effects on harbour seal or marine turtles were not considered in the ES in both Tier 1 projects and are therefore not considered further in this Tier 1 assessment.

The construction phase of the Proposed Development is expected to overlap temporally with the construction phase of the Mostyn Energy Park Extension (Q3 2023 to Q2 2024), and the operations phase of the Mona OWF Suction Bucket foundation trials (July 2023 to July 2024). However, UXO clearance operations will not be undertaken at Mostyn Energy Park Extension or Mona OWF Suction Bucket foundation trials and as such these projects have not been included in this Tier 1 assessment.

The construction of Project Erebus is anticipated for 2025 only, between 2026 to 2030 for Awel y Môr OWF, and between 2024 and 2026 for the Proposed Development. Therefore, it is unlikely that concurrent UXO detonations across these three projects will take place. This is because UXO clearance activities take place before other construction activities commence, at the beginning of the construction phase (i.e. 2024 for the Proposed Development, 2025 for Project Erebus and 2026 for Awel y Môr OWF). Therefore, a sum of the number of animals with the potential to be injured by UXO clearance would not be suitable for this assessment. However, sequential UXO clearance at the respective projects could lead to a longer duration of impact. UXO clearance at each of these projects will occur as a discrete stage within the overall construction phase and therefore will not coincide continuously over the duration of any temporal overlap. In addition, each clearance event results in a very short duration of sound emission (within seconds) so the impact will be short in duration and therefore the temporal overlap is unlikely.

The MDS for Awel y Môr includes 10 UXOs to be cleared, with two clearance events every 24 hours but up to 10 detonations in 10 days (RWE Renewables UK, 2022). Like the Proposed Development high-order detonation was assessed and modelled, although low-order clearance is more likely. The ES for Awel y Môr followed Southall *et al*. (2007) to assess the impacts from UXO detonation on marine mammals. However, the authors highlighted that empirical evidence from UXO detonations using the TTS metric is lacking, in particular the range-dependent characteristics of the peak sounds and discuss whether current propagation models can accurately predict the range at which these thresholds are reached (RWE Renewables UK, 2022). PTS ranges were modelled for a range of expected UXO sizes (5kg TNT NEQ, 15kg TNT NEQ and 164kg TNT NEQ) (RWE Renewables UK, 2022).

For harbour porpoise, the ES for the Awel y Môr OWF assessed the effects of UXO clearance using two densities (0.13 per km^2 (JCP) and 1.0 per km^2 (Sea Watch Foundation (SWF)). The maximum number of harbour porpoise estimated within the ZoI was considered highly conservative. Although, PTS is not recoverable, the magnitude of this impact was considered negligible adverse in the ES, due to the commitment to implement a UXO-specific MMMP to reduce the risk of PTS to negligible (RWE Renewables UK, 2022). Residual impacts for PTS from UXO were therefore considered unlikely for harbour porpoise, minke whale, grey seal and minor adverse significance for bottlenose dolphin, common dolphin and Risso's dolphin (RWE Renewables UK, 2022).

The Awel y Môr OWF ES presented results for various disturbance thresholds, including 26 km Effective Deterrence Ranges (EDR) for high order detonations, 5 km EDR for low order, and TTS-onset thresholds for high-order detonations. However, the authors suggested that there is no evidence of a 5 km EDR being suitable for any marine mammal species for the low order detonation and should be treated with caution as a result. Therefore, they used TTS-onset as a proxy for behavioural disturbance (as per the assessment for the Proposed Development) but caveated that this is likely to overestimate actual behavioural responses. Large TTS ranges were predicted for harbour porpoise (16 km; SPL_{pk}) and minke whale (65 km; SEL_{cum}) for a UXO of 164 kg (RWE Renewables UK, 2022). The authors concluded that the magnitude of the effects of TTS would be low for all species.

The MDS for Project Erebus anticipated one UXO detonation via low-order deflagration but modelled high-order detonations for completeness, highlighting this is not realistic (Blue Gem Wind, 2020). The ES for Project Erebus used densities from site-specific surveys to assess the number of harbour porpoise affected by injury or disturbance, and densities presented in Lohrengel *et al*. (2018), Hammond *et al*. (2021), Carter *et al.* (2022) for bottlenose dolphin, minke whale, and grey seal, respectively.

For Project Erebus, the number of marine mammals predicted to experience PTS was up to one animal for all species and low-order charge sizes, apart from 2kg NEQ, which could result in PTS in up to five harbour porpoise (Blue Gem Wind, 2020). Like Awel y Môr OWF, Project Erebus also used an EDR of 5 km for low order clearance and 26 km for high-order clearance and used TTS-onset as a proxy for disturbance. The maximum predicted TTS range was 103 km for minke whale (Blue Gem Wind, 2020). Project Erebus also emphasised that TTS-onset as a proxy for disturbance is expected to overestimate the actual biological consequences (Blue Gem Wind, 2020). This is supported by the work of Southall *et al*. (2007), which states that "*This approach is expected to be precautionary because TTS at onset levels is unlikely to last a full diel cycle or to have serious biological consequences during the time TTS persists*". Project Erebus concluded that the impact of behavioural disturbance (assessed using TTS-onset as a proxy) was unlikely to significantly affect marine mammal receptors from either low-order or high-order UXO detonation (Blue Gem Wind, 2020).

The maximum number of animals with the potential to experience PTS during UXO clearance for the highest charge size is presented in Table 7.103. For the majority of species, this value is very low (less than five animals). However, for harbour porpoise and grey seal, the number of animals with the potential to be disturbed is in the low hundreds (i.e. a maximum of 212 harbour porpoise at Project Erebus) (Table 7.103). However, this was modelled using high-order UXO clearance for Project Erebus which is very unlikely to occur in practice (the maximum UXO charge weight expected in the area is 331kg, and the project is seeking consent for one low-order detonation with a maximum of 2kg NEQ). Therefore, with measures applied at cumulative projects (i.e. use of low order clearance only for Project Erebus and MMMPs for Awel y Môr and the Proposed Development) the residual risk of injury is likely to be very small.

Table 7.103: Number Of Animals With The Potential To Experience PTS During UXO Clearance For Tier 1 Projects For The Maximum Charge Size (kg)

Project	Species	Maximum Charge Size (kg)	Maximum PTS Range (m)	Maximum Number of Animals Disturbed	Source
Proposed Development	Harbour porpoise	907	15,370	383	Section 7.12.15
	Bottlenose dolphin, common dolphin, Risso's dolphin		890	<1	
	Minke whale		4,215	<1	
	Grey seal		3,015	115	
Awel y Môr OWF	Harbour porpoise	164	8,600	30	RWE Renewables UK, 2022
	Bottlenose dolphin, common dolphin, Risso's dolphin		500	<1	
	Minke whale		1.500	<1	
	Grey seal		1,600	3	
Project Erebus	Harbour porpoise	525	13,000	212	Blue Gem Wind, 2020
	Bottlenose dolphin		730	<1	
	Common dolphin		730	3	
	Minke whale		2,200	<1	
	Grey seal		2.500	1	

Increased underwater noise during UXO clearance has the potential to cause TTS (moving away response) in marine mammal receptors, however, this effect will be short-term and reversible. Therefore, the potential for cumulative impact is considered to be very limited, even for multiple projects. Although some ecological functions could be temporarily inhibited due to TTS (e.g. cessation of feeding), these are reversible on recovery of the animal's hearing and therefore not considered likely to lead to any long-term effects on the individual. Furthermore, the effect of TTS induced by UXO clearance was assessed as of minor adverse significance for all species in the ESs for both Tier 1 projects (Blue Gem Wind, 2020; RWE Renewables UK, 2022), and for the Proposed Development.

Auditory Injury (PTS)

Overall, cumulative impact is predicted to be of local to regional spatial extent, very short-term duration (within seconds), intermittent (throughout the construction phases of the projects), and, although the impact itself is reversible (i.e. during the detonation event only), the effect of PTS is permanent. It that the impact will affect the receptor directly. Assuming standard industry mitigation will be applied for each project (e.g MMMP, low order clearance), it is anticipated that for most species animals would be deterred from the ZoI and therefore the risk of PTS would be reduced. The magnitude is therefore considered to be negligible (for bottlenose dolphin, common dolphin, Risso's dolphin, minke whale, and grey seal). For harbour porpoise the injury ranges are larger, and there is considered to be a residual risk of PTS to a small number of individuals, therefore the magnitude is considered to be -

Behavioural Disturbance (TTS as a Proxy)

Overall, the cumulative impact is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. during the detonation event) and effect of behavioural disturbance and TTS are reversible. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low for all species.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.15).

Auditory Injury (PTS)

Overall, all marine mammal IEFs are deemed to have limited tolerance to PTS, high vulnerability, low recoverability, and international value. The sensitivity of the receptor is therefore considered to be high.

Behavioural Disturbance (TTS as a Proxy)

Overall, since TTS is reversible, all marine mammal IEFs are assessed as having some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of the receptor is therefore considered to be low.

Significance of Effect

Auditory Injury (PTS)

Overall, for all IEFs except harbour porpoise, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Overall, for harbour porpoise, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this results in a ‘minor or moderate’ significance of effect. However given the low chance of temporal overlap in clearance events or concurrent detonations, based on the low numbers of detonations per day expected during clearance activities the effect is therefore assessed to be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance (TTS as a Proxy)

Overall, for all IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, it has been concluded that the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.17.2 Tier 2

Construction Phase

There is potential for cumulative impacts with 12 Tier 2 projects in the construction phase:

- Mona OWF;
- Morgan OWF Generation Assets;
- Morecambe OWF Generation Assets;
- Mooir Vannin OWF;

- Arklow Bank Wind Park Phase 2;
- Dublin Array OWF;
- NISA OWF;
- Oriel OWF;
- Codling Offshore Wind Park;
- Llŷr 1 Floating OWF;
- Llŷr 2 Floating OWF; and
- White Cross OWF.

The construction dates are unknown for Arklow Bank Wind Phase 2; however, it has been conservatively screened into the assessment in the event that a temporal overlap occurs.

For the majority of the Tier 2 projects, beyond the Scoping Report there was not enough information to conduct a quantitative assessment. Although injury and disturbance due to UXO clearance was scoped in for these projects, their respective Scoping Reports do not provide detailed information about the impact (Oriel Wind Farm Ltd., 2019; Codling Wind Park Limited, 2020; Dublin Array, 2020; SSE Renewables, 2020; Arup, 2021; Floventis Energy, 2022; White Cross, 2022). These projects are likely to have effects similar to the Proposed Development and will likely have similar mitigation (e.g. MMMPs or separate marine licenses) to mitigate harm. However, at this state, a more detailed cumulative assessment cannot be provided for this impact. The indicative programme for construction at Mooir Vannin OWF, including UXO clearance operations, is expected to commence in 2030, after construction (and UXO clearance) at the Proposed Development is complete.

However, PEIRs including PTS ranges for UXO clearance are available for the Mona OWF and Morgan OWF Generation Assets, which have been used in this assessment to provide more detailed information on this impact (EnBW and BP, 2023a, 2023e). Marine turtles have not been included in any either of the PEIRs, so are not included further in this Tier 2 assessment. For both these Tier 2 projects, the construction phases are expected to be from 2026 to 2030 and therefore may have overlap with that of the Proposed Development. Although UXO clearance activities are typically undertaken at the beginning of the construction phase (i.e. in 2024 for the Proposed Development), these timelines are only indicative at this stage and could be subject to change. For a proportionate assessment, these projects are assessed as a precaution.

Both PEIRs assessed PTS and disturbance (TTS/moving away response) resulting during UXO clearance as a potential impact during their construction phases. The same UXO charge sizes as the Proposed Development were modelled for Mona OWF and Morgan OWF Generation Assets (from 25 kg up to 907 kg, with 130 kg the most likely maximum size). Subsequently, the PEIRs predicted the largest injury ranges as a result of high order detonation of a 907 kg UXO size for harbour porpoise of up to 15 km and 28 km for PTS and TTS, respectively (EnBW and BP, 2023a, 2023e). Numbers of animals potentially impacted by PTS due to high-order clearance of the maximum charge size (907 kg) are presented in Table 7.104.

Table 7.104: Number Of Animals With The Potential To Experience PTS Onset Due To High-Order Detonation Of A 907 kg UXO For The Tier 2 Projects

Project	Species	Maximum Charge Size (kg)	Maximum PTS Range (m)	Maximum Number of Animals Disturbed	Source
Proposed Development	Harbour porpoise	907	15,370	383	Section 7.12.15
	Bottlenose dolphin, common		890	<1	

Project	Species	Maximum Charge Size (kg)	Maximum PTS Range (m)	Maximum Number of Animals Disturbed	Source
	dolphin, Risso's dolphin				
	Minke whale		4,215	<1	
	Grey seal		3,015	115	
	Harbour seal		3,015	2	
Mona OWF	Harbour porpoise	907	15,370	72	EnBW and BP (2023a)
	Bottlenose dolphin, common dolphin, Risso's dolphin		890	<1	
	Minke whale		2,720	<1	
	Grey seal		3,015	6	
	Harbour seal		3,015	<1	
Morgan OWF Generation Assets	Harbour porpoise	907	15,370	184	EnBW and BP (2023e)
	Bottlenose dolphin, common dolphin, Risso's dolphin		890	<1	
	Minke whale		2,720	<1	
	Grey seal		3,015	2	
	Harbour seal		3,015	<1	

The construction phases of the other Tier 2 projects range from 2024 to 2027, therefore have possible overlap in UXO clearance activities with the Proposed Development. However, the closest, spatially, to the Proposed Development is the NISA OWF (143.68 km away). Given the PTS and TTS ranges did not exceed tens of kilometres for the Proposed Development, Mona OWF, and Morgan OWF Generation Assets (Table 7.104), there is limited potential for cumulative effects with these other projects.

Auditory Injury (PTS)

Overall, the cumulative impact is predicted to be of local spatial extent, very short-term duration (within seconds), intermittent throughout the construction phases of the projects, and, although the impact itself is reversible (i.e. elevated underwater noise during the detonation event only), the effect of PTS permanent. It is predicted that the impact will affect the receptor directly. In line with UXO guidance, assuming standard industry measures applied for each project, it is anticipated that animals would be deterred from the ZoI, thus reducing the risk of PTS. The magnitude is therefore considered to be negligible (for bottlenose dolphin, common dolphin, Risso's dolphin, minke whale, grey seal and harbour seal). For harbour porpoise the PTS ranges were larger and there is considered to be a residual risk of PTS to a small number of individuals, therefore the magnitude is considered to be low for harbour porpoise.

Behavioural Disturbance (TTS as a Proxy)

The cumulative impact of TTS resulting from a high-order detonation is predicted to be of regional spatial extent, short-term duration, intermittent and both the impact itself (i.e. elevated underwater noise during the detonation event only) and effect of TTS is reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be low for all species.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.15).

Auditory Injury (PTS)

Overall, all marine mammal IEFs are deemed to have limited tolerance to PTS, high vulnerability, low recoverability, and international value. The sensitivity or the receptor is therefore considered to be high.

Behavioural Disturbance (TTS as a Proxy)

Overall, since TTS is reversible, all marine mammal IEFs are assessed as having some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of the receptor is therefore considered to be low.

Significance of Effect

Auditory Injury (PTS)

Overall, for all IEFs except harbour porpoise, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be high. Therefore, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Overall, for harbour porpoise, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be high. As per Table 7.31, this results in a 'minor or moderate' significance of effect. However given the low chance of temporal overlap in clearance events or concurrent detonations, based on the low numbers of detonations per day expected during clearance activities the effect is therefore assessed to be of **minor adverse** significance, which is **not significant** in EIA terms.

Behavioural Disturbance (TTS as a Proxy)

Overall, for all IEFs, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, it has been concluded that the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.17.3 Tier 3 and 4

There were no Tier 3 or 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative impacts regarding underwater noise during UXO clearance.

7.13.18 Injury, Disturbance, and Displacement from Underwater Noise Generated during Geophysical and Seismic Site Investigation Surveys

There is the potential for cumulative increased underwater noise as a result of site investigation survey activities associated with the construction and operation and maintenance phases of the Proposed Development and other plans, projects, and activities. For the purposes of this ES, this additive impact has been assessed, using the tiered approach outlined above in section 7.13.1. Based on the maximum disturbance ranges modelled for this impact for the Proposed Development (13 km), a buffer of 13 km was implemented in the CEA screening exercise.

As detailed in section 7.12.16, there are no thresholds in Popper *et al.* (2014) in relation to HF sonar (>10 kHz) for marine turtles. Thus, marine turtles were not included in the underwater noise modelling for this impact for the Proposed Development alone, and are thus, not included in this cumulative impact either.

The risk of injury to marine mammals in terms of PTS due to site investigation surveys would be expected to be localised to within the close vicinity of respective projects. The assessment for the Proposed Development found that the injury ranges are expected to be small, and the magnitude of the impact has been assessed to be negligible (see section 7.12.16). Therefore, there is very low potential for cumulative impacts for injury from elevated underwater sound due to site investigation surveys and the cumulative assessment provided in the following sections focuses on disturbance only. As animals are likely to recover from this disturbance within hours, surveys that were completed prior to the commencement of construction phase of the Proposed Development (2024-2026) were screened out from further consideration.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.94.

7.13.18.1 Tier 1

Construction and Operation and Maintenance Phases

There is potential for cumulative impacts with one Tier 1 project in the construction and operation and maintenance phases: Awel y Môr OWF. However, this impact was not assessed in the ES for Awel y Môr OWF (RWE Renewables UK, 2022). Therefore, no Tier 1 assessment was conducted.

7.13.18.2 Tier 2

Construction Phase

Magnitude of Impact

There is potential for cumulative impacts with two Tier 2 projects in the construction phase: Mona OWF and Morgan OWF Generation Assets.

For the Mona OWF and Morgan OWF Generation Assets, the MDS includes geophysical survey techniques, such as MBES, SBES, SBP, Side Scan Sonar (SSS), and Ultra High Resolution Seismic (UHRS). It also includes geotechnical activities, such as boreholes, Cone Penetration Tests (CPT), and vibrocores (EnBW and BP, 2023a, 2023e). The underwater noise modelling for the Mona OWF predicted disturbance ranges within hundreds of metres for most activities, with the highest distances of 17.3 km and 31 km presented for SBP and vibrocores, respectively (EnBW and BP, 2023a). A similar pattern was also presented by the modelling for Morgan OWF Generation Assets, and the highest behavioural disturbance ranges were 17 km and 55 km, also for SBP and vibrocores, respectively (EnBW and BP, 2023e). These values exceed those modelled for the Proposed Development, where the highest disturbance range was 13 km for mild disturbance (140 dB re 1 µPa (rms)) due to VSP (Table 7.77).

Overall, the impact of site investigation surveys leading to behavioural disturbance is predicted to be of local spatial extent (i.e. limited to three projects, including the Proposed Development, in close proximity to one another), short-term duration (for the individual surveys), intermittent, and high reversibility (as increased underwater noise only occurs during surveys). The effect of behavioural disturbance is also reversible, as animals returning to baseline levels soon after the surveys have stopped. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.16).

It is expected that, to some extent, marine mammals will be able to adapt their behaviour to reduce impacts on survival and reproduction rates and tolerate elevated levels of underwater noise during site investigation surveys. Marine mammals are deemed to have some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance from elevated underwater noise during site investigation surveys is therefore considered to be medium.

Significance of Effect

Overall, the magnitude of the impact of behavioural disturbance is deemed to be low and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

The operation and maintenance phase of the Proposed Development may interact cumulatively with that of four Tier 2 projects: the Mona OWF, Morgan OWF Generation Assets, the Morgan and Morecambe OWF Transmission Assets and Mooir Vannin OWF.

At the time of writing, there was no publicly available information to quantify this impact at the Morgan and Morecambe OWF Transmission Assets or at Mooir Vannin OWF. In addition, neither of the PEIRs for the Mona OWF and Morgan OWF Generation Assets assessed this impact in their operation and maintenance phases. Therefore, a quantitative Tier 2 assessment was not possible for the operation and maintenance phase. However, it is predicted to be of similar or lesser magnitude than provided above for the construction phase.

Overall, the impact of site investigation surveys leading to behavioural disturbance is predicted to be of local spatial extent (i.e. limited to four projects, including the Proposed Development, in close proximity to one another), short-term duration (for the individual surveys), intermittent throughout the operation and maintenance phase, and high reversibility (as increased underwater noise only occurs during surveys). The effect of behavioural disturbance is also reversible, as animals returning to baseline levels soon after the surveys have stopped. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as described above for the Proposed Development alone (see section 7.12.16).

It is expected that, to some extent, marine mammals will be able to adapt their behaviour to reduce impacts on survival and reproduction rates and tolerate elevated levels of underwater noise during site investigation surveys. Marine mammals are deemed to have some tolerance, medium vulnerability, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance from elevated underwater noise during site investigation surveys is therefore considered to be medium.

Significance of Effect

Overall, the magnitude of the impact of behavioural disturbance is deemed to be low and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.18.3 Tier 3 and 4

Construction and Operation and Maintenance Phases

There were no Tier 3 or 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative impacts regarding underwater noise during geophysical and seismic site investigation surveys.

7.13.19 Injury, Disturbance, and Displacement from Vessel Activity and other Noise Producing Activities

There is the potential for cumulative increased underwater noise as a result of vessel activities associated with all three phases of the Proposed Development and other plans, projects, and activities. For the purposes of this ES, this additive impact has been assessed using the tiered approach outlined above in section 7.13.1.

As for the assessment of the Proposed Development alone (section 7.12.17), the risk of injury in terms of PTS as a result of underwater noise produced by vessels and other non-piling activities would be expected to be very low. PTS thresholds unlikely to be exceeded or would be very localised (<10 m) from the source, given that they were not exceeded for any species in the underwater noise modelling of the Proposed Development alone (section 7.12.17). Given the above, there is very low potential for cumulative impacts to cause injury (in terms of PTS) as a result of increased underwater noise from vessels and other (non-piling) noise producing activities. Instead, the cumulative assessment provided below focuses on disturbance only for this impact.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.94.

7.13.19.1 Tier 1

Construction Phase

Magnitude of Impact

<u>All Species</u>

There is potential for cumulative impacts with two Tier 1 project in the construction phase: Awel y Môr OWF and Mostyn Energy Park Extension. It should be noted that the construction phase of Awel y Môr is anticipated to be between 2026 and 2030 (Table 7.93), so will only temporally overlap with that of the Proposed Development for less than a year.

The MDS for Awel y Môr OWF describes up to 101 construction vessels in total, of which 35 may be on site at one time (RWE Renewables UK, 2022). For the Proposed Development, the MDS assumes a total of 236 vessel round trips over the two-year construction phase (Table 7.23).

In the ES for Awel y Môr OWF, impacts associated with underwater noise due to vessel traffic and other construction activities was based on a desktop study. This study stated that using Benhemma-Le Gall *et al.* (2021), harbour porpoise and other cetaceans may be displaced up to 4 km from construction vessels. It also identified localised behavioural disturbance ranges for harbour porpoise and grey seal with avoidance reported up to 5 km from the site during dredging activities. Dredging was predicted to reduce bottlenose dolphin presence of the Awel y Môr OWF for five weeks. Similarly, minke whale presence was adversely correlated with construction related activities, including dredging (RWE Renewables UK, 2022).

It is a standard practice to present estimated ranges over which behavioural disturbance may occur for different vessel types in isolation. For the Proposed Development, disturbance ranges of up to 20 km were predicted for survey vessels, crew transfer vessels, and support vessels (Table 7.79). It is likely that several activities could be potentially consecutively across several offshore developments, and therefore disturbance ranges may extend from several vessels/locations where the activity is carried out.

Therefore, cumulatively across the Proposed Development and Awel y Môr OWF, there may be a noticeable increase in vessel activity from the baseline. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will be confined to their respective construction areas and will follow existing shipping routes to and from ports. Therefore, it would not be realistic to present a sum of all vessels anticipated within the Proposed Development and Awel y Môr OWF. Introduction of vessels during construction and operations and maintenance phases of the projects will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

EIA for the Mostyn Energy Park Extension concluded that there would be no risk of injury or significant disturbance to marine mammals from dredging or vessel activities even if dredging and vessel movements were to take place continuously (i.e. day and night) over the construction phase.

The cumulative impact is predicted to be of local spatial extent, short-term duration (due to the <1 year overlap between construction phase), intermittent (in terms of vessel movements and activities) and both the impact itself (increased underwater noise) and effect of behavioural disturbance are reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.17).

Marine Mammal IEFs

Overall, the marine mammal IEFs are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors is therefore considered to be medium.

Marine Turtle IEFs

Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance and Decommissioning Phases

Magnitude of Impact

All Species

There is potential for cumulative impacts with one Tier 1 project in both the operation and maintenance and decommissioning phases of the Proposed Development: Awel y Môr OWF. It should be noted that the operation and maintenance phase of Awel y Môr OWF is expected to be between 2030 and 2055, therefore it will still be in operation after cessation of the decommissioning phase of the Proposed Development (Table 7.93). The MDS for Awel y Môr OWF includes up to 1,232 vessel return trips annually over the 25-year operation and maintenance phase (30,800 total) (RWE Renewables UK, 2021a). Only two jack-up vessels and two service operation vessels would be on site at any one time (RWE Renewables UK, 2022). In addition, the MDS for the Proposed Development assumes that there will be up to 750 and 128 vessel round trips over the operation and maintenance and decommissioning phases, respectively (Table 7.23).

As in the construction phase, there may be a noticeable increase in vessel activity from the baseline. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will be confined to their respective construction areas and will follow existing shipping routes to and from ports. Therefore, it would not be realistic to present a sum of all vessels anticipated within the Proposed Development and Awel y Môr OWF. Introduction of vessels during operations and maintenance and decommissioning phases of the projects will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

As for the construction phase, vessel movements at the Mostyn Energy Park Extension are not expected to cause injury, disturbance, or displacement of marine mammals.

The cumulative impact is predicted to be of local spatial extent, long-term duration (temporally over the operation and maintenance and decommissioning phase, but not in terms of individual vessel movements/activities), intermittent (in terms of vessel movements/activities) and both the impact itself (increased underwater noise) and effect of behavioural disturbance are reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.17).

Marine Mammal IEFs

Overall, the marine mammal IEFs are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors is therefore considered to be medium.

Marine Turtle IEFs

Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.19.2 Tier 2

Construction Phase

Magnitude of Impact

All Species

The construction phase of the Proposed Development may interact cumulatively with that of two Tier 2 projects: the Mona OWF and Morgan OWF Generation Assets.

The MDS for the Mona OWF assumes up to 80 vessels on site at any one time and up to 2,004 vessel round trips over the construction phase (EnBW and BP, 2023a). The MDS for Morgan OWF Generation assets assumes up to 63 vessels on site at any one time, with 1,878 total round trips over the construction phase (EnBW and BP, 2023e). In contrast, there will be up to 236 vessel round trips in the construction phase of the Proposed Development (Table 7.23). It should be noted that the construction phases for both these Tier 2 projects are anticipated to be between 2026 and 2028, therefore will only overlap with that of the Proposed Development for <1 year (in 2026).

Both Mona OWF and Morgan OWF Generation Assets also include drilling, cable trenching and laying, and jack-up rig use as other noise producing activities (EnBW and BP, 2023a, 2023e). Like the assessment for the Proposed Development alone, the maximum disturbance ranges modelled for Mona OWF and Morgan OFW Generation Assets were for survey vessel movements, at 22 km and 21 km, respectively (EnBW and BP, 2023a, 2023e).

As above for the Tier 1 assessment, there may be a noticeable increase in vessel activity from the baseline due to these projects. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will be confined to their respective construction areas and will follow existing shipping routes to and from ports. Introduction of vessels will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

The cumulative impact is predicted to be of local spatial extent, short-term duration (over the construction phase), intermittent (in terms of vessel movements/activities) and both the impact itself (increased underwater noise) and effect of behavioural disturbance are reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.17).

Marine Mammal IEFs

Overall, the marine mammal IEFs are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors is therefore considered to be medium.

Marine Turtle IEFs

Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance and Decommissioning Phases

Magnitude of Impact

All Species

The operation and maintenance and decommissioning phases of the Proposed Development may interact cumulatively with that of three Tier 2 projects: the Mona OWF, Morgan OWF Generation Assets, and the Morgan and Morecambe OWF Transmission Assets. It should be noted that the operation and maintenance phases of Mona OWF and Morgan Generation are expected to be between 2029 and 2089, therefore they will still be in operation after cessation of the decommissioning phase of the Proposed Development (Table 7.93). Similarly, the operation and maintenance phase of the Morgan and Morecambe OWF Transmission Assets is anticipated to be between 2030 and 2065 (Table 7.93), so also encompasses the decommissioning phase of the Proposed Development.

At the time of writing, there was no publicly available information to quantify this impact at the Morgan and Morecambe OWF Transmission Assets. As the transmission assets only involves cables, it is likely that this impact will be of a lower extent to that presented for Mona OWF and Morgan OWF Generation Assets.

The MDS for the Mona OWF assumes up to 21 vessels on site at any one time and up to 2,351 vessel round trips over the construction phase (EnBW and BP, 2023a). This results in 61,126 vessel movements over the 26-year overlap with the operation and maintenance and decommissioning phases of the Proposed Development. The MDS for Morgan OWF Generation assets also assumes up to 21 vessels on site at any one time, with 2,351 total round trips per year (EnBW and BP, 2023e). For the Proposed Development, there will be up to 750 vessel round trips in the operation and maintenance phase and 128 in the decommissioning phase (Table 7.23).

The three Tier 2 projects are also likely to include activities such as cable repair and reburial over their operation and maintenance phases, although values for these were not included in their PEIRs.

As above for the Tier 1 assessment, there may be a noticeable increase in vessel activity from the baseline due to these projects. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will be confined to their respective construction areas and will follow existing shipping routes to and from ports. Introduction of vessels will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

The cumulative impact is predicted to be of local spatial extent, long-term duration (temporally over the operation and maintenance and decommissioning phase), intermittent (in terms of vessel movements/activities) and both the impact itself (increased underwater noise) and effect of behavioural disturbance are reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.17).

Marine Mammal IEFs

Overall, the marine mammal IEFs are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors is therefore considered to be medium.

Marine Turtle IEFs

Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.19.3 Tier 3

Construction Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with one Tier 3 project in the construction phase of the Proposed Development: The MaresConnect interconnector cable.

There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on marine mammal and marine turtles. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023).

As it transects the Proposed Development, the construction of the MaresConnect interconnector cable will result in increased vessel traffic in proximity to the Proposed Development. Non-piling noise producing activities that are likely to occur are cable laying using jet trenching techniques and the installation of cable protection. Construction is planned to occur in 2025 and the project is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage.

The cumulative impact is predicted to be of local spatial extent, short term duration (for the individual construction activities), intermittent, and both the impact itself (increased underwater noise) and effect of behavioural disturbance are reversible. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.17).

Marine Mammal IEFs

Overall, the marine mammal IEFs are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors is therefore considered to be medium.

Marine Turtle IEFs

Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with one Tier 3 project in the operation and maintenance phase of the Proposed Development: The MaresConnect interconnector cable.

There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on marine mammal and marine turtles. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023). The MaresConnect interconnector cable is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage.

As it transects the Proposed Development, the operation and maintenance phase of the MaresConnect interconnector cable will result in increased vessel traffic in proximity to the Proposed Development. Non-piling noise producing activities that are likely to occur involve the repair and reburial of cables. The operation and maintenance phase may also potentially result in increased vessel movement, although this will likely be of a lower extent than in the construction phase.

The cumulative impact is predicted to be of local spatial extent, short term duration (for the individual activities), intermittent, and both the impact itself (increased underwater noise) and effect of behavioural disturbance are reversible. It is predicted that the impact will affect the receptor directly. Therefore, the magnitude of impact is considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.17).

Marine Mammal IEFs

Overall, the marine mammal IEFs are deemed to have some tolerance to behavioural disturbance, medium vulnerability, high recoverability and international value. The sensitivity of these receptors is therefore considered to be medium.

Marine Turtle IEFs

Overall, marine turtles are deemed to be of low vulnerability, high tolerance, high recoverability, and international value. The sensitivity of these receptors to behavioural disturbance is therefore considered to be low.

Significance of Effect

Marine Mammal IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Marine Turtle IEFs

Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative increased underwater noise from vessels and other activities in the decommissioning phase of the Proposed Development.

7.13.19.4 Tier 4

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative impacts regarding vessel activity and other noise producing activities.

7.13.20 Injury due to Collision with Marine Vessels

There is the potential for cumulative increased risk of vessel collision associated with all three phases of the Proposed Development and other plans, projects, and activities. For the purposes of this ES, this additive impact has been assessed within Liverpool Bay, using the tiered approach outlined above in section 7.13.1.

All plans, projects, and activities screened into the assessment for cumulative effects from this impact are either on-going activities or projects with sufficient information in the public domain. The plans, projects, and activities within each tier screened into the CEA for each phase of development are illustrated in Table 7.94.

7.13.20.1 Tier 1

Construction Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with two Tier 1 projects in the construction phase: Awel y Môr OWF and Mostyn Energy Park Extension. It should be noted that the construction phase of Awel y Môr OWF is anticipated to be between 2026 and 2030 (Table 7.93), so will only temporally overlap with that of the Proposed Development for less than a year.

The MDS for Awel y Môr OWF project describes up to 101 construction vessels in total, of which 35 may be on site at one time (RWE Renewables UK, 2022). For the Proposed Development, the MDS assumes a total of 236 vessel round trips over the two-year construction phase (Table 7.23).

Furthermore, the ES for the Awel y Môr OWF outlined a commitment to employ a vessel management plan and follow best practice vessel handling protocols to minimise any potential for collision. The Proposed Development also includes similar embedded mitigation in the form of an EMP, which will contain best practice codes of conduct to minimise collision risk (Table 7.32). As for the Proposed Development, it is anticipated that a proportion of vessels during construction of the Awel y Môr OWF will be slow moving or even stationary for periods of time and therefore unlikely to pose a significant collision risk to marine mammals (RWE Renewables UK, 2022). There is also a potential that the sound emissions from vessels will deter animals from the potential zone of impact (see section 7.13.19).

Overall, cumulatively across the Proposed Development and Awel y Môr OWF, there may be a noticeable increase in vessel activity from the baseline. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will be confined to their respective construction areas and will follow existing shipping routes to and from ports. The risk of collision would likely be localised to these areas and routes, and not extend over a wider area. Introduction of vessels during the construction phase will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

EIA for Mostyn Energy Park Extension did not include a quantitative assessment of injury due to collision with marine vessels. However, given the less than two-year construction period and existing vessel traffic associated with the port, the Mostyn Energy Park Extension is not expected to increase the risk of injury due to collision with marine vessels.

With standard industry measures in place to reduce the risk of collision (i.e. vessel management plan, EMP), the impact is predicted to be of limited spatial extent, short-term duration (over the two-year construction phase), intermittent (in terms of vessel movements) and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.18).

Marine Mammal IEFs

Overall, all marine mammal IEFs are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Overall, marine turtle IEFs are deemed to have low tolerance, medium recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

All Species

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance and Decommissioning Phases

Magnitude of Impact

All Species

There is potential for cumulative impacts with one Tier 1 project in both the operation and maintenance and decommissioning phases of the Proposed Development: Awel y Môr OWF. It should be noted that the operation and maintenance phase of Awel y Môr OWF is expected to be between 2030 and 2055, therefore it will still be in operation after cessation of the decommissioning phase of the Proposed Development (Table 7.93). The MDS for Awel y Môr OWF includes up to 1,232 vessel return trips annually over the 25-year operation and maintenance phase (30,800 total) (RWE Renewables UK, 2021a). Only two jack-up vessels and two service operation vessels would be on site at any one time (RWE Renewables UK, 2022). In addition, the MDS for the Proposed Development assumes that there will be up to 750 and 128 vessel round trips over the operation and maintenance and decommissioning phases, respectively (Table 7.23).

As above for the construction phase, the vessel management plan outlined in the ES for Awel y Môr OWF and the EMP for the Proposed Development will outline best practice vessel handling protocols to minimise any potential for collision. Further, it is anticipated that a proportion of vessels for Awel y Môr OWF and the Proposed Development will be slow moving or even stationary for periods of time and thus unlikely to pose a significant collision risk to marine mammals (RWE Renewables UK, 2022). There is also a potential that the sound emissions from vessels will deter animals from the potential zone of impact (see section 7.13.19).

Overall, cumulatively across the Proposed Development and Awel y Môr OWF, there may be a noticeable increase in vessel activity from the baseline. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will follow existing shipping routes to and from ports and be contained within localised areas for individual maintenance and decommissioning activities. The risk of collision would likely be localised to these areas and routes, and not extend over a wider area. Introduction of vessels during the operations and maintenance and decommissioning phases will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

With standard industry measures in place to reduce the risk of collision (i.e. vessel management plan, EMP), the impact is predicted to be of limited spatial extent, long-term duration, intermittent (in terms of vessel movements) and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.18).

Marine Mammal IEFs

Overall, all marine mammal IEFs are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Overall, marine turtle IEFs are deemed to have low tolerance, medium recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

All Species

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.20.2 Tier 2

Construction Phase

Magnitude of Impact

All Species

The construction phase of the Proposed Development may interact cumulatively with that of two Tier 2 projects: the Mona OWF and Morgan OWF Generation Assets.

The MDS for the Mona OWF assumes up to 80 vessels on site at any one time and up to 2,004 vessel round trips over the construction phase (EnBW and BP, 2023a). The MDS for Morgan OWF Generation assets assumes up to 63 vessels on site at any one time, with 1,878 total round trips over the construction phase (EnBW and BP, 2023e). In contrast, there will be up to 236 vessel round trips in the construction phase of the Proposed Development (Table 7.23). It should be noted that the construction phases for both these Tier 2 projects are anticipated to be between 2026 and 2028, therefore will only overlap with that of the Proposed Development for <1 year (in 2026).

As above for the Tier 1 assessment, both the Tier 2 projects have outlined a commitment to an EMP, which includes measures to minimise collision and disturbance to marine mammals (EnBW and BP, 2023a, 2023e). Further, it is anticipated that a proportion of vessels for the Tier 2 projects and the Proposed Development will be slow moving or even stationary for periods of time and thus unlikely to pose a significant collision risk to marine mammals (EnBW and BP, 2023a, 2023e). There is also a potential that the sound emissions from vessels will deter animals from the potential zone of impact (see section 7.13.19).

As above for the Tier 1 assessment, there may be a noticeable increase in vessel activity from the baseline due to these projects. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will be confined to their respective construction areas and will follow existing shipping routes to and from ports. Introduction of vessels will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

With standard industry measures in place to reduce the risk of collision (i.e. EMPs), the impact is predicted to be of limited spatial extent, short-term duration (over the two-year construction phase), intermittent (in terms of vessel movements) and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.18).

Marine Mammal IEFs

Overall, all marine mammal IEFs are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Overall, marine turtle IEFs are deemed to have low tolerance, medium recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

All Species

Overall, the magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance and Decommissioning Phases

Magnitude of Impact

All Species

The operation and maintenance and decommissioning phases of the Proposed Development may interact cumulatively with that of four Tier 2 projects: the Mona OWF, Morgan OWF Generation Assets, the Morgan and Morecambe OWF Transmission Assets and Mooir Vannin OWF. It should be noted that the operation and maintenance phases of Mona OWF and Morgan Generation are expected to be between 2029 and 2089, therefore they will still be in operation after cessation of the decommissioning phase of the Proposed Development (Table 7.93). Similarly, the operation and maintenance phase of the Morgan and Morecambe OWF Transmission Assets is anticipated to be between 2030 and 2065 and the operation and maintenance phase of Mooir Vannin OWF is expected to be between 2032 and 2067 (Table 7.93), so also encompasse the decommissioning phase of the Proposed Development.

At the time of writing, there was no publicly available information to quantify this impact at the Morgan and Morecambe OWF Transmission Assets or at Mooir Vannin OWF. As the transmission assets only involves cables, it is likely that this impact will be of a lower extent to that presented for Mona OWF and Morgan OWF Generation Assets.

The MDS for the Mona OWF assumes up to 21 vessels on site at any one time and up to 2,351 vessel round trips over the construction phase (EnBW and BP, 2023a). This results in 61,126 vessel movements over the 26-year overlap with the operation and maintenance and decommissioning phases of the Proposed Development. The MDS for Morgan OWF Generation assets also assumes up to 21 vessels on site at any one time, with 2,351 total round trips per year (EnBW and BP, 2023e). For the Proposed Development, there will be up to 750 vessel round trips in the operation and maintenance phase and 128 in the decommissioning phase (Table 7.23).

As above for the Tier 1 assessment, there may be a noticeable increase in vessel activity from the baseline due to these projects. Although, it should be noted that the assessments are based on the MDSs and that the number of vessels present at respective projects at any given time is likely to be lower in reality. In addition, vessel movements will be confined to their respective construction areas and will follow existing shipping routes to and from ports. Introduction of vessels will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

With standard industry measures in place to reduce the risk of collision (i.e. EMPs), the impact is predicted to be of limited spatial extent, long-term duration, intermittent (in terms of vessel movements) and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.18).

Marine Mammal IEFs

Overall, all marine mammal IEFs are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Overall, marine turtle IEFs are deemed to have low tolerance, medium recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

All Species

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

7.13.20.3 Tier 3

Construction Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with one Tier 3 project in the construction phase of the Proposed Development: The MaresConnect interconnector cable.

There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on marine mammal and marine turtles. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023). It is likely that standard industry mitigation, such as an EMP or vessel management plan, will be implemented for the MaresConnect interconnector cable.

As it transects the Proposed Development, the construction of the MaresConnect interconnector cable will result in increased vessel traffic in proximity to the Proposed Development, although it is likely that this will be of a lower extent to the vessel traffic anticipated for the Tier 1 and Tier 2 OWF projects. Construction is planned to occur in 2025 and the project is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage.

As above for the Tier 1 and 2 assessments, there may be an increase in vessel activity from the baseline. However, the risk of collision would likely be localised to the areas and routes required for the construction of the MaresConnect interconnector cable, and not extend over a wider area. Introduction of vessels will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

With standard industry measures in place to reduce the risk of collision (i.e. EMPs), the impact is predicted to be of local spatial extent, long-term duration, intermittent (in terms of vessel movements) and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.18).

Marine Mammal IEFs

Overall, all marine mammal IEFs are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Overall, marine turtle IEFs are deemed to have low tolerance, medium recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

All Species

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Operation and Maintenance Phase

Magnitude of Impact

All Species

There is potential for cumulative impacts with one Tier 3 project in the operation and maintenance phase of the Proposed Development: The MaresConnect interconnector cable.

There is, however, currently no information on the impact that the MaresConnect interconnector cable will have on marine mammal and marine turtles. A planning application is predicted to be submitted in 2024 which will identify and assess these impacts (MaresConnect, 2023). It is likely that standard industry mitigation, such as an EMP or vessel management plan, will be implemented for the MaresConnect interconnector cable.

As it transects the Proposed Development, operation and maintenance activities for MaresConnect interconnector cable will result in increased vessel traffic in proximity to the Proposed Development, although it is likely that this will be of a lower extent to the vessel traffic anticipated for the Tier 1 and Tier 2 OWF projects or for the construction phase. The MaresConnect interconnector cable is anticipated to become operational in 2027 (MaresConnect, 2023), although it should be noted that these timeframes are only indicative at this stage.

As above for the Tier 1 and 2 assessments, there may be an increase in vessel activity from the baseline. However, the risk of collision would likely be localised to the areas and routes required for the construction of the MaresConnect interconnector cable, and not extend over a wider area. Introduction of vessels will not be a novel impact for marine mammals and marine turtles in the vicinity, and animals, therefore, are anticipated to demonstrate some degree of habituation to this impact.

With standard industry measures in place to reduce the risk of collision (i.e. EMPs), the impact is predicted to be of limited spatial extent, long-term duration, intermittent (in terms of vessel movements) and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. The magnitude is, conservatively, considered to be low.

Sensitivity of the Receptor

The sensitivity of the receptor is as defined above for the Proposed Development alone (section 7.12.18).

Marine Mammal IEFs

Overall, all marine mammal IEFs are deemed to have some tolerance (largely due to avoidance behaviour), medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Marine Turtle IEFs

Overall, marine turtle IEFs are deemed to have low tolerance, medium recoverability, and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

All Species

Overall, the magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. Therefore, the cumulative effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Decommissioning Phase

There were no Tier 3 plans, projects, or activities identified in the CEA with the potential to result in cumulative impacts regarding vessel collision in the decommissioning phase of the Proposed Development.

7.13.20.4 Tier 4

There were no Tier 4 plans, projects, or activities identified in the CEA with the potential to result in cumulative impacts regarding vessel collision.

7.13.21 Conclusion

Overall, there were no significant cumulative effects identified for any tiers in the CEA for marine mammals and marine turtles.

7.14 Transboundary Effects

7.14.1 Overview

A screening for transboundary effects was conducted for each marine biodiversity topic and has identified potential for transboundary effects to fish and shellfish ecology and marine mammals and marine turtles (volume 3, appendix G). These are summarised in section 7.14.2 and section 7.14.3 below, respectively. There were no potential transboundary effects identified for benthic subtidal and intertidal ecology, due to the limited extent of the benthic ecology study areas and the reduced mobility of benthic receptors in comparison to fish and shellfish, marine mammals, and marine turtles.

7.14.2 Fish and Shellfish Ecology

As assessed in sections 7.12.9 to 7.12.12 above, potential impacts on fish and shellfish IEFs were:

- Temporary habitat loss and/or disturbance;
- Long-term subtidal habitat loss;
- Underwater noise impacting fish and shellfish receptors; and
- Increased SSCs and associated deposition.

Impacts associated with habitat loss and increased SSCs are likely to be localised to the Proposed Development fish and shellfish ecology study area, which is entirely out with other European Economic Area (EEA) states. However, increased underwater noise has the potential to injure and/or disturb fish and shellfish receptors, including Annex II diadromous fish species. Therefore, there is potential for transboundary effects associated with this impact.

7.14.3 Marine Mammals and Marine Turtles

As assessed in sections 7.12.14 to 7.12.19 above, potential impacts on marine mammal and marine turtle IEFs were:

- Injury, disturbance, and displacement from underwater noise during piling;
- Injury, disturbance, and displacement from underwater noise generated during UXO clearance;
- Injury, disturbance, and displacement from underwater noise during geophysical and seismic survey activities;
- Injury, disturbance, and displacement from vessel activity and other noise producing activities;
- Injury due to collision with marine vessels; and
- Effects on marine mammals and marine turtles due to changes in prey availability.

It is acknowledged that some marine mammals and marine turtles can travel large distances to forage and consequently the marine mammals and marine turtles under the protection of neighbouring EU States may be affected. Therefore, there is the potential for transboundary impacts associated with the Proposed Development to directly affect Annex II marine mammal species. Therefore, there is potential for transboundary effects associated with this impact.

7.15 Inter-related effects

7.15.1 Overview

An inter-related effects assessment has been conducted and is presented in full in volume 2, chapter 14. The inter-related effects assessment is summarised in the following sections.

7.15.2 Benthic Subtidal and Intertidal Ecology

For benthic subtidal and intertidal ecology, the following potential impacts have been considered within the inter-related assessment:

- temporary and long term habitat loss/disturbance;
- increased SSCs and associated sediment deposition;
- increased risk of introduction and spread of INNS; and
- impacts resulting from the release of sediment bound contaminants.

Overall, it was concluded that no inter-related effects would arise for each of these impacts (see volume 2, chapter 14).

7.15.3 Fish and Shellfish Ecology

For fish and shellfish ecology, the following potential impacts have been considered within the inter-related assessment:

- temporary and long term habitat loss/disturbance;
- underwater noise impacting fish and shellfish receptors; and
- increased SSCs and associated sediment deposition.

Overall, it was concluded that no inter-related effects would arise for each of these impacts (see volume 2, chapter 14).

7.15.4 Marine Mammals and Marine Turtles

For marine mammals and marine turtles, the following potential impacts have been considered within the inter-related assessment:

- injury, disturbance, and displacement from underwater noise generated during piling;
- injury, disturbance, and displacement from underwater noise generated during UXO clearance;
- injury, disturbance, and displacement from underwater noise generated during geophysical and seismic site investigation surveys;
- injury, disturbance, and displacement from vessel activity and other noise producing activities;
- injury due to collision with marine vessels; and
- effects on marine mammals and marine turtles due to changes in prey availability.

Overall, it was concluded that no inter-related effects would arise for each of these impacts (see volume 2, chapter 14).

7.16 Conclusion

A summary of the impact assessment on each marine biodiversity topic is presented in Table 7.105, Table 7.106, and Table 7.107 below. For all impacts, significance of effect was assessed as either negligible or of minor adverse significance, neither are significant in EIA terms. Within the CEA, only negligible or minor adverse significance was concluded for all impacts, also not significant in EIA terms.

Table 7.105: Summary Of Impact Assessment For Benthic Subtidal And Intertidal Ecology

Impact	Phase	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Significant in EIA Terms?
Temporary subtidal habitat loss and/or disturbance	C O D	Ross worm IEF: negligible All other IEFs: low	All IEFs: medium	Ross worm IEF: **negligible adverse** All other IEFs: **minor adverse**	**No**
Increased SSCs and associated deposition	C D	All IEFs: low	Subtidal habitats and species IEFs: negligible, low, and medium Intertidal habitats and species IEF: low Designated sites IEFs: low	All IEFs: **minor adverse**	**No**
Long-term subtidal habitat loss	C and O D	Subtidal habitats and species IEFs: no change and low Intertidal habitats and species IEF: no change Designated sites IEFs: no change	Subtidal habitats and species IEFs: medium and high Intertidal habitats and species IEF: high Designated sites IEFs: high	All IEFs: **minor adverse**	**No**
Introduction of artificial habitat and colonisation of hard structures	O	Subtidal habitats and species IEFs: no change and low Intertidal habitats and species IEF: no change Designated sites IEFs: no change	All IEFs: high	All IEFs: **minor adverse**	**No**
Increased temperature impacting benthic communities	O	Subtidal habitats and species IEFs: no change and negligible Intertidal habitats and species IEF: negligible Designated sites IEFs: no change	All IEFs: low	All IEFs: **negligible adverse**	**No**
Increased risk of introduction and spread of INNS	C O D	Subtidal habitats and species IEFs: low Intertidal habitats and species IEF and Dee Estuary/Aber Dyfrdwy SAC IEF: assessment not required Fylde MCZ IEF: low	Subtidal habitats and species IEFs: high Fylde MCZ IEF: high	Subtidal habitats and species IEFs: **minor adverse** Fylde MCZ IEF: **minor adverse**	**No**

Impact	Phase	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Significant in EIA Terms?
Impacts resulting from the release of sediment bound contaminants	C D	Subtidal habitats and species IEFs: negligible Intertidal habitats and species IEF and Dee Estuary/Aber Dyfrdwy SAC IEF: assessment not required Fylde MCZ IEF: negligible	Subtidal habitats and species IEFs: high Fylde MCZ IEF: high	Subtidal habitats and species IEFs: **minor adverse** Fylde MCZ IEF: **minor adverse**	**No**
Accidental pollution to the surrounding area	C O D	All IEFs: negligible	All IEFs: high	All IEFs: **minor adverse**	**No**

Table 7.106: Summary Of Impact Assessment For Fish And Shellfish Ecology

Impact	Phase	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Significant in EIA Terms?
Temporary subtidal habitat loss and/or disturbance	C O D	All IEFs: low	King and queen scallop: low Spiny lobster: medium All other shellfish IEFs: medium Herring: low Sandeel: medium All other marine fish IEFs: low Diadromous IEFs: negligible	All shellfish and marine IEFs: **minor adverse** Diadromous IEFs: **negligible adverse**	**No**
Long-term subtidal habitat loss	C and O D	All IEFs: low	King and queen scallop: low Norway lobster and European lobster: medium Spiny lobster: high All other shellfish IEFs: low Herring: low Sandeel: medium All other marine fish IEFs: low Diadromous IEFs: negligible	All shellfish and marine IEFs: **minor adverse** Diadromous IEFs: **negligible adverse**	**No**
Underwater noise impacting fish and shellfish receptors	C	All IEFs: low	All shellfish IEFs: low Cod, herring, and sprat: high All other marine fish IEFs: low Allis and Twaite shad: high All other diadromous IEFs: low	All IEFs: **minor adverse**	**No**
Increased SSCs and associated deposition	C D	All IEFs: low	All shellfish IEFs: low Herring: medium All other marine fish IEFs: low All diadromous IEFs: low	All shellfish IEFs: **negligible adverse** Herring: **minor adverse** All other marine fish IEFs: **negligible adverse** All diadromous IEFs: **negligible adverse**	**No**

Table 7.107: Summary Of Impact Assessment For Marine Mammals And Marine Turtles

Impact	Phase	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Significant in EIA Terms?
Injury, Disturbance, and Displacement from Underwater Noise Generated during Piling	C	Auditory Injury Harbour porpoise and minke whale: low All other IEFs: negligible Behavioural Disturbance All IEFs: low	Auditory Injury All IEFs: high Behavioural Disturbance All marine mammal IEFs: medium Marine turtle IEFs: low	Auditory Injury All IEFs: **minor adverse** Behavioural Disturbance All marine mammal IEFs: **minor adverse** Marine turtle IEFs: **negligible adverse**	**No**
Injury, Disturbance, and Displacement from Underwater Noise Generated during UXO Clearance	C	Auditory Injury (PTS) Harbour porpoise: low All other IEFs: negligible Behavioural Disturbance (TTS as a proxy) All IEFs: negligible	Auditory Injury (PTS) All IEFs: high Behavioural Disturbance (TTS as a proxy) All IEFs: low	Auditory Injury (PTS) All IEFs: **minor adverse** Behavioural Disturbance (TTS as a proxy) All IEFs: **negligible adverse**	**No**
Injury, Disturbance, and Displacement from Underwater Noise Generated during Geophysical and Seismic Site Investigation Surveys	C	Auditory Injury All marine mammal IEFs: negligible Behavioural Disturbance All marine mammal IEFs: low	Auditory Injury All marine mammal IEFs: high Behavioural Disturbance All marine mammal IEFs: medium	Auditory Injury All marine mammal IEFs: **minor adverse** Behavioural Disturbance All marine mammal IEFs: **minor adverse**	**No**
Injury, Disturbance, and Displacement from Vessel Activity and other Noise Producing Activities	C O D	Auditory Injury All IEFs: negligible Behavioural Disturbance All IEFs: low	Auditory Injury All IEFs: high Behavioural Disturbance All marine mammal IEFs: medium Marine turtle IEFs: low	Auditory Injury All IEFs: **minor adverse** Behavioural Disturbance All IEFs: **minor adverse**	**No**
	C	All IEFs: low	All IEFs: medium	All IEFs: **minor adverse**	**No**

Impact	Phase	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Significant in EIA Terms?
Injury due to Collision with Marine Vessels	O				
	D				
Effects on Marine Mammals and Marine Turtles due to changes in Prey Availability	C	All IEFs: low	Minke whale: medium All other IEFs: low	All IEFs: **minor adverse**	**No**
	O				
	D				

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