Bowdun Offshore Wind Farm, Offshore EIA Report

Volume 2, Chapter 9: Fish and Shellfish Ecology

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Glossary

Defined Term	Definition
Allision/Contact	Allision in shipping and navigation refers to the impact of a moving vessel with a stationary object, such as a Wind Turbine. It is distinct from a collision, which involves two moving vessels.
Annex II	Species of community interest whose conservation requires the designation of Special Areas of Conservation (SACs) as identified in Annex II of Habitats Directive (Council Directive 92/43/EEC).
Applicant (the)	Bowdun Offshore Wind Farm Limited (BOWFL).
Appropriate Assessment (AA)	An assessment to determine the implications of a plan or project for a European site in view of that site's conservation objectives. An Appropriate Assessment forms part of the Habitats Regulations Appraisal (HRA) and is required when a plan or project (either alone or in combination with other plans or projects) is likely to have a significant adverse effect on a European site.
Array Area	The Array Area is the area in which the Offshore Generation Assets will be located.
Benthic	Living on or in the seabed.
Bowdun Offshore Wind Farm Limited (BOWFL)	A Special Purpose Vehicle (SPV) (legal entity) for the purpose of developing the Project. BOWFL are the Applicant for the Offshore Application.
Cetacean	Marine mammals that are entirely aquatic. These include whales, dolphins, and porpoises.
Collision (Shipping and Navigation)	Collision refers to the impact between two moving vessels, or a vessel and an object in motion. It differs from allision, which involves a moving vessel striking a stationary object.
Commercial Fishing	Any form of fishing activity legally undertaken where the catch is sold for taxable profit.
Cumulative Effects	The effects of the Proposed Development assessed together with effects from the Onshore Infrastructure forming the Project as well as one or more different projects on the same receptor/resource.
Demersal Fish	Fish which live and feed on or near the seabed.
Diadromous Fish	Fish which move between freshwater and seawater as part of their life cycle.
Digital Aerial Surveys (DAS)	A method for undertaking baseline ornithological and marine mammal data collection surveys. Usually undertaken over a period of 24 months.
Effect	Term used to express the consequence of an impact (i.e. the result of change or changes on specific environmental resources or receptors). The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity of the receptor or resource in accordance with defined significance criteria.

Defined Term	Definition
Embedded Mitigation	Measures that are adopted as part of the Proposed Development and therefore assessed within the EIA. The proposed approach for the EIA for the Proposed Development is that Embedded Mitigation includes both primary mitigation and tertiary mitigation. These are defined by the ISEP as follows: Primary: Modifications to the location or design of the development made during the pre-application phase that are an inherent part of the project, and do not require additional action to be taken. Tertiary: Actions that would occur with or without input from the EIA feeding into the design process. These include actions that will be undertaken to meet other existing legislative requirements, or actions that are considered to be standard practices used to manage commonly occurring environmental effects.
Environmental Impact Assessment (EIA)	Process for the assessment of likely significant environmental effects of a project on the physical, biological and human environment during construction, Operation and Maintenance (O&M) and decommissioning.
Environmental Impact Assessment Regulations (EIA Regulations)	Terminology used in this Offshore EIA Report to refer to three sets of regulations: • The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017; • The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017; and • The Marine Works (Environmental Impact Assessment) Regulations 2007.
European Sites	This term recognises SACs, candidate SACs (cSACs), Sites of Community Importance (SCIs), Special Protection Areas (SPAs), possible SACs (pSACs), potential SPAs (pSPAs) and Ramsar sites (where also designated as another European Site), which protect species and habitats shared across Europe and were originally designated under European legislation.
Export Cable Corridor	The area seaward of MHWS which connects the Array Area with the Landfall within which the Offshore Export Cables will be installed.
Habitats Regulations	A term that refers to the collective legislation that translates the Habitats Directive into specific legal obligations in Scotland, namely: The Conservation (Natural Habitats, &c.) Regulations 1994; The Conservation of Habitats and Species Regulations 2017; and The Conservation of Offshore Marine Habitats and Species Regulations 2017 (in each case as amended).
Habitats Regulations Appraisal (HRA)	An assessment carried out under the Habitats Regulations to determine if a plan or project could adversely affect the integrity of a European Site.
Impact	A change caused by an action that occurs during a project's lifetime.
Important Ecological Feature (IEF)	Habitats, species and ecosystems (including ecosystem function and processes) that may be affected by the Proposed Development, with reference to a geographical context in which they are considered important.
Impulsive Sound	Sound which is broadband, very brief with a high rise time and high peak level compared to the energy averaged sound level.

Defined Term	Definition
Infauna	Organisms living within the seabed sediment.
Inter-Array Cables (IAC)	Cables which link the Wind Turbines to each other and with the OSPs.
Inter-Related Effects	The potential effects of multiple impacts from the construction, O&M and decommissioning of the Project, affecting one receptor.
Interconnector Cables	Cables which will connect individual OSPs to each other to provide redundancy against cable failure elsewhere.
Intertidal Area	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS).
Landfall	The area in which the Offshore Export Cables make landfall and is also the transitional area between the Offshore Transmission Assets and the Onshore Transmission Assets. Located in the Intertidal Area at Benholm.
Marine Directorate (MD)	The Marine Directorate of the Scottish Government, formerly known as Marine Scotland. The planning and licensing authority for Scotland's seas and custodian of Scotland's National Marine Plan (NMP). The Marine Directorate – Licensing Operations Team (MD-LOT) are specifically responsible for managing Section 36 Consent and Marine Licence Applications seaward of MHWS.
Marine Directorate – Science, Evidence, Data and Digital (MD-SEDD)	The scientific division of the MD, which provides expert scientific, economic and technical advice and services on issues relating to marine fisheries, aquaculture, marine renewable energy, and the aquatic environment and its flora and fauna.
Marine Licence	A Marine Licence permits the undertaking of different activities in the marine environment, including construction, the deposition or removal of substances or objects, and dredging. The Marine (Scotland) Act 2010 requires Marine Licences to be obtained for licensable activities taking place within Scottish Territorial Seas (MHWS to 12 nm). The Marine and Coastal Access Act (MCAA) 2009 requires a Marine Licence to be obtained for licensable marine activities within the Scottish offshore region (12 nm – 200 nm).
Marine Protected Areas (MPAs)	MPAs are designated under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act (MCAA) 2009. The MPA network protects nationally and internationally important marine wildlife, habitats, geology, and underwater landforms. Scotland's MPAs are significantly important for European, North-East Atlantic, and global MPA networks.
Maximum Design Scenario (MDS)	The scenario within the design envelope likely to result in the greatest impact on a particular topic receptor, and therefore the one that should be assessed for that topic receptor.
Mean High Water Springs (MHWS)	The average tidal height throughout the year of two successive high waters during those periods of 24 hours when the range of the tide is at its greatest.
Mean Low Water Springs (MLWS)	The average tidal height throughout the year of two successive low waters during those periods of 24 hours when the range of the tide is at its greatest.
Mitigation	Measures to avoid, prevent, reduce or control effects on the environment. See also definitions for Embedded Mitigation and Additional Mitigation.
Non-Impulsive (or Continuous) Sound	Sound which is either continuous or intermittent but without the characteristics described above for impulsive sound.

Defined Term	Definition
Offshore Application	Term used to refer to the applications associated with the Proposed Development. The Applicant will apply for: • A Section 36 Consent under the Electricity Act 1989; and • Marine Licence(s) under Marine Scotland Act 2010 and Marine and Coastal Access Act 2009.
Offshore Environmental Impact Assessment (EIA) Report (hereafter, 'Offshore EIA Report')	Document prepared to report the findings of the EIA for the Proposed Development and produced in accordance with the EIA Regulations. The Offshore EIA Report is submitted to support the Offshore Application for the Proposed Development, and to comply with EIA Regulations.
Offshore Export Cables	Subsea cables used to transmit electricity generated offshore by the Wind Turbines from the OSPs to shore. The Transition Joint Bay (TJB) is the location where the Offshore Export Cables terminate, and the onshore cabling begins.
Offshore Generation Assets	The infrastructure of the Proposed Development required to generate electricity comprising of the Wind Turbines, Wind Turbine foundations and associated infrastructure e.g. IACs.
Offshore Infrastructure	All of the Offshore Infrastructure associated with the Proposed Development that is located seaward of MHWS, comprising the Offshore Generation Assets and the Offshore Transmission Assets.
Offshore Scoping Report	The report that presents the findings of the EIA scoping process undertaken for the Proposed Development with the purpose of obtaining a Scoping Opinion. The Offshore Scoping Report defines what is intended to be assessed and reported as part of the EIA.
Offshore Substation Platform(s) (OSPs)	OSPs comprise the support structure, topside and electrical components used for collecting and/or converting electricity generated by the Wind Turbines for transmission by the Offshore Export Cables.
Offshore Transmission Assets	The infrastructure of the Proposed Development required to transmit the generated electricity comprising of the OSPs, Offshore Export Cables and associated infrastructure up to MHWS.
Operation and Maintenance (O&M)	The phase of the Proposed Development following completion of construction. This phase of development includes routine inspections, repairs and replacement of infrastructure and equipment (including Interconnector Cables and IACs), Scour Protection replenishment or replacement, major component replacement, painting and/or other coating works, removal of marine growth, and replacement of access ladders.
Oslo-Paris [Convention] (OSPAR)	Convention for the Protection of the Marine Environment of the North-East Atlantic.
Particle Motion	Component of the pressure wave comprising the movement of particles within the water or sediment relative to an equilibrium point.
Pelagic Fish	Fish which live within the water column, not on or near the seabed or at the coasts.
Piling	The action of installing piles: installation can use various methodologies, the most common of which are impact piling (in which the piles are struck by a "hammer") and drilling (during which a hole is drilled into the seafloor, the drilling tool is removed, and the pile is slotted into that hole).

Defined Term	Definition
Plan Option Area (POA)	A location identified in the SMP as a preferred area for commercial scale offshore wind development.
Project (the)	An overarching term for the Bowdun Offshore Wind Farm (Bowdun OWF) comprising the offshore and onshore infrastructure required to generate and transmit electricity from the Array Area to the onshore GCP. The Project includes the Offshore Generation Assets, the Offshore Transmission Assets and the Onshore Transmission Assets.
Project Design Envelope (PDE)	A description of the range of possible elements that make up the design options for the Proposed Development under consideration when the exact engineering parameters are not yet known.
Proposed Development	Term used to define the Offshore Infrastructure associated with the Project seaward of MHWS for which consent is being sought. Further details of the parameters are included in Volume 1, Chapter 3: Project Description.
Qualifying Features	The features for which a European Site has been officially designated to protect.
Report to Inform Appropriate Assessment (RIAA)	The RIAA provides detailed information to support the process of AA (undertaken by the competent authority) as part of the HRA, which evaluates the potential impacts of a project or plan on European Sites.
Scoping Opinion	A document produced by MD-LOT which is issued in response to submission and review of the Offshore Scoping Report. The Scoping Opinion is supported with feedback and advice from consultees, which details what is expected to be included in the Offshore EIA Report and what can be scoped out of the EIA process.
Scoping Workshop	A series of sessions preceding the finalisation of the Offshore Scoping Report to provide an opportunity for the Applicant to consult on the draft scope and for stakeholders to request additional information on key issues.
Scottish Ministers (the)	The decision makers with regard to Marine Licence(s) and Section 36 Consent applications in Scottish Offshore Waters and Scottish Marine Area.
Scour Protection	Protective materials installed to avoid sediment being eroded away from the base of the foundations and/or buried subsea cable due to the flow of water.
Significance	Effect factor that is determined by the magnitude of impact along with the sensitivity of the receptor.
Site Boundary	The boundary within which all elements of the Proposed Development will be located. The Site Boundary comprises the Array Area and Export Cable Corridor which ends at MHWS.
Special Areas of Conservation (SACs)	SACs are areas designated for the conservation of certain plant and animal species listed in the Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora.
Spring Tidal Excursion	The distance suspended sediment is transported prior to being carried back on the returning tide.
Statutory Nature Conservation Body (SNCB)	A statutory adviser to the UK and Scottish Governments on Scottish, UK and international nature conservation.

Defined Term	Definition
Study Area	For each environmental topic, the baseline environment will be characterised, and the potential environmental impacts will be described within a topic-specific study area. Specific study areas are defined for each topic and are based on the maximum spatial extent across which potential impacts of the Project may be experienced by the relevant receptors (i.e. Zone of Influence).
Subtidal	Areas of the coastal marine environment that lie below the level of MLWS and are continuously submerged by seawater.
Tidal Ellipse	The illustration of the variance of tidal currents in horizontal space.
Thistle Wind Partners (TWP)	Company established for the development of the Project.
Wind Turbines	Structures comprising of a tubular tower, rotor blades, and a nacelle which houses the Wind Turbine generator.

Acronyms

Acronym	Definition
AC	Alternating Current
ADD	Acoustic Deterrent Device
AUV	Autonomous Underwater Vehicle
BEIS	Department for Business Energy and Industrial Strategy
BOEM	Bureau of Ocean Energy Management
CaP	Cable Plan
CBA	Cable Burial Assessment
CBRA	Cable Burial Risk Assessment
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries, and Aquaculture Science
CIEEM	Chartered Institute for Ecology and Environmental Management
CITIES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMACS	Centre for Marine and Coastal Sciences
CMS	Construction Method Statement
CNSE	Central North Sea Electrification
CoCP	Code of Construction Practice
COLREGS	The Convention on the International Regulations for Preventing Collisions at Sea
CSIP	Cable Specification and Installation Plan
DAS	Digital Aerial Surveys
DC	Direct Current
DSLP	Development Specification and Layout Plan
eDNA	Environmental Deoxyribonucleic Acid
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EMODNet	European Marine Observation and Data Network
EMP	Environmental Management Plan
FeAST	Feature Activity Sensitivity Tool
FMS	Fisheries Management Scotland
GES	Good Environmental Status
HDD	Horizontal Directional Drilling
HRA	Habitats Regulations Appraisal
HSE	Health and Safety Executive
HVDC	High Voltage Direct Current
IAC	Inter Array Cable

Acronym	Definition
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Seas
IEF	Important Ecological Feature
IHLS	International Herring Larvae Survey
INNS	Invasive Non-Native Species
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LMP	Lighting and Marking Plan
MarESA	Marine Evidence Based Sensitivity Assessment
MarLIN	Marine Life Information Network
MBA	Marine Biological Association
MCA	Maritime & Coastguard Agency
MCAA	Marine and Coastal Access Act 2009
MCZ	Marine Conservation Zone
MDS	Maximum Design Scenario
MD-LOT	Marine Directorate-Licensing Operations Team
MD-SEDD	Marine Directorate – Science, Evidence, Data and Digital
MFE	Mass Flow Excavator
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MMO	Marine Management Organisation
MMMP	Marine Mammal Mitigation Plan
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MSS	Marine Scotland Science
N/A	Not Applicable
NBN	National Biodiversity Network
ncMPA	Nature Conservation MPA
N/E	Not Exceeded
NEQ	Net Explosive Quantity
NLB	Northern Lighthouse Board
OFTO	Offshore Transmission Owners
OMP	O&M Programme
OSP	Offshore Substation Platform
OSPAR	Oslo Paris [Convention]
OWF	Offshore Wind Farm
O&M	Operation and Maintenance

Acronym	Definition
PDE	Project Design Envelope
PEMP	Project Environmental Monitoring Plan
PMF	Priority Marine Feature
PSA	Particle Size Analysis
RIAA	Report to Inform Appropriate Assessment
rms	Root Mean Square
SAC	Special Area of Conservation
SBL	Scottish Biodiversity List
ScotMER	Scottish Marine Energy Research
SEL	Sound Exposure Level
SFF	Scottish Fishermen’s Federation
SMP	Sectoral Marine Plan
SNCB	Statutory Nature Conservation Body
SOLAS	International Convention for the Safety of Life at Sea
SPI	Species of Principal Importance
SPL	Sound Pressure Level
SPL_{pk}	Peak Sound Pressure Level
SSC	Suspended Sediment Concentration
SSE	Scottish and Southern Electricity
TTS	Temporary Threshold Shift
TWP	Thistle Wind Partners
UK	United Kingdom
USA	United States of America
USV	Uncrewed Surface Vehicle
UXO	Unexploded Ordnance
WMP	Waste Management Plan
WSDOT	Washington State Department of Transport
WW2	World War Two
ZoI	Zone of Influence

Table of Units

Units	Definition
%	Percent
°C	Degree Celsius
cm	Centimetre
dB	Decibel
g/l	Grams per litre
gauss	Gauss (magnetic induction)
Hz	Hertz
kg	Kilograms
kg/m^3	Kilograms per cubic metre
kg/s	Kilograms per second
kHz	Kilohertz
kJ	Kilojoule
km	Kilometre
km^2	Square kilometre
kV	Kilovolt
m	Metre
mG	Milligauss
mg/l	Milligrams per litre
m^2	Square Metre
m^3	Cubic metres
mT	MilliTesla
mV/m	Millivolt per metre
MW	Megawatt
nm	Nautical mile
V/m	Volts per metre
µPa	Micropascal
µT	MicroTesla (10^{-6} T)
µV/cm	MicroVolt per centimetre
µV/m	MicroVolt per metre

9 Fish and Shellfish Ecology

9.1 Introduction

9.1.1 This chapter of the Offshore Environmental Impact Assessment (EIA) Report presents the assessment of the likely significant effects on Fish and Shellfish Ecology that may potentially occur as a result of the Proposed Development during the construction, Operations and Maintenance (O&M) and decommissioning phases.

9.1.2 The assessment presented is informed by the following technical chapters and reports:

- Volume 2, Chapter 7: Physical Processes;
- Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report; and
- Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report.

9.2 Fish and Shellfish Ecology Study Area

9.2.1 The Fish and Shellfish Ecology Study Area is shown in Figure 9.1 and defined as a 100 km buffer around the Proposed Development, including the Export Cable Corridor, and includes the Firth of Forth and Firth of Tay. As illustrated in Figure 9.1, landmasses have been excluded from this area. However, as diadromous fish migrate between the marine environment and freshwater habitats, it should be noted that the Fish and Shellfish Ecology Study Area also include rivers and other freshwater habitats flowing into it to account for the life histories of diadromous species. Any freshwater-resident fish species within the rivers and freshwater habitats along the coast of the Fish and Shellfish Ecology Study Area are, however, outwith the scope of this assessment.

9.2.2 The Fish and Shellfish Ecology Study Area was presented to and agreed with Statutory Nature Conservation Bodies (SNCBs) during Scoping (MD-LOT, 2024) and has been defined to fully encompass the large spatial and temporal variability of most fish and shellfish species. The defined Fish and Shellfish Ecology Study Area is therefore large enough to consider the Zone of Influence (ZoI) of all direct and indirect impacts associated with the Proposed Development, including impacts from subsea noise, and is an adequate size to characterise the baseline. The Fish and Shellfish Ecology Study Area encompasses the area surveyed during site-specific benthic subtidal and intertidal surveys and Digital Aerial Surveys (DAS) for birds and marine mammals. Where relevant to fish and shellfish, the results of these surveys have been incorporated into the baseline characterisation (see Section 9.5 and Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report).

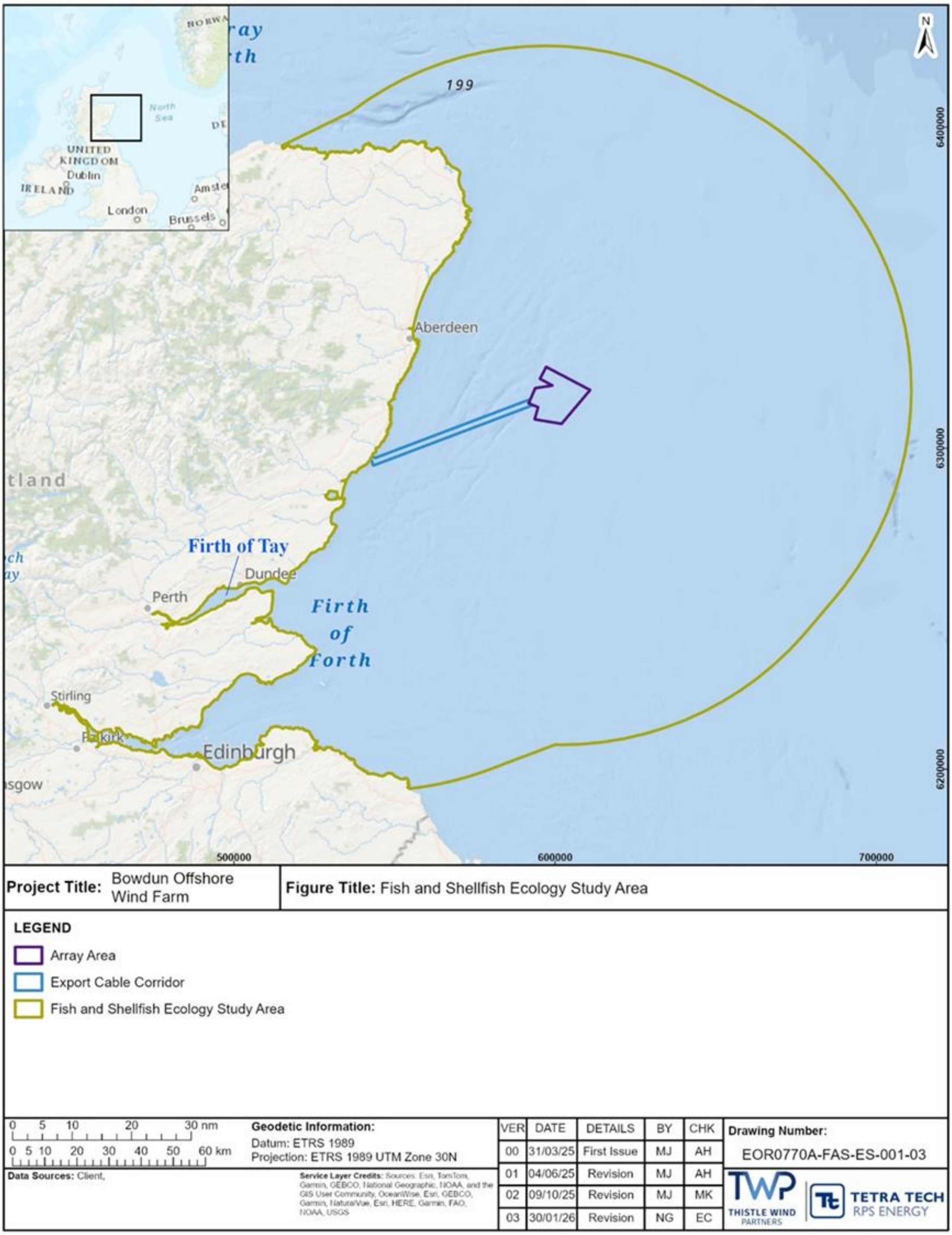

Figure 9.1: Fish and Shellfish Ecology Study Area

9.3 Legislative and Policy Context

9.3.1 The overarching policy and legislation applicable to the Proposed Development is presented in Volume 1, Chapter 2: Policy and Legislation. Policy and legislation specific to fish and shellfish ecology is contained in the Marine and Coastal Access Act (MCAA) 2009, the Habitats Regulations, Scotland's National Marine Plan, the Sectoral Marine Plan (SMP) and the United Kingdom (UK) Marine Policy Statement. A summary of the legislative provisions and policy relevant to fish and shellfish ecology are provided in Table 9.1 to Table 9.6.

Table 9.1: Summary of Legislation and Acts Relevant to Fish and Shellfish Ecology

Summary of Relevant Legislation or Act	How and where considered in the EIA Report
MCCA 2009 Marine Protected Areas (MPAs) (Scottish waters) and Marine Conservation Zones (MCZs) (English waters) existing beyond the 12 nm limit are designated under the MCAA 2009. MPAs and MCZs are areas that have been designated for the purpose of conserving marine flora and fauna, marine habitats, and features of geological or geomorphological interest (Section 117 of the MCAA 2009).	All relevant MPAs in Scottish offshore waters (beyond 12 nm) are listed in Section 9.6, and further described in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report and potential effects on the relevant qualifying features of these are considered in Section 9.10. No MCZs designated for fish and shellfish features were identified in the Fish and Shellfish Ecology Study Area.
Habitat Regulations Before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which is likely to have a significant effect on a European offshore marine site or a European site (either alone or in combination with other plans or projects), and is not directly connected with or necessary to the management of the site, a competent authority must make an appropriate assessment of the implications of the plan or project for that site in view of that site's conservation objectives.	All relevant designated sites are listed in Section 9.6, along with their proximity to the Site Boundary, and potential effects on the relevant qualifying features of these are considered in Section 9.10. In addition, Section 9.12 also considers impacts upon relevant qualifying features of these designated sites from other plans and projects cumulatively with the Proposed Development. Adverse effects on integrity of European sites with Annex II diadromous fish features have been assessed in accordance with the Habitats Regulations in the Report to Inform Appropriate Assessment (RIAA) Part 2: Special Areas of Conservation (TWP-BOW-RPS-ENV-RPT-00014).
The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention; 1979) The principal aims of the Convention are to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention).	These acts and conventions have been used to determine Important Ecological Features (IEFs) status for fish and shellfish ecology. Fish and shellfish species listed under these laws and conventions have been assigned as international or national importance depending on the different legislation that applies to them (see Table 9.13 and Table 9.14).
The Wildlife and Countryside Act 1981 (as amended) The Wildlife and Countryside Act 1981 was enacted primarily to implement the Birds Directive 79/409/EEC and Bern Convention in Great Britain.	
The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention 1992) The Convention for the Protection of the Marine Environment of the North East Atlantic was adopted in Paris, France in September 1992 and entered into force in March 1998. With the adoption of Annex V in 1998, the convention embraced a more holistic responsibility for environmental protection in the region, including its biodiversity.	

Summary of Relevant Legislation or Act	How and where considered in the EIA Report
The Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention 1979) This convention was adopted in Bonn, Germany, on 23 June 1979, and entered into force on 01 November 1983. The Bonn Convention brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range.	
Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 This Act is the key governing legislation for Scotland's District Salmon Fishery Boards, and it sets out the provisions for the constitution, composition and financing of the boards. It is also the framework for a number of other important regulatory areas, including legal methods of fishing and offences, close times, local regulatory measures, protection of juvenile and spawning salmon, passage of salmon, and general powers relating to appointment of water bailiffs and enforcement of salmon and freshwater fisheries law.	
The International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Management Convention) 2004 This is an international maritime treaty which requires signatory flag states to ensure that ships flagged by them comply with standards and procedures for the management and control of ships' ballast water and sediments.	Compliance with this convention will be undertaken by all vessels associated with the Proposed Development as an industry standard.
Marine Strategy Framework Directive (Directive 2008/56/EC) 2008 The Marine Strategy Framework Directive is a European Directive originally aimed at achieving or maintaining Good Environmental Status (GES) in European marine regions and sub-regions.	A range of GES descriptors are relevant to this chapter: • Descriptor 1: Marine biodiversity; • Descriptor 4: Food webs; • Descriptor 6: Seabed integrity; • Descriptor 8: Contaminants; and • Descriptor 11: Energy, including subsea noise. Under this directive, each of these descriptors has a range of goals and targets required to achieve GES. It could be assumed that if all impacts have been concluded as not significant in EIA terms, then the Proposed Development would be acting in a way in which maintains GES, with regards to fish and shellfish ecology.
Marine Strategy Regulations 2010 These regulations transpose Directive 2008/56/EC into UK law and requires action to be taken to achieve or maintain GES in UK seas.	
The Sandeel (Prohibition of Fishing) (Scotland) Order 2024 Prohibits sandeel fishing in Scottish waters.	This Order has been considered as part of the future baseline scenario in Section 9.6 as it came into force on 26 March 2024 and

Summary of Relevant Legislation or Act	How and where considered in the EIA Report
	therefore its effects on the sandeel population to date are not yet clear.

Table 9.2: Summary of Scotland's National Marine Plan relevant to Fish and Shellfish Ecology (Scottish Government, 2015)

Summary of Relevant Policy	How and Where Considered in the Offshore EIA Report
Chapter 4: General Policies	
General Policy 5 (Climate Change): Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.	The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in Section 9.6. Further assessment on climate change in general is presented in Volume 2, Chapter 22: Climatic Change.
General Policy 9 (National Heritage) of the National Marine Plan requires that development and use of the marine environment must: (a) Comply with legal requirements for protected areas and protected species; (b) Not result in a significant impact on the national status of Priority Marine Features (PMFs); and (c) Protect and, where appropriate, enhance the health of the marine area.	Protected fish and shellfish species and PMFs are detailed in Table 9.14. Sections 9.10 and 9.12 present assessments of the significance of the effects of the Proposed Development alone and cumulatively on protected fish and shellfish ecology receptors as well as mitigation measures, where appropriate.
General Policy 9 (National Heritage) paragraph 4.47 of the National Marine Plan: The Marine Acts place a duty on all regulators to ensure that there is no significant risk of hindering the achievement of the conservation objectives of an MPA before giving consent to an activity. Where an ongoing activity presents a significant risk of hindering the achievement of the conservation objectives of an MPA there will be a management intervention. This intervention will be practical and proportionate, utilising the most appropriate statutory mechanism to reduce the risk	Sections 9.10 and 9.12 present assessments of the significance of the effects of the Proposed Development alone and cumulatively on fish and shellfish ecology receptors, including on the features of the relevant designated sites, such as MPAs.
General Policy 10 Invasive Non-Native Species (INNS): Opportunities to reduce the introduction of invasive non-native species to a minimum or proactively improve the practice of existing activity should be taken when decisions are being made.	Embedded Mitigation measures are detailed in Table 9.22, and include the development of and adherence to an Environmental Management Plan (EMP). This will include actions to minimise INNS and will be submitted as part of the application.
General Policy 21 Cumulative impacts: Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.	Section 9.12 assesses the significance of the effects of the Proposed Development cumulatively with other plans and projects.
Chapter 8: Wild Salmon and Diadromous Fish	
WILD FISH 1: The impact of development and use of the marine environment on diadromous fish species should be considered in marine planning	Sections 9.10 and 9.12 include assessments of the significance of the effects of the

Summary of Relevant Policy	How and Where Considered in the Offshore EIA Report
and decision making processes. Where evidence of impacts on salmon and other diadromous species is inconclusive, mitigation should be adopted where practicable and information on impacts on diadromous species from monitoring of developments should be used to inform subsequent marine decision making.	Proposed Development, alone and cumulatively, on diadromous fish species.

Table 9.3: Summary of the PMFs in Scotland's Seas relevant to Fish and Shellfish Ecology (NatureScot, 2020)

Summary of Relevant Policy	How and Where Considered in the Offshore EIA Report
Fish and Shellfish Species	
PMFs are habitats and species that NatureScot have considered to be conservation priorities in Scottish waters. These include 32 species of fish and shellfish, including elasmobranch species and one decapod crustacean.	Relevant PMFs are identified in Table 9.14. Sections 9.10 and 9.12 include assessments of the significance of the effects of the Proposed Development, alone and cumulatively, on PMFs within the Fish and Shellfish Ecology Study Area, where an impact pathway exists.

Table 9.4: Summary of the SMP for Offshore Wind Energy relevant to Fish and Shellfish Ecology (Scottish Government, 2020)

Summary of Relevant Policy	How and Where Considered in the Offshore EIA Report
General Policies	
The potential adverse effects on other marine users, economic sectors and the environment resulting from further commercial scale offshore wind development should be reduced.	The potential for adverse effects on the identified environmental (i.e. fish and shellfish) receptors are considered fully in Section 9.10 with consequent effects on other environmental receptors (e.g. marine mammals and offshore ornithology) and commercial fisheries considered in Volume 2, Chapters 10, 11 and 13, respectively. The cumulative effects of the Proposed Development alongside other plans and projects are assessed in Section 9.12.
Offshore Wind and Marine Renewable Energy Policies	
Regional cumulative effects include the potential for negative effects on bird populations, benthic habitats, cetaceans, navigational safety, seascape/landscape and commercial fisheries. The SMP includes measures to mitigate potential impacts at various scales.	Potential cumulative effects of the Proposed Development alongside plans and projects have been assessed in Section 9.12.

Table 9.5: Summary of the UK Marine Policy Statement relevant to Fish and Shellfish Ecology (UK Government, 2011)

Summary of Relevant Policy	How and Where Considered in the Offshore EIA Report
Ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species and our heritage assets.	The potential for adverse effects on fish and shellfish receptors within the marine environment has been considered fully in Section 9.10. The cumulative effects of the Proposed Development alongside other plans and projects have been assessed in Section 9.12.
The marine environment plays an important role in mitigating climate change.	The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in Section 9.6. Further assessment on climate change in general is presented in Volume 2, Chapter 22: Climatic Change.
Biodiversity is protected, conserved and where appropriate recovered and loss has been halted.	The potential for adverse effects on the biodiversity of fish and shellfish species within the marine environment has been considered fully in Section 9.10. The cumulative effects of the Proposed Development alongside other plans and projects have been assessed in Section 9.12.
Marine businesses are acting in a way which respects environmental limits and is socially responsible.	This chapter considers the possibility for the Proposed Development to restrict environmental limits with regards to fish and shellfish ecology. It could be assumed that if all impacts have been concluded as not significant in EIA terms, then the Proposed Development would be acting in a way in which respects environmental limits, with regards to fish and shellfish ecology.

Table 9.6: Summary of the National Planning Policy Framework 4 (Scottish Government, 2023a)

Summary of Relevant Policy	How and Where Considered in the Offshore EIA Report
Part 2 – National Planning Policy: Climate mitigation and adaptation To encourage, promote and facilitate development that minimises emissions and adapts to the current and future impacts of climate change.	The impact of climate change on the baseline environment and how this may influence the assessment of effects is considered as part of the future baseline in Section 9.6. Further assessment on climate change in general is presented in Volume 2, Chapter 22: Climatic Change.
Part 2 – National Planning Policy: Biodiversity To protect biodiversity, reverse biodiversity loss, deliver positive effects from development and strengthen nature networks.	The potential for adverse effects on the biodiversity of fish and shellfish species within the marine environment has been considered fully in Section 9.6. The cumulative effects of the Proposed Development alongside other plans and projects have been assessed in Section 9.12.

9.4 Consultation

9.4.1 The approach to consultation for the Proposed Development is set out in Volume 1 Chapter 5: Consultation and Engagement. A summary of the issues raised during consultation activities undertaken to date specific to fish and shellfish ecology is presented in Table 9.7, together with how these issues have been considered in the production of this assessment. Further detail is presented within Volume 1, Chapter 5: Consultation and Engagement, Volume 3, Technical Appendix 5.1: Consultation Log, and Volume 3, Technical Appendix 5.2: Pre-Application Consultation Report.

Table 9.7: Summary of Key Consultation Issues Raised During Consultation Activities Undertaken for the Proposed Development Relevant to Fish and Shellfish Ecology

Date	Consultee and Type of Consultation	Summary of Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
25/04/2024	NatureScot: Scoping Workshop	Queried if basking sharks would be included in the fish and shellfish assessment. Presenter confirmed that basking sharks would be included.	The potential for impacts to basking shark have been considered throughout the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12). Mitigation measures are detailed in Section 9.9.
	NatureScot: Scoping Workshop	The impacts proposed to be scoped in were sufficient as long as the Proposed Development uses only fixed foundation turbines. Added that since floating turbines are also being considered, impacts such as aggregation and secondary entanglement should be included.	Floating Wind Turbines are no longer being considered as part of the design envelope for the Proposed Development, therefore 'impacts to fish and shellfish species due to entanglement' is no longer a potential impact and has been scoped out of this assessment. Fish aggregation around hard structures has been considered under the impact 'introduction of artificial habitat and subsequent colonisation' and the impact of changes in prey availability has been assessed in Volume 2, Chapter 10: Marine Mammals and Volume 2, Chapter 11: Offshore Ornithology.
	NatureScot: Scoping Workshop	Recommendation for more data sets to be used in the impact assessment.	The data sources utilised throughout the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12). are listed in Section 9.5.
	Marine Directorate – Licensing Operations Team (MD-LOT) and NatureScot: Scoping Workshop	Post-workshop advice included clarification on: inclusion or exclusion of the River Spey Special Area of Conservation (SAC) from the EIA and Habitat Regulations Appraisal (HRA); Data available on Marine Scotland National Marine Plan Interactive (NMPi); additional impacts for inclusion in the cumulative effectives assessment; and likely significant effect screening criteria for diadromous fish.	See rows below.
30/09/2024	Fisheries Management Scotland (FMS): Scoping Opinion	Across Scotland, wild salmon populations are in crisis, and face a range of pressures, some of which are under human control. The Scottish Government have published a wild salmon strategy and implementation plan, which sets out the actions to be taken over a five year period to 2028. The implementation plan includes a number of actions under the heading of "*understanding and mitigating pressures in the marine and coastal environment*".	The Wild Salmon Strategy and Implementation Plan (Scottish Government, 2023b) has been considered throughout the assessment, where relevant.
		Where salmon populations are below their conservation limits, any additional pressure, including from marine renewables, cannot be considered sustainable. Scottish salmon rivers are categorised by the Scottish Government under The Conservation of Salmon (Scotland) Regulations 2016, according to the likelihood of them meeting their conservation limits. The most recent river gradings have been published for 2024. There are now 112 rivers across Scotland graded as Category 3, meaning there is a less than 60% probability of meeting their conservation limit. It is now well-recognised that populations of Atlantic salmon have rapidly deteriorated across their native range. In the latest species reassessment by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, released in December 2023, Atlantic salmon have been reclassified from 'Least Concern' to 'Endangered' in Great Britain (as a result of a 30-50% decline in British populations since 2006 and 50-80% projected between 2010-2025), and from 'Least Concern' to 'Near Threatened' in terms of global populations (as a result of global populations declines of 23% since 2006).	The most recent IUCN status has been included to determine IEF status (Table 9.13 and Table 9.14).
		We note, and support, the recent position that the Marine Directorate have taken - "*Marine Scotland Science (MSS) do not consider it appropriate for an EIA/HRA to conclude there is no or negligible impact just because no evidence exists of the impact. MSS advise that impacts to diadromous fish must be adequately investigated, rather than relying on a lack of evidence to claim there is no impact*".	The potential for impacts to diadromous fish have been considered throughout the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12). Mitigation measures are detailed in Section 9.9.
		There are 17 SAC for which Atlantic salmon are either a primary reason for designation or a qualifying feature. For sea lamprey, there are six SAC sites and for river lamprey, there are six SAC sites. For freshwater pearl mussel, there are 19 SAC sites. We consider that the SAC rivers identified in the Scoping Report are appropriate from a Scottish perspective, but thought should be given to including SAC rivers from the east coast of England.	A total of six SACs and one MPA were identified within the Fish and Shellfish Ecology Study Area (Table 9.12). The total number of SACs are noted, and the Applicant acknowledges the importance of these species, however the assessment is focussed only on those sites within the defined Fish and Shellfish Ecology Study Area to ensure a proportionate approach to assessment. The Fish and Shellfish Ecology Study Area is suitably sized to incorporate the migration routes of diadromous fish in the North of Scotland (see Volume 3, Technical Appendix 9.1:

Date	Consultee and Type of Consultation	Summary of Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
			Fish and Shellfish Ecology Technical Report for further details) and does not extend to encompass any SACs along the east coast of England.
		Whilst there is often a focus on rivers designated at SACs, it is important to recognise that the drivers behind declines in wild salmon and sea trout, and other species of migratory fish, affect all rivers to a greater or lesser extent. In recognition that the marine phases of both Atlantic salmon and sea trout are included on the list of PMFs - the habitats and species of greatest conservation importance in inshore waters – we consider that all relevant rivers should be fully considered in the consenting and assessment process.	Within Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report, the PMF status of all diadromous fish has been discussed (alongside other conservation designations) and used as part of the determination of their IEF status for assessment. All relevant rivers have also been included as part of the assessment (Table 9.14).
		Under Scottish Marine Energy Research (ScotMER), the Diadromous Fish Receptor Group has identified evidence gaps related to the health, distribution, and impacts on Diadromous fish (salmon, sea trout, etc.). Scottish Government has published an 'evidence map' (available for download at the above link) which identifies and scores these evidence gaps according to a specific prioritisation process. It is important that each of these evidence gaps is considered in full by the applicant, and developers should contribute to filling these evidence gaps as a specific condition of consent.	This evidence map has been consulted and used to inform the assessment of diadromous fish within this chapter. See Section 9.6.
		In order to properly assess Environmental Statements for developments, information on the use of the development area by diadromous fish should be provided. If such information is lacking then a suitable monitoring strategy should be devised, either for the site in question or through contributing to strategic projects undertaken through ScotMER. Any monitoring strategies must include pre-construction monitoring in order that baseline information on movement, abundance, swimming depth, feeding behaviour etc. can be collected	The most recent desktop outputs from ScotMER have been used in the baseline characterisation (Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report). At the time of writing, this included Honkanen *et al.* (2024), which provided a detailed literature review about the potential for diadromous species to overlap with offshore wind projects in Scotland (including the Proposed Development). The need for any monitoring has not yet been confirmed; however the Applicant notes the upcoming ScotMER projects regarding diadromous fish. When available, any relevant results from this will be included within the Project Environmental Monitoring Programme (PEMP), to be developed post-consent.
		Offshore renewable developments have the potential to directly and indirectly impact diadromous fish. We would therefore expect developers to assess and, where necessary, mitigate the potential impacts of deployed devices on such fish during the deployment, operation and decommissioning phases. These potential impacts have been highlighted through ScotMER, and include: • Avoidance (including exclusion from particular rivers and subsequent impacts on local populations); • Disorientation effects that could potentially affect behaviour, susceptibility to predation or by-catch; and • Impaired ability to locate normal feeding grounds or river of origin; and delayed migration	The potential for diadromous fish to be adversely affected by the Proposed Development has been considered both alone (Section 9.10) and cumulatively (Section 9.12). This assessment includes consideration of potential effects on fish migration behaviour, including avoidance, disorientation and impairment of navigational or homing ability. Mitigation measures are detailed in Section 9.9.
		FMS request that, in addition to the evidence gaps identified by ScotMER, the EIA considers the effects of predator aggregation (e.g. large gadoids/grey seals) around the proposed development on migrating salmonids at both the smolt and adult stages and, additionally, physical barrier effects on salmon during construction and operation (e.g. noise, shadow flicker). In this regard, it should be noted that NatureScot has formally conceded that shadow flicker from moving Wind Turbine blades (and also the direct visual effects of moving blades) may adversely affect salmonids in freshwater habitat. Since exactly the same physical principles apply in the marine environment, surface-orientated fish like salmonids are likely to be exposed to equivalent adverse effects.	Key prey species have been identified within Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report, and as part of the determination of IEFs (Table 9.13 and Table 9.14). Impacts to the spawning and nursery grounds of these species has been factored into the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12), in order to determine population level effects to these prey species. The results of the fish and shellfish ecology assessment have been drawn into the assessments for other receptor groups, such as marine mammals and offshore ornithology to consider specific effects relating to specific prey species and prey availability. The Applicant concluded in the Response to Scoping Opinion that shadow flicker and visual effects would not generate a significant effect for fish receptors, both on an individual and population-level scale (TWP, 2025). The only published study on the effect of shadow flicker on a diadromous fish species focussed on Atlantic salmon within rivers (Dodd and Briers, 2021). This study concluded that there is no specific evidence available to support or refute any biological or ecological impact

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			of shadow flicker from Wind Turbine blades on Atlantic salmon and that any potential impact of offshore Wind Turbines was outwith the scope of the study (Dodd and Briers, 2021). Literature investigating the potential impacts from Wind Turbine shadow flicker (in the form of flickering light) relates to research on possible human impacts (Haac *et al.*, 2022; Harding *et al.*, 2008; Nordman, 2010). In the offshore environment, Atlantic salmon and sea trout commonly swim from near the surface down to multiple tens of metres in depth (Godfrey *et al.*, 2015; Holm *et al.*, 2006), and therefore have the potential to be exposed and/or receptive to visual stimuli, associated with offshore infrastructure. Taking into consideration the distance of the Wind Turbines from the coast (where it is anticipated that visual, olfactory, and or magnetic stimuli for diadromous fish returning to natal rivers play an important navigational role (Cresci *et al.*, 2017; Hasler and Scholz, 1983; Hedger *et al.*, 2008; Keefer and Caudill, 2014), it is not expected that the Wind Turbines will result in behavioural responses in diadromous species during migration. Furthermore, considering the height of the Wind Turbine blades above the surface of the water, in the context of other visual stimuli such as distortions of the water surface, rough and turbid sea state, annual daylight hours and cloud cover, it is unlikely that shadow flicker effects will have significant adverse effects on diadromous fish. A recent study by (Williamson *et al.*, 2024) concluded that, based on an evaluation of theory, whilst it is theoretically possible for Wind Turbines to generate visual cues for aquatic receptor organisms and that the cues have the potential to be aversive (Williamson *et al.*, 2024), further research is required to generate any direct evidence of potential impacts. The paper presented the physics involved to support the formulation and testing of a biological hypotheses to investigate the potential direct visual and flicker effects but did not draw any conclusions on potential impacts (Williamson *et al.*, 2024). The purpose of this EIA is to identify and proportionately assess significant impacts upon fish and shellfish receptors using the best available scientific evidence. Where available, industry guidance has also been utilised (such as the Scottish Government's Wild Salmon Strategy (2022) or Wild Salmon Strategy Implementation Plan (2023b)). The Applicant considers the information presented to be sufficient evidence to scope out the impact of shadow flicker on fish and shellfish receptors, with a particular emphasis on diadromous fish. This aligns with the approach taken by other OWFs in the area, such as Muir Mhòr OWF (2024).
		It should be emphasised that we have no wish to prevent or delay any proposed development unnecessarily and we remain keen to work constructively with the developers and Marine Scotland to identify appropriate monitoring programmes which will allow us to be able to assess the acknowledged risks of this development, and other proposed developments in a more appropriate manner. There is a clear and urgent need to fund, plan and start strategic research on the movement, abundance, swimming depth, feeding behaviour and impact pathways relevant to diadromous fish. Such research would clearly feed into the potential mitigation measures that might be deemed appropriate, and the conditions under which such mitigation should be enacted. Developers should be required to work together to fund strategic monitoring, in order to allow more certainty for all involved.	The need for any monitoring has not yet been confirmed; however the Applicant notes the upcoming ScotMER projects regarding diadromous fish. When available, any relevant results from this will be included within the PEMP, to be developed post-consent.
18/10/2024	NatureScot: Scoping Response	Consideration of the Export Cable Corridor in nearshore waters should assess impacts to diadromous fish species, particularly Atlantic Salmon from key East coast salmon rivers such as the Rivers South Esk and Dee, that are in proximity to the Landfall area.	The potential for impacts to diadromous fish, including Atlantic salmon, have been considered throughout the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12). Mitigation measures are detailed in Section 9.9.
		For basking shark, we recommend including the following data sources: Witt *et al.* (2012); Witt *et al.* (2014); Witt *et al.* (2016); Austin *et al.* (2019); and Pikesley *et al.* (2024).	The additional data sources provided by NatureScot have been incorporated into the baseline for basking shark, presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report.

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		Should the analysed site-specific benthic ecology survey data indicate the likely presence of other species, we advise that these additional species will need to be included within the EIA Report. Furthermore, benthic survey data should be used to help inform suitable fish habitat modelling as well as to determine suitable sandeel habitat and/or herring spawning habitat.	The results of the site-specific benthic surveys have been included in the baseline presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report, where relevant. The Particle Size Analysis (PSA) data collected during the benthic subtidal survey has been used to inform habitat suitability for sandeel and herring (see Section 9.6).
		We specifically welcome the ScotMER project *Diadromous Fish in the Context of Offshore Wind – Review of Current Knowledge & Future Research*, due to be published soon. This research may change conclusions on how diadromous fish are treated in both EIA and HRA going forward. However, we advise, based on evidence currently available to us, it is not possible for us to carry out an assessment of diadromous fish to the level required under HRA. We therefore advise that diadromous fish species should be assessed through EIA only and not through HRA.	The most recent desktop outputs from ScotMER have been used in the baseline characterisation (Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report). At the time of writing, this included Honkanen *et al.* (2024), which provided a detailed literature review about the potential for diadromous species to overlap with offshore wind projects in Scotland (including the Proposed Development).
		As underwater noise modelling is not yet completed, we consider it to be premature to screen out the Turbot Bank MPA and advise this MPA is screened in until the noise modelling is complete to allow for the proposed further assessment following underwater noise modelling.	Sandeel (the qualifying feature) of this MPA have been included within this fish and shellfish ecology chapter as an IEF and have been assessed accordingly. The potential impacts on sandeel from underwater sound are considered within Section 9.10. The Turbot Bank Nature Conservation MPA ("ncMPA") is located 35.8 km from the Bowdun Array Area and 46.0 km from the Export Cable Corridor at its closest point. The underwater noise modelling results show that (for unmitigated concurrent 15 m monopile installation based on the cumulative Sound Exposure Level (SEL) metric for static fish) mortality could occur out to a range of 1.99 km and recoverable injury out to 2.81 km for Group 1 fish species (see Table 9.37). It's noted that any potential short-term changes in hearing sensitivity (temporary threshold shift) are modelled out to ranges of 25 km for all hearing groups. The distance to the Turbot Bank ncMPA illustrates that behavioural disturbance from piling is not likely to impact the sandeel feature of the Turbot Bank ncMPA.
		Consideration of impacts to the species listed in paragraph 10.1.25 should be undertaken particularly if there is likely to be any impact on the national status of these species from this proposal. This assessment may be qualitative, but should provide the context of impact pathways, impacts and any mitigation.	Relevant PMFs are identified in Table 9.14 and, where a potential impact pathway exists, have been considered, alone and cumulatively, on PMFs within the Fish and Shellfish Ecology Study Area, where an impact pathway exists (see Sections 9.10 and 9.12)
		The potential impacts proposed to be scoped in and out for fish and shellfish are outlined in Tables 10.6 and 10.7 respectively. We are generally content with what is proposed.	The response was welcomed and the proposed scope for fish and shellfish ecology has been taken forward as set out in the relevant assessment (see Sections 9.10 and 9.12).
		Fish aggregation around the Wind Turbines and other hard structures should also be included for relevant fish species. This would need to be considered with other receptors in mind (e.g. marine mammals and ornithology). Fish aggregation around Wind Turbines should be addressed whether fixed or floating Wind Turbines are to be deployed.	Fish aggregation around hard structures has been considered under the impact 'introduction of artificial habitat and subsequent colonisation' and the impact of changes in prey availability has been assessed in Volume 2, Chapter 10: Marine Mammals and Volume 2, Chapter 11: Offshore Ornithology.
18/10/2024	NatureScot: Scoping Response	The EIA Report should clearly set out impacts to key prey species (such as sandeel, herring, mackerel and sprat) and their habitats arising from the development alone and cumulatively with other wind farms. Consideration of how this loss and or disturbance may affect the recruitment of key prey (fish) species through impacts to important spawning or nursery ground habitats should also be assessed (PrePARED (Predators and Prey Around Renewable Energy Developments) project may be helpful in understanding predator-prey relationships in and round offshore windfarms).	Key prey species have been identified within the Fish and Shellfish Ecology Technical Report, and as part of the determination of IEFs (Table 9.13 and Table 9.14). Impacts to the spawning and nursery grounds of these species has been factored into the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12), in order to determine population level effects to these prey species. The results of the Fish and Shellfish Ecology assessment have been drawn into the assessments for other receptor groups, such as marine mammals and offshore ornithology to consider specific effects relating to specific prey species and prey availability.
		Electromagnetic field (EMF) impacts should be considered in the cumulative assessment (due to the proposed number of offshore wind developments in Scottish waters, we are concerned that the spatial and temporal scale is not being sufficiently considered cumulatively across the network of cables)	The impact of EMF has been assessed for the Proposed Development alone (Section 9.10) and cumulatively with other plans and projects (Section 9.12).
		Embedded Mitigation is presented in Section 10.5 and Appendix A: Draft Schedule of Mitigation and Commitments. Whilst the mitigation presented isn't directly related to fish and shellfish, it will indirectly reduce the impacts of the development on fish and	Embedded Mitigation relevant to the assessment on fish and shellfish ecology are outlined in Section 9.9, with proposed monitoring outlined in Section 9.13. Where mitigation is relevant specifically to basking shark, this has been stated. USVs and

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		shellfish. Therefore, we agree with the Embedded Mitigation presented at this point, however, should the EIA assessment show that further mitigation is needed for fish and shellfish, this should be addressed.	AUVs are not currently anticipated; however, should their use be proposed, further consultation will be undertaken to agree appropriate mitigation.
		For basking shark, we advise that any mitigation for marine mammals should also be applied to basking sharks. Furthermore, if Uncrewed Surface Vehicles (USVs) or Autonomous Underwater Vehicles (AUVs) are to be used then we recommend further consultation to agree on appropriate mitigation for basking sharks (and also marine mammals).	
25/10/2024	Scottish Fishermen's Federation (SFF): Scoping Response	The 'impacts to fish and shellfish species due to entanglement' during construction and decommissioning should also be scoped in as construction and decommissioning also take a considerable amount of time (c.5 years for this Proposed Development for construction only).	Floating Wind Turbines are no longer being considered as part of the design envelope for the Proposed Development, therefore 'impacts to fish and shellfish species due to entanglement' is no longer a potential impact and has been scoped out of this assessment.
		SFF furthermore note from sub-section 10.4.14 (p169) that the Scoping Boundary including both the Development Array Area (DAA) and Export Cable Corridor totally overlaps with the spawning and nursery grounds of some commercially important demersal and pelagic fish species (including, cod, haddock, whiting, herring and sandeel). Therefore, we propose any survey activities and other seabed disturbances should be undertaken outwith spawning and nursery periods of the above-mentioned fish species to avoid juvenile fish mortality.	The spawning and nursery grounds within the Fish and Shellfish Ecology Study Area are presented in Table 9.10, and spawning periods are presented in Table 9.11. Further information (including figures) is presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report. Should any surveys be undertaken then the spawning and nursery periods will be considered.
		SFF note from sub-sections 9.4.3 (p128, Benthic Ecology) that the Local Benthic Ecology Study Area seabed is suitable for herring spawning. Therefore, the SFF are concerned about the Development impacts on all commercial value fish species in the area, especially on the herring which are also particularly sensitive to noise impacts on hearing through the swim bladder.	A herring spawning habitat suitability assessment has been undertaken using site-specific sediment composition data along with publicly available sediment composition data, where available. This is presented within Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report and summarised in Section 9.6. Impacts to herring spawning habitat have been fully assessed under the impacts of temporary and long term habitat loss, and increased Suspended Sediment Concentrations (SSCs) and associated deposition (Sections 9.10 and 9.12). The impact of subsea noise has also been assessed for all phases, with herring considered throughout (Sections 9.10 and 9.12).
		We are of the view that any activities on herring spawning habitat are prohibited based on the 'International Council for the Exploration of the Seas (ICES) Advice on fishing opportunities, catch, and effort Greater North Sea ecoregion' published 31 May 2024. Therefore, SFF propose the above-mentioned ICES advice to be taken into account and acted upon at determination stage. The link to ICES advice on Greater North Sea herring is provided as follows: North Sea herring ICES Advice.	It should be noted that the advice published 31 May 2024, has since been replaced on the 13 November 2024 (ICES, 2024a) and 30 April 2025 (ICES, 2025a). This advice states that: "*no activities on spawning habitats should be allowed unless the effects of these activities have been assessed and shown not to be detrimental.*" Potential impacts on herring are considered within Sections 9.10 and 9.12 of this chapter. As no significant effects upon herring are concluded from the assessment of the Proposed Development, alone or cumulatively with other plans and projects, the Proposed Development is considered to align with this ICES advice.
15/11/2024	MD-LOT: Scoping Opinion	The Scottish Ministers, in line with the NatureScot EIA response, are content with the study area proposed but consideration of the Export Cable Corridor in nearshore waters should assess the impacts to diadromous fish species that are in proximity to the Landfall area.	The potential for impacts to diadromous fish, including Atlantic salmon, have been considered throughout the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12). Mitigation measures are detailed in Section 9.9.
		The NatureScot EIA response provides additional data sources recommended for use when considering basking sharks. The Scottish Ministers advise the Developer to consider these additional data sources as part of its EIA Report.	The additional data sources provided by NatureScot have been incorporated into the baseline for basking shark, presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report.
		Furthermore, with regards to data sources, FMS notes in its representation that the Diadromous Fish Receptor Group under ScotMER has identified evidence gaps relating to health, distribution and impacts on diadromous fish species including, but not limited to, salmon and sea trout. The Scottish Ministers direct the Developer to the evidence map referenced in the NatureScot and FMS representation and advise the Developer to consider these evidence gaps fully in the EIA Report.	This evidence map has been consulted and used to inform the impacts considered in the assessment of diadromous fish, where appropriate. For example, based on evidence gaps and key research questions in this ScotMER resource, the following impacts have been considered for diadromous fish receptors: • impacts due to EMF; • fish aggregation around renewable energy devices (under 'introduction of artificial habitat and subsequent colonisation'); and • impacts associated with subsea noise.

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			In addition, the assessment on diadromous fish considers whether migration (and thus connectivity between marine and freshwater habitats) may be impacted. This is a key research question highlighted throughout the evidence map.
		The Scottish Ministers agree with FMS that information on the baseline use of the Proposed Development area by diadromous fish should be provided in the EIA Report. If the Developer is unable to produce such information, then a suitable monitoring strategy should be devised and detailed in full, either as part of the EIA Report or as an Appendix.	The most recent desktop outputs from ScotMER have been used in the baseline characterisation (Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report). At the time of writing, this included Honkanen *et al.* (2024), which provided a detailed literature review about the potential for diadromous species to overlap with offshore wind projects in Scotland (including the Proposed Development). There are no monitoring studies currently proposed or confirmed, however the Applicant notes the upcoming ScotMER projects regarding diadromous fish. When available, results of these will be presented in a future PEMP.
		As noted in Section 5.4.2 of this Scoping Opinion, the results of the site specific benthic surveys are not yet available and, therefore, could not be provided within the Scoping Report. The Scottish Ministers advise that, once it is analysed, and if the data indicates that other species are present, then any additional species should be included in the EIA Report. Additionally, the benthic ecology survey sampling should be used to determine suitable sandeel habitat and/or herring spawning habitat. This is supported by the NatureScot EIA response.	The results of the site-specific benthic surveys have been included in the baseline presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report, where relevant. The PSA data collected during the benthic subtidal survey has been used to inform habitat suitability for sandeel and herring (see Section 9.6).
		The Scottish Ministers agree with the Developer's intention to scope in potential impacts of Unexploded Ordnance (UXO) clearance in terms of subsea noise during the construction phase of the Proposed Development. However, the Scottish Ministers also note the representation from the MOD which states that the potential presence of UXOs and disposal sites should also be considered for the decommissioning phase and where any other intrusive works may take place. The Scottish Ministers therefore advise that the potential impacts of UXO clearance be scoped in for all stages of the Proposed Works.	The Applicant confirms that the impact of injury and disturbance from subsea noise generated during UXO clearance has been scoped in only for the construction phase (as set out in Table 11.9 of the Bowdun Scoping Report (BOWFL, 2024)). This is considered appropriate on the basis that all UXO posing a risk to construction activities would also be relevant to the decommissioning phase and therefore will have been cleared during the construction phase. The Applicant therefore believes that it would not be appropriate to present an assessment for the decommissioning phase additionally.
		Table 10.6 and Table 10.7 within the Scoping Report note the impacts proposed to be scoped into and scoped out of the fish and shellfish ecology assessment in the EIA Report. Per the NatureScot and FMS responses, the Scottish Ministers agree that fish aggregation around the Wind Turbine and other hard structures should also be considered for relevant species, regardless of whether fixed or floating foundations are being used. Additionally, the Scottish Ministers, in line with the FMS representation, advise that shadow flicker and direct visual effects from moving Wind Turbine blades should be scoped in for further assessment within the EIA Report.	The Applicant concluded that shadow flicker and visual effects would not generate a significant effect for fish receptors, both on an individual and population-level scale. The only published study on the effect of shadow flicker on a diadromous fish species focussed on Atlantic salmon within rivers (Dodd and Briers, 2021). This study concluded that there is no specific evidence available to support or refute any biological or ecological impact of shadow flicker from Wind Turbine blades on Atlantic salmon and that any potential impact of offshore Wind Turbines was outwith the scope of the study (Dodd and Briers, 2021). Literature investigating the potential impacts from Wind Turbine shadow flicker (in the form of flickering light) relates to research on possible human impacts (Haac *et al.*, 2022; Harding *et al.*, 2008; Nordman, 2010). In the offshore environment, Atlantic salmon and sea trout commonly swim from near the surface down to multiple tens of metres in depth (Godfrey *et al.*, 2015; Holm *et al.*, 2006), and therefore have the potential to be exposed and/or receptive to visual stimuli, associated with offshore infrastructure. Taking into consideration the distance of the Wind Turbines from the coast (where it is anticipated that visual, olfactory, and or magnetic stimuli for diadromous fish returning to natal rivers play an important navigational role (Cresci *et al.*, 2017; Hasler and Scholz, 1983; Hedger *et al.*, 2008; Keefer and Caudill, 2014) it is not expected that the Wind Turbines will result in behavioural responses in diadromous species during migration. Furthermore, considering the height of the Wind Turbine blades above the surface of the water, in the context of other visual stimuli such as distortions of the water surface, rough and turbid sea state, annual daylight hours and cloud cover, it is unlikely that shadow flicker effects will have significant adverse effects on diadromous fish. A recent study by Williamson *et al.* (2024) concluded that, based on an evaluation of theory, whilst it is theoretically possible for Wind Turbines to generate visual

Date	Consultee and Type of Consultation	Summary of Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
			cues for aquatic receptor organisms and that the cues have the potential to be aversive (Williamson *et al.*, 2024), further research is required to generate any direct evidence of potential impacts. The paper presented the physics involved to support the formulation and testing of a biological hypotheses to investigate the potential direct visual and flicker effects but did not draw any conclusions on potential impacts (Williamson *et al.*, 2024). The purpose of this EIA is to identify and proportionately assess significant impacts upon fish and shellfish receptors using the best available scientific evidence. Where available, industry guidance has also been utilised (such as the Scottish Government's Wild Salmon Strategy (2022) or Wild Salmon Strategy Implementation Plan (2023b)). The Applicant considers the information presented to be sufficient evidence to scope out the impact of shadow flicker on fish and shellfish receptors, with a particular emphasis on diadromous fish. This aligns with the approach taken by other OWFs in the area, such as Muir Mhòr OWF (2024). NatureScot has confirmed in post Scoping correspondence (dated 04 December 2025) that they agree with this conclusion and do not require an assessment of shadow flicker to be carried out. Fish aggregation around Wind Turbine foundations and other hard structures has been considered within the assessment for relevant species in Section 9.10. This includes consideration of potential changes in habitat availability and prey aggregation associated with the introduction of artificial structures.
		The Scottish Ministers acknowledge the MPA screening assessment included in Appendix D of the Scoping Report. This assessment concludes that underwater noise will not be capable of affecting, other than insignificantly, the qualifying sandeel feature of the Turbot Bank ncMPA and Southern Trench ncMPA and are therefore proposed to be screened out. As underwater noise modelling is still to be undertaken, the Scottish Ministers consider it premature to scope out effects on the Turbot Bank ncMPA and Southern Trench ncMPA at this stage and advise that both are scoped in, pending the results of the underwater noise modelling. This is supported by the NatureScot EIA response.	Sandeel (the qualifying feature) of the Turbot Bank ncMPA have been included within this fish and shellfish ecology chapter as an IEF and have been assessed accordingly. The potential impacts on sandeel from underwater sound are considered within Section 9.10. The Turbot Bank ncMPA is located 35.8 km from the Array Area and 46.0 km from the Export Cable Corridor at its closest point. The underwater noise modelling results show that (for unmitigated concurrent 15 m monopile installation based on the cumulative Sound Exposure Level (SEL) metric for static fish) mortality could occur out to a range of 1.99 km and recoverable injury out to 2.81 km for Group 1 fish species (see Table 9.37). It's noted that any potential short-term changes in hearing sensitivity (temporary threshold shift) are modelled out to ranges of 25 km for all hearing groups. The distance to the Turbot Bank ncMPA illustrates that behavioural disturbance from piling is not likely to impact the sandeel feature of the Turbot Bank ncMPA. The Southern Trench ncMPA does not include any fish species that are qualifying features of the site. Relevant qualifying features of the site (burrowed mud and minke whale) have been considered in Volume 2, Chapter 8: Benthic Ecology and Volume 2, Chapter 10: Marine Mammals.
		In line with the representation made by SFF, Scottish Ministers advise that potential impacts to fish and shellfish species caused by entanglement should be scoped in for both the construction and decommissioning phases as well as the operational phase, detailed in the Scoping Report, of the Proposed Development.	Floating Wind Turbines are no longer being considered as part of the design envelope for the Proposed Development, therefore 'impacts to fish and shellfish species due to entanglement' is no longer a potential impact and has been scoped out of this assessment.
		The Scottish Ministers acknowledge Section 10.1.26 within the Scoping Report which notes the relevant Embedded Mitigation measures to fish and shellfish ecology. These measures do not directly relate to fish and shellfish but will indirectly reduce the impacts of the Proposed Development on fish and shellfish receptors. The Scottish Ministers acknowledge that these measures will evolve throughout the EIA process and, therefore, are content with what is presented currently. However, should the EIA assessment show that further mitigation is needed for fish and shellfish this should be addressed within the EIA Report. This is supported by the NatureScot EIA response.	Embedded Mitigation relevant to the assessment on fish and shellfish ecology is outlined in Section 9.9, with proposed monitoring outlined in Section 9.13. Where mitigation is relevant specifically to basking shark, this has been stated.
		The Scottish Ministers agree with FMS that the Developer is expected to assess and, where necessary, mitigate the potential impacts of the Proposed Development on	The most recent desktop outputs from ScotMER have been used in the baseline characterisation (Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology

Date	Consultee and Type of Consultation	Summary of Issue(s) Raised	Response to Issue Raised and/or Where Considered in this Chapter
		diadromous fish across the lifespan of the Project. The Scottish Ministers also agree with the potential impacts in the FMS representation, for consideration within the EIA Report. This includes both the list of potential impacts highlighted by ScotMER and the further points identified by the FMS.	Technical Report). At the time of writing, this included Honkanen *et al.* (2024), which provided a detailed literature review about the potential for diadromous species to overlap with offshore wind projects in Scotland (including the Proposed Development).
		The Scottish Ministers, in line with the NatureScot EIA response, advise that the EIA Report should clearly set out the impacts to key prey species and their habitats arising from the Proposed Development alone and cumulatively with other wind farms. The Scottish Ministers acknowledge the need to understand impacts at the ecosystem scale; therefore, advise that consideration across key trophic levels will enable a better understanding of the consequences of any potential changes in prey distribution and abundance on marine mammal interests and how this may influence population level impacts. Additionally, the Scottish Ministers advise that consideration of how this loss and/or disturbance may affect the recruitment of key prey (fish) species through impacts to important spawning or nursery ground habitats should also be assessed within the EIA Report. The Predators and Prey Around Renewable Energy Developments project may be helpful when carrying out this assessment. This is also supported by the NatureScot EIA response.	Key prey species have been identified within the Fish and Shellfish Ecology Technical Report, and as part of the determination of IEFs (Table 9.13 and Table 9.14). Potential impacts to the spawning and nursery grounds of these species has been factored into the assessment of the Proposed Development alone (Section 9.10) and cumulatively (Section 9.12), in order to determine population level effects to these prey species. The results of the Fish and Shellfish Ecology assessment have been drawn into the assessments for other receptor groups, such as marine mammals and offshore ornithology to consider specific effects relating to specific prey species and prey availability.
		The Scottish Ministers note the SFF representation regarding overlap between both the array area and Export Cable Corridor for the Proposed Development and spawning and nursery grounds for some commercially important fish species. The Scottish Ministers agree that any survey activities, or other seabed disturbances, should be undertaken outwith the spawning and nursery periods of the species mentioned in the SFF representation. Furthermore, the Scottish Ministers refer the Developer to the ICES advice regarding herring, discussed in the SFF representation. This advice should be taken into account in the EIA Report.	The spawning and nursery grounds within the Fish and Shellfish Ecology Study Area are presented in Table 9.10, and spawning periods are presented in Table 9.11. Further information (along with figures) is presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report. Should any surveys be undertaken then the spawning and nursery periods and most up to date advice will be considered (ICES, 2024a; ICES, 2025a).
		The Scottish Ministers, in line with the NatureScot EIA response, also advise that the spatial and temporal use of habitats by fish and shellfish, as well as the EMF impacts from the growing network of subsea cables, should be assessed on a cumulative basis for fish and shellfish ecology in the EIA Report.	The spatial and temporal use of habitats by fish and shellfish, and the impact of EMF has been assessed for the Proposed Development alone (Section 9.10) and cumulatively with other plans and projects (Section 9.12).
		With regards to the HRA Screening Report, based on the evidence currently available, it is not possible to carry out an assessment of diadromous fish to the level required under HRA. The Scottish Ministers therefore advise that diadromous fish species should be assessed through EIA only, not through HRA. This is in line with both the NatureScot EIA response and the NatureScot HRA response. Furthermore, the Scottish Ministers advise the Developer to update Table 1.1 in the HRA Screening Report to reflect the advice of the NatureScot HRA response.	The most recent desktop outputs from ScotMER have been used in the baseline characterisation (Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report). At the time of writing, this included Honkanen *et al.* (2024), which provided a detailed literature review about the potential for diadromous species to overlap with offshore wind projects in Scotland (including the Proposed Development). Diadromous fish have been considered in RIAA, Part 2: Special Areas of Conservation (TWP-BOW-RPS-ENV-RPT-00014).
		The Scottish Ministers concur with FMS that the appropriate Scottish Special Area of Conservation ("SAC") rivers have been identified. However, the Scottish Ministers also suggest that the Developer give thought to including SAC rivers from the east coast of England in the EIA Report.	The Fish and Shellfish Ecology Study Area is suitably sized to incorporate the migration routes of diadromous fish in the North of Scotland (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report for further details) and does not extend to encompass any SACs along the east coast of England as it is unlikely migration will occur to these SACs.
28/10/2025	TWP Email	To respond to the points raised by NatureScot in their Scoping Opinion, a detailed consultation note was submitted to NatureScot. This note gives clarification on several ecological and assessment-related matters and ensures that the approach adopted within this EIA Report aligned with NatureScot's expectations and current best practice.	NA.
04/12/2025	NatureScot Email	Shadow flicker - We agree with the [Applicant's] comments on shadow flicker, this is based on all evidence (to date) being from terrestrial river systems where fish don't have the option to flee which they do at sea. The weather and environmental conditions to create shadow flicker are different at sea to terrestrial river systems where the evidence has been gathered. We do not require an assessment of shadow flicker impacts to be carried out.	The Applicant is in agreement with NatureScot and concluded that shadow flicker and visual effects would not generate a significant effect for fish receptors, both on an individual and population-level scale.

9.5 Data Sources

9.5.1 Relevant desktop datasets and the results of site-specific surveys for the Proposed Development have been reviewed and analysed to inform this fish and shellfish ecology baseline.

Desktop Study

9.5.2 Information on fish and shellfish ecology within the Fish and Shellfish Ecology Study Area was collected through a detailed desktop review of existing studies and datasets which are summarised in Table 9.8.

Table 9.8: Summary of Key Data Sources

Title	Source	Extent	Author
The Marine Life Information Network (MarLIN)	MarLIN and the Marine Biological Association (MBA)	UK waters	MarLIN (2025)
The Feature Activity Sensitivity Tool (FeAST)	NatureScot	Scottish waters	NatureScot (2025)
MPA Mapper	Joint Nature Conservation Committee (JNCC)	UK waters	JNCC (2025a)
National Biodiversity Network (NBN) Atlas	NBN Atlas	UK waters	NBN Atlas (2026)
International Bottom Trawl Survey (IBTS) and International Herring Larvae Survey (IHLS) data	ICES	UK waters	ICES (2025b), ICES (2024b), ICES (2023), ICES (2022)
Diadromous Fish in the Context of Offshore Wind – Review of Current and Future Research	The Scottish Government	Scottish waters	Honkanen *et al.* (2024)
Identifying and Mapping Sandeel Potential Supporting Habitat: An Updated Method Statement	Environmental Resources Management	The North Sea and East English Channel	Reach *et al.* (2024)
Identifying and Mapping Atlantic Herring Potential Spawning Habitat: An Updated Method Statement	Environmental Resources Management	The North Sea and East English Channel	Kyle-Henney *et al.* (2024)
Scottish Salmon and Sea Trout Fishery Statistics 2023	Scottish Government	Scottish waters	Scottish Government (2024)
Ossian Array EIA	Ossian Offshore Windfarm Limited (OWFL)	Ossian Offshore Wind farm (OWF)	Ossian OWFL (2024)

Title	Source	Extent	Author
North-East Scotland Salmon and Sea Trout Tracking Array	River Dee Trust and Marine Directorate-Science, Evidence, Data and Digital (MD-SEDD)	Scottish waters	River Dee Trust and Marine Scotland Science (2023)
Morven Offshore Wind Array Project EIA Scoping Report	Morven Offshore Wind Limited	Morven Offshore Wind Array	Morven Offshore Wind Limited (2023)
Developing essential fish habitat maps for fish and shellfish species in Scotland	MD-SEDD	Scottish waters	Franco *et al.* (2023)
UK sea fisheries annual report 2024	Marine Management Organisation (MMO)	UK waters	(MMO, 2025)
Berwick Bank Wind Farm EIA Report: Chapter 9 Fish and Shellfish Ecology	Scottish and Southern Electricity (SSE) Renewables	Berwick Bank OWF	SSE Renewables (2022)
Essential spawning grounds of Scottish herring: current knowledge and future challenges	Reviews in Fish Biology and Fisheries	Scottish waters	Frost and Diele (2022)
UK Offshore Energy Strategic Environmental Assessment 4. Appendix 1a.4 Fish and Shellfish	Department for Business, Energy and Industrial Strategy (BEIS)	UK waters	(BEIS, 2022)
A verified distribution model for the lesser sandeel	Marine Ecology Progress Series	UK waters	Langton *et al.* (2021)
Neart na Gaoithe (NNG) OWF Environmental Statement (ES): Chapter 15 Fish and Shellfish Ecology	NNG OWF	NNG OWF	Mainstream Renewable Power (2019)
Inch Cape OWF EIA, Biological Environment, Chapter 13 Natural Fish and Shellfish	Inch Cape OWF	Inch Cape OWF	Inch Cape Offshore Limited (2018)
Spawning grounds of whiting *Merlangius merlangus*	ICES Journal of Marine Science	UK waters	González-Irusta and Wright (2017)
Spawning grounds of Atlantic cod *Gadus morhua* in the North Sea	ICES Journal of Marine Science	The North Sea	González-Irusta and Wright (2016a)
Spawning grounds of haddock *Melanogrammus aeglefinus* in the North Sea and West of Scotland	ICES Journal of Marine Science	The North Sea	González-Irusta and Wright (2016b)

Title	Source	Extent	Author
Kincardine OWF ES: Chapter 5 Fish and Shellfish	Kincardine OWF	Kincardine OWF	Kincardine OWF Limited (2016)
Updating Fisheries Sensitivity Maps in British waters	Marine Scotland	UK waters	Aires *et al.* (2014)
Seagreen Environmental Impact Statement Volume 1, Chapter 12 Natural Fish and Shellfish Resource	Seagreen Alpha and Bravo OWFs (have since been renamed to Seagreen 1 and Seagreen 1A)	Seagreen 1 and Seagreen 1A	Seagreen Wind Energy Limited (2012)
Spawning and nursery grounds for selected fish species in UK waters	Centre for Environment, Fisheries, and Aquaculture Science (Cefas)	UK waters	Ellis *et al.* (2012)
Scotland's Marine Atlas: Information for the National Marine Plan	Scottish Government	Scottish Waters	Baxter *et al.* (2011)
Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: Implications for the development of marine renewables	MD-SEDD	Scottish waters	Malcolm *et al.* (2010)
North Sea Elasmobranchs: distribution, abundance, and biodiversity	ICES	The North Sea	Daan *et al.* (2005)
Fisheries sensitivity maps in British waters	Cefas	UK waters	Coull *et al.* (1998)

Identification of Designated Sites

9.5.3 A three-step process was used to identify all designated sites within the Fish and Shellfish Ecology Study Area and qualifying interest features that could be affected by the construction, O&M, and decommissioning phases of the Proposed Development. This process is described below:

- Step 1: All designated sites of international, national, and local importance within the Fish and Shellfish Ecology Study Area were identified using sources such as the JNCC mapper tool (JNCC, 2025a).
- Step 2: Information was compiled on the relevant fish and shellfish for each of these sites.
- Step 3: Using the above information and professional judgement, sites were included for further consideration if:

- a designated site directly overlaps with the Proposed Development and therefore has the potential to be directly affected by the Proposed Development; or
- sites and associated features were located within the Fish and Shellfish Ecology Study Area ZoI (see Figure 9.1), and therefore the potential ZoI for impacts associated with the Proposed Development.

Site-Specific Surveys

9.5.4 Site-specific surveys were undertaken to inform the benthic subtidal ecology, marine mammal, and ornithology baselines. Some of the outputs of these surveys were of relevance to fish and shellfish ecology and have been used to inform the baseline and assessment. A summary of these surveys is outlined in Table 9.9. Particle Size Analysis (PSA) conducted during the benthic subtidal ecology survey was used to assess spawning habitat suitability for herring *Clupea harengus* and sandeel (*Ammodytes* spp.).

Table 9.9: Summary of Site-Specific Survey Data

Title	Extent of Survey	Overview of Survey	Survey Contractor	Date	Reference to Further Information
Benthic characterisation survey	Across the Array Area and Export Cable Corridor	Grab sampling, Drop Down Video (DDV), and Environmental Deoxyribonucleic Acid (eDNA) sampling.	Ocean Ecology Limited	Spring 2024	Ocean Ecology (2024), Volume 3, Technical Appendix 8.2: Bowdun OWF Benthic Characterisation Survey 2024: Survey Report
Digital Aerial Survey (DAS)	Across the Plan Option Area (POA) plus a 12 km buffer	Monthly DAS conducted to characterise the marine mammal and ornithology baseline; however large fish species (such as sharks and tuna) were visible.	APEM	March 2022 to February 2024	Volume 3, Technical Appendix 10.2: Marine Mammal Digital Aerial Survey Report
Phase I intertidal walkover survey	Intertidal Area	Phase I intertidal walkover survey for biotope classification	RPS	2023	Technical Appendix 4.1 Scoping Report Appendix E Benthic Phase 1 Intertidal Walkover Survey Report

9.6 Baseline Environment

Overview of Baseline Environment

9.6.1 The following sections provide a summary of the fish and shellfish ecology baseline environment. Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report, includes full details of the analysis undertaken to develop the baseline and information on fish and shellfish ecology including results of site-specific surveys for the Proposed Development and other projects within the Fish and Shellfish Ecology Study Area.

9.6.2 The fish and shellfish receptors that could be potentially impacted by the Proposed Development have been determined through a thorough review of available desktop data sources (detailed in Table 9.8), and through site-specific surveys, as detailed in Table 9.9. The baseline data sources used cover a broad spatial and temporal scale, and present data that were collected using a wide range of methods. Therefore, the baseline presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report is considered to represent a comprehensive and robust description of likely species that could be present within the Fish and Shellfish Ecology Study Area.

9.6.3 The Fish and Shellfish Ecology Study Area is situated within the Northern North Sea, where a range of different fish and shellfish species are present. These include marine fish (e.g. teleost fish (bony fish) and elasmobranchs (sharks, skates and rays)), diadromous fish (i.e. those which migrate between freshwater and sea water) and shellfish (e.g. commercial crustaceans and molluscs). Commercial and non-commercial species are present within the Fish and Shellfish Ecology Study Area, with a full commercial fisheries baseline presented in Volume 3, Chapter 13.1: Commercial Fisheries Technical Report. Although species such as ocean quahog *Arctica islandica* and horse mussel *Modiolus modiolus* are shellfish, these are considered to be non-commercial species, and are included under Volume 2, Chapter 8: Benthic Ecology.

Marine Fish: Teleosts

9.6.4 Teleost fish are ray-finned fishes with skeletons made of bone. They comprise of 96% of all extant fish species. The teleost fish in the Fish and Shellfish Ecology Study Area include both demersal and pelagic species. Demersal species can be further divided into benthic fish and benthopelagic fish; with benthic fish tending to live on or in the seabed and benthopelagic fish swimming or floating close to the seabed. Typical North Sea demersal fish species include:

- Gadoids (e.g. blue whiting *Micromesistius poutassou*, cod *Gadus morhua*, European hake *Merluccius merluccius*, haddock *Melanogrammus aeglefinus*, ling *Molva molva*, Norway pout *Trisopterus esmarkii*, saithe *Pollachius virens* and whiting *Merlangius merlangus*);
- Flatfish (e.g. common dab *Limanda limanda,* lemon sole *Microstomus kitt*, long rough dab *Hippoglossoides platessoides* and plaice *Pleuronectes platessa*);
- Sandeels (e.g. lesser sandeel *Ammodytes tobianus* and Raitt's sandeel *Ammodytes marinus*);
- Anglerfish *Lophius piscatorius*;
- Gobies (Family: *Gobiidae*); and
- Gurnards (Family: *Triglidae*) (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012; Franco *et al.*, 2023).

9.6.5 Demersal fish species typically live on or around the seabed. In contrast, pelagic fish inhabit the mid-levels of the open ocean, away from the seabed and the shore. Pelagic fish can form large shoals and exhibit highly migratory behaviour. Pelagic species present within the Fish and Shellfish Ecology Study Area include herring *Clupea harengus*, horse mackerel *Trachurus trachurus*, mackerel *Scomber scrombus* and sprat *Sprattus sprattus* (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012; Franco *et al.*, 2023). In addition, there was one Atlantic bluefin tuna *Thunnus thynnus* recorded during the site-specific DAS.

9.6.6 The International Bottom Trawl Survey (IBTS) is a historic time series of trawl surveys in the North-East Atlantic and Baltic Seas. The most recently available IBTS trawl data (from 2019 to 2023, inclusive) have been assessed to ascertain the most commonly recorded species and to identify if the species assemblage has shown variation within the last five years (ICES, 2024c). Data from IBTS Survey Area 3 is most spatially relevant to the Fish and Shellfish Ecology Study Area, and the ten most commonly recorded species between 2019 and 2023 in this dataset were (in descending order):

- Norway pout;
- haddock;
- herring;
- sprat;
- whiting;
- mackerel;
- common dab;
- long rough dab (also known as 'American plaice');
- blue whiting; and
- plaice (ICES, 2024c).

9.6.7 A combination of these species were present within the top ten species per year between 2019 and 2023, with Norway pout, haddock, and herring consistently being among the top three species (ICES, 2024c). These IBTS data show a high level of temporal consistency for the major components of the targeted fish and shellfish assemblage, suggesting that these species are a good indicator of characteristic species within the Fish and Shellfish Ecology Study Area.

Marine Fish: Elasmobranchs

9.6.8 Elasmobranchs are a group of fish species with skeletons made of cartilage as opposed to bone, such as sharks, skates, and rays. There are over 30 species known to occur in UK waters, with the most abundant being the small spotted catshark *Scyliorhinus canicula*, spurdog *Squalus acanthias*, nursehound *Scyliorhinus stellaris*, tope shark *Galeorhinus galeus*, thornback ray *Raja clavata,* and cuckoo ray *Leucoraja naevus* (Baxter *et al.*, 2011; BEIS, 2022). These species have the potential to occur within the Fish and Shellfish Ecology Study Area. Other elasmobranchs that may be present within the Fish and Shellfish Ecology Study Area include (Coull *et al.*, 1998; Daan *et al.*, 2005; Ellis *et al.*, 2012; Shark Trust, 2023):

- Basking shark *Cetorhinus maximus* (listed by the IUCN as endangered);
- Blue shark *Prionace glauca*;
- Common skate complex (flapper skate *Dipturus intermedius* and common blue skate *Dipturus batis*, hereafter referred to as 'common skate') (listed by the IUCN as critically endangered);

- Cuckoo ray;
- Porbeagle shark *Lamna nasus* (listed by the IUCN as critically endangered);
- Small spotted catshark;
- Spotted ray *Raja montagui*;
- Spurdog;
- Thornback ray;
- Thorny skate *Amblyraja radiata*; and
- Tope shark (Coull *et al.*, 1998; Daan *et al.*, 2005; Ellis *et al.*, 2012).

9.6.9 Within the site-specific DAS for the Proposed Development, one basking shark was recorded in addition to a blue shark and two porbeagle shark.

Diadromous Fish

9.6.10 Diadromous fish are those which migrate between freshwater and seawater habitats in order to complete their life cycle. The term 'diadromous' encompasses species which live in seawater as adults and migrate to freshwater to spawn (anadromous) and those which live in freshwater as adults and migrate to seawater to spawn (catadromous). There are numerous rivers along the coast of the Fish and Shellfish Ecology Study Area, such as the Rivers Deveron, Don, Dee, Esk and River Tay. Therefore, diadromous fish species may migrate to and from rivers within the Fish and Shellfish Ecology Study Area and through the Site Boundary throughout the year. Based on the desktop review, the following diadromous species have the potential to migrate within the Fish and Shellfish Ecology Study Area (Baxter *et al.*, 2011; Malcolm *et al.*, 2010; Malcolm *et al.*, 2015; Newton *et al.*, 2021; Newton *et al.*, 2017; River Dee Trust and Marine Scotland Science, 2023; Smith and Smith, 1997):

- Atlantic salmon *Salmo salar* (listed by the IUCN as endangered);
- European eel *Anguilla anguilla* (listed by the IUCN as endangered);
- European smelt (also referred to as 'sparling' in the literature) *Osmerus eperlanus*;
- River lamprey *Lampetra fluviatilis*;
- Sea lamprey *Petromyzon marinus*;
- Sea trout *Salmo trutta*; and
- Shads: Allis shad *Alosa alosa* and Twaite shad *Alosa fallax*.

9.6.11 Within site-specific surveys for the Proposed Development Atlantic salmon were recorded within the eDNA surveys, alongside a record of *Lampetra* spp. (likely to be river lamprey).

9.6.12 Although residing entirely in freshwater, the freshwater pearl mussel *Margaritifera margaritifera* (listed as critically endangered by the IUCN) shares a symbiotic life history with Atlantic salmon and sea trout (Taeubert and Geist, 2017) and may, therefore, be indirectly affected if Atlantic salmon or sea trout are impacted by the Proposed Development. This species has therefore been considered as part of the assessment of potential impacts on diadromous fish.

Shellfish

9.6.13 Based on a desktop review and the results of site-specific surveys for the Proposed Development and other OWF projects, the following shellfish species have been identified as having the potential to be present within the Fish and Shellfish Ecology Study Area:

- Common whelk *Buccinum undatum* (listed by the IUCN as of least concern);
- Crab species, including: common shore crab *Carcinus maenus*, edible crab *Cancer pagurus*, and velvet swimming crab *Necora puber* (least concern);
- Lobster species, including: European lobster *Homarus gammarus* and Norway lobster *Nephrops norvegicus* (least concern);
- Scallop, including: king scallop *Pecten maximus* and queen scallop *Aequipecten opercularis* (least concern); and
- Cephalopod species, including: squid (Lolignid and Ommastrephid) and octopi (curled octopus *Eledone cirrhosa* and common octopus *Octopus vulgaris*) (least concern).

Spawning and Nursery Grounds

9.6.14 There are spawning and nursery grounds for many different species within the Fish and Shellfish Ecology Study Area and/or overlapping with the Site Boundary, as presented in Table 9.10. The spawning and peak spawning periods of these species are presented in Table 9.11.

9.6.15 Figures presenting these spawning and nursery grounds are presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report. Further, more recent data sources (Aires *et al.*, 2014; Franco *et al.*, 2023; González-Irusta and Wright, 2016a; González-Irusta and Wright, 2016b; González-Irusta and Wright, 2017; ICES, 2025c; ICES, 2025d) were also explored in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report, which broadly aligned with the spawning and nursery grounds identified by Coull *et al.* (1998) and Ellis *et al.* (2012).

9.6.16 In particular, the Site Boundary overlaps with undetermined intensity spawning grounds of herring and high intensity spawning grounds of sandeel (Table 9.10). Whilst most fish and shellfish species release pelagic eggs that drift within the water column, herring and sandeel are demersal spawners and require specific sediment compositions to spawn successfully. These species are therefore considered substrate-specific and at higher risk to habitat disturbance. Herring require sediment comprised of less than 5% mud and greater than 10% gravel (Reach *et al.*, 2013). Sandeel habitation and spawning requires sediment comprised of less than 10% mud and greater than 70% sand (Latto *et al.*, 2013). The PSA data collected during the site-specific benthic subtidal ecology survey (Paragraph 9.5.4) was used to assess spawning habitat suitability for herring and sandeel, as per the sediment classifications outlined in Reach *et al.* (2013)

and Latto *et al.* (2013), respectively (summarised in Paragraphs 9.6.17 *et seq.*). In addition, the grab sampling data was also used to assess the egg laying habitat for critically endangered flapper skate (see Paragraph 9.6.21).

Table 9.10: Species with Spawning and Nursery Grounds within the Fish and Shellfish Ecology Study Area (adapted from Coull *et al.* (1998) and Ellis *et al.* (2012), N/A = Not Applicable)

Species	Spawning Grounds	Spawning Intensity†	Nursey Grounds	Nursery Intensity†
Teleost Fish				
Anglerfish	x	N/A	✓*	Low
Blue whiting	x	N/A	✓*	Low
Cod	✓*	Low	✓*	High
European hake	x	N/A	✓*	Low
Haddock	x	N/A	✓*	Not specified
Herring	✓*	Undetermined	✓*	High
Horse mackerel	x	N/A	✓*	Undetermined
Lemon sole	✓*	Undetermined	✓*	Not specified
Ling	x	N/A	✓*	Low
Mackerel	x	N/A	✓*	Low
Norway pout	✓*	Low	✓*	Not specified
Plaice	✓*	Low	✓*	Low
Saithe	x	N/A	✓*	Not specified
Sandeel	✓*	High	✓*	Low
Sprat	✓*	Undetermined	✓*	Not specified
Whiting	✓*	Low	✓*	High
Elasmobranchs				
Common skate complex	x	N/A	✓*	Low
Spotted ray	x	N/A	✓*	Low
Spurdog	x	N/A	✓*	Low
Tope shark	x	N/A	✓*	Low
Thornback Ray	x	N/A	✓	Low
Shellfish				
Nephrops	✓*	Undetermined	✓*	Not specified

*Asterisk signifies that grounds overlap with the Site Boundary; no asterisk signifies that grounds are present within the Fish and Shellfish Ecology Study Area but do not overlap with the Site Boundary.
†Colours refer to the intensity of the grounds that overlap with the Site Boundary (if any), otherwise they refer to the intensity of the grounds within the Fish and Shellfish Ecology Study Area if there is no overlap with the Site Boundary.

Table 9.11: Spawning Periods for Species with Spawning and Nursery Grounds within the Fish and Shellfish Ecology Study Area (Adapted from Coull *et al*. (1998) and Ellis *et al*. (2012))

Species	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Teleost Fish												
Anglerfish												
Blue whiting				P	P							
Cod		P	P									
European hake		P	P									
Haddock		P	P	P								
Herring (Buchan/Shetland Stock)												
Horse mackerel					P	P						
Lemon sole												
Ling												
Norway pout		P	P									
Plaice	P	P										
Saithe	P	P										
Sandeel												
Sprat					P	P						
Whiting												
Elasmobranchs												
Common skate complex	?	?	?	?	?	?	?	?	?	?	?	?
Spotted ray				?	P	P	P	?				
Spurdog												
Thornback ray			P	P	P	P	P					
Tope shark												
Shellfish												
Nephrops				P	P	P						
Key:	Spawning period				Peak spawning		P		Unknown		?	

Herring, Sandeel and Flapper Skate Spawning Habitat Suitability Assessment

9.6.17 As presented in Figure 9.2, the sampling sites which represented preferred or marginal spawning habitat suitability were located in the east of the Proposed Development's Array Area and the northern area of the Fish and Shellfish Ecology Study Area within the Turbot Bank MPA. These intersect with areas of gravelly sand substrates from the European Marine Observation and Data Network (EMODnet) broad-scale seabed habitat map for Europe (EMODnet, 2025). These EMODnet seabed substrates fit the spawning suitability classifications from Reach *et al.* (2013) and Kyle-Henney *et al.* (2024), further supporting the conclusions that the majority of the Site Boundary consists of unsuitable spawning habitat for herring. To help characterise the Fish and Shellfish Ecology Study Area further, PSA data available on the One Benthic Data Portal (Cefas, 2024) were assessed using the same methodology as for the site-specific grab samples. There were 237 available data points within the Fish and Shellfish Ecology Study Area on the One Benthic Data Portal (Cefas, 2024) at the time of writing. These points are also illustrated in Figure 9.2 and are largely concentrated within the Turbot Bank MPA. There were also some samples south of the Site Boundary. The majority of data points are recorded between 2009 to 2026, with the earliest survey data from 2001. The majority of samples from within the Turbot Bank MPA represented preferred and marginal spawning herring spawning habitat, with fewer samples presenting unsuitable habitat. Samples south of the Site Boundary presented mostly unsuitable herring spawning habitat (Figure 9.2). These correspond to the EMODnet seabed substrates, further emphasising that the majority of the Array Area does not contain preferred spawning habitat for herring.

9.6.18 Of the 90 site-specific grab samples collected across the Site Boundary, the PSA results indicate that 80 of grab sample sites comprised of sediments unsuitable for herring spawning (88.8%). There were 37 grab samples with mud compositions over 5%, with an average of 12.8% mud content. There were 43 samples with too low a gravel content, with an average of 2.8% gravel. Seven out of 90 samples were classified as suitable (therefore a marginal sediment habitat preference). Two out of 90 samples were classified as sub-prime (therefore a preferred sediment habitat) and one sample met the Reach *et al.* (2013) classification of 'prime' (therefore a preferred sediment habitat). These grab samples defined as preferred sediment habitat were within the Proposed Development's Array Area, see Figure 9.2 below.

9.6.19 Of the 90 site-specific grab samples collected across the Site Boundary, the PSA results indicate that 15 sites comprised of sediments unsuitable for sandeel spawning (16.6%). These samples had mud compositions that were over 10%, with an average of 23.8% mud. Higher mud content prevents sandeel from maintaining their burrows as the burrows are more likely to collapse and can also reduce respiration due to fine particulate clogging their gill tissues. There were 41 out of 90 samples classified as sub-prime (therefore a preferred sediment habitat), representing 45.5% of the dataset. There were 34 samples classified as suitable (therefore a marginal sediment habitat preference), representing 37.7% of the dataset. There were no samples that met the Latto *et al.* (2013) classification of 'prime' (Figure 9.3). As illustrated in Figure 9.3, the areas of gravelly sand from EMODnet (2024) are where preferred sediment samples were identified within the Site Boundary, with the site-specific grab samples showing that the samples classified as preferred are mostly located in the Array Area and the nearshore section of the Export Cable Corridor.

9.6.20 The 237 available grab samples from the One Benthic Data Portal (Cefas, 2024) were also assessed for sandeel spawning habitat suitability. The majority of preferred sandeel habitat were largely concentrated in the northern area of the Fish and Shellfish Ecology Study Area within the Turbot Bank MPA and were classified as mostly preferred and marginal spawning habitat, with fewer samples presenting unsuitable habitat. Samples south of the Site Boundary presented mostly unsuitable sandeel spawning habitat (Figure 9.3).

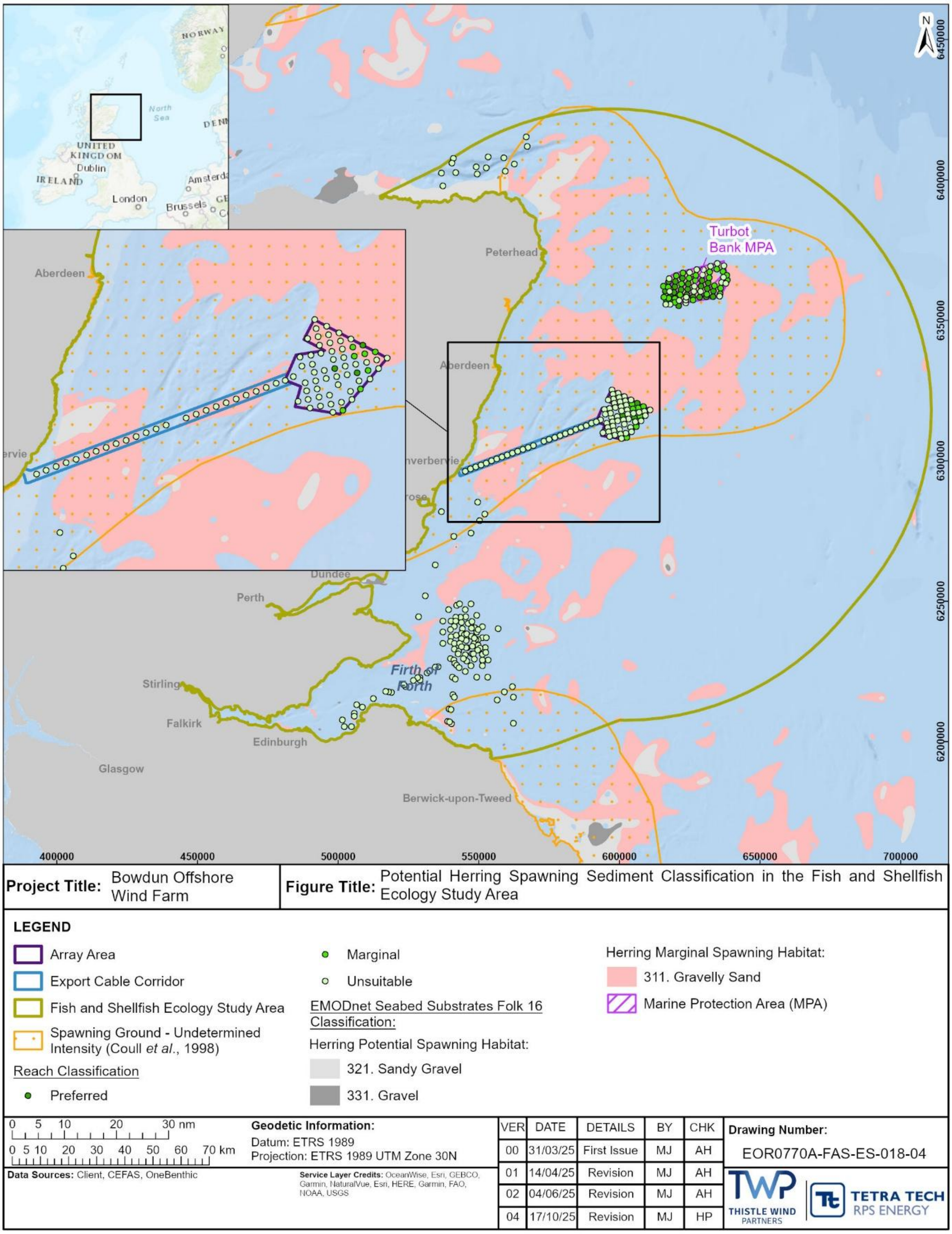
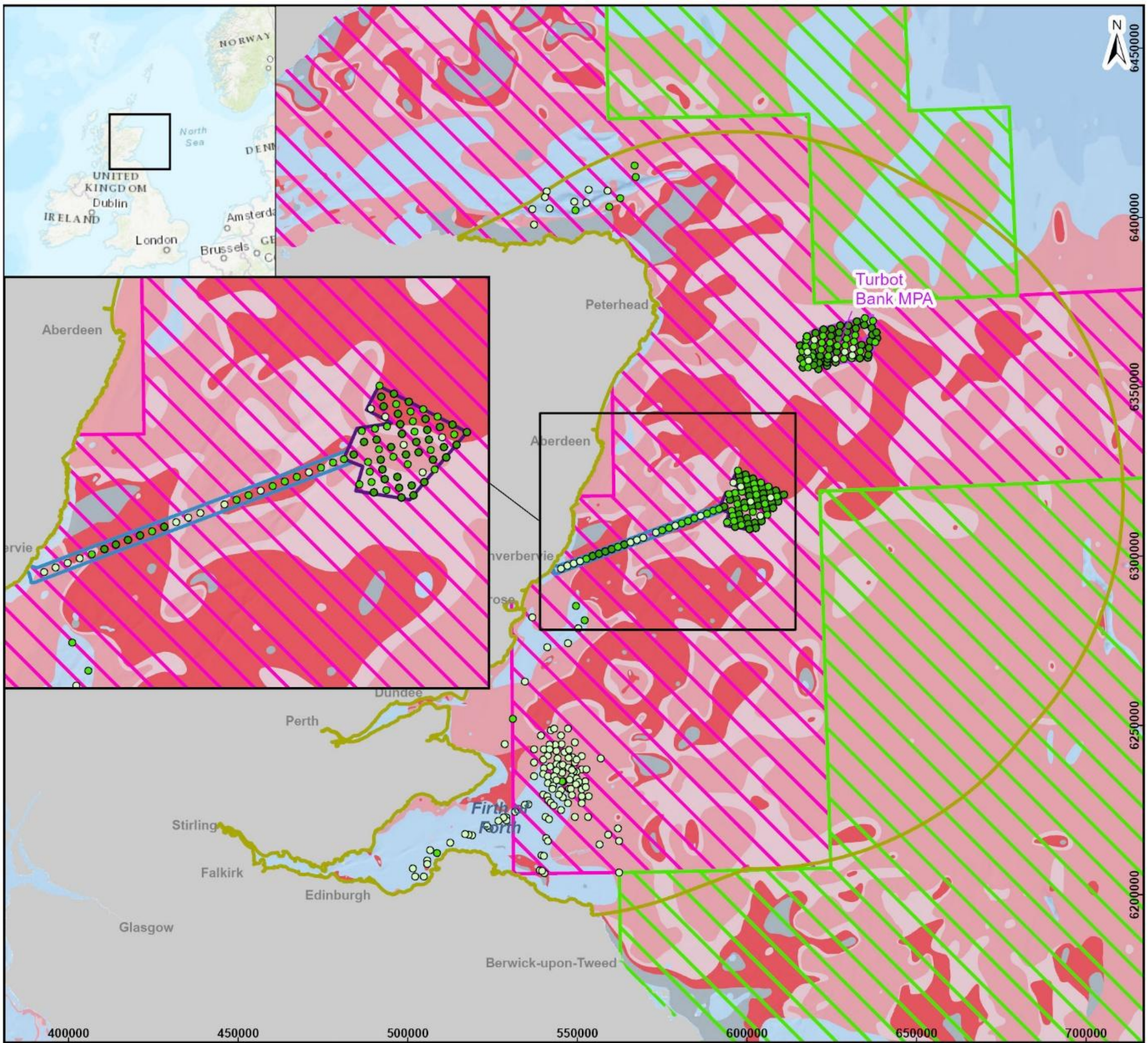


Figure 9.2: Potential Herring Spawning Sediment Classification in the Fish and Shellfish Ecology Study Area



Project Title: Bowdun Offshore Wind Farm

Figure Title: Potential Sandeel Spawning Sediment Classification in Fish and Shellfish Ecology Study Area

LEGEND

- Array Area
- Export Cable Corridor
- Fish and Shellfish Ecology Study Area

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

Latto et al, 2013 Classifications
- Preferred
- Marginal
- Unsuitable

EMODnet Seabed Substrates Folk 16 Classification:
Sandeel Preferred Habitat
- 311. Gravelly Sand
- 212. (Gravelly) Sand
- 211. Sand

Sandeel Marginal Habitat
- 321. Sandy Gravel
- Marine Protection Area (MPA)

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 70 km

Geodetic Information:
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N

Data Sources: Client, CEFAS, OneBenthic

Service Layer Credits: OceanWise, Esri, GEBCO, Garmin, NaturalVue, Esri, HERE, FAO, NOAA

VER	DATE	DETAILS	BY	CHK
00	01/04/25	First Issue	MJ	AH
01	14/04/25	Revision	MJ	AH
02	04/06/25	Revision	MJ	AH
04	17/10/25	Revision	MJ	HP

Drawing Number: EOR0770A-FAS-ES-023-04

Figure 9.3: Potential Sandeel Habitat Classification within the Fish and Shellfish Ecology Study Area

9.6.21 The critically endangered flapper skate has the potential to occur within the Fish and Shellfish Ecology Study Area. This species has specific egg laying habitats, however, a quantitative approach for identifying potential suitable habitat has not yet been devised. Recently, Phillips *et al.* (2021) and the Scottish Government (2021) have suggested that suitable habitats for flapper skate egg laying were boulder, rocky, cobble and/or mixed substrates, with water depths of between 20 m to 50 m, and with significant current flow. While site-specific current flow data were not available from the site-specific surveys for the Proposed Development, the sediment classifications derived from the grab samples provided information on the presence of boulder, rocky, cobbles, and/or mixed sediments.

9.6.22 Out of a total of 93 sampling stations, there were three where grab sampling was not possible, due to the presence of rocky substrates or potential reef identified in the DDV imagery. However, the sediment composition in the remaining 90 sampling stations was comprised predominantly of sand, and various proportions of gravel and mud. The Folk (1954) sediment classifications of each grab sample site illustrated that sand was the dominant sediment classification throughout the Site Boundary, with variations in the gravel and mud fractions across the Array Area and along the Export Cable Corridor. While there were rocky substrates identified in two possible sample locations, this only represented 1% of the total number of sampling stations (i.e. one out of 90). Therefore, while some rocky (and potentially suitable egg laying substrates) are present within the Site Boundary, they represent a minority of the overall sediment classification.

9.6.23 Water depths were recorded at each grab sampling station, and ranged from a minimum of 20 m to a maximum of 102 m. The average and median water depths were 61.9 m and 62 m, respectively, highlighting the frequency of waters deeper than 50 m across the sampling sites. Considering the high sand content and consistent depths of over 50 m recorded throughout the Site Boundary, it was concluded that this area is unlikely to represent suitable egg laying habitat for flapper skate according to Phillips *et al.* (2021) and Scottish Government (2021).

Designated Sites

9.6.24 Designated sites and relevant qualifying features identified for the fish and shellfish ecology are summarised in Table 9.12 and presented in Figure 9.4.

Table 9.12: Designated Sites and Relevant Qualifying Features for the Fish and Shellfish Ecology Study Area

Designated Site	Distance to Proposed Development Array Area (km)	Distance to Proposed Development Export Cable Corridor (km)	Relevant Qualifying Interest Feature(s)
River South Esk SAC	71.1	20.3	Annex II Atlantic salmon and freshwater pearl mussel
River Dee SAC	39.6	29.9	Annex II Atlantic salmon and freshwater pearl mussel
Turbot Bank MPA	35.8	46.9	Sandeel (Scottish PMF)
River Tay SAC	130.4	83.9	Annex II Atlantic salmon, freshwater pearl mussel, and river lamprey
River Teith SAC	206.7	169.4	Annex II Atlantic salmon, sea lamprey, and river lamprey
River Tweed SAC	136.8	120.9	Annex II Atlantic salmon
River Spey SAC	147.9	155.4	Annex II Atlantic salmon and freshwater pearl mussel

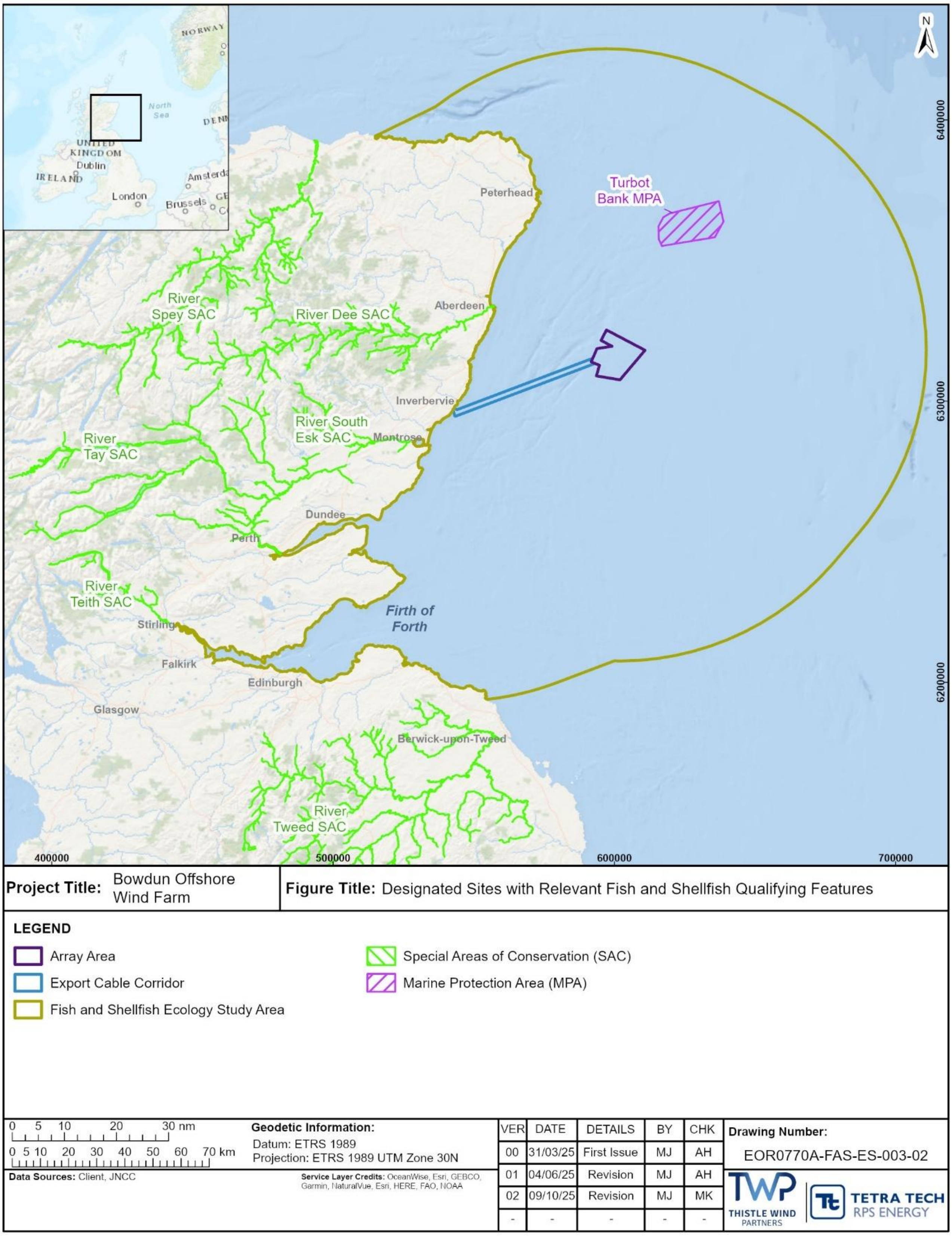


Figure 9.4: Fish and Shellfish Ecology Relevant Designated Sites

Important Ecological Features

9.6.25 IEFs have been identified for the purposes of this chapter as per best practice guidelines (Chartered Institute for Ecology and Environmental Management (CIEEM, 2022). The potential impacts of the Proposed Development which have been scoped into the assessment (see Section 9.8) have been assessed against the IEFs to determine whether or not they are significant, therefore, the IEFs assessed are those that are considered to be important and potentially impacted by the Proposed Development. Importance may be assigned due to quality or extent of habitats, habitat or species rarity or the extent to which they are threatened (CIEEM, 2022). For a species or habitats to be considered IEFs, they must have a specific biodiversity importance recognised through international or national legislation or through local, regional, or national conservation plans (e.g. Annex II habitats under the Habitats Directive, Oslo Paris [Convention] (OSPAR) List of Threatened or Declining Species, National Biodiversity Plan or the Marine Strategy Framework Directive, Scottish PMFs and the Scottish Biodiversity list (SBL)). Further information on conservation policy and legislation is provided in Section 9.3. The criteria used for determining the importance of the fish and shellfish IEFs are presented in Table 9.13.

9.6.26 Table 9.14 lists all of the IEFs within the Fish and Shellfish Ecology Study Area that have been carried forward for assessment.

Table 9.13: Criteria used to define the IEFs for Fish and Shellfish Ecology

Value	Defining Criteria
International	• Species protected under international law that are listed as a qualifying feature of an internationally designated site within the Fish and Shellfish Ecology Study Area (e.g. Annex II species). • Species listed under Appendix I and II of the Bonn Convention. • Species listed under Annex II (strictly protected fauna) or Annex III (protected fauna) of the Bern Convention. • Species listed under Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
National	• Species protected under national law (e.g. Species of Principal Importance (SPIs) listed on the SBL, species listed as qualifying features of MPAs, Wildlife and Countryside Act 1981). • Scottish PMF species. • Species listed on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea that have nationally important populations within the Fish and Shellfish Ecology Study Area. • Species listed on the International Union for the Conservation of Nature (IUCN) Red List as 'vulnerable' or higher that have nationally important populations within the Fish and Shellfish Ecology Study Area. • Species that have spawning and/or nursery areas within or in the immediate vicinity of the site boundary that are nationally important (e.g. may be primary spawning/nursery areas for that species).
Regional	• Species that provide key prey items for other species of conservation value (e.g. forage fish). • Species listed on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea that have regionally important populations within the Fish and Shellfish Ecology Study Area. • Species listed on the IUCN Red List as 'vulnerable' or higher that have regionally important populations within the Fish and Shellfish Ecology Study Area. • Species with spawning and/or nursery areas within the Fish and Shellfish Ecology study Area which are important regionally (i.e. they may spawn elsewhere, but these are key spawning/nursery areas).
Local	• Species which are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area. • Species with spawning and/or nursery grounds within the Fish and Shellfish Ecology Study Area.

Table 9.14: IEFs Within the Proposed Development Fish and Shellfish Ecology Study Area

IEF	Importance	Justification
Marine Fish: Teleosts		
Anglerfish	National	Scottish PMF. There are also low intensity nursery grounds for anglerfish overlapping with the Site Boundary.
Atlantic bluefin tuna	National	OSPAR List of Threatened and/or Declining Species and are listed as a SPI on the SBL.
Blue whiting	National	Scottish PMF and listed as a SPI on the SBL. There are low intensity nursery grounds for blue whiting overlapping with the Site Boundary.
Cod	National	OSPAR List of Threatened and/or Declining Species, Scottish PMF and listed as a SPI on the SBL. There are also low intensity spawning and high intensity nursery grounds within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary.
European hake	National	Listed as a SPI on the SBL. There are low intensity nursery grounds for European hake overlapping with the Site Boundary.
Haddock	Regional	Haddock nursery areas have been identified within the Fish and Shellfish Ecology Study Area, with the nursery grounds overlapping with the Site Boundary. The intensity of the nursery areas is not specified, so it is not determined if these are important regionally. As a precaution, haddock have been concluded to have ‘regional’ importance.
Herring	National	Scottish PMF, listed as a SPI on the SBL, and has high intensity nursery grounds overlapping the majority of the Proposed Development with spawning grounds in the immediate vicinity of the Site Boundary (around Buchan) which are nationally important. Further, herring are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds).
Horse mackerel	National	Scottish PMF. Further, horse mackerel are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds). There are nursery grounds for horse mackerel overlapping with the Site Boundary.
Lemon sole	Regional	Lemon sole spawning and nursery areas have been identified within the Fish and Shellfish Ecology Study Area, which also overlap with the Site Boundary. These are of undetermined intensity, so it is not determined if these are important regionally. As a precaution, lemon sole have been concluded to have ‘regional’ importance.
Ling	National	Scottish PMF and listed as a SPI on the SBL. There are also low intensity nursery grounds for ling overlapping with the Site Boundary.
Mackerel	National	Scottish PMF and listed as a SPI on the SBL. There are also low intensity nursery grounds for mackerel overlapping with the Site Boundary. Further, mackerel are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds).

IEF	Importance	Justification
Norway pout	National	Scottish PMF and listed as a SPI on the SBL. There are nursery and low intensity spawning grounds for Norway pout within the Fish and Shellfish Ecology Study Area with a minor overlap with the Site Boundary.
Other flatfish species (common dab, long rough dab)	Local	These species are not protected under any conservation legislation and are typically common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Plaice	National	Listed as a SPI on the SBL. There are spawning and nursery grounds for plaice within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary.
Poor cod	Local	This species is not protected under any conservation legislation and is typically common in UK waters but forms a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Saithe	National	Scottish PMF. There are also nursery grounds for saithe overlapping with the Site Boundary.
Sandeel species	National	Scottish PMF, listed as a SPI on the SBL, and a feature of an MPA within the Fish and Shellfish Ecology Study Area. Further, sandeels are key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds). There are also high intensity spawning and low intensity nursery grounds for sandeel overlapping with Site Boundary, and the PSA results suggest that this area could largely be preferred spawning habitat substrate.
Sole	National	Listed as a SPI on the SBL.
Sprat	Regional	Sprat have spawning and nursery areas within the Fish and Shellfish Ecology study Area that overlap with the Site Boundary. These may be important regionally. Further, sprat are a key forage fish species for other species of conservation value within the Fish and Shellfish Ecology Study Area (such as marine mammals and seabirds).
Whiting	National	Scottish PMF and listed as a SPI on the SBL. There are low intensity spawning grounds and high intensity nursery grounds overlapping with the Site Boundary.
		Marine Fish: Elasmobranchs
Basking shark	International	Listed under Appendix II of the Bern Convention, under the Bonn Convention, and CITES. Basking shark are also protected under the Wildlife and Countryside Act 1981 and listed on the OSPAR List and SBL. This species is also a Scottish PMF. Basking shark has an IUCN Status of 'Endangered'.
Blue shark	International	Listed under Appendix III of the Bern Convention and under the Bonn Convention. Blue shark are also listed on the OSPAR List and the SBL, and have an IUCN status of 'Near Threatened'.
Common skate	National	Listed on the OSPAR List, the SBL, and as a Scottish PMF. Common skate also has an IUCN status of 'Critically Endangered'. There are also low intensity nursery grounds for this species overlapping with the Site Boundary.

IEF	Importance	Justification
Cuckoo ray	Local	Cuckoo ray are not protected under any conservation legislation and are common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Flapper skate	National	Flapper skate is listed as a SPI on the SBL and has an IUCN status of 'Critically Endangered'. Distribution models shows that there is a high suitability for presence of flapper skate and presence of egg cases recorded within the Fish and Shellfish Ecology Study Area. It should also be noted that the various other conservation designations for common skate could be extrapolated to flapper skate, as the two species have only recently been recognised as separate species.
Nursehound	Regional	Nursehound are not protected under any conservation legislation but are listed on the IUCN Red List as 'vulnerable' and likely have regionally important populations within the Fish and Shellfish Ecology Study Area.
Porbeagle shark	International	Listed under Appendix III of the Bern Convention, under the Bonn Convention, and CITES. Porbeagle shark are also listed on the OSPAR List and SBL. This species is also a Scottish PMF. Porbeagle shark has an IUCN Status of 'Critically Endangered'.
Small spotted catshark	Local	Small spotted catshark are not protected under any conservation legislation and are common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area, with egg cases being found within the Fish and Shellfish Study Area (Shark Trust, 2023).
Spotted ray	Regional	Spotted ray are listed on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea and likely have regionally important populations within the Fish and Shellfish Ecology Study Area. There are also low intensity nursery grounds for this species overlapping with the Site Boundary and egg cases have been found within the Fish and Shellfish Study Area.
Spurdog	International	Spurdog are protected under the Bonn Convention. Spurdog are also listed on the OSPAR List and SBL. This species is also a Scottish PMF. Spurdog has an IUCN Status of 'Vulnerable'. There are also low intensity nursery grounds for this species overlapping with the Site Boundary.
Thornback ray	National	Thornback ray are listed as a SPI on the SBL, and on the OSPAR List of Threatened and/or Declining Species within OSPAR Region II: North Sea. There are also low intensity nursery grounds for this species within the Fish and Shellfish Ecology Study Area.
Thorny skate	Local	Thorny skate are not protected under any conservation legislation and are common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area. This species is also listed as 'Vulnerable' on the IUCN Red List, but there are no nationally or regionally important or recognised populations within the Fish and Shellfish Ecology Study Area.
Tope shark	International	Tope shark are protected under the Bonn Convention. Spurdog are also listed as a SPI on the SBL. Spurdog has an IUCN Status of 'Critically Endangered'. There are also low intensity nursery grounds for this species overlapping with the Site Boundary.

IEF	Importance	Justification
Diadromous fish and associated species		
Allis shad	International	Listed under Appendix III of the Bern Convention. Allis shad are also protected under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and the Wildlife and Countryside Act 1981. This species is listed on the OSPAR List and as a SPI on the SBL.
Atlantic salmon	International	Listed under Annex II of the Habitats Regulations and as a qualifying feature of SACs within the Fish and Shellfish Ecology Study Area. Atlantic salmon are also listed under Appendix III of the Bern Convention and under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. Atlantic salmon are also on the OSPAR List and a Scottish PMF.
European eel	International	Listed under Appendix II of CITES and the Bonn Convention. European eel are also listed under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. European eel are also on the OSPAR List and a Scottish PMF. This species has an IUCN status of 'Critically Endangered'.
European smelt/Sparling	N/A	Listed as a Scottish PMF but are scoped out of consideration due to being an estuarine species and therefore they are unlikely to interact with the site boundary. They are therefore not considered further.
River lamprey	International	Listed under Annex II of the Habitats Regulations but not as a qualifying feature of any SACs within the Fish and Shellfish Ecology Study Area. River lamprey are also listed under Appendix III of the Bern Convention and under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. River lamprey are also a Scottish PMF.
Sea lamprey	International	Listed under Annex II of the Habitats Regulations and as a qualifying feature of SACs within the Fish and Shellfish Ecology Study Area. Sea lamprey are also listed under Appendix III of the Bern Convention and under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. River lamprey on the OSPAR List and are also a Scottish PMF.
Sea trout	National	Sea trout are protected under national legislation: the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and as a SPI on the SBL. Sea trout are also a Scottish PMF.
Twaite shad	International	Listed under Appendix III of the Bern Convention. Twaite shad is also protected under national legislation, such as the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003 and the Wildlife and Countryside Act 1981. This species is also listed as a SPI on the SBL.
Freshwater pearl mussel	International	Listed under Annex II of the Habitats Regulations and as a qualifying feature of SACs within the Fish and Shellfish Ecology Study Area. Freshwater pearl mussel are also listed under Appendix III of the Bern Convention and under the Wildlife and Countryside Act 1981. Freshwater pearl mussel are also listed as a SPI on the SBL. This species has an IUCN status of 'Critically Endangered'.

IEF	Importance	Justification
		Shellfish
Common whelk	Local	Common whelk are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Crabs	Local	The crab species described in the shellfish baseline are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Lobsters	Local	The lobster species described in the shellfish baseline are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area. Norway lobster also has spawning grounds of undetermined intensity and nursery grounds of unspecified intensity within the Fish and Shellfish Ecology Study Area and overlapping with the Site Boundary.
King and queen scallop	Local	King and queen scallop are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.
Squid and octopi	Local	The squid and octopi species described in the shellfish baseline are not protected under any conservation legislation and may be common in UK waters but form a key component of the biodiversity within the Fish and Shellfish Ecology Study Area.

Future Baseline Scenario

9.6.27 The EIA Regulations require that '*a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort, on the basis of the availability of environmental information and scientific knowledge*' is included within the Offshore EIA Report.

9.6.28 If the Proposed Development does not come forward, an assessment of the 'without development' future baseline conditions have also been carried out and are described within this section.

9.6.29 The fish and shellfish baseline environment is not static and may change naturally over time, even if the Proposed Development does not come forward. This is due to naturally occurring cycles and processes, such as spawning behaviour, primary production, and associated prey availability throughout the food web. In addition to this potential natural change, the potential effects of climate change on the marine environment should also be considered. Variability and long term changes on physical processes, ocean acidification, stratification, and water temperature may bring direct and indirect changes to fish and shellfish populations and communities in the mid to long term future (Heath *et al.*, 2012).

9.6.30 Increased sea surface temperatures have been predicted to occur due to climate change. A study by Hughes *et al.* (2018) illustrated that Scottish waters (coastal and oceanic) have warmed by between 0.05°C and 0.07°C per decade, from 1870 to 2016. Increased temperatures will likely have an effect on fish and shellfish species at all biological levels (cellular, individual, population, species, community and ecosystem) both directly and indirectly. As sea temperatures rise, species adapted to cold water (such as cod and herring) may spawn earlier in the year and/or demonstrate earlier larval development (McQueen and Marshall, 2017; Weigel *et al.*, 2021). Further, typical North Sea species may migrate further north towards cooler waters, while species adapted to warm water may become more established in their absence (Dahms and Killen, 2023; Hastings *et al.*, 2020).

9.6.31 It has also been predicted that changes in weather patterns under climate change (such as increased spring storms), could alter the stratification of water columns and primary production (Morison *et al.*, 2019). This could result in knock on impacts on fish and shellfish species due to altered food availability throughout trophic levels. Overall, climate change presents many uncertainties about the future fish and shellfish baseline.

9.6.32 In addition, changes to fisheries management measures may also affect the fish and shellfish baseline. For example, the Sandeel (Prohibition of Fishing) (Scotland) Order 2024 introduced a ban on sandeel fishing from March 2024 within the Scottish zone (i.e. the sea adjacent to Scotland out to 200 nm) with similar measures in the English waters of the North Sea. This order was appealed by the EU during a tribunal in late 2024 and into 2025. The results of this tribunal were published in June 2025, with the ban on sandeel fishing retained in both Scottish and English waters of the North Sea. It is anticipated that this closure will provide wider direct benefits to sandeel populations (through reduction of pressures from fishing) and indirect benefits to a wide range of fish, seabird and marine mammal species, given that sandeel are important prey species for them.

Data Limitations and Assumptions

9.6.33 The desktop data used were the most up to date publicly available information which could be obtained from the applicable data sources as presented in Table 9.8 at the time of writing. Data that have been collected are based on existing literature and consultation with stakeholders and SNCBs. It should be noted that some datasets are over a decade old, such as Coull *et al.* (1998), Ellis *et al.* (2012), and Aires *et al.* (2014). However, these are industry-standard datasets and have been included and assessed with the caveat that they are now quite dated. Long term time series of data, such as the IBTS and IHLS have demonstrated the continued validity of these datasets, with spawning and nursery grounds continuing to remain broadly consistent with these studies (González-Irusta and Wright, 2016a; González-Irusta and Wright, 2016b; González-Irusta and Wright, 2017). A full assessment of the fish and shellfish baseline is presented in Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report.

9.6.34 It is always possible that not all potential fish and shellfish species within the Fish and Shellfish Ecology Study Area have been identified. However, given the detailed desktop study completed and the precautionary approach adopted, which has included the identification of a broad Fish and Shellfish Ecology Study Area, it is unlikely that any key species have been omitted from the baseline characterisation.

9.7 Key Parameters for Assessment

Maximum Design Scenario

9.7.1 The Maximum Design Scenario (MDS) identified in Table 9.15 are those parameters expected to have the potential to result in the greatest effect on an identified receptor or receptor group. Any other development scenario within the Project Design Envelope (PDE), will result in the same, or less, level of environmental effect. The scenario has been selected from the details provided in Volume 1, Chapter 3: Project Description.

9.7.2 The assessment of the impacts associated with the Proposed Development for fish and shellfish ecology has been informed by and will inform other chapters within the Offshore EIA Report. For example, the assessment on the impact of ‘increased SSCs and associated deposition’ has been informed by Volume 2, Chapter 7: Physical Processes, and Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment. Further, the assessment of ‘impacts to fish and shellfish due to subsea noise’ has been informed by modelling presented in Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report. Finally, the assessment presented in this chapter for fish and shellfish ecology has been used to inform the assessment of ‘changes in prey availability’ in Volume2, Chapter 10: Marine Mammals, and Volume 2, Chapter 11: Offshore Ornithology.

Table 9.15: Maximum Design Scenario Considered for Each Potential Impact on Fish and Shellfish Ecology

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
Temporary habitat loss and/or disturbance	✓	✓	✓	**Construction Phase - Subtidal** Up to **19,414,805 m²** of subtidal temporary habitat loss and/or disturbance, this represents up to **6.66%** of the total area of the Site Boundary, due to: Trenchless Technique Exit Pit Excavation (e.g. Horizontal Directional Drilling (HDD) Up to 17,130 m² of habitat disturbance associated with excavation of exit pits comprising: • Up to 16,800 m² from deposition of 8,400 m³ of HDD excavation material; and • Up to 330 m² of habitat disturbance from the installation of up to 3 HDD exit pits. Sandwave clearance Up to 835,872 m² of habitat disturbance associated with sandwave clearance comprising: • Wind Turbine foundations: 141,000 m² for the installation of up to 50 Wind Turbine foundations (this may also include boulder clearance but sandwave clearance is the greater impact of the two); • Offshore Substation Platform (OSP) foundations: 24,359 m² for the installation of up to 3 OSP foundations; • Inter-array Cables (IACs): up to 49,552 m² (assumes 0.56% requires clearance with a 58.6 m width of disturbance); • Interconnector Cables: up to 11,814 m² (assumes 0.56% requires clearance with a 58.6 m width of disturbance); and • Offshore Export Cables: up to 609,147 m² (assumes 4.95% requires clearance with a 58.6 m width of disturbance).	The MDS for this impact considers the maximum seabed footprint of temporary habitat loss and/or disturbance during the construction, O&M, and decommissioning phases of the Proposed Development. The MDS for this impact is represented by the 50 x 20 MW Wind Turbine layout scenario. **Construction Phase – Subtidal** Trenchless Techniques Exit Pit Excavation Based on up to: • assuming a mound of uniform thickness of 0.5 m height; and • 110 m² per exit pit. Sandwave clearance Based on up to: • 151 km total length of IACs on the seabed; • 36 km total length of Interconnector Cable; and • 210 km total length of Offshore Export Cables.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				Sandwave clearance material deposition • Up to 8,774,332 m² of habitat disturbance associated with the deposition of sandwave clearance material comprising: • Wind Turbines foundations: up to 1,188,770 m² from deposition of 594,385 m³ of sandwave clearance material; • OSP foundations: up to 272,824 m² from deposition of 136,412 m³ of sandwave clearance material; • IACs: up to 395,910 m² from deposition of 197,955 m³ of sandwave clearance material; • Interconnector Cables: up to 94,382 m² from deposition of 47,191 m³ of sandwave clearance material; and • Offshore Export Cables: up to 6,822,446 m² from deposition of 3,411,223 m³ of sandwave clearance material. Cable installation (including boulder clearance) Up to 9,638,945 m² of habitat disturbance associated with cable installation comprising: • IACs: up to 3,753,860 m² disturbance from installation of up to 151 km of IACs (99.44% of the total length, including the length which requires boulder clearance, both with a 25 m width of disturbance, separate to sandwave clearance); • Interconnector Cables: up to 894,960 m² from installation of up to 36 km of Interconnector Cable (99.44% of the total length, including the length which requires boulder clearance, both with a 25 m width of disturbance, separate to sandwave clearance); and • Offshore Export Cables: up to 4,990,125 m² of disturbance from installation of up to 210 km of Offshore Export Cables (95.05% of the total length, including the length	Sandwave clearance material deposition The area of seabed affected by the placement of sandwave clearance material has been calculated based on the maximum volume of sediment to be placed on the seabed, assuming all this sediment is coarse material (i.e. is not dispersed through tidal currents). 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. Temporary loss of benthic habitat is assumed beneath this. Cable installation (including boulder clearance) The MDS assumes that up to 151 km of the IACs cable will be on the seabed, with up to 16 km within the Wind Turbine foundation. Based on the assumption that the width of disturbance for sandwave also includes subsequent cable installation as repeat disturbance. As such, up to 95.05% of the length of Offshore Export Cables, and up to 99.44% of the length of IACs and Interconnector Cables will need burial only. Boulder clearance is captured within the disturbance corridor for cable installation.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				which requires boulder clearance, both with a 25 m width of disturbance, separate to sandwave clearance). Jack-up events • Up to 148,400 m^2 of disturbance due to jack up vessel use for the installation of up to 3 OSPs and up to 50 Wind Turbine foundations; and • Up to 126 m^2 of disturbance due to jack up vessel use for the installation of up to 3 HDD exit pits. Additional Subtidal Information In addition, up to 13,987 m^2 of temporary habitat loss and/or disturbance could occur due to crater formation from the clearance of UXO. This value has not been included in the total disturbance presented above, as the footprint from UXO clearance will likely overlap with area subject to temporary habitat disturbance from other site preparation activities. Additionally, the footprint associated with the UXO clearance has not been derived from Volume 1, Chapter 3: Project Description. Instead, it has been calculated based on appropriate crater sizes estimated in Ordtek (2018) and applied to the 40 UXOs that may require clearance during the construction phase of the Proposed Development (30 in the Array Area and 10 along the Export Cable Corridor). **Construction phase – Intertidal** There is no impact in the Intertidal Area as cables will be installed via trenchless techniques (e.g. HDD) with exit pits located below MLWS and above MHWS. **Operation & Maintenance (O&M) phase** A total of **11,688,813 m^2** of temporary subtidal habitat loss and/or disturbance, this represents up to **4.01%** of the total area of the Site Boundary, over the 30-year life cycle of the Proposed Development due to:	Jack-up events Based on the assumption that there will be up to a maximum of up to 2 jack-up positions per OSP and Wind Turbine foundation. Additional Subtidal Information UXO clearance MDS calculated from the maximum estimated crater diameter of 21.10 m in Ordtek, 2018. **O&M phase** Disturbance caused by reburial of IACs, Interconnector Cables, and Offshore Export Cables.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				Disturbance caused by reburial of IACs, Interconnector Cables, and Offshore Export Cables • Up to 4,915 m of cable reburial may be required per year for repair of IACs. The width of the minimum installation corridor is up to 25 m; • Up to 2,040 m of cable reburial may be required per year for repair of Interconnector Cables. The width of the minimum installation corridor is up to 25 m; and • Up to 6,390 m of cable reburial may be required per year for repair of Offshore Export Cables. The width of the minimum installation corridor is up to 25 m. Jack-up events • Up to 1,680,000 m^2 of disturbance due to jack up vessel use for the repair of Wind Turbines; and • Up to 63 m^2 of disturbance due to jack up vessel use for repair and reburial event at the 3 HDD exit pits. **Decommissioning phase** A Decommissioning Programme will be submitted to MD-LOT for consultation and approval. The Decommissioning Programme will be updated during the Project's lifespan to take account of changing best practice and new technologies. The approach for decommissioning is yet to be determined, however, for the purposes of this MDS total removal of all infrastructure including buried cables and cable protection has been assumed, and as such the environmental impact of decommissioning will be the same if not lower than construction.	**Decommissioning phase** In the decommissioning phase, the MDS accounts for the maximum amount of infrastructure which could be removed from the seabed. This approach varies from other impacts as it represents the MDS for temporary habitat loss and/or disturbance specifically. The MDS approach to decommissioning will vary between impacts.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
Long term habitat loss and/or disturbance	✓	✓	✓	**Construction and O&M phases** Up to **2,251,000 m²** of subtidal long term habitat loss and/or disturbance due to infrastructure installed in the construction phase, which will persist into the O&M phase. This represents up to **0.77%** of the total area of the Site Boundary and comprises: • Footprint area of 170,000 m² due to fixed 3-legged suction bucket jacket Wind Turbine foundations (up to 50 foundations with a seabed footprint of 3,400 m² per foundation including Scour Protection); • Footprint area of 15,000 m² due to OSP foundations (up to 3 OSPs) and their Scour Protection; • Footprint area of 755,000 m² due to cable protection for IACs (up to 75.5 km of cable requiring protection, with a cable protection width up to 10 m); • Footprint area of 40,500 m² due to cable crossing protection for IACs (up to 9 crossings, with a length of 500 m and width up to 9 m each); • Footprint area of 180,000 m² due to cable protection for Interconnector Cables (up to 18 km of cable requiring protection, with a cable protection width up to 10 m); • Footprint area of 13,500 m² due to cable crossing protection for Interconnector Cables (up to 3 crossings, with a length of 500 m and width up to 9 m each); • Footprint area of 1,050,000 m² due to cable protection for Offshore Export Cables (up to 105 km of cable requiring protection, with a cable protection width of 10 m); and • Footprint area of 27,000 m² due to cable crossing protection for Offshore Export Cables (up to 6 crossings, with a length of 500 m and width up to 9 m each). The construction phase will last c. five years, and the O&M phase will last up to 30 years.	**Construction and O&M phases** The MDS for this impact considers the maximum seabed footprint of infrastructure installed during the construction phase. This will persist through the up to 30-year O&M phase. This impact considers the design parameters that will result in the greatest footprint of habitat loss and disturbance. The MDS for this impact is represented by the 50 x 20 MW wind turbine layout scenario.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				Decommissioning phase A Decommissioning Programme will be submitted to MD-LOT for consultation and approval. The Decommissioning Programme will be updated during the Project's lifespan to take account of changing best practice and new technologies. The approach for decommissioning is yet to be determined, however, for the purposes of this MDS it has been assumed that all Scour Protection, cable protection, and cable crossing protection will be left *in situ*. Therefore, up to **2,251,000 m²** of long-term habitat loss will persist past the decommissioning phase. This value is the total footprint area for all Scour Protection, cable protection, and cable crossing protection. This represents up to **0.77%** of the total area of the site boundary.	**Decommissioning phase** In the decommissioning phase, the MDS accounts for the maximum seabed footprint of infrastructure that could remain *in situ*. It should be noted that after an up to 30-year O&M phase, these hard structures left *in situ* on the seabed would represent established habitats within the Site Boundary. The MDS assumes that the Scour Protection is pre-installed, with the pile then installed through the Scour Protection. The total footprint therefore remains the same as with Scour Protection only.
Colonisation of hard structures	✓	✓	✓	**Construction and O&M phases** Introduction of up to **2,705,020 m²** of hard structure surface area installed throughout the construction phase and persisting into the up to 30-year O&M phase. The MDS is for 3-legged suction bucket jacket Wind Turbine foundations (up to 67 foundations) and is due to: • Surface area of 448,350 m² from up to 67 Wind Turbine foundations; • Surface area of 24,570 m² from up to three OSP foundations; • Footprint area of 236,100 m² from Scour Protection for Wind Turbines and OSPs; • Footprint area of 1,915,000 m² from cable protection; and • Footprint area of 81,000 m² from cable crossings.	**Construction and O&M phases** The MDS for this impact considers the maximum surface area of hard structures installed on the seabed during the construction phase and persisting into the O&M phase. This represents artificial habitat which may be colonised by benthic species. Surface area has been calculated for Wind Turbines and OSPs based on the dimensions given within the PDE. The MDS for this impact is represented by the 67 x 15 MW wind turbine layout scenario.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				Decommissioning phase A Decommissioning Programme will be submitted to MD-LOT for consultation and approval. The Decommissioning Programme will be updated during the Project's lifespan to take account of changing best practice and new technologies. The approach for decommissioning is yet to be determined, however, for the purposes of this MDS it has been assumed that all Scour Protection, cable protection, and cable crossing protection will be left *in situ*. Therefore, up to **2,232,100 m²** of hard structures will be left *in situ* on the seabed, allowing this impact to persist past the decommissioning phase.	Footprint areas for Scour Protection, cable crossings and cable protection have been calculated as per the long term habitat loss and/or disturbance impact.
Increased SSC and associated deposition	✓	✓	✓	**Construction phase** <u>Drilling for pile installation</u> Up to 318,086 m^3 of drill arising for all piles in the Array Area for the 40 x 25 MW fixed monopile Wind Turbine Layout, comprising: • Maximum number of drilled piles: 40 (max foundations = 40; max piles per foundation = 1); • Maximum dimensions of drilled pile section: 15 m diameter, 45 m maximum penetration depth; • Maximum volume of drill arisings per pile: 7,952.12 m^3; and • Maximum concurrent drilling events: 2. <u>IAC installation</u> • Maximum total length of IAC on the seabed for the whole Array Area: 151 km for the 40 x 25 MW and 50 x 20 MW Wind Turbine Layouts; • Trench dimensions: up to 6 m wide; 1.5 m deep (average); 'V' shape profile;	The MDS corresponds to (a combination of) the greatest amount of material disturbed and the greatest geographical extent of the impact. **Construction phase** <u>Drilling for pile installation</u> Based on the greatest amount of material disturbed in a drilling event, considering the largest pile dimension, largest pile penetration depth and number of concurrent drilling events. Assumes 2 concurrent drilling events can occur for neighbouring foundations, resulting in the MDS for instantaneous SSC. Piles relating to OSP's are smaller in diameter and require less drilling depth than Wind Turbine foundations therefore do not represent the MDS.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				• Trench excavation method: Jetting, Mass Flow Excavation (MFE), Ploughing/Pre-Ploughing, Trenching/Pre-Trenching (incl. dredging, cutting); and • MFE pre-lay trenching rate: 400 m/hour. Offshore Export Cable installation • Maximum number of Offshore Export Cables: 3; • Maximum total length of each Offshore Export Cable: 70 km; • Trench dimensions: up to 6 m wide; 1.5 m deep (average); 'V' shape profile; • Excavation method: Jetting, MFE, Ploughing/Pre-Ploughing, Trenching/Pre-Trenching (incl. dredging, cutting); and • MFE Pre-lay trenching rate: 400 m/hour. Interconnector Cable installation • Maximum number of Interconnector Cables: 3; • Maximum total length of each Export Cable: 12 km; • Trench dimensions: up to 6 m wide; 1.5 m deep (average); 'V' shape profile; • Excavation method: Jetting, MFE, Ploughing/Pre-Ploughing, Trenching/Pre-Trenching (incl. dredging, cutting); and • MFE Pre-lay trenching rate: 400 m/hour.	IAC installation Pre-lay trenching by MFE will give MDS for sediment disturbance. Conservatively assumes 100% fluidisation of material expelled from trench. In reality, pre-lay jetting will move a proportion of material rather than bringing it fully into suspension. Modelling was carried out for sediment release along a section of an indicative cable route which runs parallel and then perpendicular to the tidal axis for 2 full tidal cycles. Offshore Export Cable installation Pre-lay trenching by MFE will give MDS for sediment disturbance. Conservatively assumes 100% fluidisation of material expelled from trench. In reality pre-lay jetting will move a proportion of material rather than bringing it fully into suspension. Export Cable Corridor pre-lay trenching modelling assumes sediment release along the whole Export Cable Corridor.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				Sandwave clearance • Sandwave clearance width along IAC: 58.6 m; • Area of IAC sandwave clearance: 49,552 m^2 for the 40 x 25 MW and 50 x 20 MW Wind Turbine Layouts; • Sandwave clearance width along Interconnector Cable: 58.6 m; • Area of Interconnector Cable sandwave clearance: 11,814 m^2; • Area of OSP sandwave clearance: 24,359 m^2 for up to 3 OSPs; • Area of fixed foundation sandwave clearance: 172,220 m^2 for the 67 x 15 MW Wind Turbine Layouts; • Sandwave clearance width along Export Cable Corridor: 58.6 m; • Area of Offshore Export Cable sandwave clearance: 609,147 m^2; and • Clearance method: MFE and/or Dredger. Trenchless techniques exit pit excavation • Number of exit pits: up to 3; • 2,800 m3 excavated material for each pit for the 220 kV scenario (8,400 m3 for all pits); and • Exit pit dimensions: 2.2 m x 50 m. Trenchless techniques drilling fluid release (at Landfall) • Number of exit/release events: up to 3; • Up to 2,870 m^3 drilling mud generated per duct, based on bore diameter of 2.2 m and duct length of 755 m (8,610 m^3 total for all three ducts); • 100,000 mg/l (100 kg/m^3) assumed conservative maximum concentration of bentonite in drilling mud; and	Sandwave clearance Sandwave clearance/levelling activities may be undertaken using a range of techniques – MFE and suction hopper dredging. Releases via both are modelled. A MFE near-bed sediment release rate of 1,000 kg/s is conservatively estimated based on the MDS trench cross section dimensions, the speed of progress of the tool, and the bulk density of the local sediment type. Dredge spoil release is simulated as an instantaneous release at the water surface. 10% of an 11,000 m^3 hopper is assumed to form the passive phase of the plume. Other seabed preparation such as boulder clearance is not considered here as the activity does not represent the MDS in terms of potential increases in SSC and associated changes to seabed substrate. Trenchless techniques exit pit excavation Based on maximum exit pit dimensions. Trenchless techniques drilling fluid release (at Landfall) Based on maximum HDD duct dimensions. Assumes a conservative bentonite concentration of 100 kg/m^3 in drilling mud. Other stages of drilling (pilot hole drilling and stages of reaming) may result in smaller release events separated in time. But the MDS is considered as a release of drilling mud from a single conduit.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				• Wet punch-out. **O&M phase** Cable repairs • Number of annual IAC repairs: 1; • Maximum annual length of IAC reburial: 4,915 m; • Number of annual Interconnector Cable repairs: 0.18; • Maximum annual length of Interconnector Cable reburial: 2,040 m; • Number of annual static Offshore Export Cable repairs: 1; and • Maximum annual length of Offshore Export Cable reburial: 6,390 m. **Decommissioning phase** A Decommissioning Programme will be submitted to MD-LOT for consultation and approval. The Decommissioning Programme will be updated during the Project's lifespan to take account of changing best practice and new technologies. The approach for decommissioning is yet to be determined, however, for the purposes of this MDS total removal of all infrastructure including buried cables and cable protection has been assumed, and as such the environmental impact of decommissioning will be the same if not lower than construction.	**O&M phase** The MDS for sediment disturbance during operation will be no greater than that set out for the construction phase of the Proposed Development. Cable repairs These limited activities would disturb a much smaller volume of material for each repair/reburial event than simulated for the construction phase. **Decommissioning phase** The MDS for sediment disturbance during decommissioning will be no greater than that set out for the construction phase of the Proposed Development.
Subsea noise impacting fish and shellfish receptors	✓	✓	✓	**Construction Phase** Piling *Fixed foundation monopile – 25 MW:* • Number of fixed foundations: 40; • Maximum number of piles: 40; • Maximum pile diameter: 15 m;	**Construction Phase** Piling The impact assessment will consider the worst-case impact ranges from both single and concurrent pilling scenarios. Noise modelling will estimate impact ranges for instantaneous auditory injury,

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				• Maximum pile length: 123 m, with final pile penetration of 45 m; • Maximum hammer energy: 6,250 kJ; and • Maximum duration of piling: 8.6 hours. *Jacket foundations 3-legged jacket – 25 MW:* • Number of fixed foundations: 40; • Maximum number of piles: 120; • Maximum pile diameter: 5 m; • Maximum pile length: 90 m, with final pile penetration of 85 m; • Maximum hammer energy: 4,500 kJ; and • Maximum duration of piling: 16.2 hours. *Realistic– Fixed Foundation monopile - 25 MW:* • Number of fixed foundations: 40; • Maximum number of piles: 40; • Maximum pile diameter: 15 m; • Maximum pile length: 123 m, with final pile penetration of 45 m; • Average hammer energy: 6,000 kJ; and • Average duration of piling: 4.3 hours. *Concurrent piling – all three scenarios:* • Up to 2 vessels piling concurrently; and • Minimum 1 km and maximum 20 km distance between concurrent piling events.	accumulated auditory injury (over the duration of the installation period) and disturbance. Three scenarios have been chosen for modelling purposes that will encompass all potential foundation options. *Monopile foundations* The MDS for monopile foundations is based on 25 MW, monopile option. The parameters modelled for this option will encompass the OSPs. *Jacket foundations* The MDS for foundations is based on the 25 MW, 3-legged jacket option. The parameters modelled for this option will encompass the OSPs. *Realistic Scenario* This is based on the 25 MW monopile, using the average hammer energy and average piling duration (instead of maximums) in order to provide context to the maximum scenario. A key parameter in the estimation of accumulated injury, is the duration of impact piling. Concurrent piling will be modelled in addition to single pile events. In all cases concurrent piling would lead to a larger spatial extent of ensonification in total, in comparison to a single piling event. Minimum spacing between concurrent piling represents the highest risk of

<table>
<tr><th rowspan="2">Potential Impact</th><th colspan="3">Phase*</th><th rowspan="2">Maximum Design Scenario (MDS)</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><u>UXO clearance</u>
• Maximum realistic charge weight of UXO - 254 kg (Net Explosive Quantity (NEQ));
• A maximum of 40 UXOs are anticipated to require clearance (based on most probable case for Array Area (30 UXOs) and Export Cable Corridor (10 UXOs) combined);
• A maximum of 2 detonations during 24 hrs; and
• A maximum of 40 days of UXO clearance activities (assuming one clearance per day).

<u>Site investigation surveys</u>
Typical Geophysical equipment:
• Multibeam Echosounder (MBES):
  ◦ Frequency 400 kHz; and
  ◦ Source level 225 dB re 1 µPa (root mean squared (rms)).
• Side-scan sonar (SSS):
  ◦ Low frequency 230 kHz;
  ◦ High frequency 550 kHz; and
  ◦ Source level 210 dB re 1 µPa (rms).
• Parametric Sub-bottom profiler (SBP):
  ◦ 100 kHz (primary); 4, 5, 6, 8, 10, 12 kHz selectable secondary frequencies; and
  ◦ Source level 248 dB re 1 µPa (rms).
• Two dimensional (2D) Ultra High-Resolution Seismic (UHRS):
  ◦ Frequency 0.05 to 4 kHz; and
  ◦ Source level 219 dB re 1 µPa (rms).</td><td>auditory injury to animals as noise from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event. This represents the MDS for concurrent piling injury impacts.
Maximum spacing between concurrent piling represents a larger area of ensonification. This represents the MDS for concurrent piling disturbance impacts.

<u>UXO clearance</u>
Maximum number used in the MDS (reflecting the most probable worst case) and the maximum size of UXOs encountered within the Site Boundary is based on the UXO Hazard Assessment undertaken for the Array. The actual detail of any possible UXO that may need clearance is not known at this stage.

Although not specific to fish and shellfish, the (JNCC, 2025b) guidelines for minimising the risk of injury to marine mammals from UXO clearance, states that the default method for clearance should be a low noise method, as required by the Government’s Joint Position Statement (UK Government, 2025). The MDS represents the maximum charge weight likely to be present, noise modelling will estimate impact rages for low order as the default, with high order impact ranges for context.</td></tr>
</table>

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				Typical Geotechnical equipment: • Vibrocore; and • Boreholes. Geophysical and geotechnical surveys will take place during the pre-construction period, involving up to 14 vessels on site at any one time and up to 110 vessel movements (return trips) in total. Vessel noise and other noise producing activities During the construction phase, a total of 16 vessels will be on site in the Export Cable Corridor at any one time, with an estimated 449 return trips in total. A total of 25 vessels will be on site in the Array Area at any one time with an estimated 1,671 return trips in total. Vessel types include installation (jack-up/dynamic positioning), cargo barge/heavy transport, Scour Protection installation, grouting, drilling, support (dive/trenching, including Service Operation Vessel), tug/anchor, cable laying (and burial), guard, survey, crew transfer vessels, sandwave clearance, pre-lay grapnel run, rock dumping, boulder clearance, UXO clearance, and micro-tunnelling or HDD support vessels. Other noise producing activities, include drilling activities (if required): • Drilling of up to a maximum of 32.5 hours per pile over a maximum realistic duration of 268 days (15 MW 4-leg piled jacket).	Site investigation surveys Site investigation surveys are conducted in the pre-construction phase. However, details of the specific equipment types are not yet known. The assessment will be based on literature/known acoustic characteristics associated with typical equipment used for site surveys. Vessel noise and other noise producing activities Maximum numbers of vessels on site at any one time and largest numbers of return trips during each phase will result in the greatest potential impact. Range of other activities producing underwater noise, including maximum timescales were also included. Drilling noise will be assessed using an appropriate source level and modelled as continuous noise over a 24-hour period. Injury and disturbance from vessel use during UXO clearance and site investigation surveys is included under this potential impact pathway.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				O&M phase Site investigation surveys MDS based on the same geotechnical equipment used for the construction phase. Operational noise from Wind Turbines • Fixed foundation monopile structure with a maximum number of 67 Wind Turbines; • Fixed foundation 3-legged jacket structure with a maximum number of 67 Wind Turbines; • Fixed foundation 4-legged jacket structure with a maximum number of 67 Wind Turbines; and • Fixed foundation 3-legged suction bucket structure with a maximum number of 67 Wind Turbines. • The O&M phase will last up to 30 years. **Decommissioning phase** Vessel noise and other noise producing activities A Decommissioning Programme will be submitted to MD-LOT for consultation and approval. The Decommissioning Programme will be updated during the Project's lifespan to take account of changing best practice and new technologies. The approach for decommissioning is yet to be determined, however, for the purposes of this MDS it is assumed there will be a range of vessels used for decommissioning activities such as removal of foundations, cables and cable.	**O&M phase** Site investigation surveys Site investigation surveys may also be required during the O&M phase. The assessment conducted for the pre-construction phase will be applied to the O&M phase as the same types of equipment are typically used. Operational noise from Wind Turbines Most of the O&M phase noise will be generated from above the water structures (e.g. tower, nacelle, Wind Turbine and rotors). The MDS is based upon the maximum number of Wind Turbines and reflects the maximum scale of the array. **Decommissioning phase** The MDS for subsea noise during decommissioning will be no greater than that set out for the construction phase of the Proposed Development.
Impacts to fish and shellfish receptors due to Electromagnetic Fields (EMF)	×	✓	×	**O&M phase** EMFs may be emitted to the marine environment from inter-array, interconnector, and Offshore Export Cables. Where burial is required, a minimum burial depth of 0.5 m applies to all cables, however there will be a target burial depth of 1.5 m. Where burial is not possible, cable protection will be used. There will be a total of **397 km** of cables, comprised of:	The MDS for this impact is based on the greatest cable lengths proposed, in the water column, buried in the seabed, and protected where burial is not possible.

Potential Impact	Phase*			Maximum Design Scenario (MDS)	Justification
	C	O	D		
				• Up to 151 km of 132 kV IACs are on the seabed (with 75.5 km of these cables buried); • Up to 36 km of 275 kV IC; and • Up to 210 km of 275 kV Offshore Export Cables (up to 3 Offshore Export Cables, with a maximum length of 70 km each). The O&M phase will last for 30 years.	

* Proposed Development Phase refers to construction (C), O&M (O) and decommissioning (D).

Impacts Scoped Out of the Assessment

9.7.3 A Scoping Workshop (see Table 9.7) was used to facilitate stakeholder engagement on topics to be scoped out of the assessment.

9.7.4 On the basis of the baseline environment and the Project Description outlined in Volume 1, Chapter 3: Project Description, a number of impacts are scoped out of the assessment for fish and shellfish ecology. These were either agreed with key stakeholders through consultation (Table 9.7) or the impact was proposed to be scoped out in the Offshore Scoping Report (BOWFL, 2024), and this was confirmed in the Scoping Opinion received (MD-LOT, 2024).

9.7.5 This impact is outlined, together with a justification for scoping it out, in Table 9.16.

Table 9.16: Impact Scoped Out of the Assessment for Fish and Shellfish Ecology

Potential Impact	Phase			Justification
	C	O&M	D	
Accidental pollution to the surrounding environment	✓	✓	✓	There is a risk of accidental pollution from vessels and equipment during all three phases of development. However, the risk will be minimised through the implementation of standard project controls and good practice measures applied through post-consent management plans, such as an EMP, which will include an Marine Pollution Contingency Plan (MPCP). The EMP and MPCP will include procedures for spill prevention and response, identification of potential contaminants, emergency preparedness and contact protocols, and adherence to relevant international and industry guidance for pollution prevention at sea. These measures are well established and routinely applied to comparable offshore developments. The likelihood of accidental pollution occurring is considered to be low. In the unlikely event of an incident, the scale and duration of any effects would be minimised through the application of the MPCP. Therefore, this impact was scoped out of further consideration within the Offshore EIA Report, and this approach was agreed upon by stakeholders in the Scoping Opinion.
Release of sediment-bound contaminants	✓	✓	✓	Sediment chemistry analyses from the recent site-specific benthic subtidal ecology survey for the Proposed Development recorded low levels of contamination (see Volume 3, Technical Appendix 8.1: Benthic Ecology Technical Report). The likelihood of contaminant release from sediment due to seabed disturbance and the remobilisation of sediment-bound contaminants is, therefore, considered to be low. This impact has, therefore, been scoped out of further consideration within the Offshore EIA Report, and this approach was agreed upon by stakeholders in the Scoping Opinion (BOWFL, 2024; MD-LOT, 2024).
Subsea noise from vessels impacting fish and shellfish	✓	✓	✓	The presence of vessels associated with all three phases of development is not likely to represent a significant change from the baseline vessel traffic in the Fish and Shellfish Ecology Study Area (see Volume 2, Chapter 14: Shipping and Navigation for more information). Therefore, this impact was scoped out of further consideration within the Offshore EIA Report, and this approach was agreed upon by stakeholders in the Scoping Opinion (MD-LOT, 2024).
Impacts to fish and shellfish from INNS	✓	✓	✓	There is potential for the increased risk of introduction and spread of INNS during all phases of development. This is due to vessel movement which may act as vectors facilitating the spread of INNS. In addition, the installation of artificial hard structures (such as foundations, Scour Protection, and cable protection) may represent increased available habitat for INNS to colonise in the O&M phase. This impact has been scoped in for benthic ecology (see Volume 2, Chapter 8: Benthic Ecology). However, given the wider ranging nature and habitat use of fish and shellfish species in comparison to benthic species, this impact is not likely to represent a significant impact to fish and shellfish ecology. This, in combination with the Embedded Mitigation of an INNS management plan, was deemed

Potential Impact	Phase			Justification
	C	O&M	D	
				sufficiently rational to scope this out of further assessment within the Offshore EIA Report, and this approach was agreed upon by stakeholders in the Scoping Opinion (MD-LOT, 2024).
Impacts to diadromous fish from shadow flicker	✓	✓	✓	Although not considered in the Offshore Scoping Report, this impact was raised by some consultees during the Scoping Opinion (Table 9.7). As this is a novel impact for the OWF industry, the justification to scope this out was based on expert technical judgement and consultation with MD-LOT, post-Scoping Opinion (TWP, 2025). NatureScot confirmed, in email correspondence dated 04 December 2025, that they do not require an assessment of shadow flicker impacts to be carried out. The full justification to scope this impact out is presented in Table 9.7.
Impacts to fish from entanglement	✓	✓	✓	Floating Wind Turbines are no longer being considered as part of the design envelope for the Proposed Development. As fixed foundations will be utilised and no floating Offshore Infrastructure, there is no risk of entanglement. The full justification to scope this impact out is presented in Table 9.7.

9.8 Methodology for Assessment of Effects

Overview

9.8.1 The fish and shellfish assessment of effects has followed the methodology set out in Volume 1, Chapter 4: Environmental Impact Assessment Methodology. Specific to the fish and shellfish ecology assessment, the following guidance documents have also been considered:

- Guidelines for Ecological Impact Assessment (EcIA) in the UK and Ireland (CIEEM, 2022);
- Marine Evidence Based Sensitivity Assessment (MarESA) – A Guide (Tyler-Walters et al., 2018);
- Sound Exposure Guidelines for Fishes and Sea Turtles (Popper et al., 2014);
- Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Habitat (Kyle-Henney et al., 2024; Reach et al., 2013);
- Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat (Latto et al., 2013; Reach et al., 2024); and
- Guidance on Environmental Considerations for OWF Development (OSPAR Commission, 2008).

Criteria for Assessment

9.8.2 Information about the Proposed Development (including the MDS discussed in Section 9.7 above) and the proposed activities within all stages of the Proposed Development life cycle (construction, O&M, and decommissioning) have been combined with information about the fish and shellfish baseline to identify the potential interactions between the Proposed Development and fish and shellfish ecology.

9.8.3 Impacts are categorised through various characteristics as shown in Table 9.17.

Table 9.17: Descriptions of Categories Related to EIA Impacts

Impact Categories	Description
Direct or Indirect	Direct impacts occur at the same time as an action and occur within the same area, as opposed to indirect impacts which still result from an action but arise later or in a different area.
Adverse or Beneficial	Adverse impacts have an adverse effect on the environment while beneficial impacts have a beneficial effect on the environment.
Reversible or Irreversible	Reversible impacts are temporary, with natural recovery possible, unlike irreversible impacts, where natural recovery is not possible.
Cumulative	Impacts that arise from a combination of the Proposed Development and other projects.
Transboundary	When an impact has an effect on an area that falls within the boundary of another European Economic Area (EEA).
Inter-related	The potential effects of multiple impacts from the construction, O&M and decommissioning of the Proposed Development, affecting one receptor.

9.8.4 The criteria for defining magnitude in this chapter are outlined in Table 9.18. Each assessment considered the spatial extent, duration, frequency and reversibility of impact when determining magnitude which are outlined within the magnitude section of each impact assessment (e.g. a duration of hours or days would be considered for most receptors to be of short-term duration, which is likely to result in a low magnitude of impact).

Table 9.18: Definition of Terms relating to Magnitude of Impact

Magnitude of Impact	Definition
High	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse)
	Large scale or major improvement or resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial)
Medium	Loss of resource, but not adversely affecting integrity of resource; partial loss of/damage to key characteristics, features or elements (Adverse)
	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial)
Low	Some measurable change in attributes, quality or vulnerability, minor loss, or alteration, to one (maybe more) key characteristics, features or elements (Adverse)
	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial)
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse)
	Very minor benefit to, or positive addition of one or more characteristics, features or elements (Beneficial)

9.8.5 The criteria for defining sensitivity in this chapter are outlined in Table 9.19. The Feature Activity Sensitivity Tool (FeAST) and/or a MarESA are available for some fish and shellfish species. The FeAST and MarESA provide assessments of sensitivity against a set of defined pressures. Where available, species-specific FeASTs and MarESAs have been used to inform the sensitivity of some IEFs. For IEFs that do not have a FeAST or MarESA, the sensitivity has been informed by the best available scientific literature and through expert judgement of the technical specialist(s). Not all impacts assessed in Section 9.10 have relevant sensitivity pressures associated with them on FeAST and MarESA, so these have not been used for some impacts. For potential impacts wherein there are no relevant FeAST or MarESA pressures (or where they haven't been assessed due to limited information), the best available scientific literature and expert judgement has been used to inform the sensitivity of the receptor.

9.8.6 There are only two relevant fish and shellfish IEFs listed as features on the FeAST: common skate and sandeels, however the assessments provided on FeAST are limited for many pressures as this tool is still in development. There are MarESAs for the following IEFs: basking shark, common skate (and by extrapolation, flapper skate), common shore crab, edible crab, Norway lobster, and king scallop. It should be noted that all the aforementioned species except basking shark have an outdated MarLIN sensitivity assessment, which was superseded for some species by the MarESA in 2014. There are some slight differences in the pressures included and the naming of some pressures between the MarLIN sensitivity assessment and the more recent MarESA. However, the MarLIN sensitivity assessments are still relevant to define the sensitivity of the receptor and have been referred to as 'MarESA' throughout to increase readability and prevent confusion.

Table 9.19: Definition of Terms Relating to the Sensitivity of the Receptor

Sensitivity of the Receptor	Definition
Very High	Very high importance and rarity, international receptor with no potential or very limited potential for recovery
High	High importance and rarity, international and / or national receptor and limited potential for recovery
Medium	High or medium importance and rarity, regional receptor, and potential for recovery
Low	Low or medium importance and rarity, local receptor and high potential for recovery
Negligible	Very low importance and rarity, local receptor and very high potential for recovery

9.8.7 The magnitude of the impact and the sensitivity of the receptor are combined when determining the likely significance of the effect upon fish and shellfish ecology. The particular method employed for this assessment is presented in Table 9.20 and Table 9.21.

9.8.8 Where a range is suggested for the likely significance of effect, for example, minor to moderate, it is possible that this may span the significance threshold. The technical specialist's professional judgement has been applied to determine which outcome defines the most likely effect, which takes into account the sensitivity of the receptor and the magnitude of impact. Where professional judgement is applied to quantify final likely significance from a range, the assessment will set out the factors that resulted in the final assessment of likely significance. These factors may include the likelihood that an effect will occur, data certainty and relevant information about the wider environmental context.

9.8.9 The EIA Regulations require the identification and reporting of significant environmental effects. For the purposes of this assessment:

- A level of moderate or more will be considered a likely 'significant' effect in terms of the EIA Regulations; and
- A level of minor or less will be considered likely 'not significant' in terms of the EIA Regulations.

Table 9.20: Matrix Used for the Assessment of the Significance of the 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
Very High	Minor	Moderate or Major	Major	Major

Table 9.21: Definition of Likely Significance

Impact	Justification
Negligible	No effects or those that are beneath levels of perception, within normal bounds of variation, or within the margin of forecasting error.
Minor	These beneficial or adverse effects are generally, but not exclusively, raised as local factors. They are unlikely to be critical in the decision-making process but are important in enhancing the subsequent design of the Proposed Development.
Moderate	These beneficial or adverse effects have the potential to be important and may influence the decision-making process. The cumulative effects of such factors may influence decision-making if they lead to an increase in the overall adverse or beneficial effect on a particular resource or receptor.
Major	These beneficial or adverse effects are very important and are likely to be material in the decision-making process. These effects are generally, but not exclusively, associated with sites or features of international, national, or regional importance. However, a major change in a site or feature of local importance may also enter this category.

Designated Sites

9.8.10 This fish and shellfish ecology chapter assesses the likely significant effects in EIA terms on the qualifying feature(s) of Natura 2000 sites (i.e. nature conservation sites in Europe designated under the Habitats or Birds Directives) and/or sites in the UK that comprise the National Site Network (collectively termed 'European sites'). All relevant fish and shellfish qualifying features of European sites have been included in the assessment as IEFs: sandeel, Atlantic salmon, sea lamprey, and freshwater pearl mussel, and have therefore been considered (Table 9.14). The RIAA for the Proposed Development presents an assessment of the potential adverse effects on the integrity of European sites themselves. A summary of the outcomes reported in the RIAA is provided in RIAA, Part 1: Introduction (TWP-BOW-RPS-ENV-REP-00013).

9.8.11 Where locally designated sites and national designations (other than European sites) fall within the boundaries of a European site and where qualifying features are the same, only the European site and qualifying features have been taken forward for assessment. Potential impacts on the integrity and conservation status of the locally or nationally designated site are assumed to be inherent within the assessment of the European site so a separate assessment for the local or national site is not undertaken.

9.9 Embedded Mitigation

9.9.1 As part of the Proposed Development design process, a number of Embedded Mitigation measures have been proposed to reduce the potential for impacts on fish and shellfish ecology (see Table 9.22). They are considered at every stage of the Proposed Development through design and best practice and, as there is a commitment to implementing these measures, these have been considered in the assessment presented in Section 9.10 (i.e. the determination of magnitude and therefore likely significance assumes implementation of these measures). These Embedded Mitigation measures are considered standard industry practice for this type of development.

Table 9.22: Embedded Mitigation Adopted as Part of the Proposed Development

ID*	Embedded Measures Adopted as Part of the Proposed Development	Justification
1	Development of, and adherence to, a Cable Specification and Installation Plan (CSIP) post-consent.	The CSIP will outline the technical specifications of the cables in the Proposed Development and describe the relevant cable installation methodology, and identify risks of cable burial, and any measures required to address these risks to limit the disturbance of the seabed and relevant species as far as practicable.
3	Development of, and adherence to, a Piling Strategy. This will detail use of Acoustic Deterrent Devices (ADDs), slow start, soft start, and ramp up procedures, as appropriate, as well as any Additional Mitigation measures, where determined to be required, in consultation with stakeholders including NatureScot and Marine Directorate-Licensing Operations Team (MD-LOT).	These measures will reduce the likelihood of injury from elevated subsea noise to sensitive fish and shellfish receptors the immediate vicinity of piling operations as far as practicable, by possibly allowing individuals to move away from the area before sound levels reach a level at which injury may occur.
4	Development of, and adherence to, a Cable Burial Risk Assessment (CBRA) and the Cable Burial Assessment (CBA). Implementation, management and monitoring of cable protection, via burial or external protection where adequate burial depth is not feasible, will be undertaken as informed by these assessments. Results of these assessments, and commitments to post construction monitoring, will be provided in the Cable Plan (CaP).	The potential impacts of cable installation can be mitigated through burying cables to a target cable burial depth, as detailed in the CBRA and CBA. This, alongside the cable installation strategy, should provide sufficient depth to avoid most exposure through metocean processes. Details of any required cable protection will be included in the CaP.
5	Development of, and adherence to, an Environmental Management Plan (EMP), including a Marine Pollution Contingency Plan (MPCP) and a Biosecurity Plan with commitments to monitoring and actions to minimise Invasive Non-Native Species (INNS).	Measures will be adopted to ensure that the potential for release of pollutants from construction, O&M and decommissioning plant 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. Further detail on the mitigation of INNS is presented for its associated impact in Volume 2, Chapter 8: Benthic Ecology.

ID*	Embedded Measures Adopted as Part of the Proposed Development	Justification
6	Development of, and adherence to, a Marine Mammal Mitigation Protocol (MMMP), to minimise the risk of auditory injury to marine mammals from noise generating activities resulting from the construction of the Proposed Development. Mitigation will include measures such as Marine Mammal Observers (MMOs), Passive Acoustic Monitoring (PAM) and Acoustic Deterrent Devices (ADDs).	The MMMP includes mitigation measures that are applicable to basking shark and will reduce likelihood of auditory injury from impact piling, UXO clearance and geophysical surveys (Volume 4, Appendix 27: Outline Marine Mammal Mitigation Protocol).
7	Development of, and adherence to, a Construction Method Statement (CMS) along with a Code of Construction Practice (CoCP).	Construction procedures will follow the CMS and CoCP, with measures to control specific health and safety risks identified. The CMS and CoCP will also decrease the risk of collision and/or allision during the construction phase and vessel sinking.
8	All relevant Health and Safety Executive (HSE) procedures will be followed.	As with the CMS, construction procedures will consider all relevant health and safety risks and follow HSE legislation and guidance to mitigate these potential identified risks.
9	Development of, and adherence to, a combined Navigational Safety and Vessel Management Plan (NSVMP), describing Project vessels' requirements, passages, monitoring and controls.	Although more relevant to marine mammals to prevent vessel collisions, this mitigation will also help to mitigate against any collisions to basking shark. This measure will also decrease the risk of collision/allision and thus reduce the potential for accidental pollution to the surrounding environment.
13	Development of, and adherence to, a Lighting and Marking Plan (LMP). The LMP will confirm compliance with legal requirements with regards to shipping, navigation and aviation marking and lighting.	Decreases the risk of collision with vessels or allision with Offshore Infrastructure and thus reduces the potential for accidental pollution to the surrounding environment.
16	Application for, and use of, Safety Zones of up to 500 m during construction, major maintenance, and decommissioning phases. Advisory safe passing distances of up to 500 m will also be applied for mobile installation vessels.	Decreases the risk of allision with Offshore Infrastructure or collision with construction vessels and thus reduces the potential for accidental pollution to the surrounding environment.
18	All vessels working on the Proposed Development will meet the required certification standards and carriage requirements, along with following international marine regulations.	Decreases the risk of allision/contact with Offshore Infrastructure or collision with vessels and thus reduces the potential for accidental pollution to the surrounding environment.

ID*	Embedded Measures Adopted as Part of the Proposed Development	Justification
20	Suitable Aids to Navigation (AtoN) lighting and marking of the Proposed Development including construction buoyage and the use of a Cable Marker Board shall be implemented complying with International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendations G1162 (IALA, 2021), to be finalised and approved in consultation with the Maritime and Coastguard Agency (MCA) and Northern Lighthouse Board (NLB) through a LMP.	Decreases the risk of collision with vessels or allision with Offshore Infrastructure and thus reduces the potential for accidental pollution to the surrounding environment.
21	Wind Turbine design to have a minimum lower blade tip height of 33.12 m above Lowest Astronomical Tide (LAT),	Decreases the risk of allision/contact with Offshore Infrastructure and thus reduces the potential for accidental pollution to the surrounding environment.
23	Development of, and adherence to, an Operation and Maintenance Programme (OMP) in conjunction with approved post-consent construction plans.	Decreases the risk of collision with vessels or allision with Offshore Infrastructure and thus reduces the potential for accidental pollution to the surrounding environment.
24	Development of, and adherence to, a Development Specification and Layout Plan (DSLP). The development of the DSLP includes consultation with the relevant authorities for approval, including the MCA and NLB.	Decreases the risk of collision with vessels or allision with Offshore Infrastructure and thus reduces the potential for accidental pollution to the surrounding environment.
34	Drafting and implementation of a decommissioning programme, prepared in accordance with requirements of the Energy Act 2004, which will set out the extent of infrastructure to be removed as well as the methods and processes which will be used.	The aim of this plan is to adhere to the existing UK and international legislation and guidance (at the time of writing) during the decommissioning phase. This programme will be developed to reduce the amount of long-term disturbance to the environment as far as reasonably practicable.
36	Where practicable, the use of low order disposal of Unexploded Ordnance (UXOs) will be implemented (i.e. deflagration).	Low order techniques will be adopted wherever practicable (e.g. deflagration and clearance shots) as mitigation to reduce noise levels and thereby injury and disturbance to sound-sensitive receptors during UXO clearance. There is a small risk that low order disposal could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment.
40	Creation of a Waste Management Plan (WMP), which will describe the processes for handling and managing any waste materials.	The WMP will set out procedures to ensure all waste processing and handling activities with the potential to affe3ct the environment are appropriately managed.
42	Compliance of project vessels with international marine regulations as adopted by the Flag State, including International Regulations for Preventing Collisions at Sea (COLREGS) (IMO, 1972)	Decreases the risk of allision with Offshore Infrastructure or collision with vessels and thus reduces the potential for accidental pollution to the surrounding environment.

ID*	Embedded Measures Adopted as Part of the Proposed Development	Justification
	and International Convention for the Safety of Life at Sea (SOLAS) (IMO, 1974).	
53	Low order clearance techniques are the default method for UXO clearance (Mitigation measure 36) and would not require Additional Mitigation over and above the Embedded Mitigation measures within the outline MMMP (Volume 4, Appendix 27: Outline Marine Mammal Mitigation Protocol). However, should high order clearance be unavoidable Additional Mitigation may be required dependant on the results of the UXO Risk Assessment. Appropriate mitigation measures will be discussed and agreed with MD-LOT and NatureScot with the detail to be agreed for the finalised MMMP.	Establish a process to assess potential effects on receptors and outline a pragmatic approach with stakeholders and regulators if further Additional Mitigation is needed.
54	Development of, and adherence to, a Project Environmental Monitoring Plan (PEMP) to include details of any agreed surveys or monitoring requirements. The PEMP will provide the mechanism to validate the impact assessment, assess the effectiveness of mitigation measures, and inform adaptation of mitigation measures throughout the construction and O&M phases of the Proposed Development.	The PEMP will detail the methodology that will be used validate the impact assessment predictions made within the EIA. Subsea noise levels will be measured and monitored during the construction phase (impact piling operation). The PEMP will also provide for the mechanism for any adaptation of fish and shellfish mitigation measures if required to reduce impacts from the Proposed Development.

*see Volume 3, Technical Appendix 4.6: Schedule of Mitigation and Commitments

9.10 Assessment of Significance

9.10.1 Table 9.15 summarises the potential impacts arising from the construction, O&M and decommissioning phases of the Proposed Development, as well as the MDS against which each impact has been assessed. An assessment of the likely significance of the effects of the Proposed Development on the fish and shellfish receptors caused by each identified impact is given below.

IMPACT 1 – TEMPORARY HABITAT LOSS AND/OR DISTURBANCE

9.10.2 Temporary habitat loss and/or disturbance may arise due to the activities associated with the construction, O&M, and decommissioning phases of the Proposed Development.

Construction phase

Magnitude of impact

9.10.3 The MDS for this impact accounts for up to 19,414,805 m^2 (19.4 km^2) of temporary habitat loss and/or disturbance during the construction phase (Table 9.15). This represents 6.66% of the total area of the Site Boundary. The MDS has been defined based on the following site preparation and construction activities:

- Trenchless technique (e.g. HDD);
- Sandwave and boulder clearance;
- Installation of IACs, Interconnector Cables and the Offshore Export Cables;
- Removal of disused cables; and
- Footprints from jack-up vessels.

9.10.4 In addition, up to 13,987 m^2 of temporary habitat loss and/or disturbance could occur due to crater formation from the clearance of UXO. This value has not been included in the total disturbance presented above, as the footprint from UXO clearance will likely overlap with area subject to temporary habitat disturbance from other site preparation activities. Additionally, the footprint associated with the UXO clearance has not been derived from Volume 1, Chapter 3: Project Description. Instead, it has been calculated based on appropriate crater sizes estimated in Ordtek (2018), and applied to the 40 UXOs that may require clearance during the construction phase of the Proposed Development (30 in the Array Area and 10 along the Export Cable Corridor).

9.10.5 Cable installation will result in up to 9,638,945 m^2 (9.64 km^2) of temporary habitat loss and disturbance within the construction phase, which represents the largest footprint of impact of all site preparation and construction activities (Table 9.15). This will include the installation of up to 151 km of IACs, up to 36 km of Interconnector Cables, and up to 210 km of Offshore Export Cables, with a maximum 25 m width of disturbance from the installation tool. For the purposes of the MDS, the total footprint of affected seabed has been calculated, assuming a mound of sediment 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 and so this estimate can be considered precautionary.

9.10.6 A recent study reviewed the effects of cable installation on subtidal sediments and habitats, using monitoring reports from over 20 OWFs in the UK (RPS, 2019). After cable installation, sandy sediments were shown to recover quickly, with little to no evidence of disturbance in the years following cable installation (RPS, 2019). Although the report presented some evidence that cable trenches in coarse and mixed sediments were visible for several years after installation, they were shallow (i.e. tens of centimetres) relative to the surrounding seabed and spread over a horizontal distance of several metres and therefore did not represent a large shift from the baseline environment (RPS, 2019). Given that the seabed sediments within the Site Boundary are largely sandy (see Volume 3, Technical Appendix 8.1: Benthic Ecology Technical Report), the results of this study would suggest that disturbance to these sediments is likely to be temporary with seabed recovery in the relative short term (RPS, 2019). Furthermore, post-construction monitoring of the Block Island OWF (off the coast of Rhode Island, United States of America (USA)) demonstrated that 62% of the trenches that were formed during cable installation had recovered within four months, and the remainder was partially recovered (Bureau of Ocean Energy Management (BOEM), 2020), further highlighting the temporary nature of this impact.

9.10.7 Similar to cable installation, depressions on the seabed may occur due to the use of jack-up vessels. The MDS accounts for a total area of up to 148,400 m^2 (0.2 km^2) (Table 9.15). Studies on comparable seabed substrates have shown that seabed impact following jack-up vessel usage is also likely to be temporary in nature with seabed recovery occurring in the relatively short term. For example, monitoring studies at Barrow OWF in the Irish Sea demonstrated that depressions were almost entirely infilled 12 months post construction (Barrow Offshore Windfarm Limited, 2008). Similarly, post-construction seabed monitoring at the Block Island Wind Farm in the USA suggested that depressions from jack-up vessels were expected to fully recover after several months to several years (BOEM, 2020).

9.10.8 Seabed preparation activities associated with the Proposed Development include sandwave clearance (and deposition of cleared material) and boulder clearance. As detailed in Paragraph 9.10.4 above for UXO clearance, any mounds of cleared material associated with sandwave clearance will erode over time with the displaced material re-joining the natural sedimentary environment, gradually reducing the size of the mounds. As the sediment that will be deposited on the seabed will be similar to that of the surrounding areas, displaced communities would be expected to recolonise in areas of temporary seabed disturbance.

9.10.9 The trenchless technique exit pit extraction (at the Landfall at Benholm, Aberdeenshire) may result in up to 17,130 m^2 (0.017 km^2) of temporary habitat loss and/or disturbance (Table 9.15). The predicted disturbance footprint for the exit pit is adjacent to the coast at Benholm, Aberdeenshire and for most fish and shellfish there is no pathway of potential impact. However, consultation received in the Scoping Opinion emphasised the importance of the Rivers South Esk and Dee, which flow into the North Sea (Table 9.8) for diadromous fish species (notably Atlantic Salmon). The potential HDD exit pit locations are between 21.8 km to 21.9 km from the mouth of the River South Esk and between 40.3 km and 40.4 km from the mouth of the River Dee. Therefore, due to this distance and the low disturbance footprint (0.017 km^2), temporary habitat disturbance associated with HDD exit pit extraction is unlikely to cause significant impediment of migratory and/or foraging activity of diadromous fish (notably Atlantic salmon) within the Rivers South Esk and Dee.

9.10.10 The programme for the site preparation and construction works is scheduled to last for five years, inclusive from the start of 2031 to the end of 2036. Pre-construction surveys are scheduled to take place in advance of the site preparation and construction works in 2026. The site preparation and construction activities detailed in the preceding paragraphs will be phased intermittently over the construction phase. For example, boulder and UXO clearance activities will be undertaken a year prior to sandwave clearance for cable installation and other cable installation activities. It is also important to note that footprint of temporary habitat loss and disturbance in this phase will not represent one continuous area and will be spread spatially and temporally over the Array Area and Export Cable Corridor. Once construction in a localised area has been completed, this area will not be disturbed further during the construction phase. This area will start to recover following cessation of construction activities in the vicinity allowing mobile species, such as sandeel and other fish and shellfish species, to repopulate the areas of previous disturbance.

9.10.11 The impact is predicted to be of local spatial extent (6.67% of the total area of the Site Boundary), medium term duration, intermittent and 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 the Receptor

9.10.12 Substrate type is the primary driver for recoverability and rate of recovery of an area after large scale seabed disturbance (Desprez, 2000; Newell *et al.*, 1998). For example, studies have shown that muddy or sandy habitats (such as those recorded within the Site Boundary) can return to baseline species abundance after approximately one to two years (Desprez, 2000; Newell *et al.*, 1998). Further, post-construction monitoring of the Walney Wind Farm Extension in the Irish Sea reported a degraded benthic and demersal fish and shellfish community in comparison to pre-construction levels within its Array Area, but no significant difference within its export cable corridor (Centre for Marine and Coastal Studies (CMACS (2012)).

9.10.13 The fish and shellfish IEFs may be indirectly affected through temporary loss and disturbance of foraging habitat and associated prey items. For example, crabs and other crustaceans and smaller demersal fish species are considered important prey species for larger fish. However, since this impact is predicted to affect only a small proportion of seabed habitats in the Site Boundary at any one time, and given that there are similar habitats (and prey species) occurring throughout the Fish and Shellfish Ecology Study Area, these impacts are likely to be limited. Further, temporary habitat disturbance will also expose benthic infaunal species from the sediment, potentially offering foraging opportunities to opportunistic scavengers immediately after completion of works. The implications of changes in fish and shellfish prey species are also discussed for higher trophic level receptors (i.e. marine mammals and birds) in Volume 2, Chapter 10: Marine Mammals and Volume 2, Chapter 11: Offshore Ornithology.

Marine Fish IEFs

9.10.14 The marine fish IEFs that are likely to be most sensitive to temporary habitat loss and disturbance are those which live or spawn on or near the seabed sediment (e.g. herring, sandeel, some elasmobranchs). Other fish species identified as IEFs in Table 9.14 (particularly adults) are considered less vulnerable to temporary habitat loss as they can move away from impacted areas and recolonise quickly once activities have ceased, compared to species and life history stages (e.g. juveniles) which are less mobile.

9.10.15 Demersal species, such as anglerfish and flatfish IEFs, are not considered to be particularly vulnerable to this impact. For example, neither positive nor negative effects of construction and operation of the Block Island Wind Farm were observed for a range of north American flatfish species (Wilber *et al.*, 2018) suggesting a degree of resilience to this impact in flatfish, and an ability to move away from temporarily affected areas of the seabed.

9.10.16 As demersal spawners, temporary loss and disturbance to seabed habitats could lead to sandeel mortality if individuals cannot colonise their preferred sandy spawning habitats in the immediate vicinity, or where these habitats may be at carrying capacity (Wright *et al.*, 2000). The FeAST tool reports sandeel as having a medium sensitivity to 'surface abrasion' and high sensitivity to 'physical removal (extraction of substratum)' and 'sub-surface abrasion/penetration' (NatureScot, 2025). Sandeel may also be particularly vulnerable during their winter hibernation period when they are less mobile and remain buried in the seabed substrates. The Site Boundary is located in an area of low intensity spawning and low intensity nursery grounds for sandeel and a mix of preferred, marginal and unsuitable habitat type (Figure 9.3 and Table 9.10).

9.10.17 Sandeel spawning and nursery grounds are also widespread throughout the Fish and Shellfish Ecology Study Area as a whole. However, only a small proportion of the maximum footprint of temporary habitat loss and disturbance will be occurring at any one time during the construction phase, with recovery of sediments, and associated sandeel populations into them, following cessation of activities. For example, site preparation activities (such as boulder, sandwave, and UXO clearance) will occur in parts of the Array Area and Export Cable Corridor in the year before construction activities begin. Further, the construction activities will be staggered both spatially and temporally throughout the remainder of the construction phase. Further detail on the construction programme is provided in Volume 1, Chapter 3: Project Description.

9.10.18 Short and long term monitoring studies at the Horns Rev Offshore Wind Farm (OWF) in the Baltic Sea have reported that OWF construction (Jensen *et al.*, 2004) and operation (Van Deurs *et al.*, 2012) did not lead to significant adverse effects on sandeel populations. In addition, sandeel populations recovered quickly following construction operations (Jensen *et al.*, 2004). Thus, recovery of sandeel populations in the Site Boundary would be expected following temporary habitat loss and disturbance, with the rate of recovery dependent on the recovery of sediments to a condition suitable for sandeel recolonisation. Recovery may also occur through larval recolonisation of suitable sandy sediments with larvae likely to be distributed during spring months following spawning in winter/spring (Ellis *et al.*, 2012).

9.10.19 North of the Fish and Shellfish Ecology Study Area, results of a post-construction monitoring study at the Beatrice OWF showed that sandeel abundance either increased or remained at similar levels when comparing abundance from 2014 to 2020, with the offshore construction phase of Beatrice OWF commencing in April 2017 (Beatrice OWF Limited, 2021a). This study reported no evidence that construction resulted in adverse impacts on the local sandeel population and builds upon previous work by Stenberg *et al*. (2011) which also concluded that the construction of the Horns Rev 1 OWF (southern North Sea) neither threatened nor directly benefitted sandeel over a seven year survey period.

9.10.20 Sandeel is likely to be impacted by temporary habitat loss, although recovery is expected to occur as the seabed sediments recover as well as via larval colonisation of the sandy sediments. The sandeel IEF is deemed to be of high vulnerability and national value but with high potential for recovery. The sensitivity of the receptor is, therefore, considered to be medium.

9.10.21 Herring are demersal spawners, with specific spawning substrate requirements. Therefore, temporary habitat loss and disturbance may lead to mortality in a similar manner to sandeel if spawning habitats are lost or disturbed due to the construction of the Proposed Development. Suitable spawning grounds are therefore vital for herring stock resilience, although these habitats can be adversely impacted by environmental impacts, such as storms, and anthropogenic pressures (Moll *et al.*, 2018; Thurstan and Roberts, 2010). Herring stocks have historically followed “boom and bust” cycles, with recolonisation of spawning grounds and subsequent population recovery not fully understood (Dickey-Collas *et al.*, 2010; Schmidt *et al.*, 2009; Trochta *et al.*, 2020). Herring have very particular spawning habitat preferences, however a degree of plasticity in spawning ground utilisation can buffer against temporary changes to their environment, and increase population resilience (Frost and Diele, 2022; Schmidt *et al.*, 2009).

9.10.22 Based on site-specific herring spawning habitat suitability assessment, the majority of habitats present within the Site Boundary are considered to be unsuitable for herring spawning. However, there are areas of marginal and preferred habitats within the Array Area (Figure 9.2). The potential for direct temporary loss and disturbance to herring spawning grounds within the Site Boundary is, therefore, likely. Spawning grounds have also been recorded in the wider Fish and Shellfish Ecology Study Area (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report for more information), however there is not considered to be a pathway of potential impact for temporary habitat loss or disturbance to the wider Study Area.

9.10.23 The herring IEF is deemed to be of high vulnerability, high recoverability and national value. Herring spawning grounds are likely to be impacted by temporary habitat loss and disturbance associated with the construction of the Proposed Development, given there are some areas showing habitat suitability within the Site Boundary. The sensitivity of the receptor is, therefore, considered to be medium.

9.10.24 For many of the remaining marine fish IEFS, there are spawning and/or nursery grounds overlapping with the Site Boundary (and thus the ZoI of temporary habitat loss and disturbance; Table 9.10). However, these are not unique to the Site Boundary and are largely widespread throughout the Fish and Shellfish Ecology Study Area as a whole (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report for more information). Further, as the remaining marine fish IEFs are highly mobile species (with many mainly occupying the pelagic zone, such as Atlantic bluefin tuna, mackerel, sprat, and various elasmobranchs), they are likely to be able to move away from areas of disturbance and temporary habitat loss. This rationale has been used by FeAST and MarESA for two of the remaining marine fish IEFs, common skate and basking shark.

9.10.25 The common skate IEF and basking shark IEF both have MarESAs, with the former also included on FeAST (NatureScot, 2025; Neal and Pizzolla, 2006; Wilson *et al.*, 2020). Common skate has been assessed as having medium sensitivity to 'surface abrasion', and no sensitivity to 'sub-surface abrasion/penetration' on FeAST (NatureScot, 2025). This medium sensitivity is based on the potential for surface abrasion to spawning habitats, however, data has shown that these are not likely to be present within the Fish and Shellfish Ecology Study Area (Table 9.10; Ellis *et al.* (2012)). The spawning (and egg-laying) habitats for flapper skate have been characterised as being rocky, boulder, cobble, and mixed substrates in water depths of between 20 m to 50 m (Phillips *et al.*, 2021; Scottish Government, 2021). These habitat types were not largely identified within the Site Boundary, and where they occurred, they were not high enough in abundance to support extensive egg-laying habitat (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report). It is likely that these habitat preferences are very similar for common skate, given the close relatedness and life histories of these two species within the common skate complex.

9.10.26 The MarESA for common skate presents low sensitivity to 'substratum loss' (Neal and Pizzolla, 2006). The MarESA for basking shark concludes that this IEF has no sensitivity to 'removal of substratum', 'abrasion/disturbance of the surface of the seabed' and 'penetration or disturbance of the substratum subsurface' (Wilson *et al.*, 2020). These sensitivities can reasonably be applied to the other marine fish IEFs, as they are all highly mobile and many either live and/or spawn in the pelagic zone.

9.10.27 Overall, the remaining marine fish IEFs are deemed to be of low vulnerability, high recoverability and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

<u>Diadromous fish IEFs</u>

9.10.28 As diadromous fish species are highly mobile and typically occupy the pelagic zone during their marine phase, they will be outwith the ZoI for temporary habitat loss and disturbance. Therefore, any temporary habitat loss and disturbance to the seabed within the Export Cable Corridor and the Array Area is not likely to cause any direct impact upon diadromous fish IEFs, nor is it likely to affect their migration patterns.

9.10.29 There is the potential for indirect impacts on diadromous fish IEFs due to potential changes in prey and host species from temporary habitat loss and disturbance. For example, adult sea lamprey are parasitic and known to prey on a wide range of larger fish and some cetacean species (Silva *et al.*, 2014). Like the marine fish IEFs, most large mobile host species are likely to be able to avoid any potential effects associated with temporary seabed habitat loss due to their mobility but likely to return into the areas affected following cessation of construction activities.

9.10.30 The diadromous fish IEFs are deemed to be of low vulnerability, high recoverability and of national to international value. 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.

<u>Shellfish IEFs</u>

9.10.31 The shellfish IEFs (with the exception of squid and octopi IEFs) live directly on the seabed and are typically less mobile than fish IEFs making them potentially more vulnerable to impacts associated with temporary habitat loss and disturbance. For example, a mark and recapture study on berried European lobster reported that 84% of berried females remained within 500 m of their release site (Agnalt *et al.*, 2007). An earlier similar study by Smith *et al.* (2001) reported that tagged European lobsters did not appear to undertake extensive alongshore or on-/offshore migrations. Recapture distances ranged from 0 km to 45 km, but 95% of recaptured European lobsters moved less than 4 km from their original release positions over periods of up to 862 days (Smith *et al.*, 2001). Finally, Øresland and Ulmestrand (2013) demonstrated limited movement in this species, with only 58 out of 4,016 tagged European lobsters recaptured over 1 km away from the release site.

9.10.32 Similarly, Vigo *et al.* (2021) demonstrated that the home ranges of tagged Norway lobster were approximately 17.75 m^2 to 736.25 m^2, once the individuals had settled in place. Norway lobster, European lobster, and the other larger crustacean IEFs 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). For example, Norway lobster is considered to have a moderate recoverability and sensitivity to 'substratum loss' and a high recoverability and low sensitivity to 'abrasion and physical disturbance' according to its MarESA (Hill and Sabatini, 2008). There are Norway lobster spawning and nursery habitats within the Fish and Shellfish Ecology Study Area, and these areas overlap with the Site Boundary (Table 9.10). The construction phase activities responsible for temporary habitat loss and disturbance within the Site Boundary will therefore have a direct impact on the spawning and nursery habitats of Norway lobster. The sensitivity of the Norway lobster IEF is considered to be medium.

9.10.33 Of the crab IEFs, there are MarESAs available for two species: common shore crab and edible crab (Neal and Pizzolla, 2008; Neal and Wilson, 2008). The common shore crab has a high recoverability and low sensitivity to 'substratum loss' and 'abrasion and physical disturbance' (Neal and Pizzolla, 2008). This is because this species can live across a wide range of substrata, and is unlikely to be impacted by a temporary loss of substratum (Neal and Pizzolla, 2008). A capture-mark-recapture study at the Lillgrund OWF in Sweden found no evidence that the project had negative effects on common shore crab populations (Langhamer *et al.*, 2016). The edible crab also has a high recoverability and low sensitivity to 'abrasion and physical disturbance', due the high potential for population recovery (Neal and Wilson, 2008). This IEF has a moderate recoverability and sensitivity to 'substratum loss' as some individuals will be able to escape, and will quickly recolonize whatever seabed remains or migrate to new habitats if necessary (Neal and Wilson, 2008).

9.10.34 This impact will only represent a small temporary loss and disturbance to seabed habitats within the Site Boundary, and sediments are likely to recover rapidly, with recolonisation of associated communities afterwards (RPS, 2019). Seabed substrate type largely dictates the potential for and rate of recovery of an area after large scale seabed disturbance (e.g. dredging or trawling activities) (Desprez, 2000; Newell *et al.*, 1998). For example, muddy or sandy habitats (such as those recorded within the Site Boundary) can return to baseline species abundance after approximately one to two years (Desprez, 2000; Newell *et al.*, 1998). A recent study at the Westermost Rough OWF within a European lobster fishing ground reported that the size and abundance of European lobsters increased following temporary closure of the area for the construction of the OWF (Roach *et al.*, 2018). This study implies wind farm construction activities did not impact European lobster populations and instead allowed some relief from fishing activity (Roach *et al.*, 2018).

9.10.35 The king and queen scallop IEFs, whilst predominantly sessile, 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 this distance of their release point after 18 months (Howell and Fraser, 1984). Thus, king and queen scallop may have improved resilience to this impact, as they could potentially flee localised areas of disturbance. Scallop tend to aggregate, as their larval distribution is reliant on relatively unpredictable hydrographic features (Delargy *et al.*, 2019). For example, Le Pennec *et al.* (2003) reported that king scallop larvae could travel up to 40 km in 18 days, while Sinclair *et al.* (1985) proposed that their larvae could also undertake vertical migrations and retain self-sustaining populations. Nonetheless, the king and queen scallop IEFs are expected to continue spawning outwith the ZoI for this impact. As suitable settlement habitat will remain following cessation of construction activities, it is expected that king and queen scallop will continue to be recruited within the Site Boundary and the wider Fish and Shellfish Ecology Study Area, either through vertical or horizontal larval transport. King and queen scallop are therefore likely to recover well from disturbance due to temporary habitat loss and disturbance. This is supported by the MarESA (only available for king scallop), which concluded that this species has a high recovery potential against the pressure of 'substratum loss' (Marshall and Wilson, 2008).

9.10.36 The shellfish IEFs are deemed to be of medium vulnerability, high recoverability and local value. The sensitivity of the receptor is, therefore, considered to medium for the Norway lobster IEF and low for all others.

Significance of the effect

9.10.37 Overall, for the sandeel, herring and Norway Lobster IEFs, the magnitude of the impact is deemed to be low and the sensitivity of the receptor considered to be medium. The effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.10.38 For all other fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.10.39 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

O&M phase

9.10.40 The MDS accounts for up to a total of 11,688,813 m^2 (11.68 km^2) of temporary habitat loss and disturbance during the 30-year O&M phase due to cable repair and reburial (Table 9.15). The impacts of cable repair and reburial will be similar to those identified for cable installation in the construction phase above. This represents up to 4.01% of the total area of the Site Boundary. However, it should be noted that only a small proportion of the total temporary habitat loss and disturbance is likely to occur at any one time, with the MDS for this impact calculated over the 30-year lifecycle of the Proposed Development. Therefore, individual cable maintenance activities will be small scale and intermittent events.

9.10.41 The spatial extent of this impact in the O&M phase is small in relation to the Fish and Shellfish Ecology Study Area, although there is the potential for repeated disturbance to the habitats in the immediate vicinity of the infrastructure because of these activities. The effects associated with this phase of the Proposed Development are expected to be similar to the construction phase, but of a much lower magnitude.

9.10.42 The impact is predicted to be of local spatial extent (4.01% of the total area of the Site Boundary), long term duration, intermittent and 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 the receptor

9.10.43 The sensitivity of the receptor is as already presented for the construction phase (in Paragraphs 9.10.13 *et seq*.) and is not repeated here.

Significance of the effect

9.10.44 Overall, for the sandeel, herring and Norway Lobster 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.

9.10.45 For all other fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.46 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.10.47 As the approach for decommissioning is yet to be determined, no footprint of temporary habitat loss and disturbance could be calculated for this phase. However, for the purposes of this MDS, the total removal of all infrastructure including buried cables and cable protection has been assumed, and as such the environmental impact of decommissioning will be the same if not lower than construction (Table 9.15).

9.10.48 The impact is predicted to be of local spatial extent, medium term duration, intermittent and 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 the receptor

9.10.49 The sensitivity of the receptor is as already presented for the construction phase (in Paragraphs 9.10.13 *et seq.*) and is not repeated here.

Significance of the effect

9.10.50 Overall, for the sandeel, herring and Norway Lobster 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.

9.10.51 For all other fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.52 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

IMPACT 2 - LONG TERM HABITAT LOSS AND/OR DISTURBANCE

9.10.53 Long term habitat loss and/or disturbance may arise due to the installation of infrastructure in the construction phase and persist into the O&M phase (hence these two phases have been combined for this impact). While some infrastructure will be removed during the decommissioning of the Proposed Development, any infrastructure that is proposed to be left *in situ* represents the MDS for this impact in the decommissioning phase.

Construction and O&M phases

Magnitude of impact

9.10.54 The MDS accounts for up to a total of 2,251,000 m^2 (2.25 km^2) of long-term habitat loss and disturbance as infrastructure is installed during the construction phase, which will persist into the 30-year O&M phase (Table 9.15). This represents 0.77% of the total area of the Site Boundary. The MDS has been based on the installation of the following infrastructure on the seabed:

- Wind Turbine foundations and associated Scour Protection;
- OSP foundations and associated Scour Protection and mud mats; and
- Cable protection and cable crossing protection for IACs, interconnector and Offshore Export Cables (Table 9.15).

9.10.55 It should be noted that the MDS footprint for this impact will be spread out over the Array Area and Export Cable Corridor within the Site Boundary and does not represent one continuous area of 2.25 km^2 of long-term habitat loss.

9.10.56 Overall, the impact is predicted to be of local spatial extent (0.77% of the total area of the Site Boundary), long term duration, continuous, and of low reversibility during the construction and O&M phases. It is predicted that the impact will affect the receptor directly. This impact presents some measurable, but minor long-term loss of and alteration to areas of seabed within the Site

Boundary, but not within the Fish and Shellfish Ecology Study Area. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

9.10.57 Fish and shellfish IEFs that rely on the presence of suitable sediment and subtidal habitats for their survival would typically be more vulnerable to this impact, depending on the availability of said habitats within the wider Fish and Shellfish Ecology Study Area. The long-term loss and disturbance of seabed habitats due to the Proposed Development will reduce the area of suitable habitat and available food resources within the Site Boundary for the fish and shellfish communities associated with them. However, the total footprint of seabed potentially impacted represents a low percentage of the extensive subtidal habitats present within Site Boundary and within the Fish and Shellfish Ecology Study Area as a whole.

Marine fish IEFs

9.10.58 The Fish and Shellfish Ecology Study Area coincides with spawning and nursery habitats for a range of species, with several overlapping with the Site Boundary directly (Table 9.10). Sandeel and herring are the most vulnerable teleost fish IEFs to long term seabed habitat loss due to their demersal spawning habitat requirements. As stated in Paragraphs 9.10.13 *et seq*. (for 'Temporary Habitat Loss and/or Disturbance'), these species lay their eggs on the seabed and require specific sediment composition in order to do so successfully. Some elasmobranchs, such as spotted ray, thornback ray, common skate, and flapper skate, are also demersal spawners, as they lay egg cases in shallow nearshore nurseries. Low intensity nursery grounds for several of these species were identified as overlapping with the Site Boundary and/or being present throughout the Fish and Shellfish Ecology Study Area (Table 9.10). Sandeel spawning intensity is high within the Site Boundary, though this area forms a relatively small proportion of the high intensity spawning grounds present across the Fish and Shellfish Ecology Study Area. Herring spawning grounds of undetermined intensity are also present within the Site Boundary. Given that these habitats are extensive throughout the Fish and Shellfish Ecology Study Area, these species are unlikely to be significantly impacted by long term habitat loss and disturbance that may overlap with their nursery grounds.

9.10.59 As described in Paragraph 9.10.15 for 'Temporary habitat loss and/or disturbance', long term loss and disturbance to seabed habitats could lead to sandeel mortality if individuals cannot colonise their preferred sandy spawning habitats in the immediate vicinity, or where these habitats may be at carrying capacity (Wright *et al.*, 2000). The FeAST tool reports sandeel as having a high sensitivity to 'physical removal (extraction of substratum)' and 'physical change (to another seabed type)' (NatureScot, 2025). Sandeel may also be particularly vulnerable during their winter hibernation period when they are less mobile and remain buried in the seabed substrates. The Site Boundary is located in an area of high intensity spawning and low and unspecified intensity nursery grounds for sandeel and a mix of preferred, marginal and unsuitable habitat type (Figure 9.3 and Table 9.10). There is suitable sandeel spawning habitat located throughout the north of the Fish and Shellfish Ecology Study Area as a whole (Figure 9.3), with Turbot Bank MPA designated for sandeel spawning and nursery habitat (far outwith the ZoI for this impact, see Figure 9.4). The maximum footprint of long-term habitat loss and disturbance will only make up a small proportion of the Site Boundary as a whole (0.77%). Therefore, it is unlikely that long term habitat loss and disturbance within the Site Boundary will affect sandeel at a population level. Furthermore, monitoring as the Horns Rev I OWF (Denmark) 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 OWF north of the Fish and Shellfish Ecology Study Area demonstrated no negative effects on sandeel populations (Beatrice OWF Limited, 2021a).

9.10.60 The sandeel IEF is deemed to be of high vulnerability, high recoverability and regional value. The sensitivity of the receptor is, therefore, considered to be medium.

9.10.61 As detailed in Paragraph 9.10.20 for 'Temporary habitat loss and/or disturbance', herring also have very particular spawning habitat preferences and could suffer if these habitats are lost or disturbed. However, based on site-specific herring spawning habitat suitability assessment, the habitats present within the Site Boundary are considered to be largely unsuitable for herring spawning (Figure 9.2). Spawning grounds of undetermined intensity have been recorded across the Site Boundary, and the wider Fish and Shellfish Ecology Study Area (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report for more information). The spawning ground in the Site Boundary makes up a fraction of the wider herring spawning ground across the Fish and Shellfish Ecology Study Area, therefore the majority of the spawning ground is outwith the ZoI for this impact, which is confined within the Site Boundary. Overall, it is considered unlikely that herring populations will be largely affected by long term habitat loss and disturbance from the Proposed Development.

9.10.62 The herring IEF is deemed to be of high vulnerability, medium recoverability, and of national value. The sensitivity of the receptor is, therefore, considered to be medium.

9.10.63 For many of the remaining marine fish IEFS, there are spawning and/or nursery grounds overlapping with the Site Boundary (and thus the ZoI of long-term habitat loss and disturbance; Table 9.10). However, these are not unique to the Site Boundary and are largely widespread throughout the Fish and Shellfish Ecology Study Area as a whole (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report for more information). Further, as the remaining marine fish IEFs are highly mobile species (with many mainly occupying the pelagic zone, such as Atlantic bluefin tuna, mackerel, sprat, and various elasmobranchs), they could easily move away from long term habitat loss and disturbance to the seabed (which does not represent a significant area within the Site Boundary: 0.77%). This rationale has been used by FeAST and MarESA for two of the remaining marine fish IEFs. The common skate IEF and basking shark IEF both have MarESAs, with the former also included on FeAST (NatureScot, 2025; Neal and Pizzolla, 2006; Wilson *et al.*, 2020). On the FeAST, common skate has been assessed as having low sensitivity to 'physical change (to another seabed type)' due to its high mobility (NatureScot, 2025). This species was not assessed against the FeAST pressure 'physical removal (extraction of substratum)' due to insufficient information on potential effects to rocky habitats in which their egg cases are typically laid (NatureScot, 2025). The MarESA for common skate presents a low sensitivity to 'substratum loss', again citing this species' high mobility (Neal and Pizzolla, 2006). However, the MarESA notes concerns about the potential for substratum loss in egg-laying habitats for this species.

9.10.64 The spawning (and egg-laying) habitats for flapper skate have been characterised as being rocky, boulder, cobble, and mixed substrates in water depths of between 20 m to 50 m (Phillips *et al.*, 2021; Scottish Government, 2021). These were not identified as largely present across the Site Boundary (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report). It is likely that these habitat preferences are very similar for common skate, given the close relatedness and life histories of these two species within the common skate complex. Therefore, these species are not likely to be significantly vulnerable to this impact within the Site Boundary.

9.10.65 The MarESA for basking shark concludes that this IEF has no sensitivity to 'physical change (to another seabed type)', 'physical change (to another sediment type)' and 'habitat structure changes – removal of substratum (extraction)' (Wilson *et al.*, 2020). These sensitivities can reasonably be applied to the other marine fish IEFs, as they are all highly mobile and many either live and/or spawn in the pelagic zone.

9.10.66 Overall, the remaining marine fish IEFs are deemed to be of low vulnerability, high recoverability and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

<u>Diadromous Fish IEFs</u>

9.10.67 As diadromous species are highly mobile and not reliant on demersal offshore habitats for spawning or breeding, they are considered to be less susceptible to the impact of long-term habitat loss and disturbance. Diadromous species are only likely to interact within the ZoI while migrating to and from rivers and freshwater habitats. Thus, this impact is unlikely to be of particular relevance for diadromous fish species as it will not present a barrier to migration or affect their ecology during their marine life stages.

9.10.68 Diadromous species may be indirectly affected due to impacted prey species, such as sandeel and herring. However, the majority of marine fish species are unlikely to be impacted by any long term habitat loss and disturbance associated with the Proposed Development and population level effects are not likely to occur (see Paragraphs 9.10.57 to 9.10.66).

9.10.69 The diadromous fish IEFs are deemed to be of low vulnerability, high recoverability and national to international value. 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.

Shellfish IEFs

9.10.70 As most of the shellfish IEFs are less mobile than the fish IEFs, they are potentially more vulnerable to the effects of long-term habitat loss and disturbance at the seabed. The installation of infrastructure associated with the Proposed Development has the potential to directly damage the habitats inhabited by these IEFs. The potential for long term habitat loss directly around the Proposed Development infrastructure represents a small proportion of habitat within the Fish and Shellfish Ecology Study Area, and is unlikely to impact on the wider scallop population. This is supported by the MarESA for king scallop, which notes that king scallop tend to have a high potential for recovery from the pressure 'substratum loss' (Marshall and Wilson, 2008).

9.10.71 There are Norway lobster spawning and nursery habitats within the Fish and Shellfish Ecology Study Area, which overlap with the Site Boundary (Table 9.10). Construction phase activities responsible for long term habitat loss and disturbance within the Site Boundary will, therefore, have a direct impact on the spawning and nursery habitats of Norway lobster. The Site Boundary accounts for a small portion of the spawning and nursery habitat within the Fish and Shellfish Ecology Study Area, so it is likely adjacent spawning and nursery areas across the wider Fish and Shellfish Ecology Study Area could be utilised. This is supported by the MarESA for Norway lobster, which notes Norway lobster tend to have moderate potential for recovery from 'substratum loss' (Hill and Sabatini, 2008). The sensitivity of the Norway lobster IEF is, therefore, considered to be medium.

9.10.72 The spawning and nursery habitats of various other shellfish IEFs identified in this assessment, such as common shore crab and edible crab are not available in the datasets utilised in this assessment (Aires *et al.*, 2014; Coull *et al.*, 1998; Ellis *et al.*, 2012). Given the wide range of available habitat throughout the Fish and Shellfish Ecology Study Area and the low footprint of impact within the Site Boundary (0.77%), it is not likely that this impact will significantly impact these species. As detailed in Paragraph 9.10.32, common shore crab and edible crab are expected to have some recoverability to 'substratum loss' (Langhamer *et al.*, 2016; Neal and Pizzolla, 2008; Neal and Wilson, 2008; Van Bernem, 1999).

9.10.73 The shellfish IEFs are deemed to be of low to medium vulnerability, moderate to high recoverability and local value. The sensitivity of the receptor is, therefore, considered to be low. Precautionarily, the sensitivity of the Norway lobster IEF is considered to be medium.

Significance of the effect

9.10.74 Overall, for the sandeel, herring and Norway Lobster 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.

9.10.75 For all other fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.76 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.10.77 The approach for the decommissioning phase is yet to be determined, however, for the purposes of this assessment, the MDS assumes that all Scour Protection, cable protection, and cable crossing protection will be left *in situ*. Therefore, up to 2,251,000 m^2 (2.25 km^2) of long-term habitat loss will persist through the decommissioning phase and onwards. This value has been calculated as the total footprint area for all Scour Protection, cable protection, and cable crossing protection installed during the construction phase. This represents up to 0.77% of the total area of the Site Boundary.

9.10.78 It should be noted that the MDS footprint for this impact will be spread out over the Array Area and Export Cable Corridor, within the Site Boundary and does not represent one continuous area of 2.25 km^2 of long-term habitat loss persisting during and after the decommissioning of the Proposed Development.

9.10.79 The impact is predicted to be of local spatial extent (0.77% of the total area of the Site Boundary), long term duration, continuous, and of low reversibility as left *in situ*. It is predicted that the impact will affect the receptor directly. This impact presents some measurable, but minor long-term loss of and alteration to areas of seabed within the Site Boundary, but not within the Fish and Shellfish Ecology Study Area. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

9.10.80 The sensitivity of the receptor is as already presented for the construction and O&M phases (in Paragraphs 9.10.57 *et seq.*) and is not repeated here.

Significance of the effect

9.10.81 Overall, for the sandeel, herring and Norway lobster 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.

9.10.82 For all other fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.83 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

IMPACT 3 - COLONISATION OF HARD STRUCTURES

9.10.84 Colonisation of hard structures is associated with the installation of infrastructure in the construction phase, and ongoing presence of infrastructure through the O&M phase. Whilst some infrastructure will be removed during the decommissioning of the Proposed Development, that left *in situ* represents the MDS for this impact in the decommissioning phase.

9.10.85 Hard structures in the marine environment (for example on foundations or Scour Protection) can attract many marine organisms including benthic and biofouling species. This can lead to the development of artificial reefs with these structures replicating naturally occurring rocky habitats (Karlsson *et al*., 2022). When hard structures are placed into areas of predominantly soft, sedimentary environments the colonisation of species can alter the naturally occurring habitats and create localised hotspots of prey resources (Inger *et al*., 2009). Karlsson *et al*. (2022) recorded these effects at the Hywind Floating OWF (Scotland) where colonisation of infrastructure included plumose anemones *Metridium senile* and fan worms *Spirobranchus* sp. which dominated the bottom and mid-section of floating Wind Turbines, with kelp Laminaria sp., other brown seaweeds, and blue mussels *Mytilus edulis* found in the upper 20 m to surface level. Additionally, anthropogenic structures may also have direct impacts on fish and shellfish communities through their potential to cause fish aggregation effects (Petersen and Malm, 2006). Volume 2, Chapter 8: Benthic Ecology examines this impact from the perspective of benthic colonisation and habitat creation, whereas this assessment looks at the subsequent consequences for fish and shellfish populations (with implications upon the wider marine food web).

Construction and O&M phase

Magnitude of impact

9.10.86 The MDS accounts for up to a total of 2,705,020 m^2 (2.71 km^2) of artificial hard structures installed during the construction phase, which will persist into the 30-year O&M phase (Table 9.15). This includes footprints of hard structures and also the surface area of Wind Turbine foundations and OSPs. As per Paragraph 9.10.54 for long term habitat loss and disturbance, the MDS includes the installation of the following artificial hard infrastructure on the seabed:

- Wind Turbine foundations and associated Scour Protection;
- OSP foundations and associated Scour Protection and mud mats; and
- Cable protection and cable crossing protection for IACs, interconnector and Offshore Export Cables (Table 9.15).

9.10.87 It should be noted that the MDS footprint and surface areas associated with the Array Area and Export Cable Corridor will be spread out within the Site Boundary and do not represent one continuous area of 2.71 km^2 of artificial hard structures.

9.10.88 Overall, the impact is predicted to be of local spatial extent, long term duration, continuous, and of low reversibility during the construction and O&M phases. It is predicted that the impact will affect the receptor directly. This impact presents some measurable, but minor long-term alteration to areas of seabed within the Site Boundary, but not within the Fish and Shellfish Ecology Study Area. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

Marine Fish and Shellfish IEFs

9.10.89 Artificial hard structures installed during the construction phase of the Proposed Development can act as artificial reefs and provide habitat for a wide range of species, from lower trophic level biofouling species to higher predators, such as large fish, seabirds, and marine mammals (Degraer *et al.*, 2021; Degraer *et al.*, 2020). This impact has been considered from a benthic ecology perspective in Volume 2, Chapter 8: Benthic Ecology. Three types of species attracted to these artificial hard structures can be discerned:

- Species that predate the biofouling community for a prolonged period such as the cod and pouting *Trisopterus luscus*;
- Species that occasionally predate the biofouling community such as horse mackerel; and
- Species such as mackerel that are attracted for non-trophic reasons, for example, to find shelter or to encounter other individuals of their species, which may lead to their creating larger schools and thus increasing their safety and chances of finding food and mates (Degraer et al., 2020).

9.10.90 Colonisation of artificial hard structures can occur over a number of years following the initial construction, until a structured recolonised population is formed (Krone *et al*., 2013). Research on the topic of artificial reef effect of OWFs is beginning to assess population changes and observations of recolonisation in a more quantitative manner (Bouma and Lengkeek, 2013; Krone *et al.*, 2013).

9.10.91 It is uncertain whether artificial reefs facilitate recruitment into the local population, or if these observations are simply a result of concentrating biomass from surrounding areas (Inger *et al*., 2009). Current evidence suggests that the abundance of fish can be greater in the vicinity of Wind Turbine foundations than in the surrounding area, which supports the findings of Linley *et al*. (2007) that finfish species are likely to have a neutral to beneficial likelihood of benefitting from introduction of these structures. Studies of finfish distributions before and after installation of OWFs demonstrate that some species, such as cod, spend at least part of their life cycles closely associated with these artificial structures (Bergström *et al.*, 2013; Reubens *et al.*, 2014). Increased prey availability associated with artificial hard structures may enhance settlement, survival, and/or growth of their predators, such as cod, and allow them to conserve energy (Schwartzbach *et al.*, 2020). Artificial habitats associated with OWF infrastructure have also been recorded to act as refuges for cod (Lindeboom *et al.*, 2011; Winter *et al.*, 2010) and plaice (Buyse *et* *al.*, 2022; Lindeboom *et al.*, 2011; Winter *et al.*, 2010) with these effects likely to occur for other species. Key pelagic prey species, such as horse mackerel, mackerel, herring, and sprat, have been shown to utilise artificial hard structures for spawning and/or predation on the newly developed community (Glarou *et al.*, 2020).

9.10.92 Some studies have also shown evidence of increased abundance of small demersal fish species in the vicinity of Wind Turbine structures, most likely due to the increase in epifaunal communities and the resulting greater structural complexity of the habitat (e.g. mussel and barnacles Cirripedia spp.) (Wilhelmsson *et al.*, 2006a; Wilhelmsson *et al.*, 2006b). Buyse *et al.* (2022) investigated how the distribution of plaice was affected by the introduction of Wind Turbines and Scour Protection at both individual Wind Turbine and overall OWF scale in two Belgian OWFs. Plaice abundance was found to be four times higher on sandy patches of Scour Protection compared to surrounding sand (Buyse *et al.*, 2022). The authors suggest that the configuration of the hard Scour Protection offers increased food and shelter opportunities, while the sandy patches in between facilitate the natural burrowing behaviour of plaice, resulting in increased abundances at the Wind Turbine scale (Buyse *et al.*, 2022).

9.10.93 Contrastingly, there have been post-construction studies that found no evidence of fish abundance being beneficially nor adversely affected by the presence of OWFs (Barrow Offshore Windfarm Limited, 2008; Walker *et al.*, 2010). Therefore, based on this and on the literature described in Paragraphs 9.10.89 *et seq.*, this impact is considered to have some form of a beneficial effect on the fish and shellfish IEFs and the wider ecosystem food web.

9.10.94 Crustacean species, such as the crab and lobster IEFs, are likely to benefit from the introduction of hard structures due to the creation of hard structure refuge areas (Linley *et al.*, 2007). Where hard infrastructure is placed within areas of sandy and coarse gravelly sediments (i.e. much of the Site Boundary), this presents novel habitat and new potential sources of food in these areas. This could potentially extend the habitat range of shellfish species such as edible crab IEF, which strongly associate with OWF foundations, which may serve as nursery areas (Hooper and Austen, 2014). Evidence from post-construction monitoring surveys at the Horns Rev OWF in the North Sea suggest that hard structures are particularly suitable for hatchery and nursery grounds for the edible crab, as well as several other species (Vattenfall, 2006). These surveys also concluded that crustacean larvae and juveniles can rapidly colonise the hard structures (Vattenfall, 2006).

9.10.95 The introduction of hard structures may lead to colonisation from INNS (see Volume 2, Chapter 8: Benthic Ecology for an assessment of this impact, as it was scoped out for fish and shellfish ecology (Table 9.16)) which can lead to potential impacts on native shellfish populations through competition or habitat loss. There is currently limited evidence within the literature on the effect of this potential impact on fish and shellfish communities in OWFs and their sensitivity to INNS colonisation. Given this, implementation of precautionary mitigation measures are recommended to reduce or prevent spread of INNS where practicable (Baulaz *et al.*, 2023). To this end an EMP will be in place that will include measures to manage INNS risk, including a Biosecurity Plan (see Table 9.22).

9.10.96 Overall, the marine fish IEFs and the shellfish IEFs are deemed to be of low vulnerability, low recoverability (due to the persistence of hard structures throughout the lifecycle of the Proposed Development, however these could result in beneficial effects) and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

Diadromous Fish IEFs

9.10.97 As all of the hard infrastructure will be installed in the offshore waters of the Site Boundary, the diadromous fish IEFs are only likely to interact with these structures during the marine phases of their lifecycles. There will be no hard infrastructure installed in the Intertidal Area in Benholm, Aberdeenshire associated with the Landfall. Given their typically pelagic migrations, it is expected that diadromous fish IEFs are unlikely to utilise hard structures associated with the Proposed Development for foraging or shelter opportunities as they pass through the Site Boundary in offshore waters. Sea lamprey parasitise a wide range of larger fish species and some cetacean species (Silva *et al.*, 2014), however there is not anticipated to be any potential impact to these host species (as set out in Paragraphs 9.10.89 *et seq*.).

9.10.98 There is potential for impacts upon diadromous fish IEFs due to increased predation by marine mammals which are attracted to the fish aggregation around the hard infrastructure. Tagging of harbour seal *Phoca vitulina* and grey seal *Halichoerus grypus* around OWFs in Dutch and UK waters presented evidence that seals were utilising wind farm sites as foraging habitats, specifically targeting structures such as foundations (Russell *et al.*, 2014). However, other studies have shown there to be no change in seal behaviour (McConnell *et al.*, 2012), and the effects may be site-specific. It is possible that if seals do utilise OWFs as foraging areas, diadromous fish species may be impacted by the increased predation in an area where predation was lower prior to development. It is, however, unlikely that this would result in significantly increased predation on solely diadromous species. Research has shown that Atlantic salmon smolts spend little time in coastal waters, and actively swim away from natal rivers making their way to feeding grounds soon after maturation (Gardiner *et al.*, 2018a; Gardiner *et al.*, 2018b; Newton *et al.*, 2021; Newton *et al.*, 2019; Newton *et al.*, 2017). Due to the evidence that Atlantic salmon tend not to forage in the coastal waters of Scotland, they are therefore at low risk of potential impact from increased predation from seals and other predators in the Site Boundary as their presence within it is likely to be transitory.

9.10.99 Sea trout may be at higher risk of increased seal predation than Atlantic salmon due to their higher usage of coastal environments. Given that sea trout are typically more coastal than Atlantic salmon, greater abundance would be expected inshore (near the Export Cable Corridor) than compared with the largely offshore waters of the rest of the Site Boundary. Sea trout are generalist, opportunistic feeders, with a diet comprising mainly of fish, coastal crustaceans, polychaetes, and surface insects with seasonal variations

(Knutsen *et al.*, 2001; Rikardsen *et al.*, 2006). As this impact presents the potential for increased juvenile crustaceans and other shellfish species, which are possible prey items from sea trout, it is possible that foraging sea trout may be attracted to the hard structures introduced by installation of the Proposed Development.

9.10.100 Available evidence indicates, however, that sea trout typically forage in dynamic, shallow coastal waters and remain strongly associated with nearshore habitats. Telemetry studies show that sea trout consistently prefer near-shore, surface-oriented areas and rarely move into offshore habitats (Moore *et al.*, 2020; Strøm *et al.*, 2021). Sea trout feeding ecology also demonstrates a preference for mobile pelagic prey such as sprat and sandeels, rather than benthic hard-bottom species, with more reliance on coastal crustaceans in winter months (Rikardsen *et al.*, 2006; Roche *et al.*, 2017). Although direct evidence of sea trout responses to offshore foundations is lacking, the known coastal distribution and pelagic-oriented feeding behaviours of sea trout suggest that foundation structures located offshore do not represent preferred foraging habitat. Given that it is unlikely that sea trout will spend time foraging around the foundations, there is a low risk of impact from increased predation from higher abundances of marine predators within the Site Boundary.

9.10.101 The diadromous fish IEFs are deemed to be of low vulnerability, high recoverability and national to international value. 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 the effect

9.10.102 Overall, for all fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.103 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.10.104 The approach for decommissioning phase is yet to be determined, however, for the purposes of this assessment, the MDS assumes that all Scour Protection, cable protection, and cable crossing protection will be left *in situ,* and that Wind Turbine and OSP foundations will be removed. Therefore, up to 2,232,100 m^2 (2.23 km^2) of artificial hard structures will be present into, and following, the decommissioning phase. This value has been calculated as the total footprint area for all Scour Protection, cable protection, and cable crossing protection installed during the construction phase. This represents up to 0.93% of the total area of the Site Boundary. It should be noted that the MDS footprint for this impact will be spread out over the Array Area and Export Cable Corridor, within the Site Boundary and does not represent one continuous area of 2.23 km^2 of hard structure during and after the decommissioning of the Proposed Development.

9.10.105 The potential impact is predicted to be of local spatial extent (0.93%) of the total area of the Site Boundary), long term duration, continuous, and of low reversibility (as left *in situ*). It is predicted that the impact will affect the receptor directly. This impact presents some measurable, but minor long-term alteration to areas of seabed within the Site Boundary, but not within the Fish and Shellfish Ecology Study Area. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

9.10.106 The sensitivity of the receptor is as presented in Paragraphs 9.10.89 to 9.10.101 and is not repeated here.

Significance of the effect

9.10.107 Overall, for all fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.108 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

IMPACT 4 - INCREASED SSCs AND ASSOCIATED DEPOSTION

9.10.109 Increased SSCs and associated deposition may arise due to the activities associated with the construction, O&M, and decommissioning phases of the Proposed Development.

9.10.110 The assessment of this impact was informed by modelling undertaken for the Physical Processes assessment, related to the MDS as outlined in Table 9.15, with the detail of the assessment provided in Volume 2, Chapter 7: Physical Processes and Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment.

Construction phase

Magnitude of impact

9.10.111 The site preparation activities and installation of infrastructure associated with the Proposed Development may lead to increased SSCs and associated deposition. During the construction phase, these activities will include drilling for pile installation, cable installation, sandwave clearance, HDD exit pit excavation and drilling fluid release (Table 9.15). Meta-analyses were conducted by Newcombe and Macdonald (1991) and Newcombe and Jensen (1996) in order to help quantify the response of fish species to increased SSCs. These analyses concluded that concentration alone is a relatively poor indicator of the effects of suspended sediments, and the product of sediment concentration (mg/l) combined with the duration of exposure is a better indicator of the severity of effects (Newcombe and Jensen, 1996; Newcombe and Macdonald, 1991). Therefore, the results of the physical processes modelling provide both sediment concentrations (in mg/l) and duration of exposure (in tidal cycles and/or days, where appropriate).

9.10.112 Drilling action for pile installation may result in up to 318,086 m^3 of drill arisings, from up to 40 drilled piles. This will result in a localised and temporary plume of elevated SSC, which will be advected in the direction of the ambient tidal currents, broadly aligned to the coast. It is expected to be dispersed to relatively low concentrations within hours of release, and to background concentrations within a few tidal cycles (Volume 2, Chapter 7: Physical Processes and Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment).

9.10.113 Cable installation will involve installations in trenches of up to 6 m width with an average depth of 1.5 m, and a v-shaped profile. Installation may occur using an MFE, with a pre-lay trenching rate of 400 m per hour (Table 9.15). Sandwave levelling for cable installation may cover areas presented in Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment, with associated volumes of displaced sediment. Sandwave clearance will be undertaken using a MFE and/or a dredger. The physical processes modelling was undertaken for a MFE for both sandwave clearance and cable installation. This modelling found that increased SSCs associated with this could lead to there being more sediment than water for a very short period of time within 5 m of the excavator activity. However, the plumes were expected to be vertically and horizontally dispersed to less than 1,000 mg/l within tens of metres. The modelling suggested that the SSCs were expected to reach less than 5 mg/l in all locations within three days of the cessation of excavation (Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment).

9.10.114 Finally, HDD exit pit extraction and HDD drilling fluid release (at the Landfall at Benholm, Aberdeenshire) may occur at three exit pits. These will affect the Intertidal Area at Benholm, Aberdeenshire, so are not relevant for most fish and shellfish ecology receptors. However, consultation received in the Scoping Opinion emphasised the importance of the Rivers South Esk and Dee for diadromous fish (notably Atlantic Salmon), which are in proximity to the Landfall area (Table 9.7). In order to ensure works associated with the Landfall are fully assessed with respect to the diadromous fish, physical processes modelling for the HDD exit pit extraction and drilling fluid release have been included in the assessment. The exit pit extraction may result in a volume of up to 2,800 m^3 of excavated material per pit, for a total of 8,400 m^3 of excavated material. The drilling fluid release may result in the release of up to 2,870 m^3 drilling mud per pit, for a total of up to 8,610 m^3 of drilling mud, with an assumed conservative maximum bentonite concentration of 100,000 mg/l. The drilling fluid may remain in suspension for several hours to days and will disperse to very low, non-measurable concentrations over time by wave and tidal action. The drilling fluid lubricating clay may accumulate in the HDD exit pit if it is slightly denser than surrounding seawater or may move over the adjacent seabed downslope under gravity in an offshore direction (Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment).

9.10.115 Overall, the 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 receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

9.10.116 Increased SSCs and associated deposition could impact fish and shellfish IEFs within the ZoI.

9.10.117 A review by Wenger *et al*. (2017) on the effects of dredging on fish considered the impact of increased SSCs at great length, with a wide range of responses presented in the studies reviewed:

- 14 studies showed no effect of suspended sediment (although only 11 of these recorded an exposure time);
- 12 studies observed behavioural changes;
- 34 studies recorded physical damage and substantial behavioural changes;
- 37 studies measured physiological stress and sublethal responses; and
- 49 studies recorded some level of mortality (Wenger et al., 2017).

9.10.118 The fish species reviewed had markedly different tolerances to suspended sediments, with some species able to withstand concentrations up to 28,000 mg/l, while others experience mortality starting at 25 mg/l (Wenger *et al*., 2017). As per Newcombe and Macdonald (1991) and Newcombe and Jensen (1996) (Paragraph 9.10.111), the linear discriminant analysis indicated that increasing both the concentration and exposure time to suspended sediment increased the severity of fish response (Wenger *et al*., 2017).

<u>Marine Fish IEFs</u>

9.10.119 In general, eggs and larvae are the most susceptible life stage to increased SSCs and associated deposition (Engell-Sørensen and Skyt, 2001; Yang *et al*., 2019). Adult fish are highly mobile and able to avoid areas with high sediment loads (Robertson *et al*., 2006). For example, SSCs on the scale of mg/l can be lethal to eggs and larvae but only lethal to juveniles and adults on the scale of g/L, however, this does not apply to clupeid fish (such as herring), which are more sensitive to suspended sediment (Engell-Sørensen and Skyt, 2001). Eggs and larvae of species which are demersal spawners (such as herring and sandeel) are most likely to be affected by SSCs and associated deposition, given their proximity to the seabed wherein this impact will arise. This is evidenced by the medium and high sensitivities of sandeel to light and heavy siltation rate changes, respectively, on FeAST (NatureScot, 2025). Sandeel spawning grounds were identified within the Fish and Shellfish Ecology Study Area and areas of suitable spawning habitat within the Site Boundary were identified from the PSA results (Figure 9.3). Therefore, increased SSCs in the areas of suitable spawning habitat within the Site Boundary and wider ZoI (one tidal excursion) may impact on sandeel leading to avoidance behaviour until the fine sediments are dissipated by the current. However, modelled deposition levels are expected to be highly localised (i.e. dispersed within tens of metres) and reduce to background concentrations (>5 mg/l) within a few tidal cycles for drilling and within three days for cable installation (see Paragraphs 9.10.112 and 9.10.113 and Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment for further information). Therefore, overall, the potential impact on sandeel spawning populations due to this impact are predicted to be limited.

9.10.120 Furthermore, the results of the PSA conducted on the sediment samples collected within the Site Boundary demonstrated that the area is largely unsuitable spawning habitat for herring (Figure 9.2). Therefore, it is unlikely that herring populations (including their eggs and larvae) will be largely affected by this impact.

9.10.121 The impact of suspended sediment on fish eggs is also important for pelagic eggs (which the majority of the teleost fish IEFs produce), as their survival is dependent on their ability to remain in the level of the water column where the abiotic parameters are ideal for survival and development. Suspended sediments can stick to eggs, causing them to become heavier and sink. A high risk of mortality can be expected if eggs sink, primarily due to reduced oxygen levels, benthic predation, and mechanical or physiological stress (Engell-Sørensen and Skyt, 2001). Studies have demonstrated that the development of fish eggs and larvae can be impacted by SSCs of thousands of mg/l (Appleby and Scarratt, 1989; Auld and Schubel, 1978). A study by Westerberg *et al.* (1996) on the effect of sedimentation on cod eggs showed that adhering particles resulted in a loss of egg buoyancy proportional to the SSC and the exposure time. Therefore, even relatively low SSCs over a longer exposure time could make eggs sink to the seabed (Westerberg *et al.*, 1996). The authors also reported increased mortality of cod yolk-sac larvae after exposure to SSCs of 10 mg/l (Westerberg *et al.*, 1996). Modelling undertaken of SSCs associated with the Proposed Development identified isolated sediment plumes, which would be vertically and horizontally dispersed to less than 1,000 mg/l within tens of metres and reach less than 5 mg/l within three days (see Paragraphs 9.10.112 and 9.10.113 and Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment for further information). Therefore, 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 activity, with dispersion continuing over successive tides.

9.10.122 The eggs of pelagic spawning IEFs may be less vulnerable to the impact of increased SSCs as they may be high enough in the water column to avoid the ZoI associated with sedimentation at the seabed. Sinking and suffocating of eggs (as detailed in Paragraph 9.10.121) may then only effect eggs or larvae in close proximity to the construction works. Sediments are also expected to be rapidly dispersed by the ambient tidal currents present in the Proposed Development. Given that the IEFs are characteristic of the North Sea, they are expected to be tolerant to temporary increases in SSCs as a result of the strong currents naturally present within the region.

9.10.123 Adult fish are more mobile than eggs and larvae, and therefore may show greater avoidance behaviour within areas affected by increased SSCs. For example, avoidance of turbid water is a common response behaviour to elevated SSCs (Collin and Hart, 2015). In a study by Westerberg *et al.* (1996), avoidance behaviour was observed in adult herring and cod exposed to sediment plumes as low as 2 mg/l. It is therefore proposed that this increased mobility makes adults of 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. For example, short-term exposure to turbidity in a laboratory setting reduced foraging success of juvenile Australasian snapper *Pagrus auratus*, while month-long exposure caused higher rates of gill ventilation, gill deformation, weight loss and mortality (Lowe *et al.*, 2015). Field experiments in New Zealand estuaries demonstrated that total suspended sediments were negatively correlated with capture rates of juvenile Australasian snapper and the condition of individuals, and were positively correlated with rates of gill deformation and gill parasite loads (Lowe *et al.*, 2015). Further, a study on juvenile coral reef damselfish *Acanthochromis polyacanthus* demonstrated reduced food acquisition, and subsequent reduced growth rate and body condition, associated with suspended sediments levels measured up to 180 mg/l (Wenger *et al.*, 2012). While there are limited studies on the effect of SSCs on juveniles of the marine fish IEFs in this assessment, the results observed on the Australasian snapper and coral reef damselfish highlighted above may still be relevant. Although it should be noted that these were laboratory studies, with artificially manipulated SSC levels that are outwith those predicted to occur due to construction of the Proposed Development (which are predicted to reduce to background levels within a few tidal cycles/days; see Paragraphs 9.10.112 and 9.10.113 and Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment for further information).

9.10.124 Juveniles of the marine fish IEFs are likely to occur throughout the Fish and Shellfish Ecology Study Area, with nursery habitats present inshore and offshore depending for a range of species (see Table 9.10 and Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report for a full account). As the marine fish IEFs are characteristic of the North Sea, it is likely that juveniles are acclimatised to any natural fluctuations in SSCs that may occur within their nursery habitats. Therefore, it is proposed that most juveniles will be largely unaffected by the relatively low-level temporary increases in SSCs resulting from the construction phase, which are likely to be within the range of natural variability (generally at background levels of 30 mg/l) and occur intermittently and be dispersed on succeeding tides. Recoverability, in terms of fish returning to the area affected by this impact, 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). Due to the limited duration of SSCs associated with construction activities, with rapid succession on the following tides, juvenile habitats are expected to recover quickly from this impact. As a result, it is likely that there will be little impact upon juvenile marine fish IEFs.

9.10.125 Where available, formal sensitivity assessments, such as MarESA and FeAST for the marine fish IEFs have been consulted in relation to this impact. For example, the MarESA for basking shark lists that this species is not sensitive to 'changes in suspended solids (water clarity)' and that 'smothering and siltation rate changes (light and heavy)' are not relevant pressures for this species (Wilson *et al.*, 2020). This is because this species is restricted to the pelagic zone in open water and will therefore be outwith the ZoI for increased SSCs and associated deposition, which will occur close to the seabed. Basking sharks have been recorded in turbid regions (such as in the Amazon river mouth: Skomal *et al.* (2009)), which previously have been thought to pose a risk of gill-raker clogging. However, there were no reports in the literature of basking sharks suffering from this problem (Wilson *et al.*, 2020). In addition, Sanderson *et al.* (2016) presented a model showing how the basking shark might avoid gill-raker clogging by a particular filter-feeding method: vortical cross-step filtration. Therefore, basking shark, and adult fish with similar pelagic life histories (such as some other elasmobranch IEFS, and the Atlantic bluefin tuna, horse mackerel, mackerel, and sprat IEFs) are considered to have low sensitivity to this impact.

9.10.126 It is also considered that adults of demersal species, such as the critically endangered common skate IEF and flapper skate IEF may have low sensitivity to this impact. For example, the MarESA for common skate presents a low sensitivity to 'smothering' and that the pressure of 'increase in suspended sediment' is not relevant for this species (Neal and Pizzolla, 2006). The reasoning behind this is that individuals will be mobile enough to move to unaffected areas, however it is noted that egg cases may be more sensitive to this impact (Neal and Pizzolla, 2006). Similarly, no sensitivity to 'siltation rate changes (light)' and 'water clarity changes' is presented for common skate on FeAST (NatureScot, 2025), citing high mobility as the reasoning. However, a medium sensitivity to 'siltation rate changes (heavy)' is presented on FeAST for common skate egg cases, as large levels of siltation (between 12 cm to 18 cm) would bury egg cases and block their respiratory channels (NatureScot, 2025), however, spawning grounds for this species are not likely to be present within the Fish and Shellfish Ecology Study Area (Table 9.10). The spawning (and egg-laying) habitats for the closely related flapper skate IEF have been characterised as being rocky, boulder, cobble, and mixed substrates in water depths of between 20 m to 50 m (Phillips *et al.*, 2021; Scottish Government, 2021). These were not identified as largely present across the Site Boundary (see Volume 3, Technical Appendix 9.1: Fish and Shellfish Ecology Technical Report). It is likely that these habitat preferences are very similar for common skate, given the close relatedness and life histories of these two species within the common skate complex.

9.10.127 Based on the above findings, it is considered that all marine fish IEFs (except herring and sandeel) are deemed to be of low vulnerability, high recoverability and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

9.10.128 As a precaution, the herring and sandeel IEFs are deemed to be of medium vulnerability, medium recoverability, and national value. The sensitivity of the receptor is, therefore, considered to be medium.

Diadromous Fish IEFs

9.10.129 The diadromous fish IEFs are expected to have some tolerance to high SSCs as their migration routes typically require them to travel through estuarine habitats, which naturally have considerably higher background SSCs than in the marine environment (Bash *et al.*, 2001). As the activities associated with the Proposed Development will produce temporary increases in SSCs, with levels lower than those naturally present in estuarine environments, it is predicted that diadromous fish IEFs will be temporarily affected at most. It may be that certain species are not affected at all if the timing of their migration does not overlap with the timing of activities associated with the Proposed Development. As detailed in Paragraph 9.10.111, the duration of exposure is important when assessing the severity of effect (Newcombe and Jensen, 1996; Newcombe and Macdonald, 1991).

9.10.130 Any potential effects on these species are likely to be short term behavioural effects, such as temporary changes to swimming behaviour. For example, the swimming behaviour of rainbow smelt *Osmerus mordax* (a diadromous species) was evaluated at various SSCs from 0 mg/l to 40 mg/l (Chiasson, 1993). Individuals were significantly more active at SSCs equal to and greater than 10 mg/l, which was interpreted as an alarm response (Chiasson, 1993). In addition, repeated exposure of rainbow smelt to SSCs at 24 hour intervals produced significantly more active fish upon the third exposure (Chiasson, 1993). In addition, the effects of increased SSCs on swimming ability of juvenile sea trout and rainbow trout *Oncorhynchus mykiss* were investigated by Berli *et al.* (2014). Both species experienced a decrease in swimming performance as turbidity increased, but rainbow trout were impaired to a greater extent. This was attributed to impairment of the ability of the fish to utilise anaerobic metabolic pathways in high sediment environments (Berli *et al.*, 2014).

9.10.131 Avoidance response is another temporary behavioural effect that may occur due to increased SSCs. A laboratory study by Robertson *et al.* (2007) demonstrated that short-term increases in suspended sediment levels influenced the behaviour of juvenile Atlantic salmon. The initial introduction of SSCs of 20 mg/l increased foraging activity, which subsequently declined at sediment levels greater than 180 mg/l (Robertson *et al.*, 2007). Avoidance responses were demonstrated in early laboratory studies on juvenile Coho salmon *Oncorhynchus kisutch* (Bisson and Bilby, 1982). Other studies on Coho salmon (which shares life history traits with the diadromous fish IEFs) have illustrated that avoidance behaviour ceases post-disturbance or if the fish becomes acclimated (Berg, 1979; Berg and Northcote, 1985). Avoidance behaviour may occur at very low SSC levels (Wenger *et al.*, 2017), but may vary between species. For example, avoidance responses of the migrating juveniles of six species of diadromous fish in New Zealand were investigated at different levels of suspended solids using a two-choice avoidance tank (Boubée *et al.*, 1997). Avoidance responses varied between species and suspended solid levels with three species showing no avoidance behaviour, even at the highest turbidity levels tested (Boubée *et al.*, 1997). Various other salmonid species have been demonstrated to exhibit avoidance reactions and move away from the vicinity of adverse sediment conditions, if refuge conditions are present (Bash *et al.*, 2001; Sigler *et al.*, 1984).

9.10.132 The studies presented in the preceding paragraphs were laboratory based, and some do not cover the exact diadromous IEFs identified for this assessment, thus the potential for other responses does exist. However, the slight temporary behavioural responses detailed are likely to be similar for the diadromous fish IEFs, due to similar life histories, and natural turbidity of the estuarine environments within the Fish and Shellfish Ecology Study Area. Investigations into the impacts of increased SSCs on diadromous species in the offshore environment are limited (Kjelland *et al.*, 2015), although there is the potential for increased turbidity to improve the survival rates of Pacific salmon species *Oncorhynchus* spp. during migrations due to lower predation associated with reduced visibility (Gregory and Levings, 1998).

9.10.133 Overall, this impact is not expected to create a significant barrier to migration for the diadromous fish IEFs. The diadromous fish IEFs are deemed to be of low vulnerability, high recoverability and national to international value. The sensitivity of the receptor is, therefore, considered to be low. Due to the obligate life history of freshwater pearl mussel IEF with Atlantic salmon and sea trout, the sensitivity of the freshwater pearl mussel IEF is also considered to be low.

Shellfish IEFs

9.10.134 Many shellfish species have high tolerances to increased SSCs and are reported to be insensitive to increases in turbidity (Wilber and Clarke, 2001). This includes crustacean IEFs, such as common shore crab, edible crab, and Norway lobster which have all been assessed as having low or no sensitivity to the pressure: 'increase in suspended sediment' on their respective MarESAs (Hill and Sabatini, 2008; Neal and Pizzolla, 2008; Neal and Wilson, 2008). These species also have very low to no sensitivity to the pressures 'smothering' and 'increase in turbidity', which can be associated with this impact (Hill and Sabatini, 2008; Neal and Pizzolla, 2008; Neal and Wilson, 2008). The low to no sensitivity of these IEFs to pressures associated with increased SSCs is largely due to their high mobility levels and therefore their ability to relocate to unaffected areas (Hill and Sabatini, 2008; Neal and Pizzolla, 2008; Neal and Wilson, 2008). Egg bearing (e.g. 'berried') Norway lobster and European lobster could potentially be more vulnerable to increased SSCs as the eggs they carry attached to their bodies required regular aeration. However, Norway lobster inhabit large burrows, which can penetrate 20 cm to 30 cm into the sediment and be over a metre long (Rice and Chapman, 1971), and are therefore considered unlikely be affected by this impact. As lobsters are mobile species, they are able to move to more suitable conditions if necessary, during periods of increased SSCs in 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' in Paragraphs 9.10.111 to 9.10.115 above). Spawning and nursery grounds for Norway lobster are located within the Site Boundary (and main ZoI), and across the Fish and

Shellfish Ecology Study Area. However, the MarESA for Norway lobster states the species is not sensitive to both smothering and an increase in suspended sediment (Hill and Sabatini, 2008). Therefore, the Norway lobster IEF is 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 potential impact to this species will be low.

9.10.135 Although far less mobile than the crustacean IEFs, the king scallop IEF was also assessed as having low sensitivity to increased suspended sediment and no sensitivity to increased turbidity in its MarESA (Marshall and Wilson, 2008). Whilst both king and queen scallop could potentially be buried due to sediment deposition, the sensitivity to smothering was still considered to be low on the king scallop MarESA (Marshall and Wilson, 2008). For example, a study by Hendrick *et al.* (2016) demonstrated that queen scallop had some ability to emerge after being buried under 2 cm of sediment, but mortality occurred after several days of burial and under sediments over 5 cm. The modelling of sediment plume movement and deposition have shown this is unlikely to occur in this case due to activities associated with the construction of the Proposed Development (see Paragraphs 9.10.112 and 9.10.113 and Volume 3, Technical Appendix 7.3: Physical Processes Technical Assessment for further information). The king scallop IEF appears 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). However, similar to the study on queen scallop, 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 (e.g. quickly opening and closing their shell to clear unwanted particles) at SSCs of <100 mg/l and up to 700 mg/l, suggesting self-preservation behaviour in response (Szostek *et al.*, 2013). Scallop species may be able to visually detect the size and speed of moving particles to identify preferrable feeding conditions (Speiser and Johnsen, 2008), and may therefore be able to avoid areas of increased SSCs. Further, both species have some mobility, with queen scallops believed to be more mobile than king scallop, although this is yet to be quantified (Howarth and Stewart, 2014). Given the relatively low level of SSCs and deposition modelled (generally within background levels and being diminished on successive tides), the potential for avoidance behaviour and re-emergence from light deposition, king and queen scallop populations are not considered to be sensitive to this potential impact in the short or long term. The low to no sensitivity to the pressures associated with this impact on the king scallop MarESA (Marshall and Wilson, 2008) can reasonably be applied to queen scallop, given the similarity between the two species.

9.10.136 Overall, all shellfish IEFS are deemed to be of low vulnerability, high recoverability and local value. The sensitivity of the receptor is, therefore, considered to be low.

Significance of the effect

9.10.137 Overall, for the herring and sandeel 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.

9.10.138 For all other fish and shellfish IEFS, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.139 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

O&M phase

Magnitude of impact

9.10.140 Operations and maintenance activities associated with cable repair events may cause increased SSCs and associated depositions, from up to one annual IAC repair over a maximum distance of 4,915 m, up to one annual Interconnector Cable repair over a maximum distance of 2,040m, and up to one annual Offshore Export Cable repair over a maximum distance of 6,390 m (Table 9.15). The adherence to the CaP and Environmental Management Plan (EMP) as outlined in Section 9.9 are likely to mitigate any large increases in SSCs and associated deposition and would not be greater than those modelled during the construction phase. Specifically, the repair activities will be undertaken using similar methods as during the construction phase, but over a much reduced area and timescale, and therefore the sediment plumes and associated deposition will be smaller and will return to baseline conditions more quickly than those assessed during the construction phase (see Paragraphs 9.10.111 to 9.10.115).

9.10.141 Therefore, the impact is predicted to be of local spatial extent, short term duration (for each individual repair event), intermittent and 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 the receptor

9.10.142 The sensitivity of the receptor is as already presented for the construction phase (in Paragraphs 9.10.116 *et seq*.) and is not repeated here.

Significance of the effect

9.10.143 Overall, for the herring and sandeel 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.

9.10.144 For all other fish and shellfish IEFS, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.145 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.10.146 The MDS for decommissioning phase assumes the total removal of infrastructure including buried cables and cable protection, with the exact programme to be submitted to MD-LOT for consultation and approval (Table 9.15). The decommissioning methods are assumed to be similar to those used during construction, with the magnitude of increased SSCs and associated deposition not being greater than that set out for the assessment in the construction phase of the Proposed Development (see Paragraphs 9.10.111 to 9.10.115).

9.10.147 Therefore, the 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 receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

9.10.148 The sensitivity of the receptor is as already presented for the construction phase (in Paragraphs 9.10.116 *et seq*.) and is not repeated here.

Significance of the effect

9.10.149 Overall, for the herring and sandeel 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.

9.10.150 For all other fish and shellfish IEFS, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual effect

9.10.151 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

IMPACT 5 - SUBSEA NOISE IMPACTING FISH AND SHELLFISH RECEPTORS

9.10.152 Subsea noise may arise due to activities associated with the construction, O&M, and decommissioning phases of the Proposed Development.

9.10.153 The assessment of this impact was informed by subsea noise modelling undertaken, related to the MDS as outlined in Table 9.15, with full detail of the modelling provided in Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report.

Construction phase

9.10.154 In the construction phase, subsea noise may arise from the following activities:

- Piling of Wind Turbine and OSP foundations;
- UXO clearance;
- Site investigation surveys; and
- Other construction activities.

Magnitude of impact - piling

9.10.155 Piling of Wind Turbine foundations and OSP foundations could lead to injury and disturbance for fish and shellfish IEFs during the construction phase of the Proposed Development. For piling, the subsea noise modelling considered three potential foundation options and a concurrent piling scenario (Table 9.15):

- Fixed foundation monopile – 25 MW option;
  - 40 foundations;
  - 40 piles;
  - maximum pile diameter of 15 m;
  - maximum pile length of 123 m, with final pile penetration of 45 m;
  - maximum hammer energy of 6,250 kJ; and
  - maximum piling duration of 8.6 hours.
- Jacket foundations – 25 MW 3-legged jacket:
  - 40 foundations;
  - 120 piles;
  - maximum pile diameter of 5 m;
  - maximum pile length of 90 m, with final pile penetration of 85 m;
  - maximum hammer energy of 4,500 kJ; and
  - maximum piling duration of 16.2 hours.
- Realistic scenario – 25 MW fixed foundation monopile with the average hammer energy and average piling duration, instead of the maximums modelled for the scenarios above:

    - 40 foundations;
    - 40 piles;
    - maximum pile diameter of 15 m;
    - maximum pile length of 123 m, with final pile penetration of 45 m;
    - maximum hammer energy of 6,000 kJ; and
    - maximum piling duration of 4.3 hours.
- Concurrent piling – all three scenarios:
    - up to two vessels piling concurrently; and
    - minimum of 1 km and maximum of 20 km distance between concurrent piling events.

9.10.156 The subsea noise modelling and the MDS, therefore considers the greatest potential impact from subsea noise on fish and shellfish IEFs, based on the greatest hammer energy, alongside a more realistic scenario (using the average hammer energies and piling durations). The subsea noise modelling of concurrent piling (i.e. piling at more than one location simultaneously) ensures a precautionary assessment has been undertaken, alongside the single piling scenarios. The results of the subsea noise modelling are discussed in Paragraphs 9.10.177 to 9.10.190 to define the 'sensitivity of the receptor' in relation to injury and behavioural impacts upon the fish and shellfish IEFs.

9.10.157 The impact is predicted to be of local spatial extent, short term duration (in terms of piling hours), intermittent over the construction phase and high reversibility, with the soundscape returning to near baseline conditions upon completion of piling. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Magnitude of impact – UXO clearance

9.10.158 UXO clearance (including detonation) has the potential to cause injury and disturbance to the fish and shellfish IEFs. UXO clearance will be completed prior to the construction activities, as part of the site preparation. The MDS assumes clearance of up to 40 UXOs within the Site Boundary, with a maximum realistic charge weight of 254 kg NEQ (Table 9.15). The total duration of UXO clearance is estimated at up to 20 days, with up to two detonations within 24 hours. The maximum duration of UXO clearance is 40 days, with one detonation within 24 hours.

9.10.159 As detailed in Table 9.22, the use of low order disposal of UXOs (e.g. deflagration and clearance shots) where practicable is an Embedded Mitigation measure. This will reduce subsea noise levels and thereby injury and disturbance to fish and shellfish IEFs during UXO clearance. The low order UXO clearance campaign will involve subsonic combustion with a donor charge of up to 0.08 kg NEQ for each clearance event, and a clearing shot of up to 0.5 kg NEQ to neutralise residual explosive material at each location. There is a small risk that low order disposal could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment.

9.10.160 To understand the magnitude of noise emissions from UXO clearance, subsea noise modelling has been undertaken considering the key parameters summarised above. In addition, the implications of UXO clearance on fish (in terms of injury and disturbance) are discussed in Paragraphs 9.10.213 to 9.10.215. Compared to piling, UXO clearance will consist of single, isolated events of very short duration.

9.10.161 The impact is predicted to be of local spatial extent (up to 40 clearances isolated within the Site Boundary), short term duration during the site preparation activities, intermittent and high reversibility, with the soundscape returning to near baseline conditions upon completion of UXO clearance. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Magnitude of impact – site investigation surveys

9.10.162 Site investigation surveys will be conducted prior to construction, although details on the specific equipment to be used are not currently available. There are no thresholds in Popper *et al*. (2014) in relation to subsea noise from high frequency sonar (>10 kHz) for fish. This is because the hearing range of fish species falls well below the frequency range of high frequency sonar systems (such as geophysical site investigation survey equipment). Consequently, the effects of high frequency sonar-like seabed imaging surveys on fish have not been conducted as part of the noise modelling study, due to the frequency of the source being beyond the range of hearing and also due to the lack of any suitable thresholds. Therefore, the subsea noise modelling and MDS considered the following geotechnical survey equipment: borehole drilling and vibro-coring (Table 9.15). The site investigation surveys will be short term and spatially limited, reducing the magnitude of their likely impact on the fish and shellfish IEFs. They will also operate largely outside of the hearing frequencies of most fish and shellfish, thereby reducing the potential for injury and behavioural impacts to low or negligible levels (see Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report).

9.10.163 The impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility, with the soundscape returning to near baseline conditions upon completion of the surveys. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Magnitude of impact – vessel noise and other construction activities

9.10.164 All other subsea noise sources in the construction phase, including vessel noise, jack-up usage, cable laying, cable trenching, and drilling are non-percussive and will result in much lower sound levels and therefore much smaller injury ranges (in all cases no injury was predicted) than those modelled for piling operations.

9.10.165 Therefore, the impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility, with the soundscape returning to near baseline conditions upon completion of the construction activity. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor – piling

9.10.166 Subsea noise can potentially have an adverse impact on marine and diadromous fish species ranging from physical injury and mortality to behavioural effects. 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 (Popper *et al*., 2014). These are the most relevant and best available guidelines for assessing the impacts of subsea noise on fish species (see Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report for further information).

9.10.167 The Popper *et al*. (2014) guidelines broadly place fish species into the following groups according to the presence or absence of a swim bladder and on the potential for that swim bladder to improve the sound sensitivity and range of hearing:

- Group 1: fish species which lack swim bladders (e.g. sandeel, lampreys, elasmobranchs and flatfish species). These species are only sensitive to particle motion, not sound pressure and show sensitivity to only a narrow band of frequencies (see Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report for further information on particle motion). These species are less susceptible to barotrauma.
- Group 2: fish species which have a swim bladder, but the swim bladder does not play a role in hearing (e.g. salmonids (such as Atlantic salmon and sea trout)). These species are susceptible to barotrauma, although hearing only involves particle motion, not sound pressure.
- Group 3: fish species with swim bladders that are close, but not connected, to the ear (e.g. gadoid species (such as cod) and European eel). These species are sensitive to both particle motion and sound pressure and have a more extended frequency range than Groups 1 and 2, extending to about 500 Hz.
- Group 4: fish species that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring, sprat and shads). These species are sensitive primarily to sound pressure, although they can also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than Groups 1, 2 and 3.
- Eggs and larvae: separated due to greater vulnerability and reduced mobility. Very few peer-reviewed studies report on the response of eggs and larvae to anthropogenic subsea noise.

9.10.168 The Popper *et al*. (2014) guidelines set out criteria for injury effects due to different sources of subsea noise. Those relevant to the Proposed Development are considered to be those for impulsive piling sources only, as non-impulsive sources were not considered to be a key potential impact and therefore were screened out of the guidance (Popper *et al*., 2014). The criteria include a range of indices including Sound Exposure Level (SEL), rms and Peak Sound Pressure Level (SPL_{pk}). 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 subsea noise levels and therefore all sources of subsea noise, no matter how loud, would theoretically elicit the same assessment result. However, because the qualitative risks are generally qualified as "low", with the exception of a "moderate" risk at "near" range (i.e. within tens of metres) for some types of hearing groups and impairment effects, this is not considered to be a significant issue with respect to determining the potential effect of subsea noise on fish.

9.10.169 Few studies have been conducted on impacts of subsea noise on shellfish, including the IEFs defined for this assessment, and little is known about the effects of anthropogenic subsea noise upon them (Hawkins and Popper, 2017; Morley *et al.*, 2014; Williams *et al.*, 2015). There are therefore no injury or disturbance criteria that have been developed for shellfish and could not be applied to the shellfish IEFs. However, the shellfish IEFs are expected to be less sensitive than fish species and therefore injury ranges for fish could be considered conservative estimates for shellfish species.

9.10.170 An assessment of the potential for injury/mortality and behavioural effects on the fish and shellfish IEFs with reference to the Popper *et al.* (2014) fish hearing groups is presented in Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report, with the results summarised and used to inform the assessment of this impact throughout.

9.10.171 The injury threshold criteria used in the subsea noise modelling for impulsive piling are presented in Table 9.23. This includes parameters for both SEL and SPL_{pk}, both of which are unweighted. Physiological effects relating to injury criteria are as follows (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.
- Temporary Threshold Shift (TTS): Short term changes in hearing sensitivity may, or may not, reduce fitness and survival. Temporary 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 noise that causes TTS, normal hearing ability returns over a period that is variable, depending on many factors, including the intensity and duration of exposure.

Table 9.23: Criteria for the Onset of Injury and Disturbance to Fish from Impulsive Piling (Popper *et al.*, 2014)

Hearing Group	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Group 1 Fish: no swim bladder (particle motion detection)	SEL, dB re 1 μPa^{2}s	>219	>216	>186
	SPL_{pk}, dB re 1 μPa	>213	>213	-
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	SEL, dB re 1 μPa^{2}s	210	203	>186
	SPL_{pk}, dB re 1 μPa	>207	>207	-
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	SEL, dB re 1 μPa^{2}s	207	203	186
	SPL_{pk}, dB re 1 μPa	>207	>207	-
Eggs and larvae	SEL, dB re 1 μPa^{2}s	>210	(Near) Moderate	(Near) Moderate

9.10.172 Behavioural reactions of fish to subsea noise have been found to vary between species based on their hearing sensitivity. Typically, fish sense sound via particle motion in the inner ear which is detected from sound-induced motions in the fish's body (see Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report for further details on particle motion). The detection of sound pressure is restricted to those fish which have air filled swim bladders; however, particle motion (induced by sound) can be detected by fish without swim bladders. However, it should be noted that the presence of a swim bladder does not necessarily mean that the fish can detect pressure. Some fish have swim bladders that are not involved in the hearing mechanism and can only detect particle motion.

9.10.173 Highly sensitive species, such as herring, have elaborate specialisations of their auditory apparatus, known as an otic bulla, which is a gas filled sphere, connected to the swim bladder, which enhances hearing ability. The gas filled swim bladder in species such as cod and Atlantic salmon may be involved in their hearing capabilities, so although there is no direct link to the inner ear, these species are able to detect lower sound frequencies and as such are considered to be of medium sensitivity to sound. All flatfish, lampreys, and elasmobranch species have no swim bladders and as such are considered to be relatively less sensitive to sound pressure.

9.10.174 The most recent criteria for disturbance are considered to be those contained in Popper *et al*. (2014) which set out qualitative criteria for disturbance due to different sources of sound. 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 9.24.

Table 9.24: Criteria for the Onset of Behavioural Effects in Fish (Popper *et al*., 2014)

Hearing Group	Relative Risk of Behavioural Effects		
	Impulsive piling	Explosives	Non-impulsive sound
Group 1 Fish: no swim bladder (particle motion detection)	(Near) High (Intermediate) Moderate (Far) Low	(Near) High (Intermediate) Moderate (Far) Low	(Near) Moderate (Intermediate) Moderate (Far) Low
Group 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
Groups 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	(Near) Moderate (Intermediate) Low (Far) Low	(Near) High (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Moderate (Far) Low

9.10.175 It is important to note that the *Popper et al*. (2014) criteria for behavioural disturbance (Table 9.24) due to subsea noise are qualitative rather than quantitative. Consequently, a subsea noise source of a particular type (e.g. piling) would be predicted to result in the same potential impact, no matter the level of subsea noise produced or the propagation characteristics.

9.10.176 Therefore, the criteria presented in the Washington State Department of Transport Biological Assessment Preparation for Transport Projects Advanced Training Manual (WSDOT, 2011) have been used in this assessment for predicting the distances at which behavioural effects may occur due to subsea noise from impulsive piling. This manual suggests an unweighted Sound Pressure Level (SPL) of 150 dB re 1 μPa (rms) as the criterion for onset of behavioural effects, based on work by Hastings (2002). SPL in excess of 150 dB re 1 μPa (rms) are expected to cause temporary behavioural changes, such as elicitation of a startle response, disruption of feeding, or avoidance of an area. The document notes that levels exceeding this threshold are not expected to cause direct permanent injury but may indirectly affect the individual fish (such as by impairing predator detection). It is important to note that this threshold is for onset of potential effects, and not necessarily an 'adverse effect' threshold.

Marine and Diadromous Fish IEFs

9.10.177 For the different piling scenarios, the modelling using the SEL metric considers fish as both moving and static receptors. Presenting results of fish modelled as static receptors allows for the most precautionary approach to assessment. To model moving receptors, a swim speed of 1 m/s was used for basking shark (Sims *et al.*, 2000), and 0.5 m/s for all other fish species (Popper *et al.*, 2014). Due to the difference in swim speeds, the modelling results for the basking shark IEF have been presented in their own row in the results tables from the other Group 1 fish species.

9.10.178 The MDS considers both single and concurrent piling of three different foundation scenarios: monopile, 3-legged jacket, and realistic (see Table 9.15). For the fixed monopile Wind Turbine foundations, the piling schedule modelled included a maximum hammer energy of 6,250 kJ and a total piling duration of 8.6 hours.

9.10.179 The potential injury and disturbance ranges for single piling of the monopile Wind Turbine foundation scenario are presented in Table 9.25 for fish modelled as moving receptors using the cumulative SEL metric. For Group 1 fish (including basking shark), the modelling results suggest that the thresholds for mortality and recoverable injury will not be exceeded, with higher ranges modelled for Groups 2, 3 and 4 fish (Table 9.25). Recoverable injury and TTS ranges were higher for all hearing groups; however, these are reversible. For eggs and larvae, mortality was modelled out to 3,780 m, and disturbance (for all hearing groups) was modelled out to 60,451 m (Table 9.25).

Table 9.25: Potential Injury and Disturbance Ranges for Single Monopile Installation, Based on the Cumulative SEL Metric for Moving Fish (N/E – Threshold not Exceeded)

Hearing Group	Response	Threshold (SEL: db re 1 μPa²s)	Range (m)
Group 1	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	22,266
Basking shark	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	19,805
Group 2	Mortality	210	177
	Recoverable injury	203	3,926
	TTS	186	22,266
Groups 3 and 4	Mortality	207	1,056
	Recoverable injury	203	3,926
	TTS	186	22,266
Eggs and larvae	Mortality	210	3,780
All hearing groups	Disturbance	150 dB re 1μPa (rms)	60,451

9.10.180 The potential injury and disturbance ranges for single piling of the monopile Wind Turbine foundation scenario are presented in Table 9.26 for fish modelled as static receptors using the cumulative SEL metric. The modelling results suggest that the thresholds for mortality will be exceeded for all hearing groups, with a maximum of 5,860 m for Groups 3 and 4 (Table 9.26). Recoverable injury and TTS ranges were higher; however, these are reversible. For eggs and larvae, mortality was modelled out to 3,780 m, and disturbance (for all hearing groups) was modelled out to 60,451 m (Table 9.26).

Table 9.26: Potential Injury and Disturbance Ranges for Single Monopile Installation, Based on the Cumulative SEL Metric for Static Fish

Hearing Group	Response	Threshold (SEL: db re 1 μPa^{2}s)	Range (m)
Group 1	Mortality	219	1,436
	Recoverable injury	216	1,993
	TTS	186	25,000
Basking shark	Mortality	219	1,436
	Recoverable injury	216	1,993
	TTS	186	25,000
Group 2	Mortality	210	3,780
	Recoverable injury	203	10,430
	TTS	186	25,000
Groups 3 and 4	Mortality	207	5,860
	Recoverable injury	203	10,430
	TTS	186	25,000
Eggs and larvae	Mortality	210	3,780
All hearing groups	Disturbance	150 dB re 1μPa (rms)	60,451

9.10.181 Finally, the potential injury and disturbance ranges for single piling of the monopile Wind Turbine foundation scenario are presented in Table 9.27 using the SPL_{pk} metric. For all hearing groups, the mortality and recoverable injury ranges were modelled as within the low hundreds of meters for the first hammer strike, and out to between 888 m to 1,389 m for the highest hammer energy (Table 9.27).

Table 9.27: Potential Injury Ranges for Single Monopile Installation, Based on the SPL_{pk} Metric

Hearing Group	Response	Threshold (SPL_{pk} db re 1 µPa)	Range (m)	
			First Strike	Highest Energy
Group 1	Mortality	213	180	888
	Recoverable injury	213	180	888
Basking shark	Mortality	213	180	888
	Recoverable injury	213	180	888
Group 2	Mortality	207	282	1,389
	Recoverable injury	207	282	1,389
Groups 3 and 4	Mortality	207	282	1,389
	Recoverable injury	207	282	1,389
Eggs and larvae	Mortality	207	282	1,389

9.10.182 The MDS considers single piling of three different fixed foundation scenarios: monopile, 3-legged jacket and realistic (see Table 9.15). For the three-legged jacket Wind Turbine foundations, the piling schedule modelled included a maximum hammer energy of 4,500 kJ and a total piling duration of 16.2 hours.

9.10.183 The potential injury and disturbance ranges for single piling of the three-legged jacket Wind Turbine foundation scenario are presented in Table 9.28 for fish modelled as moving receptors using the cumulative SEL metric. For Group 1 (including basking shark) the modelling results suggest that the thresholds for mortality will not be exceeded, with a range of up to 13 m modelled for Group 2, and 96 m modelled for Groups 3 and 4 fish (Table 9.28). Recoverable injury and TTS ranges were higher; however, these are reversible. For eggs and larvae, mortality was modelled out to 2,931 m, and disturbance (for all hearing groups) was modelled out to 55,359 m (Table 9.28).

Table 9.28: Potential Injury and Disturbance Ranges for Jacket Pile Installation, Based on the Cumulative SEL Metric for Moving Fish

Hearing Group	Response	Threshold (SEL: db re 1 µPa²s)	Range (m)
Group 1	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	20,977
Basking shark	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	17,579
Group 2	Mortality	210	13
	Recoverable injury	203	1,173
	TTS	186	20,977

Hearing Group	Response	Threshold (SEL: db re 1 μPa²s)	Range (m)
Groups 3 and 4	Mortality	207	96
	Recoverable injury	203	1,173
	TTS	186	20,977
Eggs and larvae	Mortality	210	2,931
All hearing groups	Disturbance	150 dB re 1μPa (rms)	55,359

9.10.184 The potential injury and disturbance ranges for single piling of the three-legged jacket Wind Turbine foundation scenario are presented in Table 9.29 for fish modelled as static receptors using the cumulative SEL metric. Thresholds were exceeded for all responses and hearing groups, with the highest mortality range of 3,985 m modelled for Groups 3 and 4 fish (Table 9.29). Recoverable injury and TTS ranges were higher; however, these are reversible. For eggs and larvae, mortality was modelled out to 2,931 m, and disturbance (for all hearing groups) was modelled out to 55,359 m (Table 9.29).

Table 9.29: Potential Injury and Disturbance Ranges for Pile Installation of Jacket Piles, Based on the Cumulative SEL Metric for Static Fish

Hearing Group	Response	Threshold (SEL: db re 1 μPa²s)	Range (m)
Group 1	Mortality	219	1,026
	Recoverable injury	216	1,495
	TTS	186	25,000
Basking shark	Mortality	219	1,026
	Recoverable injury	216	1,495
	TTS	186	25,000
Group 2	Mortality	210	2,931
	Recoverable injury	203	7,384
	TTS	186	25,000
Groups 3 and 4	Mortality	207	3,985
	Recoverable injury	203	7,384
	TTS	186	25,000
Eggs and larvae	Mortality	210	2,931
All hearing groups	Disturbance	150 dB re 1μPa (rms)	55,359

9.10.185 Finally, the potential injury and disturbance ranges for single piling of the three-legged jacket Wind Turbine foundation scenario are presented in Table 9.30 using the SPL_{pk} metric. For all hearing groups, the mortality and recoverable injury ranges were modelled as between 211 m and 342 m for the first hammer strike, and between 544 m to 882 m for the highest hammer energy (Table 9.30).

Table 9.30: Potential Injury Ranges for Pile Installation of Jacket Piles, Based on the SPL_{pk} Metric

Hearing Group	Response	Threshold (SPL_{pk} db re 1 µPa)	Range (m)	
			First Strike	Highest Energy
Group 1	Mortality	213	211	544
	Recoverable injury	213	211	544
Basking shark	Mortality	213	211	544
	Recoverable injury	213	211	544
Group 2	Mortality	207	342	882
	Recoverable injury	207	342	882
Groups 3 and 4	Mortality	207	342	882
	Recoverable injury	207	342	882
Eggs and larvae	Mortality	207	342	882

9.10.186 The MDS considers single piling of three different foundation scenarios: monopile, three-legged jacket, and realistic (see Table 9.15). For the realistic piling schedule (based on the 25 MW monopile option, using the average hammer energy and average piling duration instead of maximums), the piling schedule modelled included a full power hammer energy of 6,000 kJ and a total piling duration of 4.3 hours.

9.10.187 The potential injury and disturbance ranges for single piling of the realistic piling scenario are presented in Table 9.31 for fish modelled as moving receptors using the cumulative SEL metric. For Group 1 fish (including basking shark), the modelling results suggest that the thresholds for mortality will not be exceeded, with a range of 118 m modelled for Group 2 fish and 763 m modelled for Groups 3 and 4 fish (Table 9.31). Recoverable injury and TTS ranges were higher; however, these are reversible. For eggs and larvae, mortality was modelled out to 2,696 m, and disturbance (for all hearing groups) was modelled out to 59,735 m (Table 9.31).

Table 9.31: Potential Injury and Disturbance Ranges for the Realistic Scenario (Fixed Foundation Monopile), Based on the Cumulative SEL Metric for Moving Fish

Hearing Group	Response	Threshold (SEL: db re 1 µPa²s)	Range (m)
Group 1	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	22,149
Basking shark	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	19,688
Group 2	Mortality	210	118

Hearing Group	**Response**	**Threshold (SEL: db re 1 μPa²s)**	**Range (m)**
	Recoverable injury	203	2,579
	TTS	186	22,149
Groups 3 and 4	Mortality	207	763
	Recoverable injury	203	2,579
	TTS	186	22,149
Eggs and larvae	Mortality	210	2,696
All hearing groups	Disturbance	150 dB re 1μPa (rms)	59,735

9.10.188 The potential injury and disturbance ranges for single piling of the realistic piling scenario are presented in Table 9.32 for fish modelled as static receptors using the cumulative SEL metric. Thresholds were exceeded for all responses and hearing groups, with the highest mortality range of 3,634 m modelled for Groups 3 and 4 fish (Table 9.32). Recoverable injury and TTS ranges were higher; however, these are reversible. For eggs and larvae, mortality was modelled out to 2,696 m, and disturbance (for all hearing groups) was modelled out to 59,735 m (Table 9.32).

Table 9.32: Potential Injury and Disturbance Ranges for the Realistic Scenario (Monopile), Based on the Cumulative SEL Metric for Static Fish

Hearing Group	**Response**	**Threshold (SEL: db re 1 μPa²s)**	**Range (m)**
Group 1	Mortality	219	909
	Recoverable injury	216	1,349
	TTS	186	25,000
Basking shark	Mortality	219	909
	Recoverable injury	216	1,349
	TTS	186	25,000
Group 2	Mortality	210	2,696
	Recoverable injury	203	6,329
	TTS	186	25,000
Groups 3 and 4	Mortality	207	3,634
	Recoverable injury	203	6,329
	TTS	186	25,000
Eggs and larvae	Mortality	210	2,696
All hearing groups	Disturbance	150 dB re 1μPa (rms)	59,735

9.10.189 Finally, the potential injury and disturbance ranges for single piling of the realistic piling scenario are presented in Table 9.33 using the SPL_{pk} metric. For all hearing groups, the mortality and recoverable injury ranges were modelled as within 180 m to 282 m for the first hammer strike, and out to between 872 m to 1,363 m for the highest hammer energy (Table 9.33).

Table 9.33: Potential Injury Ranges for the Realistic Scenario (Fixed Foundation Monopile), Based on the SPL_{pk} Metric

Hearing Group	Response	Threshold (SPL_{pk} db re 1 µPa)	Range (m)	
			First Strike	Highest Energy
Group 1	Mortality	213	180	872
	Recoverable injury	213	180	872
Basking shark	Mortality	213	180	872
	Recoverable injury	213	180	872
Group 2	Mortality	207	282	1,363
	Recoverable injury	207	282	1,363
Groups 3 and 4	Mortality	207	282	1,363
	Recoverable injury	207	282	1,363
Eggs and larvae	Mortality	207	282	1,363

9.10.190 The subsea noise modelling also considered concurrent piling, using two pile installation vessels at once, with a minimum of 1 km and maximum of 20 km between concurrent piling events. Potential injury and disturbance ranges for concurrent piling of the three different piling scenarios (monopile, three-legged jacket, and realistic) are presented in Table 9.34 to Table 9.39. These are all based on the cumulative SEL metric, as ranges calculated using the SPL_{pk} metric will remain the same as those detailed in Table 9.27, Table 9.30, and Table 9.33, for single piling.

9.10.191 The results of the concurrent piling modelling illustrate that mortality, recoverable injury, and TTS ranges are similar or slightly larger than the single piling scenarios for all hearing groups when modelled as moving fish, but considerably larger for fish modelled as static receptors (Table 9.34 to Table 9.39). The behavioural disturbance ranges are slightly higher for the concurrent and single piling scenarios. It should be noted that, in reality, most fish species are not likely to remain static for the duration of piling, and therefore being modelled as static receptors is highly precautionary.

9.10.192 Therefore, as per Table 9.39, mortality may occur for Group 1 species at 1,261 m, for Group 2 at 3,339 m, for Groups 3 and 4 at 4,806 m, and for eggs and larvae at 3,399 m. Recoverable injury and TTS ranges increase to the tens of thousands of metres, with TTS ranges of 25,000 m for all hearing groups (Table 9.39).

Table 9.34: Potential Injury and Disturbance Ranges for Concurrent Monopile Installation, With a Separation of 1 km, Based on the Cumulative SEL Metric for Moving Fish

Hearing Group	Response	Threshold (SEL: db re 1 μPa²s)	Range (m)
Group 1	Mortality	219	5
	Recoverable injury	216	12
	TTS	186	23,086
Basking shark	Mortality	219	4
	Recoverable injury	216	6
	TTS	186	21,211
Group 2	Mortality	210	1,056
	Recoverable injury	203	7,969
	TTS	186	23,086
Groups 3 and 4	Mortality	207	2,813
	Recoverable injury	203	7,969
	TTS	186	23,086
Eggs and larvae	Mortality	210	5,860
All hearing groups	Disturbance	150 dB re 1μPa (rms)	73,451

Table 9.35: Potential Injury and Disturbance Ranges for Concurrent Monopile Installation, With a Separation of 1 km, Based on the Cumulative SEL Metric for Static Fish

Hearing Group	Response	Threshold (SEL: db re 1 μPa²s)	Range (m)
Group 1	Mortality	219	1,993
	Recoverable injury	216	2,813
	TTS	186	25,000
Basking shark	Mortality	219	1,993
	Recoverable injury	216	2,813
	TTS	186	25,000
Group 2	Mortality	210	5,860
	Recoverable injury	203	15,235
	TTS	186	25,000
Groups 3 and 4	Mortality	207	9,141
	Recoverable injury	203	15,235
	TTS	186	25,000
Eggs and larvae	Mortality	210	5,860
All hearing groups	Disturbance	150 dB re 1μPa (rms)	73,451

Table 9.36: Potential Injury and Disturbance Ranges for Concurrent Three-legged Jacket Foundation Installation, With a Separation of 1 km, Based on the Cumulative SEL Metric for Moving Fish

Hearing Group	Response	Threshold (SEL: db re 1 µPa²s)	Range (m)
Group 1	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	22,559
Basking shark	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	20,274
Group 2	Mortality	210	206
	Recoverable injury	203	4,220
	TTS	186	22,559
Groups 3 and 4	Mortality	207	1,056
	Recoverable injury	203	4,220
	TTS	186	22,559
Eggs and larvae	Mortality	210	4,337
All hearing groups	Disturbance	150 dB re 1µPa (rms)	70,356

Table 9.37: Potential Injury and Disturbance Ranges for Three-legged Jacket Foundation Installation, With a Separation of 1 km, Based on the Cumulative SEL Metric for Static Fish

Hearing Group	Response	Threshold (SEL: db re 1 µPa²s)	Range (m)
Group 1	Mortality	219	1,612
	Recoverable injury	216	2,286
	TTS	186	25,000
Basking shark	Mortality	219	1,612
	Recoverable injury	216	2,286
	TTS	186	25,000
Group 2	Mortality	210	4,337
	Recoverable injury	203	11,954
	TTS	186	25,000
Groups 3 and 4	Mortality	207	7,032
	Recoverable injury	203	11,954
	TTS	186	25,000
Eggs and larvae	Mortality	210	4,337
All hearing groups	Disturbance	150 dB re 1µPa (rms)	70,356

Table 9.38: Potential Injury and Disturbance Ranges for Concurrent Piling of the Realistic Scenario, With a Separation of 1 km, Based on the Cumulative SEL Metric for Moving Fish

Hearing Group	Response	Threshold (SEL: db re 1 μPa²s)	Range (m)
Group 1	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	22,852
Basking shark	Mortality	219	N/E
	Recoverable injury	216	N/E
	TTS	186	20,830
Group 2	Mortality	210	587
	Recoverable injury	203	4,923
	TTS	186	22,852
Groups 3 and 4	Mortality	207	1,642
	Recoverable injury	203	4,923
	TTS	186	22,852
Eggs and larvae	Mortality	210	3,399
All hearing groups	Disturbance	150 dB re 1μPa (rms)	72,395

Table 9.39: Potential Injury and Disturbance Ranges for Concurrent Piling of the Realistic Scenario, With a Separation of 1 km, Based on the Cumulative SEL Metric for Static Fish

Hearing Group	Response	Threshold (SEL: db re 1 μPa²s)	Range (m)
Group 1	Mortality	219	1,261
	Recoverable injury	216	1,759
	TTS	186	25,000
Basking shark	Mortality	219	1,261
	Recoverable injury	216	1,759
	TTS	186	25,000
Group 2	Mortality	210	3,399
	Recoverable injury	203	8,907
	TTS	186	25,000
Groups 3 and 4	Mortality	207	4,806
	Recoverable injury	203	8,907
	TTS	186	25,000
Eggs and larvae	Mortality	210	3,399
All hearing groups	Disturbance	150 dB re 1μPa (rms)	72,395

9.10.193 As detailed in the preceding tables, behavioural disturbance ranges extend to tens of kilometres for the different piling scenarios (between 55,359 for single piling up to a maximum of 73,451 m for concurrent piling). This was modelled using a threshold SPL of 150 dB re 1 µPa (rms) (from WSDOT (2011), see Paragraph 9.10.176 for further details). It should be noted that these ranges are for all hearing groups combined and will be highly conservative for the less sensitive fish IEFs (i.e. those in Groups 1 and 2). Additional information is provided here to further characterise the sensitivity of the receptor with regards to behavioural disturbance.

9.10.194 In some cases (e.g. previous offshore wind projects), TTS has been used as a proxy for behavioural disturbance. The maximum TTS value of 25,000 m was the same for each of the groups in the three concurrent piling scenarios, with fish as static receptors (Table 9.35). It should be noted that, in reality, most fish species are not likely to remain static for the duration of piling, and therefore being modelled as static receptors is highly precautionary.

9.10.195 Behavioural responses to subsea noise have been found to vary between species, based on their hearing sensitivity. There have been several studies on the behavioural effects of the sound pressure component of impulsive noise (which includes piling operations) on fish. For example, Mueller-Blenkle *et al*. (2010) demonstrated behavioural responses in cod and sole to subsea noise similar to that produced during piling, with variation noticed across individuals (i.e. depending on the age, sex, and condition of the fish, as well as the possible increased stress levels due to confinement in cages). Mueller-Blenkle *et al*. (2010) could not define a clear relationship between the level of exposure and the extent of the behavioural response, although an observable behavioural response was reported at 140 to 161 dB re 1 µPa (SPL_{pk}) for cod and 144 dB to 156 dB re 1 µPa (SPL_{pk}) for sole. Nonetheless, these thresholds have not been interpreted as the level at which an avoidance reaction will be elicited, as Mueller-Blenkle *et al*. (2010) were not able to show this.

9.10.196 In addition, Pearson *et al.* (1992) examined the effects of geophysical survey noise on caged rockfish *Sebastes* spp. and observed a startle or 'C-turn response' beginning at around 200 dB re 1 µPa (SPL_{pk}). However, this behavioural response was less common in larger fish. Similarly, McCauley *et al*. (2000) exposed various caged fish species to seismic airgun noise to assess behavioural, physiological and pathological changes. The study observed:

- A general behavioural response in many fish was to move to the bottom of the cage during periods of high-level exposure (around 156 to 161 dB re 1 µPa (rms); approximately equivalent to around 168 dB to 173 dB re 1 µPa (SPL_{pk}).
- A greater startle response was seen in small fish to the above levels than in larger fish.
- A return to normal behavioural patterns occurred between 14 to 30 minutes after airgun operations ceased.
- No significant increases in physiological stress were attributed to air gun exposure.

- Some preliminary evidence of damage to the hair cells when fish were exposed to the highest subsea noise levels, although it was determined that such damage would only likely occur at short range from the source (McCauley et al., 2000).

9.10.197 Behavioural disturbance due to piling can also be inferred from post-construction monitoring studies of other OWFs. For example, a post-construction monitoring study for cod at the Beatrice OWF recorded no change in the presence of spawning individuals between pre and post construction (although spawning intensity was found to be low across both surveys) (Beatrice OWF Limited, 2021b). Similarly, a sandeel monitoring study at the Beatrice OWF found no evidence of adverse impacts on sandeel populations between pre and post construction levels over a six year period (Beatrice OWF Limited, 2021a). Based on these results, it can be inferred that behavioural disturbance associated with piling and other construction noise from an OWF are likely to be temporary and that fish communities (specifically cod and sandeel in this case) show a higher degree of recoverability following construction. As cod are a Group 3 fish (with some of the highest sensitivity to subsea noise), these results could be extrapolated to other fish IEFs with similar, or lower, hearing sensitivities.

9.10.198 With specific reference to diadromous fish (which are a key consideration for the assessment, based on consultation received in Table 9.7), a study by Harding *et al*. (2016) failed to produce physiological or behavioural responses in Atlantic salmon when subjected to noise similar to piling. However, the noise levels tested were estimated at <160 dB re 1μPa (rms), below the level at which injury or behavioural disturbance would be expected for Atlantic salmon (Harding *et al*., 2016). Nedwell *et al*. (2006) compared behavioural responses to piling in sea trout and Atlantic salmon. This study found no significant behavioural response in both species (Nedwell *et al*., 2006). Physical impacts on migrating salmonids exposed to piling noise of 218 dB re 1μPa2s (SEL) were recorded by Bagočius (2015), although at these high noise levels, avoidance reactions would be expected, in order to avoid injury

9.10.199 As there are no agreed thresholds for behavioural effects on fish from piling, a risk based approach has been undertaken using published literature summarised in Paragraphs 9.10.195 to 9.10.198. Based on these studies, the 160 dB re 1 μPa (SPL_{pk}) noise contour has been mapped as a reference for behavioural responses in fish species in general. It is unlikely that species will experience behavioural disturbance beyond this noise contour, based on the described studies which demonstrated responses (including avoidance) at levels above this threshold. The 160 dB re 1 μPa (SPL_{pk}) contour is over conservative, given that many fish IEFs (such as flatfish, elasmobranchs, lampreys, and salmonids) are at the lower end of the sensitivity spectrum (i.e. hearing Groups 1 and 2) and that Group 1 and 2 species are sensitive to particle motion only and not sound pressure level.

9.10.200 The 160 dB re 1 μPa (SPL_{pk}) contour is presented on Figure 9.5 for single piling of the maximum piling scenario for monopile foundations at the north and south of the Array Area (as this represents the worst-case scenario in the MDS). The single piling scenario with the maximum hammer energy of 6,250 kJ has been used as the SPL_{pk} metric and will remain the same for both single and concurrent piling. Therefore, potential disturbance ranges will not increase the risk of behavioural or barrier effects under concurrent piling scenarios.

9.10.201 The extent of the 160 dB re 1 μPa (SPL_{pk}) contour should be noted, with the large majority of the contour falling offshore, and its relatively small area of effect in terms of the availability of habitat in the Fish and Shellfish Ecology Study Area. While the majority of the 155 and 150 dB re 1 μPa (SPL_{pk}) contours do extend closer to the shore of mainland Scotland, behavioural disturbance is unlikely at this level (based on the studies outlined above).

9.10.202 Figure 9.6 and Figure 9.7 show the 160 dB re 1 μPa (SPL_{pk}) contour in relation to the spawning grounds of the cod and sandeel. These figures illustrate that behavioural disturbance could occur within the low intensity cod and high intensity sandeel spawning grounds, although the area of the 160 dB re 1 μPa (SPL_{pk}) contour is limited compared to the wider availability of their spawning grounds, particularly within the Moray Firth and Firth of Forth, wherein the contour does not extend. This figure should be interpreted with caution as sandeel are a Group 1 species and sensitive to particle motion only.

9.10.203 Figure 9.8 shows the 160 dB re 1 μPa (SPL_{pk}) contour in relation to the spawning grounds for herring alongside cumulative larval densities. This figure illustrates that the 160 dB re 1 μPa (SPL_{pk}) contour associated with piling at the south of the Array Area does not extend to the hotspot of herring larval density, while piling at the north does. Therefore, the herring IEF is deemed to be of high vulnerability, medium recoverability, and national importance. The sensitivity of the receptor is, precautionarily, considered to be high.

9.10.204 Finally, Figure 9.9 shows the 160 dB re 1 μPa (SPL_{pk}) contour in relation to the designated sites identified in Table 9.13. This figure should be interpreted with caution as the Turbot Bank ncMPA is designated for sandeel which is sensitive to particle motion only. The potential injury and disturbance range data presented within Table 9.35 shows that for Group 1 species (which includes sandeel) that injury and disturbance ranges would not extend to the Turbot Bank ncMPA which is located 35.8 km from the Bowdun Array Area at its closest point.

9.10.205 The modelled contours for the north piling location show the 160 dB re 1 μPa (SPL_{pk}) contour extending to the Scottish coast in the vicinity of the River Dee SAC which is designated for migrating salmon. Salmonids are a Group 2 species sensitive to particle motion only, and it is therefore considered highly precautionary that they would be sensitive to sound levels at this threshold. The potential injury and disturbance range data presented within Table 9.35 shows that for Group 2 species (which includes salmonids) that injury and disturbance ranges would not extend to the mouth of the River Dee SAC which is located 39.6 km from the Bowdun Array Area at its closest point. For piling in the south of the array the 160 dB re 1 μPa (SPL_{pk}) contour does not extend as far as the Scottish coast. For the other SACs which are designated for migrating salmon there is limited risk of piling noise creating any barrier effect due to the relatively limited area around piling events (for both north and south locations) where noise levels could be high enough to cause a behavioural response in salmon.

9.10.206 The remaining marine and diadromous fish IEFs are deemed to be of low vulnerability, high recoverability and local to international value. The sensitivity of the receptor is therefore, precautionarily, considered to be low.

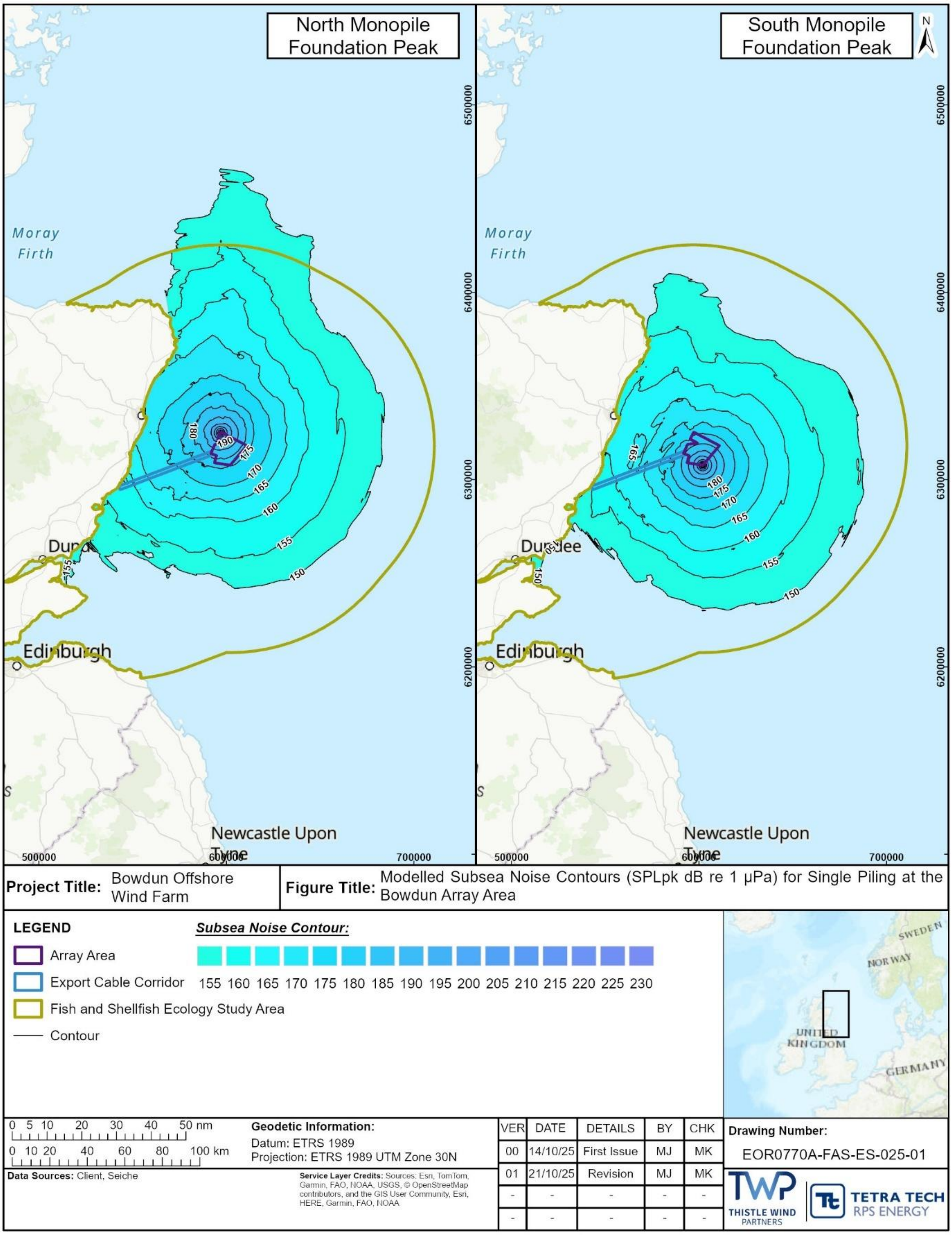


Figure 9.5: Modelled Subsea Noise Contours (SPL_{pk} dB re 1 µPa) for Single Piling at the North and South Locations

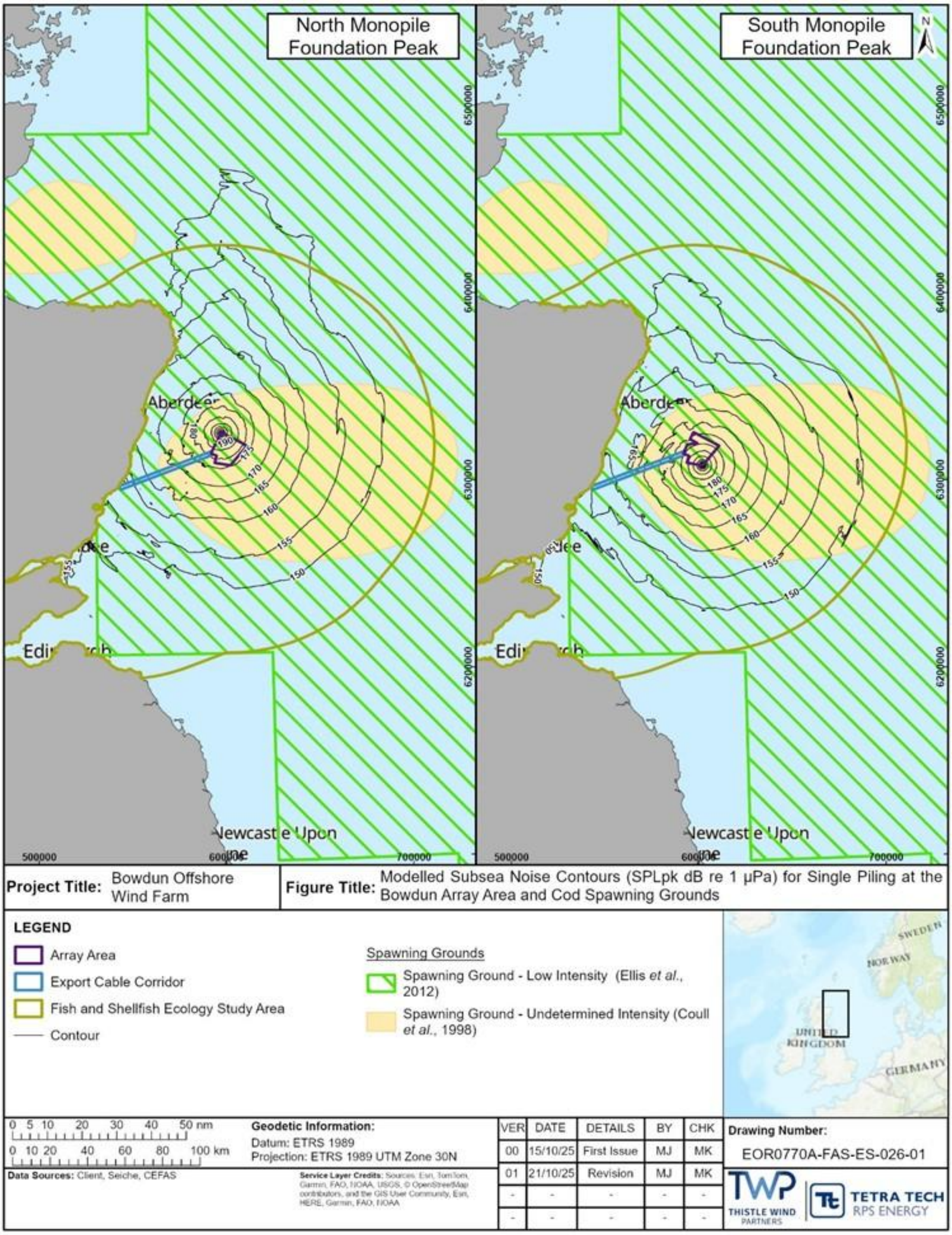


Figure 9.6: Modelled Subsea Noise Contours (SPL_{pk} dB re 1 µPa) for Single Piling at the North and South Locations and Cod Spawning Grounds

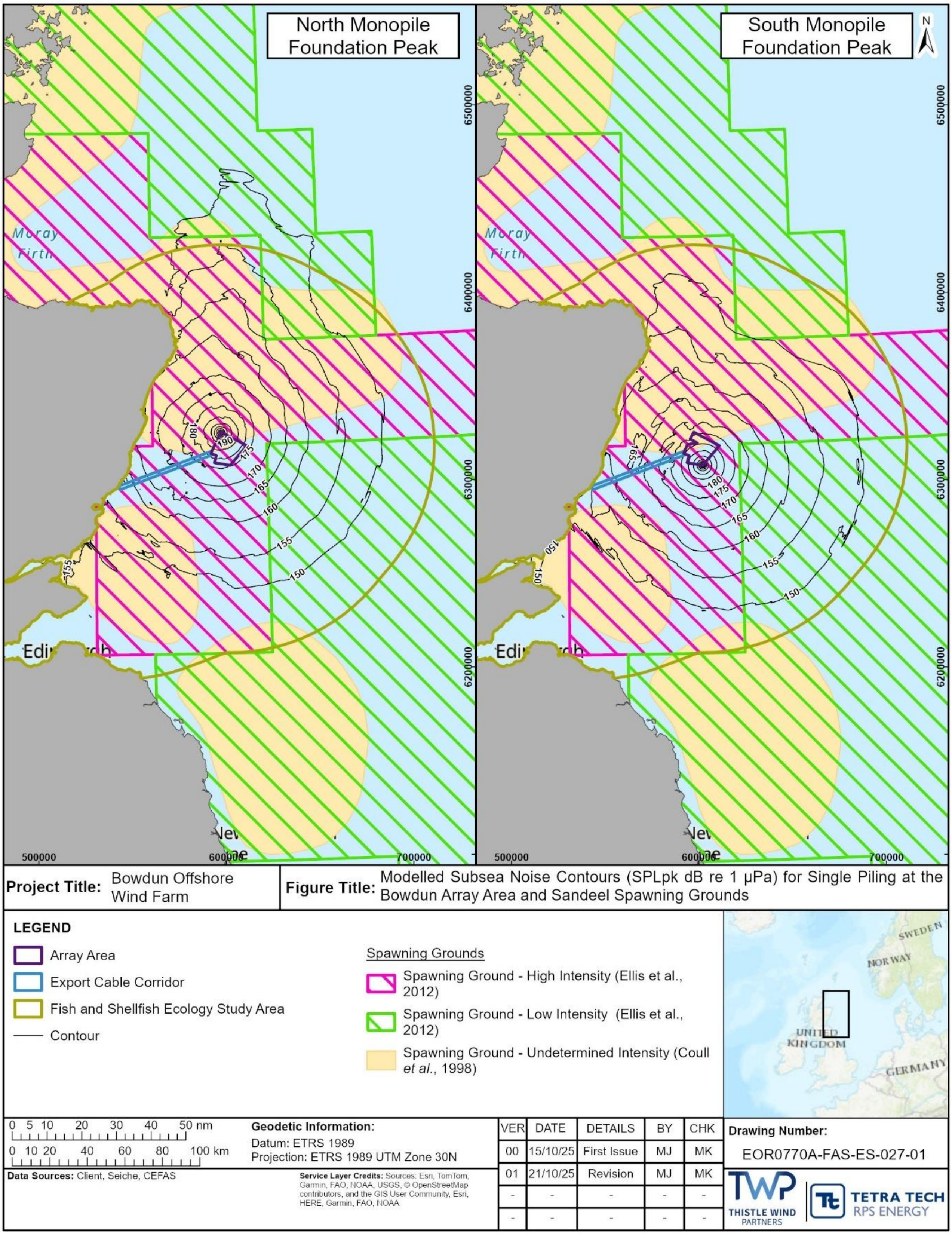


Figure 9.7: Modelled Subsea Noise Contours (SPL$_{pk}$ dB re 1 µPa) for Single Piling at the North and South Locations and Sandeel Spawning Grounds

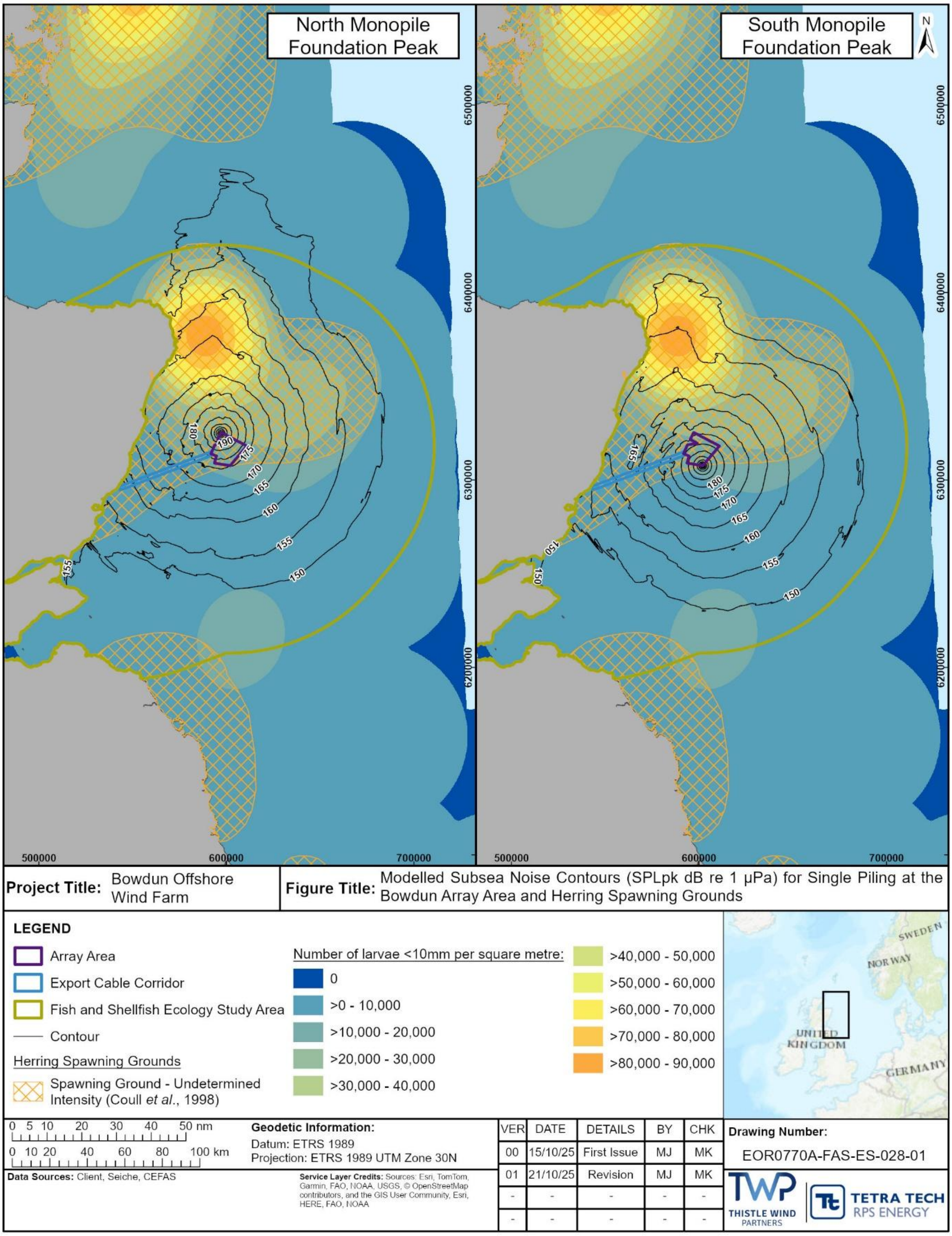


Figure 9.8: Modelled Subsea Noise Contours (SPL_{pk} dB re 1 μPa) for Single Piling at the North and South Locations and Herring Larval Density and Spawning Grounds

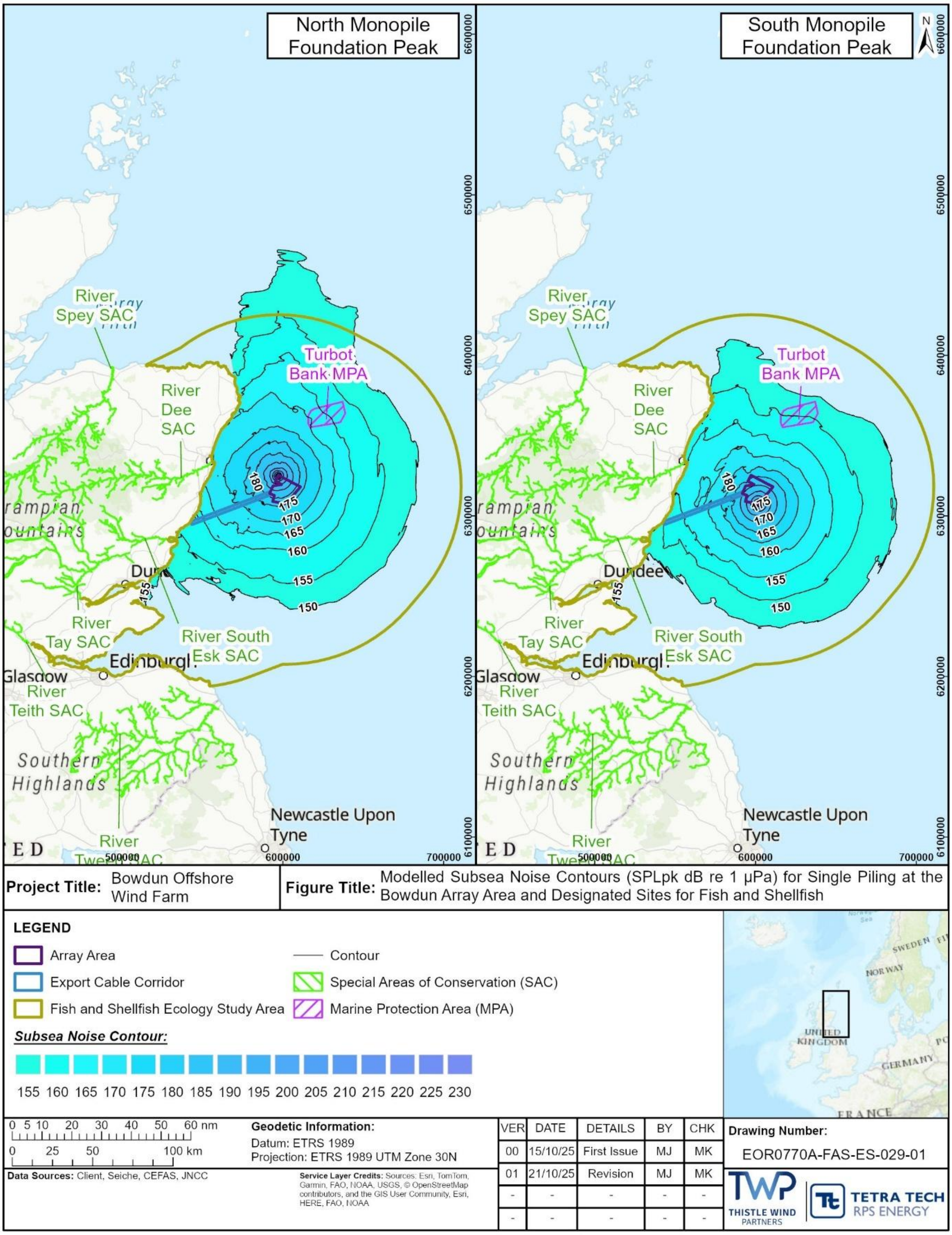


Figure 9.9: Modelled Subsea Noise Contours (SPL_{pk} dB re 1 μPa) for Single Piling at the North and South Locations and Designated Sites for Fish and Shellfish

Shellfish IEFs

9.10.207 Injury and disturbance criteria have not been developed for shellfish and, therefore, modelling could not be conducted for the shellfish IEFs. As the shellfish IEFs are expected to be less sensitive than fish species, the injury and disturbance ranges modelled for fish could be considered conservative overestimates for the shellfish IEFs. Nonetheless, an overview of literature available on shellfish sensitivity to subsea noise has been provided in the following paragraphs.

9.10.208 To date, no effect or influence of noise or vibrations has been reported on shellfish mortality rates or fisheries yields. Further, no studies have indicated a direct mortal effect of anthropogenic noise, either immediate or delayed (Scott *et al.*, 2020).

9.10.209 Of the shellfish IEFs identified, studies suggest that crustaceans such as European lobster, Norway lobster and various crab species are likely to be physiologically resilient to subsea noise due to the lack of gas within their bodies (Popper *et al.*, 2001). For example, a study by Christian *et al.* (2003) found no significant difference between acute effects of seismic airgun exposure (an impulsive high amplitude noise source similar to piling; >189 dB re 1 μPa (peak–peak) at 1 m) upon adult snow crabs *Chionoecetes opilio*.

9.10.210 Sub-lethal physiological effects have been identified from anthropogenic subsea noise sources including bruised internal organs in snow crabs exposed to seismic survey noise emissions (at unspecified SPLs) (Chadwick, 2004), changes in serum biochemistry and hepatopancreatic cells in American lobster *Homarus americanus* (Payne *et al.*, 2007), and metabolic rate changes in green shore crab *Carcinus maenas* exposed to shipping noise (Wale *et al.*, 2013).

9.10.211 There is currently no evidence to suggest shellfish eggs and larvae are at risk of direct harm from underwater noise such as piling, although it should be noted that studies are limited (Edmonds *et al.*, 2016). Of the limited studies that have focussed on shellfish eggs and larvae, impaired embryonic development and mortality has been observed after playback of seismic survey noise among gastropods and bivalves (De Soto *et al.*, 2013; Nedelec *et al.*, 2014). There is limited information on the impact of impulsive noise upon crustacean eggs, and no research has been conducted on commercially exploited decapods around the UK. All studies focus on the impact of seismic noise, which has been demonstrated to delay the hatching of snow crab eggs, causing resultant larvae to be smaller than controls (Chadwick, 2004). However, Pearson *et al.* (1994) reported no statistically significant difference between the mortality and development rates of the free-swimming, planktonic larval stage of Dungeness crab *Metacarcinus magister* larvae exposed to single field-based discharges (231 dB re 1 μPa (zero-peak) at 1 m) from a seismic airgun.

9.10.212 Therefore, the shellfish IEFs are deemed to be of low vulnerability, high recoverability and local value. The sensitivity of the receptor is, therefore, considered to be low.

Sensitivity of the receptor – UXO clearance

9.10.213 The criteria used in the subsea noise modelling assessment for explosives (i.e. UXO clearance activities) are given in Table 9.40. These are not available for eggs and larvae.

Table 9.40: Criteria for the Onset of Injury to Fish due from Explosives (Popper *et al.*, 2014)

Hearing Group	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Group 1 Fish: no swim bladder (particle motion detection)	Peak, dB re 1μPa	229 - 234	(Near) High (Intermediate) Low (Far) Low	(Near) High (Intermediate) Moderate (Far) Low
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	Peak, dB re 1μPa	229 - 234	(Near) High (Intermediate) High (Far) Low	(Near) High (Intermediate) Moderate (Far) Low
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	Peak, dB re 1μPa	229 - 234	(Near) High (Intermediate) High (Far) Low	(Near) High (Intermediate) High (Far) Low

9.10.214 As detailed in Paragraphs 9.10.158 to 9.10.160, the use of low order disposal of UXOs (e.g. deflagration and clearance shots) where practicable is an Embedded Mitigation measure. There is a small risk that low order disposal could unintentionally arise in a high order detonation and therefore this scenario has also been considered in the assessment. Details and assumptions of the different charge sizes involved in both low and high order disposal are detailed in Table 9.41.

Table 9.41: Details of High and Low Order UXO Disposal Assumptions and their Relevant Charge Sizes used in the Subsea Noise Modelling

Charge Size (kg NEQ)	Notes/Assumptions
Low Order and Low- Yield Donor Charge Configurations	
0.25 kg	Maximum size of donor charge used for low-order technique.
0.5 kg	Maximum size of clearing shot to neutralise any residual explosive material.
Potential UXOs (High Order Disposal)	
227 kg	Realistic worst case UXO charge weight, based on British World War Two (WW2) mine Mk XIV.
720 kg	Maximum estimated UXO size that is anticipated to be encountered, based on a 1,000 kg German WW2 mine BM1000.

9.10.215 The modelled mortality and potential mortal injury ranges (using the SPL_{pk} metric) for low order and high order are presented in Table 9.42 and Table 9.43. The criteria used in this underwater noise assessment for explosives are detailed in further detail in Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report, and are derived from Popper *et al*. (2014). There are no thresholds in Popper *et al*. (2014) in relation to eggs and larvae in terms of sound pressure, therefore only results for fish have been presented. As detailed in Table 9.42, the mortality and potential mortal injury ranges for the low order clearance activities were modelled out to tens of metres for all fish hearing groups, with these increasing to multiple hundreds of metres for high order clearance activities (Table 9.43).

9.10.216 It should be noted that, due to a combination of dispersion (i.e. where the waveform elongates), multiple reflections from the sea surface and seabed and molecular absorption of high frequency energy, the subsea noise is unlikely to still be impulsive in character once it has propagated more than a few kilometres. Furthermore, the modelling assumes that the UXO acts like a charge suspended in open water whereas in reality it is likely to be partially buried in the sediment. In addition, it is possible that the explosive material will have deteriorated over time meaning that the predicted subsea noise levels are likely to be overestimated. In combination, these factors mean that the results should be treated as precautionary potential impact ranges which are likely to be significantly lower than predicted.

Table 9.42: Potential Impact Ranges for Low Order and Low Yield UXO Clearance Activities Based on the SPL_{pk} Metric

UXO Clearance Parameter	Impact Range (m)
0.08 kg Low Order Donor Charge	
Fish (lower range: Potential Mortal Injury)	44
Fish (upper range: Mortality)	27
0.5 kg Clearing Shot	
Fish (lower range: Potential Mortal Injury)	81
Fish (upper range: Mortality)	49

Table 9.43: Potential Impact Ranges for High Order UXO Clearance Activities Based on the SPL_{pk} Metric

UXO Clearance Parameter	Impact Range (m)
227 kg UXO – High Order Explosion	
Fish (lower range: Potential Mortal Injury)	620
Fish (upper range: Mortality)	375
720 kg UXO – High Order Explosion	
Fish (lower range: Potential Mortal Injury)	910
Fish (upper range: Mortality)	550

All Fish and Shellfish IEFs

9.10.217 Overall, as a precaution, the herring IEF is deemed to be of medium vulnerability, high recoverability, and national importance. The sensitivity of the receptor is, therefore, considered to be medium.

9.10.218 The remaining marine and diadromous fish IEFs are deemed to be of low vulnerability, high recoverability and local to international value. The sensitivity of the receptor is, therefore, considered to be low. There are limited data on the sensitivity (if any) of shellfish species to subsea noise generated from UXO clearance. As shellfish species have a lower sensitivity to subsea noise than the fish IEFs, the results presented in Table 9.42 and Table 9.43 for the fish IEFs could be considered highly over precautionary estimates. Therefore, the shellfish IEFs are deemed to be of low vulnerability, high recoverability and local value. The sensitivity of the receptor is, therefore, considered to be low.

Sensitivity of the receptor – site investigation surveys

9.10.219 The criteria used in the subsea noise modelling assessment for non-impulsive piling and other continuous sound sources (such as site investigation surveys, vessels and other construction activities), are given in Table 9.44 The only numerical criteria for these sources are for recoverable injury and TTS for Groups 3 and 4 Fish.

9.10.220 It should be noted that there are no thresholds in Popper *et al*. (2014) in relation to subsea noise from high frequency sonar (>10 kHz). This is because the hearing range of fish species falls well below the frequency range of high frequency sonar systems (such as geophysical site investigation survey equipment). Consequently, the effects of high frequency sonar-like seabed imaging surveys on fish have not been conducted as part of the noise modelling study, due to the frequency of the source being beyond the range of hearing and also due to the lack of any suitable thresholds.

Table 9.44: Criteria for the Onset of Injury to Fish due to Non-Impulsive Sources (Popper *et al.*, 2014)

Hearing Group	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Group 1 Fish: no swim bladder (particle motion detection)	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
Group 2 Fish: where swim bladder is not involved in hearing (particle motion detection)	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Moderate (Intermediate) Low (Far) Low
Groups 3 and 4 Fish: where swim bladder is involved in hearing (primarily pressure detection)	(Near) Low (Intermediate) Low (Far) Low	170 dB re 1µPa (root mean square (rms)) for 48 hours	158 dB re 1µPa (rms) for 12 hours
Eggs and larvae	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low	(Near) Low (Intermediate) Low (Far) Low

9.10.221 Modelled impact ranges for recoverable injury and TTS are illustrated in Table 9.45. These ranges were very low, with thresholds not exceeded for borehole drilling.

Table 9.45: Estimated Recoverable Injury and TTS Ranges for Site Investigation Activities for Group 3 and 4 Fish

Site Investigation Survey Equipment	Impact Range (m)	
	Recoverable injury 170 dB re 1 µPa (rms) for 48 hours	TTS 158 dB re 1 µPa (rms) for 12 hours
Borehole drilling	N/E	N/E
Vibro-coring	10	53

9.10.222 As Group 3 and 4 fish are the most sensitive to subsea noise, and the impact ranges modelled for site investigation surveys were very low, it can reasonably be assumed that injury ranges for the other hearing groups (and the shellfish IEFs, by proxy) will be similar or lower. Therefore, all fish and shellfish IEFs are deemed to be of low vulnerability, high recoverability (upon cessation of site investigation surveys and due to recoverable injury thresholds largely not being exceeded) and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

Sensitivity of the receptor – vessel noise and other construction activities

9.10.223 A range of construction activities were considered in the MDS for this impact (Table 9.15) and see Volume 3, Technical Appendix 10.4: Subsea Noise Technical Report for full detail). As illustrated in Table 9.44, the only numerical criteria for these sources are for recoverable injury and TTS for Groups 3 and 4 Fish, which are the most sensitive to subsea noise. Modelled impact ranges for recoverable injury and TTS are, therefore, illustrated in Table 9.46. These results suggest very low TTS ranges (maximum of 16 m) with recoverable injury thresholds not exceeded at all.

Table 9.46: Estimated Recoverable Injury and TTS Ranges for Site Investigation Activities for Group 3 and 4 Fish

Subsea Noise Source	Impact Range (m)	
	Recoverable injury **170 dB re 1 µPa (rms) for 48 hours**	**TTS** **158 dB re 1 µPa (rms) for 12 hours**
Construction Activities		
Cable laying	N/E	16
Cable trenching/cutting	N/E	8
Jack up rig	N/E	N/E
Drilled piling	N/E	N/E

9.10.224 As Group 3 and 4 fish are the most sensitive to subsea noise, and the impact ranges presented in Table 9.46 were very low or not exceeded, it can reasonably be assumed that injury ranges for the other hearing groups (and the shellfish IEFs, by proxy) will be similar or lower. Therefore, all fish and shellfish IEFs are deemed to be of low vulnerability, high recoverability (upon cessation of vessel use and construction activities and due to recoverable injury thresholds not being exceeded) and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

Significance of the effect - piling

9.10.225 Overall, for the herring IEF, the magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be high. The effect will, therefore, be minor to moderate adverse significance. Given that the noise contours presented in Figure 9.8 extend to herring spawning grounds and hotspots of larval density, a **Moderate** adverse significance has been concluded, which is significant in EIA terms.

9.10.226 For all other fish and shellfish IEFs, 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 Negligible to Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Significance of the effect – UXO clearance

9.10.227 Overall, for the herring IEF, 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.

9.10.228 For all other fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Significance of the effect – site investigation surveys

9.10.229 Overall, for all fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Significance of the effect – vessel noise and other construction activities

9.10.230 Overall, for all fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual Effect

9.10.231 For all fish and shellfish IEFs except herring, no Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

9.10.232 A moderate adverse significance was concluded for the herring IEF due to piling in the construction phase. Therefore, prior to the commencement of piling at the Proposed Development, appropriate Additional Mitigation measures will be discussed and agreed with stakeholders. These may include the use of noise abatement systems or site-specific surveys to determine key herring spawning periods. Appropriate mitigation will be secured through the Piling Strategy under conditions of the Section 36 Consent and the Marine Licence. It is anticipated that following tailoring of Additional Mitigation measures as described above, the significance of this impact will be reduced to minor adverse for herring, which is not significant in EIA terms.

O&M phase

Magnitude of impact

9.10.233 Within the O&M phase, there is potential for subsea noise to be produced by the following:

- Site investigation surveys; and
- Wind Turbine operation (Table 9.15).

9.10.234 The site investigation surveys and vessel movements will be of a similar extent, or lower, to that assessed in Paragraphs 9.10.162 to 9.10.165 for the construction phase. Therefore, the impact associated with these in the O&M phase is predicted to be of very local spatial extent, short term duration, intermittent and high reversibility, with the soundscape returning to near baseline conditions upon cessation of the survey and/or vessel activity. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

9.10.235 Subsea noise may also arise during the O&M phase as a result of Wind Turbine operation. The operational noise generated by fixed foundation Wind Turbines contributes low-frequency sound to the underwater ecosystem, primarily stemming from the movement of mechanical components within the nacelle. This noise generally occurs below 1 kHz and frequently features pronounced tonal elements linked to gear mesh frequencies and their harmonics (Pangerc *et al.*, 2016). Furthermore, the wind-induced vibrations of the Wind Turbine tower at elevated wind speeds have been recognised as a potential source of underwater noise (Elmer, 2007).

9.10.236 The noise levels emitted by offshore Wind Turbines are relatively low and comparable to those produced by commercial vessels at equivalent distances (Tougaard *et al.*, 2020). The distance from the Wind Turbine is the primary factor affecting sound pressure levels, while wind speed and Wind Turbine size play a lesser role (Tougaard *et al.*, 2020). A review of the available literature found the highest broadband sound pressure level measured close to an offshore Wind Turbine was 137 dB re 1 µPa at a distance of 40 m (Thomsen *et al.*, 2015). However, modelled noise levels rapidly attenuate with distance and at a higher rate than predicted by simple spherical spreading, approximately 24 dB/decade compared to the theoretical 20 dB/decade (Tougaard *et al.*, 2020). Though individual Wind Turbines generate relatively low noise levels, modelling indicates that the cumulative noise from multiple Wind Turbines can increase sound levels up to several kilometres from a wind farm, particularly in low ambient noise conditions.

9.10.237 However, most fish and shellfish species are not particularly sensitive to the low-frequency tonal sounds produced by Wind Turbines, and the sound pressure generated by operational noise typically falls below the level known to cause harm. The rapid decrease in sound pressure with distance away from the source decreases the likelihood of significant behavioural or physiological impacts. The continuous and predictable nature of Wind Turbine noise also allows for potential habituation among fish populations.

9.10.238 Therefore, it has been concluded that the risk of effects on fish (either injury or behavioural responses) from operational subsea noise from the structure-borne noise is very low. Overall, for operational subsea noise from Wind Turbines the impact is predicted to be of local spatial extent, long term duration, continuous (but at very low levels), and low reversibility (although it is reversible upon decommissioning). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

9.10.239 There have been few studies to date on the effect of operational noise from OWFs on fish and shellfish receptors. The thresholds and sensitivities presented for site investigation surveys and vessel use in the construction phase (see Paragraphs 9.10.219 to 9.10.224) are still relevant to the O&M phase, however further literature specific to operational noise from Wind Turbines is presented here to help characterise the sensitivity.

Marine Fish IEFs

9.10.240 While the literature on the direct effects of operational Wind Turbine noise on fish is sparse, there have been several studies on the fish communities at operational OWFs in general. For example, a recent meta-analysis of finfish abundance at operational OWFs indicated that there was generally a greater abundance of fish inside of wind farms (Methratta and Dardick, 2019), which can likely be attributed to artificial reef effects, availability of refuges, and increased foraging potential around these structures (see the impact of 'Colonisation of Hard Structures' in Paragraphs 9.10.84 *et seq.*). Similarly, a study at the Lillgrund OWF in Sweden found that the demersal fish diversity and abundance was not significantly impacted at the scale of the entire OWF (Bergström *et al.*, 2013). Localised increased densities of some piscivore species were observed near foundations, with the authors suggesting that any potentially negative effects from the operational OWF (such as noise disturbance and EMFs) did not override the attractive effect of the introduced structures for any of the fish species investigated (Bergström *et al.*, 2013). Further, multi-year studies at the Block Island OWF in the USA demonstrated that there were no statistically significant changes in landings of demersal fish and shellfish species due to the operation of the OWF (Wilber *et al.*, 2022). Catches of black sea bass *Centropristis striata* and cod increased following Wind Turbine installation, and it can be inferred that these species were not deterred by operational noise from Wind Turbines (Wilber *et al.*, 2022). Flatfish abundance, size, and condition varied over time and space, but these changes were not consistently linked to the construction or operation of the Block Island OWF (Wilber *et al.*, 2022), further inferring that these species were not negatively impacted by operational noise.

9.10.241 A study by Sigray and Andersson (2011) on cod and plaice demonstrated that Wind Turbines generate particle motion that these species can sense. Close to the Wind Turbine foundation, the maximum particle motion is comparable with levels observed in studies concerned with behavioural reactions. However, at distances of 10 m away, the amplitudes decreased to levels comparable with hearing thresholds of cod and plaice, suggesting that the physical area where the environment is affected by anthropogenically generated particle motion is restricted to the immediate neighbourhood of the Wind Turbine (Sigray and Andersson, 2011). The results indicate that a single Wind Turbine has a limited impact on fish, corroborating a study made by Andersson and Öhman (2010).

9.10.242 Limited behavioural effects were recorded in a recent study specifically measuring operational Wind Turbine noise at the Miaoli OWF in Taiwan. A two year study reported that operational Wind Turbine noise (measured in the 20 Hz to 250 Hz frequency band) was significantly higher in autumn and winter and correlated with wind speed (Siddagangaiah *et al.*, 2024). The average SPL during these seasons was 138 to 143 dB re 1 μPa (Siddagangaiah *et al.*, 2024). Despite this, operational noise did not influence the seasonal fish chorusing patterns, which consistently began in spring, peaked in summer, decreased in autumn, and were absent in winter (Siddagangaiah *et al.*, 2024). Fish chorusing behaviour is essential for maintaining social cohesion, foraging, territorial defence, and spawning for some fish and shellfish species (Buscaino *et al.*, 2015; Siddagangaiah *et al.*, 2024; van Oosterom *et al.*, 2016). Thus, this recent study provided a novel insight into the evidence base around operational Wind Turbine noise on fish behaviour.

9.10.243 A study by Puig-Pons *et al.* (2021) the behavioural responses of caged Atlantic bluefin tuna to Wind Turbine and vessel noise presented a strong relationship with ensonification pressure level and time. During the first exposure to simulated Wind Turbine noise with an SPL of 182 dB re 1 μPa, Atlantic bluefin tuna started to show behavioural changes after around eight minutes. These behavioural changes involved schooling behaviour and swimming depth: the shoal swam close to each other, swam in a smaller circle, moved closer to the surface, and some individuals changed direction Puig-Pons *et al.* (2021). After subsequent noise emissions, (taken up to 30 minutes apart to allow individuals to recover), the Atlantic bluefin tuna did not show any behavioural reaction of the Wind Turbine noise, perhaps indicating some level of habituation Puig-Pons *et al.* (2021). A similar study on the same species demonstrated that individuals exposed to Wind Turbine noise for a short duration did not exhibit clear behavioural differences than under control conditions (Pérez-Arjona *et al.*, 2014). However, when exposed to this noise source for a longer duration, Atlantic bluefin tuna displayed altered behaviour, such as moving towards the surface, and some individuals were disorientated. However, individuals in this study also appeared to become habituated after several repetitions (Pérez-Arjona *et al.*, 2014). These two studies highlight that species may show altered behaviour due to Wind Turbine noise but are likely to show some degree of habituation over time, suggesting that population level effects (and thus impacts to marine food webs) are unlikely.

9.10.244 Finally, a recent study by Cresci *et al.* (2023) demonstrated that cod larvae orient towards the source of low-frequency subsea noise, similar to that generated by offshore Wind Turbines. Conducted in a Norwegian fjord using drifting behavioural chambers, this experiment showed that while exposure to a continuous noise source of 100 Hz did not affect cod larval swimming speeds or turning behaviour, it did influence their directional movement. Exposed cod larvae oriented towards the noise source, unlike control larvae, which oriented north-west (Cresci *et al.*, 2023). These findings suggest that subsea noise from offshore Wind Turbines could impact the dispersal of cod larvae (and potential the larvae of other species) (Cresci *et al.*, 2023). Similarly, work by Debusschere *et al.* (2016) demonstrated that pile driving and operational noise from OWFs can significantly impact the early life stages of sea bass *Dicentrarchus labrax* larvae. The noise exposure was shown to potentially disrupt the development and behaviour of sea bass larvae, which are crucial for fish populations and serve as important prey for pelagic predators (Debusschere *et al.*, 2016). It is therefore possible that operational Wind Turbine noise could impact the larval stages of the IEFs. However, when compared to the various studies that have shown no significant negative impacts on fish communities as a whole due to the presence of operational OWFs (see Paragraph 9.10.240), it is likely that impacts upon larvae may not translate into population or ecosystem level effects.

9.10.245 Therefore, all marine fish IEFs are deemed to be of low vulnerability, high recoverability and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

Diadromous Fish IEFs

9.10.246 There are currently no studies on the sensitivities of the diadromous fish IEFs to operational noise from Wind Turbines. However, there is some, limited, research on the impact of tidal turbine noise on salmonids. Halvorsen *et al.* (2011) exposed juvenile Chinook salmon *Oncorhynchus tshawytscha* to simulated tidal turbine noise in experimental settings. However, the necropsies of the fish demonstrated that non-lethal, low levels of tissue damage may have occurred but there were no effects of noise exposure on their auditory systems. Similarly, modelling by Schramm *et al.* (2017) demonstrated that rainbow trout were not likely to exhibit any responses to a tidal turbine.

9.10.247 The literature summarised and sensitivity assigned in Paragraphs 9.10.240 to 9.10.244 for the marine fish IEFs can be applied to the diadromous fish IEFs. This is because as some of the diadromous fish IEFs are classified as either a lower hearing group (i.e. lampreys in Group 1 and salmonids in Group 2, the least sensitive hearing groups to subsea noise) or equal hearing group (i.e. European eel in Group 3 and shads in Group 4) to the marine fish species detailed.

9.10.248 Therefore, the diadromous fish IEFs are deemed to be of low vulnerability, high recoverability and national to international value. 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.

Shellfish IEFs

9.10.249 To date, there is limited information on the sensitivity (if any) of shellfish species to operational noise from OWFs. However, many studies have shown refuge and reef effects associated with OWF foundations for shellfish species (Hooper and Austen, 2014; Linley *et al.*, 2007; Vattenfall, 2006). As detailed in Paragraph 9.10.240 for the marine fish IEFs, it may be that any potential disturbance from operational OWF noise does not override the attractive effect of the introduced structures for shellfish species, particularly crustaceans.

9.10.250 Given that the shellfish IEFs are considered to be less sensitive to subsea noise than the fish IEFs, it has been concluded that the sensitivity of shellfish IEFs to this impact will be of a lesser extent than that of the fish IEFs.

9.10.251 Therefore, the shellfish IEFs are deemed to be of low vulnerability, high recoverability and local value. The sensitivity of the receptor is, therefore, considered to be negligible.

Significance of the effect

9.10.252 Overall, for the fish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

9.10.253 Overall, for the shellfish IEFs, 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 or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual Effect

9.10.254 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.10.255 Subsea noise may be produced from decommissioning activities in this phase. As detailed in Table 9.15, the approach for decommissioning is yet to be determined, however, for the purposes of the MDS it is assumed there will be a range of vessels used for decommissioning activities such as removal of foundations, cables and cable. Details of these activities in the decommissioning phase are currently unavailable, and a decommissioning Programme will be submitted to MD-LOT for consultation and approval.

9.10.256 Therefore, for the purposes of the assessment, the magnitude of impact in the decommissioning phase is expected to be of a lower extent to that detailed in Paragraphs 9.10.164 to 9.10.165 for the construction phase. This is likely to be lower due to the absence of piling and UXO clearance in the decommissioning phase.

9.10.257 Therefore, the impact is predicted to be of very local spatial extent, short term duration, intermittent and high reversibility, with the soundscape returning to near baseline conditions upon completion of the decommissioning activities. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of the receptor

9.10.258 The sensitivity of the receptor is as already presented for the construction phase (see Paragraphs 9.10.221 to 9.10.222) and is not repeated here.

Significance of the effect

9.10.259 Overall, for all fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual Effect

9.10.260 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

IMPACT 6 - IMPACTS TO FISH AND SHELLFISH RECEPTORS DUE TO EMF

9.10.261 EMFs may be emitted to the marine environment from IACs, Interconnector, and Offshore Export Cables. This impact is relevant to the O&M phase of the Proposed Development.

O&M phase

Magnitude of impact

9.10.262 Potential effects on the fish and shellfish IEFs may arise due to EMFs generated from up to 397 km of subsea electrical cables associated with the Proposed Development, as outlined in Table 9.15. This includes:

- Up to 167 km of 132 kV IACs (up to 151 km at the seabed and up to 16 km within the Wind Turbine foundations);
- Up to 36 km of 275 kV Interconnector Cables; and
- Up to 210 km of 275 kV Offshore Export Cables (up to three Offshore Export Cables, with a maximum length of 70 km each).

9.10.263 The conduction of electricity through subsea power cables will result in emission of localised EMFs. The MDS for this impact assessment also considers the impacts of EMFs from the IAC within the Wind Turbine foundations (up to 16 km; Table 9.15).

9.10.264 EMFs comprise both the electrical fields, measured in volts per metre (V/m), and the magnetic fields, measured in microtesla (μT), millitesla (mT), milligauss (mG) or gauss. Within the North Sea, background magnetic field levels are approximately 50 μT, and background electric field measurements are approximately 25 μV/m (Tasker *et al.*, 2010). Subsea power cables are constructed using magnetic outer sheathing materials, which can partially block the direct electrical field, meaning that only the magnetic field and the resultant induced electrical field are emitted into the marine environment. By design, DC (Direct Current) and AC (Alternating Current) cables typically contain two and three conductor bundles, respectively, which are superimposed and twisted around each other. This design feature creates partial self-cancellation of the total magnetic field emitted (Hervé, 2021; Snyder *et al.*, 2019).

9.10.265 The strength of the magnetic field (and consequently, induced electrical fields) decreases rapidly horizontally and vertically with distance from source. On the seabed, it is standard industry practice to bury cables and use cable protection where burial is not possible (which has been incorporated into the MDS, see Table 9.15). This can reduce EMF levels at the seabed surface as a result of field decay with distance of the seabed from the cable (Chapman *et al.*, 2023; Gill *et al.*, 2005; Gill *et al.*, 2009; Snyder *et al.*, 2019). For example, a recent study by Snyder *et al.* (2019) demonstrated that Inter-array and Offshore Export Cables buried between depths of 1 m to 2 m reduced the magnetic field at the seabed surface four-fold. For unburied cables protected by thick concrete mattresses or rock berms, the field levels were found to be similar to those of the buried cables (Snyder *et al.*, 2019). This study also demonstrated that magnetic field levels directly over live AC IACs cables associated with offshore wind projects ranged between 65 mG at the seabed and 5 mG at 1 m above the seabed (Snyder *et al.*, 2019). At horizontal distances from the cables, magnetic fields greatly reduced at the sea floor to between 10 mG and <0.1 mG (Snyder *et al.*, 2019).

9.10.266 Clear differences in the EMFs emitted between AC and DC systems are also apparent. The flow of electricity associated with an AC cable changes direction (as per the frequency of the AC transmission) and creates a constantly varying electrical field in the surrounding marine environment (ElectroMagneticWorks Inc, 2022; Huang, 2005). Conversely, DC cables transmit energy in one direction creating a static electrical field and magnetic field. Average magnetic field levels of DC cables are also higher than those of equivalent AC cables (ElectroMagneticWorks Inc, 2022; Huang, 2005).

9.10.267 Overall, EMF levels in the vicinity of subsea cables are influenced by a variety of design and installation factors. These include distance between cables, cable sheathing material, number of conductors, and internal cable configuration.

9.10.268 A large proportion of the cables will be buried beneath surface sediments to a minimum burial depth of 0.5 m, and a target burial depth of 1.5 m (Table 9.15). The intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation level is the same for buried and unburied cables (Hutchison *et al.*, 2021). So, whilst EMFs emitted from unburied cables will be considerably higher than compared to buried cables (i.e. due to the reduced surface sediments/protection upon these), EMF levels are expected to return to the baseline level within a few metres distance from the cable, to a maximum of a few tens of metres (Bochert and Zettler, 2006; Hutchison *et al.*, 2021; Snyder *et al.*, 2019). Therefore, as for the buried cables at the seabed, the area of effect is highly limited in extent, particularly in the context of the Fish and Shellfish Ecology Study Area as a whole, and barrier effects are not anticipated to occur.

9.10.269 The Export Cable Corridor will be comprised of up to three Offshore Export Cables. Given that EMF levels are expected to return to baseline levels within metres to tens of metres from cables, barrier effects are not predicted to occur over the length of the Export Cable Corridor.

9.10.270 The impact is predicted to be of local spatial extent, long term duration (over the O&M phase), intermittent (as effects could only occur within metres of cables), and 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 the receptor

9.10.271 Many marine fish species are able to detect EMFs with electromagnetic sensing in fish and shellfish involving a variety of sensory systems (Hutchison *et al.*, 2020). Electro-receptive species are able to detect weak electric fields in order to locate prey and predators, communicate, find mates and/or orientate themselves (Kim, 2007). Electro-receptive species may also be able to respond to magnetic fields using electro-sensory apparatus with some species (particularly elasmobranchs) possessing both electro and magneto-sensory apparatus (Anderson *et al.*, 2017). Magneto-receptive species respond to small changes in the inclination, intensity and/or direction of a magnetic field (Nordmann *et al.*, 2017) and may rely on a magnetic compass and/or magnetic map to navigate (Lohmann *et al.*, 2008a).

<u>Marine fish IEFs</u>

9.10.272 Studies have been conducted examining the effects of EMFs from subsea power cables on marine fish behaviours to determine the thresholds for detection and response to EMFs. These studies have found limited evidence that EMFs from subsea power cables affected marine fish assemblages (Love *et al.*, 2016), the spatial distribution, swimming speed, acceleration, or distance moved by the lesser sandeel and herring larvae (Cresci *et al.*, 2020; 2022), or the size, morphology, or the cardiac functions of juvenile cod (Lorillard, 2023). While these studies cover larvae and juveniles of three key IEFs (cod, herring, and sandeel), literature surrounding the impact of EMFs on adult marine teleost fish is limited, with most focussing on elasmobranchs.

9.10.273 Elasmobranchs are known to be the most electro-receptive of all fish species. They possess specialised electro-receptors which enable them to detect very weak voltage gradients (down to 0.5 µV/m) which are naturally emitted from their prey (Gill *et al.*, 2005; Kim, 2007). There is also research to suggest that embryonic elasmobranchs (which could be preyed upon by larger species) are able to modulate their own bioelectrical signals to reduce predation risk (Kempster *et al.*, 2013).

9.10.274 Both attraction and repulsion reactions to electrical fields have been observed in elasmobranchs. Spurdog (an IEF) has been shown to avoid electrical fields at 10 µV/cm (Gill and Taylor, 2001), although it should be noted that this level is considerably higher than levels associated with offshore electrical cables. Gill *et al.* (2009) demonstrated that the small spotted catshark and thornback ray (both IEFs) could respond to EMF of the type and intensity associated with subsea power cables. However, these responses were not predictable and did not always occur (Gill *et al.*, 2009). In terms of magnetosensitive and electrosensitive sharks, EMF from 50 Hz to 60 Hz AC sources appears undetectable; laboratory research conducted with skates indicated that as the frequency of EMF increases above 1 Hz, skates become less sensitive (Snyder *et al.*, 2019). In a risk-based approach to investigate the effects of EMFs on southern North Sea elasmobranch species, Hermans *et al.* (2024) concluded that the risk from subsea power cables has a large uncertainty and varies across life stages and species ecology. Therefore, species and stimulus-specific sensitivities to EMFs are likely to present across the elasmobranch IEFs.

9.10.275 Further highlighting this, Kempster and Collin (2011) noted the physiological capacity for detection of EMFs in the basking shark, which is an IEF, but limited current evidence exists on specific impacts of EMFs of any strength on this species. The MarESA for basking shark lists this species as not sensitive to the pressure of 'electromagnetic changes' (Wilson *et al.*, 2020), however notes the absence of species-specific information. The conclusion of no sensitivity in the MarESA was therefore, rationalised as although individuals may avoid or move away from localised areas of strong electric and magnetic fields, any temporary attractive or avoidance responses are likely to result in anything other than small-scale energy loss (Wilson *et al.*, 2020).

9.10.276 Similarly, while there was no pressure relevant to EMFs presented on the MarESA for the common skate IEF, the FeAST for this species concluded a low sensitivity to 'electromagnetic changes' (NatureScot, 2025). The rationale for this sensitivity assessment stated that although skate species use electro and/or magnetic sensors for prey detection, orientation, and finding mates (Kalmijn, 1971; Kalmijn, 1982; Kalmijn, 1997), given the mobility of common skate, it was considered likely that local changes in the electromagnetic field will cause little impact to this species (NatureScot, 2025).

9.10.277 Although information on the potential sensitivities of the marine fish IEFs to this impact is varied within the literature, the range over which individuals could detect EMFs associated with the Proposed Development is limited to a scale of metres around the subsea cables at the seabed and in the water column (Bochert and Zettler, 2006; Hutchison *et al.*, 2021; Snyder *et al.*, 2019). Demersal marine fish species (such as elasmobranchs, gadoids, flatfish, etc.) are more likely to come into the ZoI of subsea power cables on the seabed and thus encounter higher EMF levels when near them. Demersal species are also likely to be exposed for longer periods of time and may be more constrained in terms of lateral location. However, the rapid decay of the EMF with horizontal and vertical distance (Bochert and Zettler, 2006; Hutchison *et al.*, 2021; Snyder *et al.*, 2019) (i.e. within metres) reduces the extent of potential impacts.

9.10.278 Pelagic species (such as herring, tuna, and some elasmobranch species) generally swim well above the seafloor and are therefore unlikely to experience significant exposure to EMFs from subsea cables that are either buried or laid directly on the seabed. Further, EMFs from these cables are likely to only be detected within a matter of metres (Hutchison *et al.*, 2021). Beyond this range, levels of EMFs will be expected to be at baseline levels, resulting in a highly localised ZoI.

9.10.279 Therefore, the marine fish IEFs are deemed to be of low vulnerability, high recoverability (by swimming away) and local to international value. The sensitivity of the receptor is, therefore, considered to be low.

Diadromous fish IEFs

9.10.280 As detailed in Paragraph 9.10.271, many animals are able to detect the Earth's natural electric and magnetic fields (referred to as 'magnetoreception'; Nordmann *et al.* (2017)) and use them as cues to guide their migration patterns. Given their life histories, accurate migration is essential for diadromous fish species. Magnetoreception and/or the possession of magneto-receptive material has been demonstrated in European eels (Moore and Riley, 2009; Naisbett-Jones *et al.*, 2017) and salmonid species (Lohmann and Lohmann, 2019; Moore *et al.*, 1990; Naisbett-Jones *et al.*, 2020; Putman *et al.*, 2014). EMFs within the marine environment may therefore interfere with the navigational ability of diadromous species. For example, Putman *et al.* (2014) reported that drifts in the Earth's magnetic field accounted for 23% and 44% of variation in migratory routes taken by two salmonid species in British Columbia, Canada. There is evidence of a response to electric and/or magnetic fields in the following diadromous IEFs: Atlantic salmon, European eel, river lamprey, sea lamprey, and sea trout (Gill and Bartlett, 2010; Gill *et al.*, 2005; Snyder *et al.*, 2019).

9.10.281 During the marine phase of their life cycles, diadromous fish species may be exposed to EMFs from the cables on the seafloor. EMFs emitted from these cables are likely to only be detected within a matter of metres; beyond which, baseline levels will be established. As such, potential impacts associated with EMFs from the cables will be highly localised. Lamprey species possess specialised ampullary electroreceptors that are sensitive to weak, low frequency electric fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983). These are hypothesised to be used for detecting prey, although further research is required (Tricas and Carlson, 2012). Chung-Davidson *et al.* (2008) demonstrated that weak electric fields may play a role in the reproduction of sea lamprey and suggested that electrical stimuli may mediate different behaviours in feeding and spawning individuals. This study demonstrated that sea lamprey migratory behaviour was affected (i.e. adults did not move) when stimulated with electrical fields of intensities of between 2.5 mV/m and 100 mV/m, with normal behaviour observed at electrical field intensities higher and lower than this range (Chung-Davidson *et al.*, 2008). It should be noted, however, that these levels are considerably higher than modelled induced electrical fields expected from AC subsea cables. There is currently no evidence of lamprey responses to magnetic fields (Gill and Bartlett, 2010).

9.10.282 Research on the effects of a High Voltage Direct Current (HVDC) cable on the migration patterns of a range of fish species, including salmonids, failed to demonstrate any effect in two studies from Sweden (Westerberg *et al.*, 2007; Wilhelmsson *et al.*, 2010). Research conducted at a DC undersea cable near San Francisco, California, found that migration success and survival of chinook salmon was not impacted by the cable (Kavet *et al.*, 2016). However, behavioural changes were noted when near the cable, with individual chinook salmon appearing to remain around it for longer periods (Kavet *et al.*, 2016). Yano *et al.* (1997) studied magnetic compass orientation in oceanic migrating chum salmon *Oncorhynchus keta*, off the coast of Japan. Four chum salmon were fitted with a tag which generated an artificial magnetic field which produced an alternating intensity of around 6 gausses, with polarity which reversed every 11.25 minutes. The authors did not observe any effects on horizontal or vertical movements of the chum salmon when the magnetic field was modified (Yano *et al.*, 1997). Further, Armstrong *et al.* (2015) investigated the effects of mains frequency (50 Hz) magnetic fields on behaviour of captive Atlantic salmon. This study found that large Atlantic salmon (62 cm to 85 cm long) demonstrated no significant differences in approach, traverse or departure times associated with coils emitting a magnetic field of 95 μT. Post-smolts (24 cm to 41 cm in length) were exposed to three 30 minute periods of magnetic fields of 1.3 μT, 11.4 μT, and 95 μT with 30 minutes of control conditions before each treatment. There was no evidence that the numbers of post-smolts passing through the coils was related to the sequence of intensity of the magnetic fields. There were also no observations of unusual behaviours in association with magnetic fields up to 95 μT (Armstrong *et al.*, 2015). Salmonids are thought to use chemical and olfactory signals in coastal waters to locate their natal rivers (Ueda, 2014) and EMFs during offshore migrations (Gill and Bartlett, 2010; Lohmann *et al.*, 2008b). As Atlantic salmon are a pelagic species during their marine phase, the potential effects of EMF would therefore mostly be perceived in shallower waters (Snyder *et al.*, 2019).

9.10.283 European eel have also been suggested to use the earth's magnetic field for navigational purposes during migration (Gill and Bartlett, 2010; Snyder *et al.*, 2019). Studies on this species have highlighted some limited effects of subsea cables (Westerberg and Lagenfelt, 2008), with evidence of direct detection of EMF through its lateral line (Moore and Riley, 2009). Westerberg and Lagenfelt (2008) demonstrated short term changes in European eel swimming speed during migration (i.e. tens of minutes) due to exposure to AC electric subsea cables, even though the overall direction remained unaffected. A review by Ohman *et al.* (2007) concluded that any delaying effect (i.e. on average 40 minutes) were not likely to impact fitness over the 7,000 km migration route of European eel, with little to no impact on migratory behaviour noted beyond 500 m from OWF infrastructure. A review by Gill and Bartlett (2010) concluded that migrating European eels may interact with EMFs if they pass directly next to the cable (particularly in shallow waters of <20 m). The effect, if any, could be trivial temporary changes in swimming direction or avoidance behaviour, but the biological significance of this could not be determined (Gill and Bartlett, 2010). The research summarised in this paragraph indicates that behavioural effects in response to EMF are limited both temporally and spatially and may not cause barriers to migration for European eel.

9.10.284 This reviewed literature demonstrates that while EMFs can result in altered patterns of fish behaviour, these changes are temporary and highly localised to within metres of the cable and are therefore not likely to represent large-scale barriers to migration, impede population health, or cause trophic level effects. It should be noted that although there is limited information available in the literature on the impacts and sensitivities of shellfish species to EMFs (Paragraphs 9.10.286 *et seq.*), freshwater pearl mussel would not be directly impacted by EMFs produced by subsea cables associated with the Proposed Development given that they are a freshwater resident species. There will be no subsea cables associated with the Proposed Development in any freshwater habitats.

9.10.285 The diadromous fish IEFs are deemed to be of low vulnerability, high recoverability (by swimming away) and national to international value. 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.

Shellfish IEFs

9.10.286 Crustaceans, such as lobster and crab species, have been recorded to demonstrate a response to magnetic fields and may use magnetoreception for navigation. For example, a field experiment demonstrated that Caribbean spiny lobster *Panulirus argus* have a magnetic compass by tethering individuals inside a magnetic coil (Lohmann *et al.*, 1995). Exposure to EMF has thus been suggested to affect a variety of physiological processes within crustaceans. For example, Lee and Weis (1980) demonstrated that EMF exposure affected moulting in species of fiddler crab (*Uca pugilator* and *Uca pugnax*).

9.10.287 Love *et al.* (2017) conducted field experiments on crab movement off southern California and in the Puget Sound. Dungeness crab *Metacarcinus magister* and red rock crab *Cancer productus* were given a choice of walking over an energised power cable to a baited trap or walking directly away from that cable to a second baited trap. The authors found no evidence that the EMF emitted by the energised subsea power cable influenced the catchability of these two crab species (Love *et al.*, 2017). In addition, there was no difference in the crabs' responses to lightly buried versus unburied cables (Love *et al.*, 2017). Similarly, no significant change in distance or speed of travel over time when American lobster were exposed to magnetic fields of 53 μT to 65 μT (Hutchison *et al.*, 2020). Similarly, a field study by Hutchison *et al.* (2018) observed the behaviour of American lobster to AC and DC fields from a buried subsea cable. The authors found that these AC and DC fields did not cause a barrier to movement or migration of American lobster, which were able to freely cross the cable (Hutchison *et al.*, 2018). However, studies by Scott *et al.* (2018) and Woodruff *et al.* (2012) on edible crab and Dungeness crab reported behavioural changes during exposure to increased EMF levels, and both species showed increased activity when not exposed.

9.10.288 With the exception of edible crab, the research presented in the preceding paragraphs does not focus on shellfish IEFs relevant to this assessment. Limited research undertaken on the European lobster IEF demonstrated no neurological response to magnetic field strengths considerably higher than those expected directly over an average buried power cable (Normandeau Associates Inc *et al.*, 2011; Ueno *et al.*, 1986). However, European lobster exposed to EMFs have been demonstrated to have a significant decrease in egg volume at later stages of egg development and more larval deformities (Scott *et al.*, 2020). Similarly, Harsanyi *et al.* (2022) noted that chronic exposure to EMF effects could lead to physiological deformities and reduced swimming test rates in the larvae of European lobster and edible crab. However, these deformities were in response to EMF levels of 2,800 μT, and therefore are considerably higher than EMF effects expected for buried cables (Harsanyi *et al.*, 2022). A capture-mark-recapture study by Langhamer *et al.* (2016) demonstrated the presence of the Lillgrund OWF (Sweden) had no impact on the population of common shore crab, although it should be noted that EMFs were not specifically assessed in this study.

9.10.289 Regarding the edible crab IEF, Scott (2019) demonstrated that EMF exposure could result in varying egg volumes for this species, compared to control conditions. Exposed larvae were significantly smaller, but there were no statistically significant differences in hatched larval numbers, deformities, mortalities, or fitness (Scott, 2019). More recently, Scott *et al.* (2021) measured stress related parameters (l-Lactate, d-Glucose, total haemocyte count) in addition to behavioural and response parameters (shelter preference and time spent resting/roaming) in edible crab over 24 hour periods. Although, EMF strengths of 250 μT were recorded to have limited physiological and behavioural impacts, exposure to 500 μT and 1,000 μT were found to disrupt the l-Lactate and d-Glucose circadian rhythm and alter total haemocyte count (thus suggesting a stress response in edible crab) (Scott *et al.*, 2021). Individuals showed a clear attraction to shelters with a significant reduction in time spent roaming when exposed to EMFs of 500 μT and 1,000 μT, but not at 250 μT (Scott *et al.*, 2021). Normandeau Associates Inc *et al.* (2011) reported maximum magnetic fields of 78.27 μT at an unburied subsea cable. Therefore, as these physiological and behavioural impacts on edible crab did not occur at levels of 250 μT (Scott *et al.*, 2021), it can be assumed that the magnetic fields generated by the subsea cables associated with the Proposed Development will be lower than 250 μT, and therefore will not result in the adverse impacts recorded by Scott *et al.* (2021).

9.10.290 Regarding the squid and octopi IEF, there is currently no evidence for electroreception or magnetic sensitivity in cephalopods (Williamson, 1995), with their excellent vision believed to be largely responsible for their navigational behaviour (Pungor and Niell, 2023). There is little scientific literature about the potential sensitivity of the common whelk, king scallop, and queen scallop IEFs to EMFs. However, as these species are not migratory, it is less likely that magnetoreception could be impaired by EMFs generated by subsea power cables.

9.10.291 As with the sensitivity of marine fish IEFs and diadromous IEFs, the range over which the shellfish IEFs could be sensitive to EMFs is limited to within metres of the subsea cables (Snyder *et al.*, 2019). Demersal shellfish IEFs (e.g. crustaceans, common whelk, and scallops) that dwell on the seafloor bottom will be closer to the undersea power cables and thus encounter higher EMF levels when near the cable. Shellfish IEFs are also likely to be exposed for longer periods of time and may be largely constrained in terms of location. However, the rapid decay of the EMF with horizontal distance (Bochert and Zettler, 2006; Hervé, 2021) (i.e. within metres) minimises the extent of potential impacts.

9.10.292 The shellfish IEFs are deemed to be of low vulnerability, high recoverability and local value. The sensitivity of the receptor is, therefore, considered to be low.

Significance of the effect

9.10.293 Overall, for all fish and shellfish IEFs, 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 Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the impact is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and Residual Effect

9.10.294 No Additional Mitigation is considered necessary because the likely effect, in the absence of mitigation, is not significant in EIA terms.

9.11 Inter-Related Effects

9.11.1 A description of the likely inter-related effects arising from the Proposed Development on fish and shellfish ecology is provided in Volume 2, Chapter 23: Inter-Related Effects.

9.11.2 Inter-relationships are considered to be the impacts and associated effects of different aspects of Bowdun OWF on the same receptor. Inter-related effects are considered to be either:

- lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of Bowdun OWF (construction, O&M and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three project stages (e.g. underwater sound effects from piling, operational Wind Turbines, vessels and decommissioning); and
- receptor-led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on fish and shellfish ecology, such as habitat loss and disturbance, may interact to produce a different, or greater effect on receptors than when the effects are considered in isolation. Receptor-led effects may be short term, temporary or transient effects, or incorporate longer term effects.

9.11.3 For fish and shellfish ecology the following potential impacts have been considered within the inter-related assessment:

- temporary habitat loss and/or disturbance;
- long term habitat loss and/or disturbance;
- introduction of artificial habitat and subsequent colonisation;
- increased SSCs and associated deposition;
- subsea noise impacting fish and shellfish receptors; and
- impacts to fish and shellfish receptors due to EMF;

9.11.4 Table 9.47 lists the inter-related effects (project lifetime effects) that are predicted to arise during the construction, O&M phase, and decommissioning of the Proposed Development and also the inter-related effects (receptor-led effects) that are predicted to arise for fish and shellfish receptors.

9.11.5 Effects on fish and shellfish ecology also have the potential to lead to secondary effects on other receptors and these effects are fully considered in the topic-specific chapters. These receptors and effects are:

- Marine mammals;
    - changes to the fish and shellfish community within the Fish and Shellfish Ecology Study Area resulting from impacts associated with the Proposed Development may lead to changes in prey availability for marine mammals (see Volume 2, Chapter 10: Marine Mammals);
- Offshore ornithology;
    - changes in prey availability, as above for marine mammals (see Volume 2, Chapter 11: Offshore Ornithology); and
- Commercial fisheries;
    - changes to the fish and shellfish community within the Fish and Shellfish Ecology Study Area resulting from impacts associated with the Proposed Development may affect the commercial fisheries industry (see Volume 2, Chapter 13: Commercial Fisheries).

Table 9.47: Summary of Likely Significant Inter-Related Effects for Fish and Shellfish Ecology from Individual Effects Occurring Across the Construction, O&M and Decommissioning Phase of the Proposed Development (Project Lifetime Effects) and from Multiple Effects Interacting Across all Phases (Receptor-led Effects)

Description of Impact	Phase			Likely Significant Inter-Related Effects
	C	O&M	D	
Project Lifetime Effects				
Temporary habitat loss and/or disturbance	✓	✓	✓	If considered additively across the construction, O&M, and decommissioning phases, the total area of temporary habitat loss and disturbance is larger than for each individual stage. It should be noted, however, that across the three phases of the Proposed Development, there is potential for the same areas to be repeatedly disturbed, as the footprints of impact are localised to the various infrastructure on the seabed. Repeated disturbance could occur at single Wind Turbines, the OSPs, and specific sections of the cables. Therefore, a total footprint of impact across all three phases would likely be an overestimation, with overlap in footprints across phases. Further, the seabed habitats potentially disturbed within the Site Boundary are widespread across the Fish and Shellfish Ecology Study Area. Therefore, project lifetime effects will be proportionally small in this wider context. This is further bolstered by the recoverability of temporarily disturbed seabed, and the high potential for fish and shellfish receptors to return to affected areas. Therefore, across the lifetime of the Proposed Development, the effects of this impact are not anticipated to interact in such a way as to result in inter-related effects of greater significance than the assessments presented for each individual phase (e.g. **minor** adverse throughout). Overall, no likely significant inter-related effects are anticipated across the lifetime of the Proposed Development.
Long term habitat loss and/or disturbance	✓ (combined as one phase in the MDS Table 9.15)		✓	In the assessment of significance for this impact, the construction and O&M phases were combined as the infrastructure resulting in long term habitat loss and disturbance installed throughout the construction phase will persist into the O&M phase (i.e. the footprints of long-term habitat loss in the construction phase will be in the same locations as in the O&M phase). The MDS for the decommissioning phase considered that the majority of the infrastructure was left *in situ,* and the footprints of infrastructure left *in situ* will also be in the same locations as they were in the combined construction and O&M phases. Therefore, the footprint of long-term habitat loss and disturbance will not differ if considered additively across the combined construction & O&M phase and the decommissioning phase (i.e. the total area of long-term habitat loss and disturbance over all three phases will not be larger than described for the individual phases). Further, the seabed habitats potentially disturbed within the Site Boundary are widespread across the Fish and Shellfish Ecology Study Area. Therefore, project lifetime effects will be proportionally small in this wider context. Therefore, across the lifetime of the Proposed Development, the effects of this impact are not anticipated to interact in such a way as to result in inter-related effects of greater significance than the assessments presented for each individual phase (e.g. **minor** adverse throughout). Overall, no likely significant inter-related effects are anticipated across the lifetime of the Proposed Development.
Introduction of artificial habitat and subsequent colonisation	✓ (combined as one phase in the MDS: Table 9.15)		✓	As above for 'Long term habitat loss and/or disturbance'.
Increased SSCs and associated deposition	✓	✓	✓	Effects from increased SSCs and associated deposition in each phase of the Proposed Development will be short lived and intermittent. Fish and shellfish receptors potentially affected by this impact in each phase are likely to have recovered in the intervening period between both: • individual activities resulting in increased SSCs and associated deposition (such as seabed preparation); and • phases. Further, the fish and shellfish IEFs (except herring and sandeel) were considered to be of low sensitivity and/or high recoverability to this impact. The herring and sandeel IEFs were precautionarily deemed to be of medium sensitivity, though no significant effects were determined for any of the fish and shellfish IEFs. Therefore, across the lifetime of the Proposed Development, the effects of this impact are not

Description of Impact	Phase			Likely Significant Inter-Related Effects
	C	O&M	D	
				anticipated to interact in such a way as to result in inter-related effects of greater significance than the assessments presented for each individual phase (e.g. **minor** adverse throughout). Overall, no likely significant inter-related effects are anticipated across the lifetime of the Proposed Development.
Subsea noise impacting fish and shellfish receptors	✓	✓	✓	Subsea noise could occur during all phases of the Proposed Development, however those with the highest impact ranges would only occur in the construction phase (e.g. piling and UXO clearance). However, subsea noise produced as a result of piling during construction is likely to reach over a larger area compared to other noise-producing activities associated. Therefore, it is considered unlikely that piling would act additively with other noise-producing activities occurring at the same time, as the noise produced during piling is likely to mask other noise sources. Piling noise, although occurring during construction phase only, would contribute to the overall duration of noise impacts over the lifetime of the Proposed Development. The effects of this noise source are not anticipated to interact in such a way with other noise sources (such as those in the O&M Phase) as to result in inter-related effects of greater significance than the assessments presented for each individual. Increased subsea noise during UXO clearance could interact with other noise sources. However, UXO clearance is planned using low order techniques which has the potential to result in localised disturbance only. For each UXO clearance event, the duration of the impact – including mitigation techniques - will be very short (i.e. hours). Subsea noise from UXO clearance, although occurring during construction phase only, could contribute to the overall duration of noise impacts throughout all phases of the Proposed Development. Significance was considered to be minor adverse and therefore not significant in EIA terms. The effects of this noise source are not anticipated to interact in such a way with other noise sources as to result in inter-related effects of greater significance than the assessments presented for each individual phase (e.g. **minor** adverse throughout). Elevated subsea noise during site-investigation surveys and construction activities could be additive over all phases of the Proposed Development, with sequential noise from site-investigation surveys leading to an extended effect on fish and shellfish receptors. However, these noise producing activities will occur intermittently, during short term events with cessation of noise in between events. Therefore, these impacts will be highly localised. Additive effects are possible (though unlikely given intermittency of these noise producing activities) and the duration of elevated subsea noise from all activities could be extended. Significance was considered to be minor adverse and therefore not significant in EIA terms. The effects of these noise sources are not anticipated to interact in such a way with other noise sources as to result in inter-related effects of greater significance than the assessments presented for each individual phase (e.g. **minor** adverse throughout).
Impacts to fish and shellfish receptors due to EMF	×	✓	×	This impact will only occur during the O&M phase, and will not overlap with other phases, therefore no likely significant inter-related effects are anticipated across the lifetime of the Proposed Development.
Receptor-led Effects				
• **Temporary habitat loss and/or disturbance** • **Long term habitat loss and/or disturbance** • **Introduction of artificial habitat and subsequent colonisation** • **Increased SSCs and associated deposition** • **Subsea noise impacting fish and shellfish receptors** • **Impacts to fish and shellfish receptors due to EMF**	✓ (all impacts except EMF)	✓ (all impacts)	✓ (all impacts except EMF)	There is potential for temporal and spatial interactions between the impacts listed across all phases of the Proposed Development. However, these individual impacts were largely assigned as negligible to minor adverse significance as standalone impacts. Although potential receptor-led effects may arise, it is important to recognise that the individual activities will not necessarily occur simultaneously or in the same physical areas of the Site Boundary. For example, the activities considered in the MDS for multiple impacts associated with the construction phase may not temporally overlap (such as UXO clearance, sandwave clearance, piling, and cable laying). Therefore, across the phases of the Proposed Development, receptor-led effects are not anticipated to interact in such a way as to result in inter-related effects of greater significance than the assessments presented for individual impacts in isolation (e.g. **minor** adverse throughout). Overall, no likely significant inter-related effects are anticipated across the lifetime of the Proposed Development.

9.12 Cumulative Effects Assessment

Methodology

9.12.1 The Cumulative Effects Assessment (CEA) assesses the impacts associated with the Proposed Development together with other relevant projects and activities. Cumulative effects are defined as the effect of the Proposed Development in combination with the effects from a number of different projects, on the same receptor or resource. Further details on CEA methodology are provided in Volume 1, Chapter 4: Environmental Impact Assessment Methodology.

9.12.2 The projects selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise (see Volume 3, Technical Appendix 4.4: Cumulative Effects Assessment - Screening). Volume 3, Technical Appendix 4.4: Cumulative Effects Assessment - Screening provides further information in relation to other projects and how this information is obtained and applied to the assessment. Each project has been considered on a case-by-case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

9.12.3 In order to assess the potential for temporal overlap between projects on the CEA long list and the Proposed Development, the following temporal assumptions have been applied. Seabed preparation activities for the Proposed Development are scheduled to begin in Q2 2031, with commissioning expected to be completed in Q1 2036 with an operational period of 30 years from 2036.

9.12.4 In undertaking the CEA for the Proposed Development, it is important to bear in mind that other projects under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside the Proposed Development. Therefore, a tiered approach has be adopted. This provides a framework for placing relative weight upon the potential for each project to be included in the CEA to ultimately be realised, based upon the project’s current stage of maturity and certainty in the projects’ parameters. The tiered approach which will be utilised within the Proposed Development CEA employs the following tiers:

- Tier 1 – The onshore elements of the Project;
- Tier 2 – Projects that have an application submitted, are consented, under construction or operational to the extent not already captured with the baseline;
- Tier 3 – Projects which have submitted a Scoping Report and/or have received a scoping opinion; and
- Tier 4 – Reasonably foreseeable projects including those with Crown Estate Scotland option or lease agreements.

9.12.5 The specific projects scoped into the CEA for fish and shellfish ecology, are outlined in Table 9.48. As detailed in the bullets above, Tier 1 encompasses only the onshore elements of the Project. There are not anticipated to be any receptor impact pathways for fish and shellfish ecology between the onshore elements of the Project and the Proposed Development, therefore there is no Tier 1 assessment included in the CEA for fish and shellfish ecology.

9.12.6 Some of the potential impacts considered within the Proposed Development alone assessment are specific to a particular phase of development (e.g. construction, O&M or decommissioning). Where the potential for cumulative effects with other projects only have potential to occur where there is spatial or temporal overlap with the Proposed Development during certain phases of development, impacts associated with a certain phase may be omitted from further consideration where no projects have been identified that have the potential for cumulative effects during this period.

9.12.7 For the impact of subsea noise, a buffer of 100 km (with an area of 32,557.73 km^2) has been implemented to identify relevant projects and activities. This is standard practice, to account for the wider ranging ZoI for subsea noise, in comparison to all other potential impacts to fish and shellfish ecology. For the impact of increased SSCs and associated deposition, the CEA screening buffer used in Volume 2, Chapter 7: Physical Processes was used to identify relevant projects (i.e. one spring tidal excursion). This is because the assessment for this impact is based on that presented in Volume 2, Chapter 7: Physical Processes. For all other impacts, a buffer of 50 km (with an area of 12,121.60 km^2) has been implemented, which is suitably precautionary given the localised nature of the impacts. These buffers were presented during Scoping and agreed upon through the Scoping Opinion process (see Table 9.7). These buffers were applied to both the Array Area and the Export Cable Corridor, so there were some projects screened into the CEA that were within these buffers from one but not the other. As a precaution, any projects that were within these buffers from either the Array Area or Export Cable Corridor were included for consideration in the CEA, even if they fell outwith the buffer for one.

Table 9.48: List of Other Projects Considered within the CEA for Fish and Shellfish Ecology

Project	Status	Distance to the Array Area (km)	Distance to the Export Cable Corridor (km)	Description of Project	Dates of Construction (If Applicable) Proposed Development: 2031-2036	Dates of Operation (If Applicable) Proposed Development: 2036/2037-2067	Overlap with the Proposed Development
Tier 1							
There were no Tier 1 projects in the CEA long list brought forwards to the CEA for fish and shellfish ecology.							
Tier 2							
Offshore Wind Projects and Associated Cables							
Kincardine OWF	Operational	20.14	7.63	Kincardine OWF consists of up to 7 wind turbines with 6 currently operational. Capacity of 50 MW.	N/A	2021-2045	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Ossian OWF	Application submitted but not yet determined	25.36	40.14	The Ossian Floating Wind project is proposed for up to 265 floating Wind Turbines with a capacity of 3,600 MW. Operational lifetime 35 years.	2031-2038	2039-2073	The construction and O&M phases of Ossian OWF have the potential to overlap with all phases of the Proposed Development.
Seagreen 1 OWF	Operational	27.87	19.88	Seagreen 1 OWF consists of up to 114 Wind Turbines at a capacity of 1,075 MW.	N/A	2023-2047	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Seagreen 1A Project	Consented	36.30	19.47	Seagreen 1A is made up of the 36 remaining Wind Turbines consented as part of the Seagreen 1 OWF.	2029-2032	2033-2057	The construction, O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Aberdeen OWF	Operational	38.60	34.71	Aberdeen OWF consists of up to 11 Wind Turbines at a capacity of 96.8 MW.	N/A	2018-2042	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Seagreen Phase 1 OFTO	Operational	40.48	32.37	Consented up to 6 Export Cables with no maximum capacity.	N/A	2023-Unknown	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.

Project	Status	Distance to the Array Area (km)	Distance to the Export Cable Corridor (km)	Description of Project	Dates of Construction (If Applicable) Proposed Development: 2031-2036	Dates of Operation (If Applicable) Proposed Development: 2036/2037-2067	Overlap with the Proposed Development
Seagreen Phase 1A Offshore Transmission Owner (OFTO)	Consented	42.87	28.05	Consent includes an Export Cable approximately 110 km in length to a landfall location at Cockenzie.	2029-2032	2033-Unknown	The construction, O&M and decommissioning phases of this project have the potential to overlap with the construction O&M phases of the Proposed Development.
Hywind Scotland Wind Farm (Buchan Deep Demo)	Operational	44.43	54.73	Floating OWF with 5 Wind Turbines and 30 MW installed capacity.	N/A	2017-2037	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Berwick Bank Wind Farm	Consented	46.53	47.70	Berwick Bank Wind Farm is proposed for up to 307 Wind Turbines with a capacity of up to 4,100 MW. Operational lifetime of 35 years.	2027-2032	2033-2067	The construction, O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Berwick Bank OFTO	Consented	46.53	47.70	Berwick Bank transmission is proposed for up to 4 cables with an operational lifetime of 35 years.	2026-2029	2030-2064	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Muir Mhòr OWF	Application submitted but not yet determined	52.50	66.47	Muir Mhòr OWF is proposed for up to 67 Wind Turbines at a capacity of 798 MW.	2027-2030	2031-2055	The O&M and decommissioning phase of this project have the potential to overlap with the construction and O&M phases of the Proposed Development. As outwith the 50 km screening buffer but within the 100 km screening buffer, this project is only included in the CEA for the impact of subsea noise.
Salamander OWF	Consented	58.68	69.52	Salamander OWF is proposed for up to 100 MW.	2027-2029	2030-2054	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development. As outwith the 50 km screening buffer but within the 100 km screening buffer, this project is only included in the CEA for the impact of subsea noise.

Project	Status	Distance to the Array Area (km)	Distance to the Export Cable Corridor (km)	Description of Project	Dates of Construction (If Applicable) Proposed Development: 2031-2036	Dates of Operation (If Applicable) Proposed Development: 2036/2037-2067	Overlap with the Proposed Development
Aspen OWF	Application submitted but not yet determined	88.37	102.23	Floating offshore wind farm proposed for up to 1,000 MW and up to 72 wind turbines.	2027-2031	2032-2056	The O&M and decommissioning phases of Aspen OWF have the potential to overlap with the construction and O&M phases of the Proposed Development. As outwith the 50 km screening buffer but within the 100 km screening buffer, this project is only included in the CEA for the impact of subsea noise.
Green Volt OWF (INTOG Site 6 Flotation Energy)	Consented	92.16	103.35	Green Volt OWF is proposed for up to 35 Wind Turbines at a capacity of 560 MW.	2027-2029	2030-2054	The O&M and decommissioning phases of Green Volt OWF have the potential to overlap with the construction and O&M phases of the Proposed Development. As outwith the 50 km screening buffer but within the 100 km screening buffer, this project is only included in the CEA for the impact of subsea noise.
Cables and Pipelines							
Eastern Green Link 2	Under construction	0.00	12.33	2 GW subsea cable connecting Peterhead in Aberdeenshire and Drax in North Yorkshire. Onshore construction commenced in 2025. Offshore construction begins in 2027.	2025-2028	2029-Unknown	The O&M and decommissioning phases of this project have the potential to overlap with the construction, O&M and decommissioning phases of the Proposed Development.
Forties to Cruden Bay (PL721)	Operational	39.31	48.70	170 km oil pipeline from the forties C platform to Cruden bay.	N/A	Ongoing	The O&M and decommissioning phases of this project have the potential to overlap with the construction, O&M and decommissioning phases of the Proposed Development.
Tier 3							
Offshore Wind Projects and Associated Cables							
Morven Hawthorn Pit Grid Connection Project	Pre-Application	1.81	17.41	Consists of the onshore and offshore infrastructure associated with the Morven OWF. Up to 6 Export Cables with a capacity of 525 kV.	2029-2032	2033-Unknown	The construction, O&M and decommissioning phases of this project have the potential to overlap with the construction, O&M and decommissioning phases of the Proposed Development.

Project	Status	Distance to the Array Area (km)	Distance to the Export Cable Corridor (km)	Description of Project	Dates of Construction (If Applicable) Proposed Development: 2031-2036	Dates of Operation (If Applicable) Proposed Development: 2036/2037-2067	Overlap with the Proposed Development
Morven North OWF	Pre-Application	10.03	22.20	Morven North OWF is proposed for up to 96 Wind Turbines at a capacity of 1,500 MW.	2030-2036	2037-2061	The construction, O&M and decommissioning phases of Morven North OWF have the potential to overlap with the construction and O&M phases of the Proposed Development.
Ossian Transmission Infrastructure	Pre-Application	25.28	40.03	Up to 6 Export Cables with a maximum total length of offshore cable route of 509 km. Anticipated application submission in the latter half of 2026. Operational lifetime 35 years.	2030-2033	2034-2068	The construction and O&M phases of this project have the potential to overlap with the all phases of the Proposed Development.
Morven South OWF	Pre-Application	43.61	53.83	Morven South OWF is proposed for up to 95 Wind Turbines at a capacity of 1,500 MW.	2030-2036	2037-2061	The construction, O&M and decommissioning phases of Morven OWF have the potential to overlap with the construction and O&M phases of the Proposed Development.
Bellrock OWF	Pre-Application	62.23	79.55	Bellrock OWF is proposed for a capacity of 1,800 MW with between 42 and 80 Wind Turbines.	2027-2030	2031–2055	The O&M and decommissioning phases of Bellrock OWF have the potential to overlap with the construction and O&M phases of the Proposed Development. As outwith the 50 km screening buffer but within the 100 km screening buffer, this project is only included in the CEA for the impact of subsea noise.
Cables and Pipelines							
Eastern Green Link 3	Pre-Application	6.28	23.76	The project comprises a 2 GW system linking Aberdeenshire in Scotland and Lincolnshire in England. Approximately 575 km of subsea HVDC cable from Lincolnshire to a proposed Landfall at Sandford Bay, Peterhead.	2028-2030	2031-Unknown	The O&M and decommissioning phases of Eastern Green Link 3 have the potential to overlap with all phases of the Proposed Development.

Project	Status	Distance to the Array Area (km)	Distance to the Export Cable Corridor (km)	Description of Project	Dates of Construction (If Applicable) Proposed Development: 2031-2036	Dates of Operation (If Applicable) Proposed Development: 2036/2037-2067	Overlap with the Proposed Development
Central North Sea Electrification (CNSE) Project	Pre-Application	36.00	46.20	Electrification of existing oil and gas infrastructure in the central North Sea. The infrastructure includes an onshore convertor station, an offshore convertor station, 66 kV offshore cabling connecting CNSE assets, 80 kV cabling to landfall, and 80 kV cabling from landfall to the onshore convertor station.	2027-2028	2029-Unknown	The O&M and decommissioning phases of this project have the potential to overlap with the construction and O&M phases of the Proposed Development.
Coastal Construction							
Fraserburgh Harbour Development	Pre-Application	78.98	85.99	Proposed works to existing harbour improvement and construction of New South Harbour. Proposed works include relocation of existing south breakwater box berth, dredging and widening of the entrance of two harbours, a jetty and a pier, installation of pontoons and dredging the existing channel, extension of breakwater, installation of new breakwater, dredging and installation of new dry dock.	2028–2032	N/A	The construction phase of this project has the potential to overlap with the construction phase of the Proposed Development. As outwith the 50 km screening buffer but within the 100 km screening buffer, this project is only included in the CEA for the impact of subsea noise.
Tier 4							
Offshore Wind Projects and Associated Cables							
Flora Floating Wind Farm	Pre-Planning	46.83	57.79	Innovation and Targeted Oil and Gas site 4 is proposed for up to 50 MW.	Unknown	Unknown	There may be temporal overlap between all phases of this OWF project and those of the Proposed Development.

* Project Phase refers to construction (C), operation and maintenance (O) and decommissioning (D).

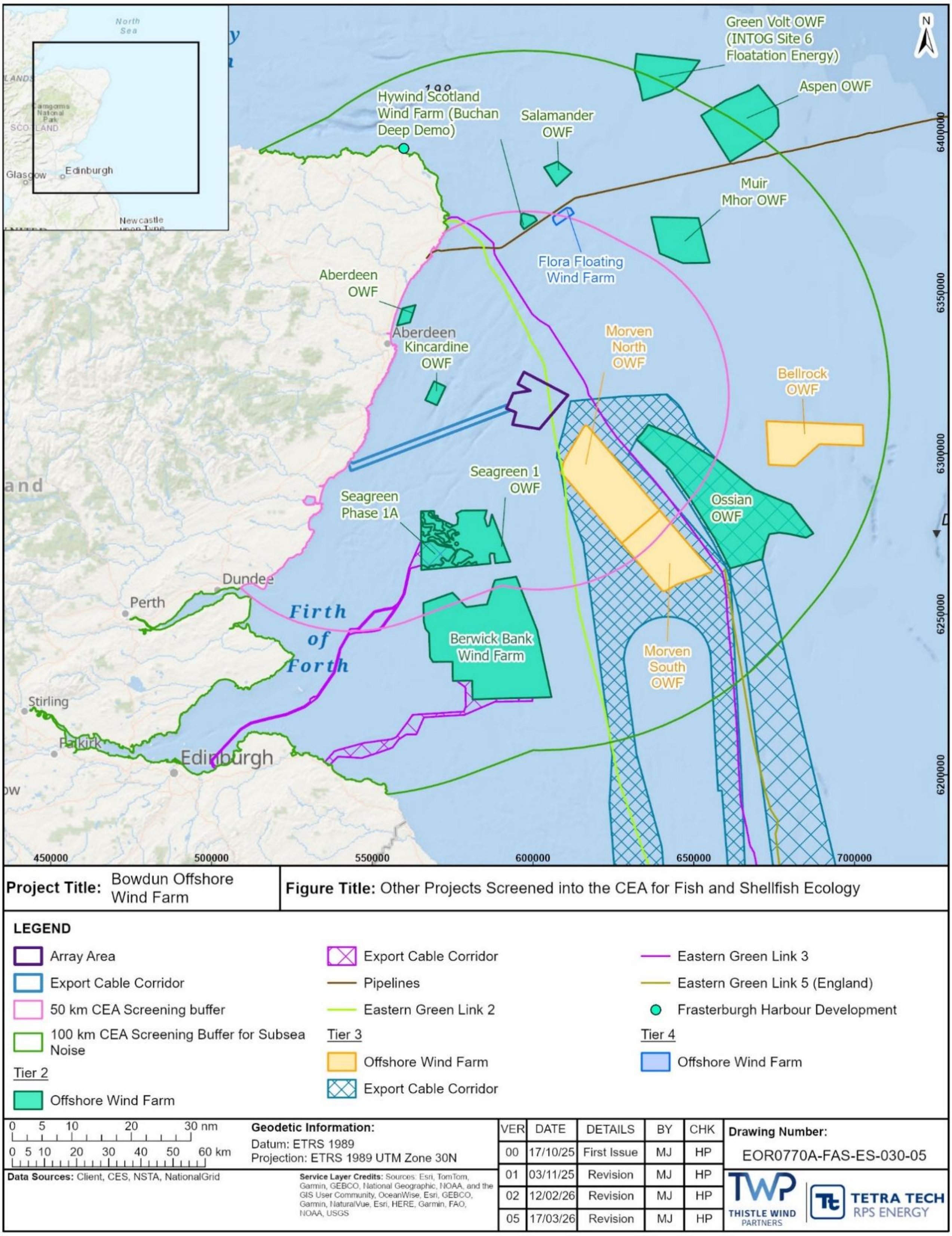


Figure 9.10: Other Projects Screened into the Cumulative Effects Assessment for Fish and Shellfish Ecology

Maximum Design Scenario

9.12.8 The MDS identified in Table 9.49 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative effects presented and assessed in this section have been selected from the details provided in Volume 1, Chapter 3: Project Description as well as the information available on other projects (see Volume 3, Technical Appendix 4.4: Cumulative Effects Assessment - Screening) to inform an MDS. Any other development scenario within the PDE will result in in the same, or less, level of environmental effect.

Table 9.49: Maximum Design Scenario Considered for Each Impact as part of the Assessment of Likely Significant Cumulative Effects on Fish and Shellfish Ecology

<table>
<tr><th rowspan="2">Potential Cumulative Effect</th><th colspan="3">Phase*</th><th rowspan="2">MDS</th><th rowspan="2">Justification</th></tr>
<tr><th>C</th><th>O</th><th>D</th></tr>
<tr><td>Temporary habitat loss and/or disturbance</td><td>✓</td><td>✓</td><td>✓</td><td>The MDS is as detailed for the Proposed Development alone in Table 9.15, cumulatively with the following projects:

Tier 2
<u>Offshore Wind Projects and Associated Cables</u>
• Kincardine OWF (O&M and decommissioning phases);
• Seagreen 1 OWF (O&M and decommissioning phases);
• Seagreen 1A Project (all phases);
• Seagreen Phase 1A OFTO (construction phase);
• Hywind Scotland OWF (O&M and decommissioning phases);
• Berwick Bank Wind Farm (all phases);
• Berwick Bank OFTO (decommissioning phase); and
• Ossian OWF (all phases)
<u>Cables and Pipelines</u>
• Eastern Green Link 2 (O&M and decommissioning phases).

Tier 3
<u>Offshore Wind Projects and Associated Cables</u>
• Morven North OWF (construction and O&M phases);
• Morven South OWF (construction and O&M phases);
• Morven Hawthorn Pit Grid Connection Project (construction and decommissioning phases); and
• Ossian Transmission Infrastructure (all phases).
<u>Cables and Pipelines</u>
• Eastern Green Link 3 (O&M and decommissioning phases); and
• CNSE Project (O&M and decommissioning phases).</td><td>A precautionary buffer of 50 km was used to screen in plans and projects from the CEA long list into the CEA for this impact.

The Tier 2 to Tier 4 projects detailed in the previous column have been screened in as they have the potential to cause temporary habitat loss and/or disturbance within their respective footprints and therefore require consideration at a cumulative scale with the Proposed Development.

Tier 2 and 3 projects which have not assessed this impact (or the parameters associated with it) have not been included in the CEA.</td></tr>
</table>

Potential Cumulative Effect	Phase*			MDS	Justification
	C	O	D		
				Tier 4 Offshore Wind Projects and Associated Cables • Flora Floating Wind Farm (all phases).	
Long term habitat loss and/or disturbance	✓	✓	✓	The MDS is as detailed for the Proposed Development alone in Table 9.15, cumulatively with the following projects: **Tier 2** Offshore Wind Projects and Associated Cables • Seagreen 1A Project (all phases); • Ossian OWF (construction and O&M phases); • Hywind Scotland OWF (O&M phase); • Berwick Bank Wind Farm (construction and O&M phases); and • Berwick Bank OFTO (O&M phase); **Tier 3** Offshore Wind Projects and Associated Cables • Morven North OWF (all phases); • Morven South OWF (all phases); • Morven Hawthorn Pit Grid Connection Project (all phases); and • Ossian Transmission Infrastructure (all phases). Cables and Pipelines • Eastern Green Link 3 (O&M phase). **Tier 4** Offshore Wind Projects and Associated Cables • Flora Floating Wind Farm (all phases).	A precautionary buffer of 50 km was used to screen in plans and projects from the CEA long list into the CEA for this impact. The Tier 2 to Tier 4 projects detailed in the previous column have been screened in as they have the potential to cause long term habitat loss and/or disturbance within their respective footprints and therefore require consideration at a cumulative scale with the Proposed Development. Tier 2 and Tier 3 projects which have not assessed this impact (or the parameters associated with it) have not been included in the CEA.

Potential Cumulative Effect	Phase*			MDS	Justification
	C	O	D		
Colonisation of hard structures	✓	✓	✓	The MDS is as detailed for the Proposed Development alone in Table 9.15, cumulatively with the following projects: **Tier 2** <u>Offshore Wind Projects and Associated Cables</u> • Seagreen 1A Project (construction and O&M phases); • Ossian OWF (all phases); • Hywind Scotland OWF (O&M phases); • Berwick Bank Wind Farm (construction and O&M phases); and • Berwick Bank OFTO (O&M phase). **Tier 3** <u>Offshore Wind Projects and Associated Cables</u> • Morven North OWF (construction and O&M phases); • Morven South OWF (construction and O&M phases); • Morven Hawthorn Pit Grid Connection Project (O&M phase); and • Ossian Transmission Infrastructure (all phases). <u>Cables and Pipelines</u> • Eastern Green Link 3 (O&M and decommissioning phases). **Tier 4** <u>Offshore Wind Projects and Associated Cables</u> • Flora Floating Wind Farm (construction and O&M phases).	A precautionary buffer of 50 km was used to screen in plans and projects from the CEA long list into the CEA for this impact. The Tier 2 to Tier 4 projects detailed in the previous column have been screened in as they have the potential for colonisation of hard structures within their respective footprints and therefore require consideration at a cumulative scale with the Proposed Development. Tier 2 and 3 projects which have not assessed this impact (or the parameters associated with it) have not been included in the CEA.

Potential Cumulative Effect	Phase*			MDS	Justification
	C	O	D		
Increased SSCs and associated deposition	✓	×	×	The MDS is as detailed for the Proposed Development alone in Table 9.15, cumulatively with the following projects: **Tier 2** Offshore Wind Projects and Associated Cables • Ossian OWF (construction phase); and • Seagreen 1A OWF (construction phase). **Tier 3** Offshore Wind Projects and Associated Cables • Morven North OWF (construction phase); and • Morven South OWF (construction phase).	This impact was informed by Volume 2, Chapter 7: Physical Processes. Therefore, the projects and phases included in the CEA for this impact include only those considered for the same impact in the CEA in Volume 2, Chapter 7: Physical Processes. The screening buffer used was one spring tidal excursion (see Volume 2, Chapter 7: Physical Processes for further detail). The Tier 2 to Tier 3 projects detailed in the previous column have been screened in as they have the potential to result in increased SSCs and associated deposition, and therefore require consideration at a cumulative scale with the Proposed Development.
Subsea noise impacting fish and shellfish receptors	✓	✓	✓	The MDS is as detailed for the Proposed Development alone in Table 9.15, cumulatively with the following projects: **Tier 2** Offshore Wind Projects and Associated Cables • Kincardine OWF (O&M and decommissioning phases); • Seagreen 1 OWF (O&M and decommissioning phases); • Seagreen 1A Project (construction and O&M phases); • Aberdeen OWF (O&M and decommissioning phases); • Hywind Scotland OWF (O&M and decommissioning phases);	A wider, but still precautionary, buffer of 100 km was used to screen in plans and projects from the CEA long list into the CEA for this impact. The Tier 2 to Tier 3 projects detailed in the previous column have been screened in as they have the potential to generate subsea noise, and therefore

Potential Cumulative Effect	Phase*			MDS	Justification
	C	O	D		
				• Aspen OWF (O&M and decommissioning phases); • Berwick Bank Wind Farm (all phases); • Green Volt OWF (INTOG Site 6 Flotation Energy) (O&M and decommissioning); • Muir Mhòr OWF (O&M and decommissioning); • Ossian OWF (construction and O&M phases); • Salamander OWF (O&M and decommissioning phases); and • Berwick Bank OFTO (decommissioning phase). **Tier 3** <u>Offshore Wind Projects and Associated Cables</u> • Bellrock OWF (O&M and decommissioning phases); • Morven North OWF (construction and O&M phases); • Morven South OWF (construction and O&M phases); • Morven Hawthorn Pit Grid Connection Project (construction and O&M phases); • Ossian Transmission Infrastructure (construction phase); and • CNSE Project (O&M and decommissioning phases). <u>Coastal Construction</u> • Fraserburgh Harbour Development (construction phase). **Tier 4** <u>Offshore Wind Projects and Associated Cables</u> • Flora Floating Wind Farm (construction and O&M phases).	require consideration at a cumulative scale with the Proposed Development. Tier 2 and 3 projects which have not assessed this impact (or the parameters associated with it) have not been included in the CEA.

Potential Cumulative Effect	Phase*			MDS	Justification
	C	O	D		
Impacts to fish and shellfish receptors due to EMF	×	✓	×	The MDS is as detailed for the Proposed Development alone in Table 9.15, cumulatively with the following projects: **Tier 2** Offshore Wind Projects and Associated Cables • Kincardine OWF (O&M phase); • Seagreen Phase 1A OFTO (O&M phase); • Seagreen 1 OWF (O&M phase); • Aberdeen OWF (O&M phase); • Hywind Scotland OWF (O&M phase); • Berwick Bank Wind Farm (O&M phase); • Ossian OWF (O&M phase); and • Berwick Bank OFTO (O&M phase). Cables and Pipelines • Eastern Green Link 2 (O&M phase). **Tier 3** Offshore Wind Projects and Associated Cables • Morven North OWF (O&M phase); • Morven South OWF (O&M phase); • Morven Hawthorn Pit Grid Connection Project (O&M phase); and • Ossian Transmission Infrastructure (O&M phase). Cables and Pipelines • Eastern Green Link 3 (O&M phase); and • CNSE Project (O&M phase). **Tier 4** Offshore Wind Projects and Associated Cables • Flora Floating Wind Farm (O&M phase).	A precautionary buffer of 50 km was used to screen in plans and projects from the CEA long list into the CEA for this impact. The Tier 2 to Tier 4 projects detailed in the previous column have been screened in as they have the potential to release EMFs and therefore require consideration at a cumulative scale with the Proposed Development. Tier 2 and 3 projects which have not assessed this impact (or the parameters associated with it) have not been included in the CEA.

* Project Phase refers to construction (C), operation and maintenance (O) and decommissioning (D).

Cumulative Effects Assessment

9.12.9 An assessment of the likely significance of the cumulative effects of the Proposed Development upon fish and shellfish receptors arising from each identified impact is given below.

TEMPORARY HABITAT LOSS AND/OR DISTURBANCE

Tier 2

Construction phase

Magnitude of impact

9.12.10 There are several Tier 2 projects with the potential for cumulative temporary habitat loss and/or disturbance during the construction phase of the Proposed Development (Table 9.50). The maximum cumulative temporary habitat loss and/or disturbance associated with the Tier 2 projects together with the construction phase of the Proposed Development is estimated at up to 236.23 km^2 (Table 9.50). This represents up to 1.95% of the 50 km CEA screening buffer applied and up to 0.73% of the Fish and Shellfish Ecology Study Area. However, it is important to note that the cumulative footprint of 236.23 km^2 will not be one continuous area. Instead, this footprint is comprised of isolated areas of temporary habitat loss and disturbance over the 50 km CEA screening buffer. The cumulative magnitude of impact of the Proposed Development with Tier 2 projects is therefore not expected to represent a material additional impact to that defined for the assessment of the Proposed Development alone.

9.12.11 Site preparation and construction activities associated with the Proposed Development are anticipated to occur intermittently. They will be spread out across the full allotted construction timeframe with a small proportion of the total area being affected at any one time. Given that the activities with the potential for temporary habitat loss and disturbance associated with the Tier 2 projects will occur intermittently at their respective locations, the cumulative impact will also be temporally intermittent. There will also be no spatial overlap between the Site Boundary and the majority of the Tier 2 projects, except Eastern Green Link 2 (see Figure 9.10 and Table 9.48), with this overlap limited to the locations that this cable intersects with the Proposed Development.

9.12.12 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Table 9.50: Cumulative Footprint of Temporary Habitat Loss and/or Disturbance for the Tier 2 Projects Overlapping with the Construction Phase of the Proposed Development

Project	MDS	Component Parts of Temporary Habitat Loss and/or Disturbance	Reference
Proposed Development	**19,414,805 m^2**	See Table 9.15	N/A
Offshore Wind Projects and Associated Cables			
Kincardine OWF	O&M: 129,000 m^2	Seabed preparation, cable installation, anchoring, trench for start of the export cable, and cable protection installation.	Kincardine OWF Limited (2016)
Seagreen 1 OWF	O&M: 356,100 m^2	Use of jack-up vessels for maintenance.	Seagreen Wind Energy Limited (2012); Seagreen Wind Energy Limited (2018)
Seagreen 1A Project	Construction and O&M: Unquantified	Footprint of Wind Turbine foundations, OSPs, cable installation and cable protection. Use of jack-up vessels for maintenance.	Seagreen Wind Energy Limited (2012)
Seagreen Phase 1A OFTO	Construction and O&M: Unquantified	Jetting, ploughing or mechanical trenching techniques for cable installation with a maximum working width of 100 m.	Seagreen 1A (2021)
Hywind Scotland OWF	O&M: No impact predicted in this phase	N/A	Statoil (2015)
Berwick Bank Wind Farm	Construction: 113,974,700 m^2	Foundation installation, jack-up vessel use, anchoring, seabed preparation, and cable installation.	SSE Renewables (2022)
	O&M: 989,000 m^2	Jack-up vessel use for repairs, cable repair and reburial activities.	

Project	MDS	Component Parts of Temporary Habitat Loss and/or Disturbance	Reference
Ossian OWF	Construction: 49,948,548 m^2 (Potential for additional 5,190 m^2 due to crater formation from the clearance of UXO (not included in Ossian OWF habitat loss total, but included in below calculation)	Jack-up vessel use, anchoring, seabed preparation, and cable installation.	Ossian OWFL (2024)
	O&M: 51,411,500 m^2	Jack-up vessel use for repairs, cable repair and reburial activities.	
Cables and Pipelines			
Eastern Green Link 2	O&M: Not quantified	Cable maintenance.	National Grid (2022)
Total (Proposed Development and Tier 2 Projects)	**236,223,653 m^2 (236.23 km^2)**		

Sensitivity of receptor

9.12.13 The sensitivity of the receptor is as defined in Paragraphs 9.10.12 to 9.10.36 above for the alone assessment.

Significance of effect

9.12.14 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.15 For all other fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.16 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the embedded measures outlined in Section 9.9) is not significant in EIA terms.

O&M phase

Magnitude of impact

9.12.17 There were several Tier 2 projects with the potential for cumulative temporary habitat loss and/or disturbance during the O&M phase of the Proposed Development (Table 9.51). The maximum total temporary habitat loss and/or disturbance associated with the Tier 2 projects together with the Proposed Development in the O&M phase is estimated at up to 103.15 km^2 (Table 9.51). This represents up to 0.85% of the 50 km CEA screening buffer applied and up to 0.32% of the Fish and Shellfish Ecology Study Area. It is important to note that the cumulative footprint of 103.15 km^2 will not be one continuous area. Instead, this footprint is comprised of isolated temporary habitat loss and disturbance over the 50 km CEA screening buffer. The cumulative magnitude of impact of the Proposed Development with the Tier 2 projects is therefore not expected to represent a material additional impact to that defined for the assessment of the Proposed Development alone.

9.12.18 O&M activities resulting in temporary habitat loss and/or disturbance associated with the Proposed Development are anticipated to occur intermittently. They will be spread out across the full 30-year O&M phase with only a small proportion of the total area for this impact being affected at any one time. Based on the similar O&M activities associated with the Tier 2 projects (Table 9.51), it is likely that they will also occur intermittently in their respective areas. There will also be no spatial overlap between the Site Boundary and the majority of the Tier 2 projects, except Eastern Green Link 2 (see Figure 9.10 and Table 9.48), with this overlap limited to the locations that this cable intersects with the Proposed Development.

Table 9.51: Cumulative Footprint of Temporary Habitat Loss and/or Disturbance for the Tier 2 Projects overlapping with the O&M Phase of the Proposed Development

Project	MDS	Component Parts of Temporary Habitat Loss and/or Disturbance	Reference
Proposed Development	**11,688,813 m^2**	See Table 9.15	N/A
Offshore Wind Projects and Associated Cables			
Kincardine OWF	O&M: 129,000 m^2	Seabed preparation, cable installation, anchoring, trench for start of the export cable, and cable protection installation	Kincardine OWF Limited (2016)
Seagreen 1 OWF	O&M: 358,100 m^2	Use of jack-up vessels for maintenance.	Seagreen Wind Energy Limited (2012); Seagreen Wind Energy Limited (2018)
Seagreen 1A Project	O&M and decommissioning: Unquantified	Use of jack-up vessels for maintenance. Removal of all cabling, Wind Turbine and OSP foundations.	Seagreen Wind Energy Limited (2012)
Seagreen Phase 1A OFTO	Construction: Unquantified	Jetting, ploughing or mechanical trenching techniques for cable installation with a maximum working width of 100 m.	Seagreen 1A (2021)
Ossian OWF	O&M: 51,411,500 m^2	Jack-up vessel use for repairs, cable repair and reburial activities.	Ossian OWFL (2024)
Hywind Scotland OWF	O&M: No impact predicted in this phase	N/A	Statoil (2015)
Berwick Bank Wind Farm	O&M: 989,000 m^2	Jack-up vessel use for repairs, cable repair and reburial activities.	SSE Renewables (2022)
	Decommissioning: Up to 34,571,200 m^2	Jack up vessels, foundation removal, cable removal and OSP removal.	
Berwick Bank OFTO	Decommissioning: Up to 4,000,000 m^2	(Potential for) Cable removal.	SSE Renewables (2023)

Project	MDS	Component Parts of Temporary Habitat Loss and/or Disturbance	Reference
Cables and Pipelines			
Eastern Green Link 2	O&M: Not quantified	Cable maintenance.	National Grid (2022)
Total (Proposed Development and Tier 2 Projects)	**103,147,613 m^2 (103.15 km^2)**		

9.12.19 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

<u>Sensitivity of receptor</u>

9.12.20 The sensitivity of the receptor is as defined in Paragraphs 9.10.12 to 9.10.36 above for the alone assessment.

<u>Significance of effect</u>

9.12.21 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.22 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

<u>Additional Mitigation and residual effect</u>

9.12.23 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Decommissioning phase

<u>Magnitude of impact</u>

9.12.24 There were two Tier 2 projects with the potential for cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development (Table 9.52). The maximum total temporary habitat loss and/or disturbance associated with the Tier 2 projects together with the Proposed Development in the decommissioning phase is estimated at up to 70.83 km^2 (Table 9.52). This represents up to 0.58% of the 50 km CEA screening buffer applied and up to 0.22% of the Fish and Shellfish Ecology Study Area. It is important to note that the cumulative footprint of 70.83 km^2 will not be one continuous area. Instead, this footprint is comprised of isolated temporary habitat loss and disturbance over the 50 km CEA screening buffer. The cumulative magnitude of impact of the Proposed Development with the Tier 2 projects is therefore not expected to represent a material additional impact to that defined for the assessment of the Proposed Development alone.

9.12.25 Decommissioning activities resulting in temporary habitat loss and/or disturbance associated with the Proposed Development are anticipated to occur intermittently, with only a small proportion of the total area for this impact being affected at any one time. Based on the similar activities associated with the Tier 2 projects in this phase (Table 9.52), it is likely that they will also occur intermittently in their respective areas. It is likely that this will be similar for the activities at the Tier 2 projects which may also result in temporary habitat loss and/or disturbance during this phrase. There will also be no spatial overlap between the Site Boundary and the majority of the Tier 2 projects, except Eastern Green Link 2 (see Figure 9.10 and Table 9.48), with this overlap limited to the locations that this cable and pipelines intersect with the Proposed Development.

9.12.26 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Table 9.52: Cumulative Footprint of Temporary Habitat Loss and/or Disturbance for the Tier 2 Projects overlapping with the Decommissioning Phase of the Proposed Development

Project	MDS	Component Parts of Temporary Habitat Loss and/or Disturbance	Reference
Proposed Development	**19,414,805 m^2**	See Table 9.15	N/A
Offshore Wind Projects and Associated Cables			
Ossian OWF	O&M: 51,411,500 m^2	Jack-up vessels and cable repair and reburial.	Ossian OWFL (2024)
Cables and Pipelines			
Eastern Green Link 2	O&M: Not quantified	Cable maintenance.	National Grid (2022)
	Decommissioning: Not quantified	Potential effects the same as route preparation and cable installation.	
Total (Proposed Development and Tier 2 Projects)	**70,826,305 m^2 (70.83 km^2)**		

Sensitivity of receptor

9.12.27 The sensitivity of the receptor is as defined in Paragraphs 9.10.12 to 9.10.36 above for the alone assessment.

Significance of effect

9.12.28 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.29 For all other fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.30 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 3

Construction phase

Magnitude of impact

9.12.31 In addition to the Tier 2 projects, there were six Tier 3 projects with the potential for cumulative temporary habitat loss and/or disturbance during the construction phase of the Proposed Development:

- Morven North OWF (construction and O&M phase);
- Morven South OWF (construction and O&M phase);
- Morven Hawthorn Pit Grid Connection Project (construction and O&M phase);
- Ossian Transmission Infrastructure (construction and O&M phase);
- Eastern Green Link 3 (O&M and phase); and
- CNSE Project (O&M phases) (Table 9.49).

9.12.32 There is limited publicly available information to define footprints of temporary habitat loss and/or disturbance for these projects. Temporary habitat loss and/or disturbance associated with the Morven North OWF, Morven South OWF and Morven Hawthorn Pit Grid Connection Project is expected to be similar in nature and extent to that calculated for the Proposed Development and/or the Tier 2 OWF developments detailed in Table 9.50. Footprints of impact associated with Ossian Transmission Infrastructure, Eastern Green Link 3 and CNSE Project are highly likely to be of a lower extent to those calculated for the Proposed Development or the other Tier 2 OWF developments. As with the Proposed Development and the Tier 2 projects, the site preparation and construction activities of the Tier 3 projects are expected to be intermittent, temporary and reversible (such as cable installation, seabed preparation, and jack-up vessel use).

9.12.33 As with the Tier 2 projects, it is important to note that cumulative temporary habitat loss and/or disturbance associated with the Tier 3 projects will not be one continuous area. Instead, this footprint will be comprised of isolated temporary habitat loss and disturbance over the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the Tier 3 projects (Figure 9.10). The cumulative magnitude of impact of the Tier 3 projects, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 projects.

9.12.34 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent, and 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

9.12.35 The sensitivity of the receptor is as defined in Paragraphs 9.10.12 to 9.10.36 above for the alone assessment.

Significance of effect

9.12.36 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.37 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.38 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

O&M phase

Magnitude of impact

9.12.39 In addition to the Tier 2 projects, there were six Tier 3 projects with the potential for cumulative temporary habitat loss and/or disturbance during the O&M phase of the Proposed Development:

- Morven North OWF (O&M phase);
- Morven South OWF (O&M phase);
- Morven Hawthorn Pit Grid Connection Project (O&M phase);

- Ossian Transmission Infrastructure (O&M phase);
- Eastern Green Link 3 (possibly in its decommissioning phases); and
- CNSE Project (possibly in its O&M and decommissioning phases) (Table 9.49).

9.12.40 There is limited publicly available information to define footprints of temporary habitat loss and/or disturbance for these projects. Temporary habitat loss and/or disturbance associated with the Morven North OWF, Morven South OWF and Morven Hawthorn Pit Grid Connection Project is expected to be similar in nature and extent to that calculated for the Proposed Development and/or the Tier 2 OWF developments detailed in Table 9.50. Footprints of impact associated with Ossian Transmission Infrastructure, Eastern Green Link 3, and the CNSE Project are highly likely to be of a lower extent to those calculated for the Proposed Development or the other Tier 2 OWF developments. As with the Proposed Development and the Tier 2 projects, the O&M activities of the Tier 3 projects are expected to be intermittent, temporary and reversible (such as cable repair and reburial).

9.12.41 As with the Tier 2 projects, it is important to note that cumulative temporary habitat loss and/or disturbance associated with the Tier 3 projects will not be one continuous area. Instead, this footprint will be comprised of isolated temporary habitat loss and disturbance over the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the Tier 3 projects (Figure 9.10). The cumulative magnitude of impact of the Tier 3 projects, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 projects.

9.12.42 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent, and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

<u>Sensitivity of receptor</u>

9.12.43 The sensitivity of the receptor is as defined in Paragraphs 9.10.12 to 9.10.36 above for the alone assessment.

<u>Significance of effect</u>

9.12.44 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.45 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.46 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.12.47 In addition to the Tier 2 projects, there were four Tier 3 projects with the potential for cumulative temporary habitat loss and/or disturbance during the decommissioning phase of the Proposed Development:

- Morven Hawthorn Pit Grid Connection Project (possibly in its O&M and decommissioning phase);
- Eastern Green Link 3 (possibly in O&M and decommissioning phases);
- CNSE Project (possibly in its O&M and decommissioning phases); and
- Ossian Transmission Infrastructure (O&M phase) (Table 9.49).

9.12.48 There is limited publicly available information to define footprints of temporary habitat loss and/or disturbance for these projects. Temporary habitat loss and/or disturbance associated with the Morven Hawthorn Pit Grid Connection Project is expected to be similar in nature and extent to that calculated for the Proposed Development and/or the Tier 2 OWF developments detailed in Table 9.50. Footprints of impact associated with Ossian Transmission Infrastructure, Eastern Green Link 3 and the CNSE Project are highly likely to be of a lower extent to those calculated for the Proposed Development or the other Tier 2 OWF developments. As with the Proposed Development and the Tier 2 projects, the decommissioning activities of the Tier 3 projects are expected to be intermittent, temporary and reversible (such as infrastructure removal).

9.12.49 As with the Tier 2 projects, it is important to note that cumulative temporary habitat loss and/or disturbance associated with the Tier 3 projects will not be one continuous area. Instead, this footprint will be comprised of isolated temporary habitat loss and disturbance over the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the Tier 3 projects (Figure 9.10). The cumulative magnitude of impact of the Tier 3 projects, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 projects.

9.12.50 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent, and 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

9.12.51 The sensitivity of the receptor is as defined in Paragraphs 9.10.12 to 9.10.36 above for the alone assessment.

Significance of effect

9.12.52 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.53 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.54 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 4

Construction, O&M and Decommissioning phases

Magnitude of impact

9.12.55 In addition to the Tier 2 and 3 projects, the Tier 4 project Flora Floating Wind Farm (in all phases) has the potential for cumulative temporary habitat loss and/or disturbance during the construction, O&M, and decommissioning phases of the Proposed Development.

9.12.56 The Flora Floating Wind Farm is currently in the pre-application stage and therefore there is little known about the potential impacts associated with the project. It is however likely the impacts will be similar to that of Ossian OWF, which is also a floating project but on a smaller scale, as Ossian OWF has a capacity of 3.6 GW and the Flora Floating Wind Farm has a maximum capacity of 50 MW (JERA Nex bp, 2026).

9.12.57 As with the Tier 2 and 3 projects, it is important to note that cumulative temporary habitat loss and/or disturbance associated with the Tier 4 project will not be one continuous area. Instead, this footprint will be comprised of isolated temporary habitat loss and disturbance over the 50 km CEA screening buffer. The cumulative magnitude of impact of the Tier 4 project, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 and 3 projects.

9.12.58 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent, and 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

9.12.59 The sensitivity of the receptor is as defined in Paragraphs 9.10.12 to 9.10.36 above for the alone assessment.

Significance of effect

9.12.60 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.61 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.62 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

LONG TERM HABITAT LOSS AND/OR DISTURBANCE

Tier 2

Construction, O&M and decommissioning phases

Magnitude of impact

9.12.63 There were five Tier 2 projects with the potential for cumulative long term habitat loss and/or disturbance during the construction, O&M, and decommissioning phases of the Proposed Development (Table 9.53). Finalised decommissioning plans are not available/quantified for the Proposed Development and Tier 2 projects. Although infrastructure may be removed during their respective decommissioning phases, as a precautionary measure, it has been assumed that infrastructure will be left *in situ*, and the cumulative long term habitat loss and/or disturbance footprint will persist into and beyond the decommissioning phase of the Proposed Development (Table 9.53). Hence, all three phases have been combined for this cumulative impact.

9.12.64 The maximum cumulative long term habitat loss and/or disturbance associated with the Tier 2 projects together with that of the Proposed Development is estimated at up to 29.82 km^2 (Table 9.53). This represents up to 0.25% of the 50 km CEA screening buffer applied and up to 0.09% of the Fish and Shellfish Ecology Study Area. It is important to note that the cumulative footprint of 29.82 km^2 will not be one continuous area but comprised of isolated areas of habitat loss and/or disturbance across the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the majority of the Tier 2 projects, except Eastern Green Link 2 (see Figure 9.10 and Table 9.48), with this overlap limited to the locations that this cable intersects with the Proposed Development. The cumulative magnitude of impact of the Proposed Development with the Tier 2 projects is therefore not expected to represent a material additional impact to that defined for the assessment of the Proposed Development alone.

9.12.65 The cumulative 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.

Table 9.53: Cumulative Footprint of Long-Term Habitat Loss and/or Disturbance for the Tier 2 Projects Overlapping with the Construction, O&M, and Decommissioning Phases of the Proposed Development

Project	MDS	Component Parts of Long-Term Habitat Loss and/or Disturbance	Reference
Proposed Development	**2,251,000 m^2**	See Table 9.15	N/A
Offshore Wind Projects and Associated Cables			
Seagreen 1A Project	All phases: Unquantified	Footprint of Wind Turbine foundations, OSPs, cable installation and cable protection. Use of jack-up vessels for maintenance. Removal of all cabling, Wind Turbine and OSP foundations.	Seagreen Wind Energy Limited (2012)
Ossian OWF	Construction and O&M: 19,270,958 m^2	Footprint of mooring lines, Scour Protection, cable protection and OSP jacket foundations (footprint of dynamic cables, mid-water mooring lines and floating foundations not included).	Ossian OWFL (2024)
Hywind Scotland OWF	O&M: 272,520 m^2	Continued presence of Wind Turbine anchors, cables, Scour Protection (rock dump and/or concrete mattresses) and cable protection.	Statoil (2015)
Berwick Bank Wind Farm	All phases: 7,798,856 m^2	Suction caisson and suction caisson jacket foundations, Scour Protection and cable protection if left *in situ*.	SSE Renewables (2022)
Berwick Bank OFTO	O&M: up to 230,000 m^2 (Scottish waters)	(Potential for) Cable protection removal.	SSE Renewables (2023)
Total (Proposed Development and Tier 2 Projects)	**29,823,334 m^2 (29.82 km^2)**		

Sensitivity of receptor

9.12.66 The sensitivity of the receptor is as defined in Paragraphs 9.10.57 to 9.10.73 above for the alone assessment.

Significance of effect

9.12.67 Overall, for the sandeel, herring and Norway lobster IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.68 For all remaining fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.69 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 3

Construction, O&M and decommissioning phases

Magnitude of impact

9.12.70 In addition to the Tier 2 projects, there were five Tier 3 projects with the potential for cumulative long term habitat loss and/or disturbance during the construction, O&M and decommissioning phases of the Proposed Development:

- Morven North OWF (all phases);
- Morven South OWF (all phases);
- Morven Hawthorn Pit Grid Connection Project (construction, O&M and possibly decommissioning phase);
- Ossian Transmission Infrastructure (construction and O&M phases); and
- Eastern Green Link 3 (O&M and possibly decommissioning phases) (Table 9.49).

9.12.71 There is limited publicly available information to define footprints of long-term habitat loss and/or disturbance for these projects. Long term habitat loss and/or disturbance associated with the Morven North OWF, Morven South OWF and Morven Hawthorn Pit Grid Connection Project is expected to be similar in nature and extent to that calculated for the Proposed Development and/or the Tier 2 OWF developments detailed in Table 9.50. Footprints of impact associated with Ossian Transmission Infrastructure and Eastern Green Link 3 are highly likely to be of a lower extent to those calculated for the Proposed Development or the other Tier 2 OWF developments. As with the Proposed Development and the Tier 2 projects, the site preparation and construction activities of the Tier 3 projects are expected to be intermittent, temporary and reversible (such as cable installation, seabed preparation, and jack-up vessel use).

9.12.72 As with the Tier 2 projects, it is important to note that the cumulative footprint will not be one continuous area, but comprised of isolated areas of long-term habitat loss and/or disturbance across the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the Tier 3 projects (Figure 9.10). The cumulative magnitude of impact of the Tier 3 projects, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 projects.

9.12.73 The cumulative 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

9.12.74 The sensitivity of the receptor is as defined in Paragraphs 9.10.57 to 9.10.73 above for the alone assessment.

Significance of effect

9.12.75 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.76 For all remaining fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.77 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 4

Construction, O&M and Decommissioning phases

Magnitude of impact

9.12.78 In addition to the Tier 2 and 3 projects, the Tier 4 project Flora Floating Wind Farm (in all phases) has the potential for cumulative long term habitat loss and/or disturbance during the construction, O&M, and decommissioning phases of the Proposed Development.

9.12.79 The Flora Floating Wind Farm is currently in the pre-application stage and therefore there is little known about the potential impacts associated with the project. It is however likely the impacts will be similar to that of Ossian OWF, which is also a floating project but on a smaller scale, as Ossian OWF has a capacity of 3.6 GW and the Flora Floating Wind Farm has a maximum capacity of 50 MW (JERA Nex bp, 2026).

9.12.80 As with the Tier 2 and 3 projects, it is important to note that cumulative long term habitat loss and/or disturbance associated with the Tier 4 project will not be one continuous area. Instead, this footprint will be comprised of isolated long term habitat loss and disturbance over the 50 km CEA screening buffer. The cumulative magnitude of impact of the Tier 4 project, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 and 3 projects.

9.12.81 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent, and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be low.

Sensitivity of receptor

9.12.82 The sensitivity of the receptor is as defined in Paragraphs 9.10.57 to 9.10.73 above for the alone assessment.

Significance of effect

9.12.83 Overall, for the sandeel, herring and Norway Lobster IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.84 For all remaining fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.85 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

COLONISATION OF HARD STRUCTURES

Tier 2

Construction and O&M phases

Magnitude of impact

9.12.86 There were five Tier 2 projects with the potential for cumulative effects associated with the colonisation of hard structures during the construction and O&M phases of the Proposed Development (Table 9.54). The maximum cumulative footprint for introduction of artificial structures and subsequent colonisation associated with the Tier 2 projects together with the construction and O&M phases of the Proposed Development is estimated at up to 39.96 km^2 (Table 9.54). This represents up to 0.33% of the 50 km CEA screening buffer applied and up to 0.12% of the Fish and Shellfish Ecology Study Area. It is important to note that the cumulative footprint of 39.96 km^2 will not be one continuous area but comprised of isolated areas of introduced artificial structures and their subsequent colonisation across the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the majority of the Tier 2 projects, except Eastern Green Link 2 (see Figure 9.10 and Table 9.48), with this overlap limited to the locations that this cable intersects with the Proposed Development. The cumulative magnitude of impact of the Proposed Development with the Tier 2 projects is therefore not expected to represent a material additional impact to that defined for the assessment of the Proposed Development alone.

9.12.87 The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and of low reversibility during the lifetime of the Proposed Development (up to 30 years). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Table 9.54: Cumulative Footprint of Colonisation of Hard Structures for the Tier 2 Projects Overlapping with the Construction and O&M Phase of the Proposed Development

Project	MDS	Artificial Hard Structures Present	Reference
Proposed Development	**2,705,020 m^2**	See Table 9.15	N/A
Offshore Wind Projects and Associated Cables			
Seagreen 1A Project	Construction and O&M: Unquantified	Footprint of Wind Turbine foundations, OSPs, cable installation and cable protection. Use of jack-up vessels for maintenance.	Seagreen Wind Energy Limited (2012)
Ossian OWF	Construction and O&M: 19,270,958 m^2	Footprint of mooring lines, Scour Protection, cable protection and OSP jacket foundations (footprint of dynamic cables, mid-water mooring lines and floating foundations not included).	Ossian OWFL (2024)
Hywind Scotland OWF	O&M: 272,520 m^2	Continued presence of Wind Turbine anchors, cables, Scour Protection (rock dump and/or concrete mattresses) and cable protection.	Statoil (2015)
Berwick Bank Wind Farm	O&M: 10,198,971 m^2	Wind Turbines and OSP jacket foundations, Scour Protection and cable protection.	SSE Renewables (2022)
	Decommissioning: 7,493,186 m^2	Scour Protection and cable protection, if left *in situ*.	
Berwick Bank OFTO	O&M: Up to 23,000 m^2	Cable protection.	SSE Renewables (2023)
Total (Proposed Development and Tier 2 Projects)	**39,963,655 m^2 (39.96 km^2)**		

Sensitivity of receptor

9.12.88 The sensitivity of the receptor is as defined in Paragraphs 9.10.89 to 9.10.101 above for the alone assessment.

Significance of effect

9.12.89 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.90 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.12.91 There was one Tier 2 project with the potential for colonisation of hard structures during the decommissioning phase of the Proposed Development (Table 9.55). The maximum cumulative footprint for colonisation of hard structures associated with the Tier 2 project together with the decommissioning phase of the Proposed Development is estimated at up to 21.5 km^2 (Table 9.55). This represents up to 0.18% of the 50 km CEA screening buffer applied and up to 0.07% of the Fish and Shellfish Ecology Study Area. It is important to note that the cumulative footprint of 21.5 km^2 will not be one continuous area but comprised of isolated areas of colonisation of hard structures across the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the majority of the Tier 2 projects, except Eastern Green Link 2 (see Figure 9.10 and Table 9.48), with this overlap limited to the locations that this cable and pipelines intersect with the Proposed Development. The cumulative magnitude of impact of the Proposed Development with the Tier 2 projects is therefore not expected to represent a material additional impact to that defined for the assessment of the Proposed Development alone.

9.12.92 Finalised decommissioning plans are not available/quantified for the Proposed Development and Ossian OWF. For the Proposed Development MDS it is currently proposed that all Scour Protection, cable protection, and cable crossing protection will be left *in situ* (subject to the final material used; Table 9.15). This will be reviewed throughout the lifetime of the Proposed Development and good practise guidance will be followed at the time. For the Tier 2 projects, although infrastructure may be removed during their respective decommissioning phases, as a precautionary measure it has been assumed that the cumulative footprint of introduced artificial hard structures will persist into and into and beyond the decommissioning phase of the Proposed Development.

Table 9.55: Cumulative Footprint of Colonisation of Hard Structures for the Tier 2 Projects Overlapping with the Decommissioning Phase of the Proposed Development

Project	MDS	Artificial Hard Structures Present	Reference
Proposed Development	**2,232,100 m^2**	See Table 9.15	N/A
Offshore Wind Projects and Associated Cables			
Ossian OWF	O&M: 19,270,958 m^2	Floating foundations, dynamic cables, jack-up vessel use, anchoring, seabed preparation, and cable installation.	Ossian OWFL (2024)
Total (Proposed Development and Tier 2 Projects)	**21,503,058 m^2 (21.50 km^2)**		

9.12.93 The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and of 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

9.12.94 The sensitivity of the receptor is as defined in Paragraphs 9.10.89 to 9.10.101 above for the alone assessment.

Significance of effect

9.12.95 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.96 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 3

Construction and O&M phases

Magnitude of impact

9.12.97 In addition to the Tier 2 projects, there were five Tier 3 projects with the potential for colonisation of hard structures during the construction and O&M phases of the Proposed Development:

- Morven North OWF (construction and O&M phases);
- Morven South OWF (construction and O&M phases);
- Morven Hawthorn Pit Grid Connection Project (O&M phase);
- Ossian Transmission Infrastructure (possibly in its O&M phases); and
- Eastern Green Link 3 (possibly in its O&M and decommissioning phases) (Table 9.49).

9.12.98 There is limited publicly available information to define footprints of colonisation of hard structures for these projects. Colonisation of hard structures associated with the Morven North OWF, Morven South OWF and Morven Hawthorn Pit Grid Connection Project is expected to be similar in nature and extent to that calculated for the Proposed Development and/or the Tier 2 OWF developments detailed in Table 9.50. Footprints of impact associated with Ossian Transmission Infrastructure and Eastern Greenlink 3 are highly likely to be of a lower extent to those calculated for the Proposed Development or the other Tier 2 OWF developments. As with the Proposed Development and the Tier 2 projects, the site preparation and construction activities of the Tier 3 projects are expected to be intermittent, temporary and reversible (such as cable installation, seabed preparation, and jack-up vessel use).

9.12.99 As with the Tier 2 projects, it is important to note that the cumulative footprint will not be one continuous area but comprised of isolated areas of introduced artificial structures and subsequent colonisation across the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the Tier 3 projects (Figure 9.10). The cumulative magnitude of impact of the Tier 3 projects, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 projects.

9.12.100 The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and of low reversibility during the lifetime of the Proposed Development (up to 30 years). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.101 The sensitivity of the receptor is as defined in Paragraphs 9.10.89 to 9.10.101 above for the alone assessment.

Significance of effect

9.12.102 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.103 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.12.104 In addition to the Tier 2 projects, there were three Tier 3 projects with the potential for colonisation of hard structures during the decommissioning phase of the Proposed Development:

- Morven Hawthorn Pit Grid Connection Project (possibly in its O&M and decommissioning phase);
- Eastern Green Link 3 (possibly in its O&M and decommissioning phase); and
- Ossian Transmission Infrastructure (possibly in its O&M phase) (Table 9.49).

9.12.105 There is limited publicly available information to define footprints of introduction of artificial structures and subsequent colonisation for these projects. The colonisation of hard structures associated with the Morven Hawthorn Pit Grid Connection Project is expected to be similar in nature and extent to that calculated for the Proposed Development and/or the Tier 2 OWF developments detailed in Table 9.50. Footprints of impact associated with Ossian Transmission Infrastructure are highly likely to be of a lower extent to those calculated for the Proposed Development or the other Tier 2 OWF developments. As with the Tier 2 projects, it is important to note that the cumulative footprint will not be one continuous area but comprised of isolated areas of introduced artificial structures and subsequent colonisation across the 50 km CEA screening buffer. There will also be no spatial overlap between the Site Boundary and the Tier 3 project (Figure 9.10). The cumulative magnitude of impact of the Tier 3 project, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 projects.

9.12.106 The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and of 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

9.12.107 The sensitivity of the receptor is as defined in Paragraphs 9.10.89 to 9.10.101 above for the alone assessment.

Significance of effect

9.12.108 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.109 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 4

Construction, O&M and Decommissioning phases

Magnitude of impact

9.12.110 In addition to the Tier 2 and 3 projects, the Tier 4 project Flora Floating Wind Farm (in all phases) has the potential for cumulative colonisation of hard structures during the construction, O&M, and decommissioning phases of the Proposed Development.

9.12.111 The Flora Floating Wind Farm is currently in the pre-application stage and therefore there is little known about the potential impacts associated with the project. It is however likely the impacts will be similar to that of Ossian OWF, which is also a floating project but on a smaller scale, as Ossian OWF has a capacity of 3.6 GW and the Flora Floating Wind Farm has a maximum capacity of 50 MW (JERA Nex bp, 2026).

9.12.112 As with the Tier 2 and 3 projects, it is important to note that cumulative introduction of artificial structures and subsequent colonisation associated with the Tier 4 project will not be one continuous area. Instead, this footprint will be comprised of isolated cumulative introduction of artificial structures and subsequent colonisation over the 50 km CEA screening buffer. The cumulative magnitude of impact of the Tier 4 project, therefore, represents no additional material impact to that defined for the assessment of the Proposed Development alone, and cumulatively with the Tier 2 and 3 projects.

9.12.113 The cumulative impact is predicted to be of local spatial extent, medium term duration, intermittent, and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be low.

Sensitivity of receptor

9.12.114 The sensitivity of the receptor is as defined in Paragraphs 9.10.89 to 9.10.101 above for the alone assessment.

Significance of effect

9.12.115 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.116 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

INCREASED SSCS AND ASSOCIATED DEPOSITION

Tier 2

Construction phase

Magnitude of impact

9.12.117 There was two Tier 2 projects identified with the potential to have a cumulative risk of impact with the Proposed Development during its construction phase: Ossian OWF and Seagreen 1A (Table 9.49).

9.12.118 There is potential for sediment-disturbing activities such as drilling foundations, MFE sandwave clearance, and dredging to occur simultaneously. This overlap may potentially result in cumulative changes in SSC and associated deposition.

9.12.119 The Ossian array area is located approximately 25 km to the east of the Array Area. The distance between the Ossian array area and the Proposed Development is greater than the extent of the Spring Tidal Excursion and they are not aligned in the direction of the tidal axis. Similarly, Seagreen 1A is located approximately 19 km from the Proposed Development Export Cable Corridor, which is greater than the extent of the tidal excursion ellipse. This therefore suggests any cumulative impacts are very unlikely. This conclusion is underpinned by and consistent with the relevant available guidance set out in Volume 2, Chapter 7: Physical Processes.

9.12.120 Therefore, the cumulative 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 receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.121 The sensitivity of the receptor is as defined in Paragraphs 9.10.116 to 9.10.136 above for the alone assessment.

Significance of effect

9.12.122 Overall, for herring and sandeel, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.123 For all other fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.124 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Volume 2, Chapter 7: Physical Processes) is not significant in EIA terms.

Tier 3

Construction phase

Magnitude of impact

9.12.125 In addition to the Tier 2 project identified in Table 9.49, the construction period of the Tier 3 projects Morven North OWF and Morven South OWF and the Proposed Development may overlap. There is potential for sediment-disturbing activities such as drilling of foundations, sandwave clearance, and dredging to occur simultaneously. This overlap may potentially result in cumulative changes in SSCs and associated deposition.

9.12.126 The Moven North array area is located approximately 10 km to the south-east of the Array Area, whilst the Morven South array area is located approximately 43.81 km away. The distance between the Morven North array area and the Array Area is greater than the extent of the spring tidal excursion ellipse and they are not aligned in along the direction of the tidal axis. The modelled scenarios (see Volume 2: Chapter 7: Physical Processes) also show the limited spatial footprint and transient nature of the plumes created from disturbance activities in these individual locations. This therefore suggests any cumulative impacts are very unlikely and will be of low magnitude and short duration if they do occur. There are no designated sites located in the potential area of cumulative influence between releases originating from the Morven North OWF and the Proposed Development (Array Area and Export Cable Corridor).

9.12.127 Therefore, the cumulative 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 receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.128 The sensitivity of the receptor is as defined in Paragraphs 9.10.116 to 9.10.136 above for the alone assessment.

Significance of effect

9.12.129 Overall, for herring and sandeel, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.130 For all other fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.131 No Additional mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Volume 2, Chapter 7: Physical Processes) is not significant in EIA terms.

SUBSEA NOISE IMPACTING FISH AND SHELLFISH RECEPTORS

Tier 2

Construction phase

Magnitude of impact

9.12.132 There were 10 Tier 2 projects with the potential for cumulative impacts associated with subsea noise in the construction phase of the Proposed Development. The results of subsea noise modelling assessments for these projects are summarised in Table 9.56. Injury and disturbance associated with subsea noise in the various phases of the Tier 2 projects overlapping with the construction phase of the Proposed Development were not concluded to be significant for the fish and shellfish species assessed in their individual EIAs (Table 9.56). Subsea noise modelling results (where available) were of a similar scale to those associated with the Proposed Development. Given the location of the Tier 2 projects within the North Sea, the fish and shellfish species assessed are comparable to the fish and shellfish IEFs identified for the Proposed Development alone assessment.

9.12.133 It should be noted that the majority of the Tier 2 projects will already be constructed during the construction of the Proposed Development. This greatly reduces the potential for cumulative effects as the highest potential for impact is associated with piling noise in the construction phase of an OWF. Of the 10 Tier 2 projects assessed, only the construction phases of the Seagreen 1A Project (up to two years; 2031 to 2032), Aspen OWF (up to one year in 2031) Berwick Bank Wind Farm (up to six years; 2027 to 2032) and Ossian OWF (up to eight years; 2031 to 2038) overlap with that of the Proposed Development (2031 to 2036).

Table 9.56: Cumulative Subsea Noise Modelling Results for the Tier 2 Projects Overlapping with the Construction Phase of the Proposed Development

Project	MDS	Subsea Noise Modelling Results	Reference
Offshore Wind Projects and Associated Cables			
Kincardine OWF	O&M: Operational noise from five Wind Turbines, cable repair, and maintenance vessel visit five days per week.	There was no subsea noise modelling undertaken for the operational noise from Wind Turbines, although it was predicted that there would be a noise output of no greater than 110dB(A) at hub height measured according to the IEC 61400-11 standard. Vessel movements and cable repair activities were modelled based on the movement of medium sized vessels, with maximum ranges from O&M activities using the dB_{ht} (*Species*) Metric being less than one metre for cod, dab, herring and salmon. Therefore, noise impacts to fish and shellfish were expected to be very limited.	Kincardine OWF Limited (2016)
Seagreen 1 OWF	O&M: Operational noise from up to 150 Wind Turbines	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and operational phases of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Seagreen Wind Energy Limited (2012); (Seagreen Wind Energy Limited, 2018)
Seagreen 1A Project	Construction and O&M: Operational noise from 36 Wind Turbines.	There was no subsea noise modelling undertaken for the construction and O&M phases of this project (which corresponds with the construction and operational phases of the Proposed Development). Operational noise was originally assessed in the Seagreen 1 OWF EIA via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Seagreen 1A (2021); Seagreen Wind Energy Limited (2012); Seagreen Wind Energy Limited (2018)

Project	MDS	Subsea Noise Modelling Results	Reference
Aberdeen OWF	O&M: Operational noise from 11 Wind Turbines.	There was no subsea noise modelling undertaken for the O&M or decommissioning phases of this project (which corresponds with the operational phases of the Proposed Development). Operational noise was predicted to have no significant effects for any fish and shellfish species. Decommissioning noise was assessed with construction noise, with a moderate impact due to piling noise. However, no piling will occur during decommissioning activities therefore this stage of the development is unlikely to have significant effects predicted for any fish and shellfish species.	(European Offshore Wind Deployment Centre, 2011a); European Offshore Wind Deployment Centre (2011b); European Offshore Wind Deployment Centre (2011c)
Hywind Scotland OWF	O&M: Operational noise from five Wind Turbines, mooring lines, and vessel maintenance.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and operational phases of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Statoil (2015)
Berwick Bank Wind Farm	Construction: piling of up to 179 Wind Turbines with jacket foundations (up to 4 legs per foundation and up to 2 x 5.5 m diameter piles) using a maximum hammer energy of up to 4,000 kJ. Up to eight OSP jacket foundations (six legs per foundation) at a maximum hammer energy of 4,000 kJ. Pre-Construction clearance of up to 14 UXOs with 300kg UXO.	The mortality and recoverable injury for both single piling of Wind Turbines and OSPs were modelled to not be exceeded for Group 1 Fish, with mortality occurring up to 19 m for Group 2 Fish, 33 m for Group 3 and 4 Fish and 495 m for fish eggs and larvae. Egg larvae mortality for OSP piling was modelled at 439 m. Recoverable injury from piling for Wind Turbine and OSPs was 67m for Group 2 Fish, 6 m for Group 3 and 4 Fish. The maximum TTS range for all Fish Groups from Wind Turbine piling was 4,161 m (2,219 for basking shark), and from piling OSPs foundations was 3,900 m for Group 1 Fish, and 3,943 m for Group 2, and Group 3 and 4 Fish. The subsea noise contours for disturbance modelled for the Berwick Bank Wind Farm extended across the south of the Fish and Shellfish Ecology Study Area, so would likely overlap with those modelled for the Proposed Development alone (Figure 9.5). However, piling activities are unlikely to overlap temporally with those of the Proposed Development. The piling phase of construction extends over a maximum of 372 days, with construction scheduled to finish in 2032. Therefore, there is the potential for concurrent pilling of the Proposed Development and Berwick Bank Wind Farm is	SSE Renewables (2022)

Project	MDS	Subsea Noise Modelling Results	Reference
		unlikely. Furthermore, the pre-construction UXO clearance of Berwick Bank Wind Farm represents no risk of cumulative noise with the Proposed Development as this will be completed before piling.	
Green Volt	O&M: Impacts are assessed relating to the loudest operational vessel type (offshore support vessel used as proxy), with a source Sound Pressure Level (SPL) of 179 RMS (dB re 1 μ Pa) and SEL(24h) of 228 (dB re 1 μ Pa2s).	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction phase of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Green Volt (2023)
Muir Mhòr OWF	O&M: Up to 67 Wind Turbines and 12 mooring lines per Wind Turbine.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and operational phases of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Muir Mhòr Offshore Wind Farm (2024)
Ossian OWF	Construction: up to 265 semi-submersible Floating Wind Turbine Foundations (6 anchors per foundation) at a maximum hammer energy of 3,300 kJ. Up to three large OSP jacket foundations and 12 and small jacket foundations, with up to 12 and six legs per foundation at a maximum hammer energy of 4,400 kJ. UXO clearance of 15 UXOs.	Subsea noise modelling was undertaken for concurrent OSP Jacket pile installation at 4,400 kJ and Wind Turbine Foundation Pile at 3,000 kJ. The greatest TTS impact area was modelled at 45,100 m for static fish and 31,200 m for moving fish (based on the cumulative SEL metric). Ranges were lower for the less sensitive hearing groups and for injurious effects. This was not assessed as having population-level effects on the fish and shellfish IEFs (including herring and cod). The subsea noise contours for disturbance modelled for the Ossian OWF are likely to overlap with those modelled for the Proposed Development alone (Figure 9.5). Both Ossian OWF and the Proposed Development are due to be constructed from 2031 onwards, with Ossian's construction Floating Wind Turbine anchors set to installed over a period of 7 years (with no piling assumed during Q1). Total piling phase of the large OSP foundations of 72 months	Ossian OWFL (2024)

Project	MDS	Subsea Noise Modelling Results	Reference
		over a period of 8 years. Therefore, there is likely to be a significant overlap. For UXO PTS ranges for 698 kg UX0 were 930 m (lower range) – 558 m (upper range). All other modelled UXO, clearing shot and donor charge ranges were of a smaller distance than this. The modelled distances of these charges are far outwith the Proposed Development and therefore propose little risk of overlap.	
Salamander OWF	O&M: Up To 210 vessel trips per year.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and O&M phase of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Salamander OWF (2024)

9.12.134 Based on the information provided in Table 9.56, the cumulative impact is predicted to be of local spatial extent, medium duration (over the construction phase), intermittent and 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

9.12.135 The sensitivity of the receptor is as defined in Paragraphs 9.10.177 to 9.10.224 above for the alone assessment.

Significance of effect

9.12.136 Overall, for the herring IEF, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered, precautionarily, to be high. The cumulative effect will, therefore, be of **Moderate** adverse significance, which is significant in EIA terms.

9.12.137 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible to Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.138 For all IEFs except herring, no Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

9.12.139 A moderate adverse significance was concluded for the herring IEF due to piling in the construction phase. Therefore, prior to the commencement of piling at the Proposed Development alone, appropriate Additional Mitigation measures will be discussed and agreed with stakeholders. These may include the use of noise abatement systems or site-specific surveys to determine key herring spawning periods. Appropriate mitigation will be secured through the Piling Strategy as a condition of the Section 36 Consent and Marine Licence. It is anticipated that following tailoring of Additional Mitigation measures as described above, the cumulative significance of this impact will be reduced to minor adverse for herring, which is not significant in EIA terms.

O&M phase

Magnitude of impact

9.12.140 There were 12 Tier 2 projects with the potential for cumulative impacts associated with subsea noise in the O&M phase of the Proposed Development. The results of subsea noise modelling assessments for these projects are summarised in Table 9.57, although it should be noted that operational noise was not assessed for several projects during this phase. All of the Tier 2 projects will be in their O&M and/or decommissioning phases during the O&M phase of the Proposed Development. This greatly reduces the potential for cumulative effects as the highest potential for impact is associated with piling noise in the construction phase of an OWF. As detailed for the alone assessment (Paragraphs 9.10.235 to 9.10.238) the risk of effects on fish (either injury or behavioural responses) from operational Wind Turbine noise is very low. Therefore, it is unlikely that wide-ranging cumulative impacts would occur, given the limited nature of operational noise disturbance to fish and shellfish receptors.

9.12.141 Overall, the cumulative impact is predicted to be of local spatial extent, long term duration, continuous (but at very low levels), and low reversibility (although is reversible upon decommissioning). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Table 9.57: Cumulative Subsea Noise Modelling Results for the Tier 2 Projects Overlapping with the O&M Phase of the Proposed Development

Project	MDS	Subsea Noise Modelling Results	Reference
Offshore Wind Projects and Associated Cables			
Kincardine OWF	O&M: Operational noise from five Wind Turbines, mooring lines, cable repair, and maintenance vessel visit five days per week.	There was no subsea noise modelling undertaken for the operational noise from Wind Turbines, though they were predicted to have a noise output of no greater than 110dB(A) at hub height measured according to the IEC 61400-11 standard. Vessel movements and cable repair activities were modelled based on the movement of medium sized vessel, with maximum ranges from O&M activities using the dB_{ht} (*Species*) Metric being less than one metre for cod, dab, herring and salmon. Therefore, noise impacts to fish and shellfish were expected to be very limited.	Kincardine OWF Limited (2016)
Seagreen 1 OWF	O&M: Operational noise from up to 150 Wind Turbines.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and operational phases of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Seagreen Wind Energy Limited (2012); Seagreen Wind Energy Limited (2018)
Seagreen 1A Project	O&M: Operational noise from 36 Wind Turbines.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and operational phases of the Proposed Development). Operational noise was originally assessed in the Seagreen 1 OWF EIA via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Seagreen Wind Energy Limited (2012)

Project	MDS	Subsea Noise Modelling Results	Reference
Aberdeen OWF	O&M: Operational noise from 11 Wind Turbines. Decommissioning: Removal of 11 Wind Turbines and foundations, IACs, Export Cables and Scour Protection.	There was no subsea noise modelling undertaken for the O&M or decommissioning phases of this project (which corresponds with the operational phases of the Proposed Development). Operational noise was predicted to have no significant effects for any fish and shellfish species. Decommissioning noise was assessed with construction noise, with a moderate impact due to piling noise. However, no piling will occur during decommissioning activities therefore this stage of the development is unlikely to have significant effects predicted for any fish and shellfish species.	(European Offshore Wind Deployment Centre, 2011a); European Offshore Wind Deployment Centre (2011b); European Offshore Wind Deployment Centre (2011c)
Hywind Scotland OWF	O&M: Operational noise from five Wind Turbines, mooring lines, and vessel maintenance	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and operational phases of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Statoil (2015)
Aspen OWF	O&M: Operational noise from 72 Wind Turbines, 432 mooring lines and 3 OSPs.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the O&M phase of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Cerulean Winds (2025)

Project	MDS	Subsea Noise Modelling Results	Reference
Berwick Bank Wind Farm	O&M: The MDS for this project did not assess subsea noise during the O&M phase.	N/A	SSE Renewables (2022)
	Decommissioning: Removal of cables, the dismantling of Wind Turbine mooring systems, and the dismantling of the offshore substation at the offshore Wind Turbine site.	N/A	
Berwick Bank OFTO	O&M: The MDS for this project did not assess subsea noise during the O&M phase.	N/A	SSE Renewables (2023)
	Decommissioning: The MDS for this project did not assess subsea noise during the decommissioning phase.	N/A	
Green Volt OWF	O&M: Loudest operational vessel type (offshore support vessel used as proxy), with a source Sound Pressure Level (SPL) of 179 RMS (dB re 1 μ Pa) and SEL (24h) of 228 (dB re 1 μ Pa2s).	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the O&M phase of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Green Volt (2023)
	Decommissioning: Undisclosed but assumed to be reverse of construction for the project.	There was no subsea noise modelling undertaken for the decommissioning phase of this project (which corresponds with the O&M phase of the Proposed Development). The project assumed on a precautionary basis that subsea noise generated during the decommissioning phase would be of a similar magnitude to that assessed for the construction phase, where no significant effects were predicted for any fish and shellfish species.	

Project	MDS	Subsea Noise Modelling Results	Reference
Muir Mhòr OWF	O&M: Operational noise from up to 67 direct drive/geared Wind Turbines, 12 mooring lines per Wind Turbine and vessel traffic.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the O&M phase of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Muir Mhòr Offshore Wind Farm (2024)
	Decommissioning: Vessel movements and removal of the Wind Turbine anchors and OEP foundations.	There was no subsea noise modelling undertaken for the decommissioning phase of this project (which corresponds with the O&M phase of the Proposed Development). However, the EIA concluded that abrasive cutting, often anticipated for Wind Turbine foundation removal, would not be at the level of piling and likely much less. Subsea noise resulting from abrasive cutting associated with decommissioning is unlikely to result in any injury, avoidance or significant disturbance of fish and shellfish since noise emissions from these activities are far less than those created during construction (e.g. piling). The significance of the decommissioning noise was minor and therefore not significant in EIA terms.	
Ossian OWF	O&M: Operational noise from 265 semi-submersible floating Wind Turbines. Up to 1,590 catenary anchor mooring lines	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the O&M phase of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Ossian OWFL (2024)

Project	MDS	Subsea Noise Modelling Results	Reference
Salamander OWF	O&M: Up To 210 vessel trips per year.	There was no subsea noise modelling undertaken for the O&M phase of this project (which corresponds with the construction and O&M phase of the Proposed Development). Operational noise was assessed via a literature review in the EIA, with no significant effects predicted for any fish and shellfish species.	Salamander OWF (2024)
	Decommissioning: Undisclosed but assumed to be reverse of construction for the project.	There was no subsea noise modelling undertaken for the decommissioning phase of this project (which corresponds with the O&M phase of the Proposed Development). The project assumed on a precautionary basis that subsea noise generated during the decommissioning phase would be of a similar magnitude to that assessed for the construction phase, where no significant effects were predicted for any fish and shellfish species.	

Sensitivity of receptor

9.12.142 The sensitivity of the receptor is as defined in Paragraphs 9.10.239 to 9.10.249 above for the alone assessment.

Significance of effect

9.12.143 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.144 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.12.145 There is potential for the Tier 2 project Ossian OWF (O&M phase) to overlap with the decommissioning phase of the Proposed Development (Table 9.48). As for the Proposed Development, this project is likely to submit a Decommissioning Programme to MD-LOT for consultation and approval and specific detail around subsea noise generated during this phase is not currently available. As there will be no piling during the decommissioning phase, which is the source of subsea noise with the highest potential for impact, it has been assumed that the cumulative magnitude of impact in the decommissioning phase is no greater than that defined in Paragraph 9.12.134 for the construction phase.

9.12.146 Overall, the cumulative 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 receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.147 The sensitivity of the receptor is as defined in Paragraphs 9.10.223 to 9.10.224 above for the alone assessment.

Significance of effect

9.12.148 Overall, for the herring IEF, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.149 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.150 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 3

Construction phase

Magnitude of impact

9.12.151 In addition to the Tier 2 projects, there were seven Tier 3 projects with the potential for cumulative impacts associated with subsea noise during the construction phase of the Proposed Development:

- Bellrock OWF (likely in its O&M phase);
- Morven North OWF (construction phase);
- Morven South OWF (construction phase);
- Morven Hawthorn Pit Grid Connection Project (likely in its construction phase);
- Ossian Transmission Infrastructure (likely in its construction phase);
- CNSE Project (likely in its O&M phase); and
- Fraserburgh Harbour Development (likely in its construction phase) (Table 9.49).

9.12.152 It is possible that the construction and O&M phases of these Tier 3 projects may overlap with the construction phase of the Proposed Development, however there are no details in the public domain on the construction programmes available for them. Cumulative effects would be reduced with lower overlap between the construction phases of the Tier 3 projects and the Proposed Development, as subsea noise levels will return to baseline conditions upon completion of individual construction activities (such as piling) for each project.

9.12.153 As Tier 3 projects, there are no EIAs available in the public domain and therefore no specific subsea noise modelling results to draw upon. However, in their Scoping Reports, the following indicative Wind Turbine parameters are provided (noting that these are not final and may be subject to change as the projects progress):

- Bellrock OWF: total of up to 80 Wind Turbines (Bellrock Offshore Wind Farm, 2024);
- Morven North OWF: total of up to 96 Wind Turbines and associated OSPs (MvOWL, 2026a); and
- Morven South OWF: total of up to 95 Wind Turbines and associated OSPs (MvOWL, 2026b).

9.12.154 In addition to piling of Wind Turbine and OSP foundations, UXO clearance is likely to be required, alongside other noise producing activities such as site investigation surveys, vessel use, and cable installation. No specific details are currently available regarding noise-producing parameters, such as maximum piling durations, maximum or realistic hammer energies, however these are likely to be of a similar scale to that of the Proposed Development alone, given the similar scales between the Proposed Development and the Tier 3 OWFs.

9.12.155 The Fraserburgh Harbour Development includes upgrades to existing harbour infrastructure and the creation of an additional harbour to expand capacity and improve accessibility (Fraserburgh Harbour Development, 2025). The development is likely to involve dredging, breakwater extensions, new pontoons and a dry dock. Construction methods will likely include demolition, rock cutting, underwater blasting which will cause subsea noise. However, the Fraserburgh Harbour Development is 78.98 km from the Proposed Development and construction is due to complete in 2032, therefore noise contours are not expected to overlap and most of the piling is likely to be complete when the construction of the Proposed Development is underway. Therefore, cumulative impacts are not predicted to be significant.

9.12.156 Overall, the cumulative impact is predicted to be of local spatial extent, medium duration (over the construction phase), intermittent and 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

9.12.157 The sensitivity of the receptor is as defined in Paragraphs 9.10.177 to 9.10.224 above for the alone assessment.

Significance of effect

9.12.158 Overall, for the herring IEF, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered, precautionary, to be high. The cumulative effect will, therefore, be of **Moderate** adverse significance, which is not significant in EIA terms.

9.12.159 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.160 For all IEFs except herring, no Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

9.12.161 A moderate adverse significance was concluded for the herring IEF due to piling in the construction phase. Therefore, prior to the commencement of piling at the Proposed Development alone, appropriate Additional Mitigation measures will be discussed and agreed with stakeholders. These may include the use of noise abatement systems or site-specific surveys to determine key herring spawning periods. Appropriate mitigation will be secured through the Piling Strategy as a condition of the Section 36 Consent and Marine Licence. It is anticipated that following tailoring of Additional Mitigation measures as described above, the cumulative significance of this impact will be reduced to minor adverse for herring, which is not significant in EIA terms.

O&M phase

Magnitude of impact

9.12.162 In addition to the Tier 2 projects, there Tier 3 projects with the potential for cumulative impacts associated with subsea noise during the O&M phase of the Proposed Development:

- Bellrock OWF (likely in its O&M phase);
- Morven North OWF (likely in its O&M phase); and
- Morven South OWF (likely in its O&M phase) (Table 9.49).

9.12.163 As Tier 3 projects, there are no EIAs available in the public domain and therefore no specific subsea noise modelling results to draw upon. However, floating OWFs may present additional operational impacts due to mooring line movements. The risk of injury or behavioural effects on fish from Wind Turbine noise, whether structure borne (Paragraphs 9.10.235 to 9.10.238) or mooring-related is considered very low. Given the distance between the Proposed Development and the Tier 3 projects (Table 9.48), it is unlikely that wide-ranging cumulative impacts would occur, given the limited nature of operational noise disturbance to fish and shellfish receptors.

9.12.164 Overall, the cumulative impact is predicted to be of local spatial extent, long term duration, continuous (but at very low levels), and low reversibility (although is reversible upon decommissioning). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.165 The sensitivity of the receptor is as defined in Paragraphs 9.10.239 to 9.10.249 above for the alone assessment.

Significance of effect

9.12.166 Overall, for the herring IEF, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.167 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.168 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

9.12.169 In addition to the Tier 2 projects, the Tier 3 project Morven Hawthorn Pit Grid Connection has the potential for cumulative impacts associated with subsea noise during the decommissioning phase of the Proposed Development.

9.12.170 It is possible that the O&M and/or decommissioning phases of this Tier 3 project may overlap with the decommissioning phase of the Proposed Development, however there are no details in the public domain available for this project. Cumulative effects would be reduced with lower overlap between the decommissioning phases of the Tier 3 project and the Proposed Development, as subsea noise levels will return to baseline conditions upon completion of individual activities (such as infrastructure removal) for each project.

9.12.171 As per the Proposed Development, it is likely that subsea noise produced by decommissioning activities associated with the Tier 3 project will be highly limited in extent, with injury and disturbance thresholds not exceeded.

9.12.172 Overall, the cumulative 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 receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.173 The sensitivity of the receptor is as defined in Paragraphs 9.10.223 to 9.10.224 above for the alone assessment.

Significance of effect

9.12.174 Overall, for the herring IEF, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.175 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.176 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 4

Construction, O&M and Decommissioning phases

Magnitude of impact

9.12.177 In addition to the Tier 3 projects identified in Table 9.49, the construction, O&M and decommissioning phases of the Tier 4 project Flora Floating Wind Farm may overlap with that of the Proposed Development. There is potential for cumulative impacts associated with subsea noise during these phases of the Proposed Development.

9.12.178 The Flora Floating Wind Farm is currently in the pre-application stage and therefore there is little known about the potential impacts associated with the project. It is however likely the impacts will be similar to that of Ossian OWF, which is also a floating project but on a smaller scale, as Ossian OWF has a capacity of 3.6 GW and the Flora Floating Wind Farm has a maximum capacity of 50 MW (JERA Nex bp, 2026).

9.12.179 The risk of injury or behavioural effects on fish from Wind Turbine noise, (Paragraphs 9.10.235 to 9.10.238) is considered very low. Given the distance between the Proposed Development and the Tier 4 projects (Table 9.48), it is unlikely that wide-ranging cumulative impacts would occur, given the limited nature of operational noise disturbance to fish and shellfish receptors.

9.12.180 Overall, the cumulative impact is predicted to be of local spatial extent, long term duration, continuous (but at very low levels), and low reversibility (although is reversible upon decommissioning). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.181 The sensitivity of the receptor is as defined in Paragraphs 9.10.223 to 9.10.224 above for the alone assessment.

Significance of effect

9.12.182 Overall, for the herring IEF, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **Minor** adverse significance, which is not significant in EIA terms.

9.12.183 For all other fish and shellfish IEFs, the cumulative magnitude of the impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.184 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

IMPACTS TO FISH AND SHELLFISH DUE TO EMF

Tier 2

O&M phase

Magnitude of impact

9.12.185 There were several Tier 2 projects with the potential for cumulative EMF impacts during the O&M phase of the Proposed Development (Table 9.58). As for the Proposed Development alone, subsea cables associated with these Tier 2 projects could release EMFs into the marine environment. The maximum cumulative length of subsea cables of the Tier 2 projects together with the Proposed Development is estimated at up to 6,073 km (Table 9.58).

9.12.186 Other cable parameters, such as voltage and burial depth, vary between the Proposed Development and the Tier 2 projects and are not possible to combine into one cumulative value, unlike maximum cable lengths. However, cable burial and/or cable protection measures are outlined within the EIAs for the Tier 2 projects, such as those detailed in Table 9.15 for the Proposed Development.

9.12.187 EMFs emitted by subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. The intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al*., 2021). This attenuation is applicable to buried, unburied, and dynamic cables (Hutchison *et al*., 2021). Therefore, the cumulative magnitude of impact with the Tier 2 projects is likely to be highly localised to within metres to tens of metres from cables.

Table 9.58: Cumulative Potential Sources of EMFs for the Tier 2 Projects within the O&M Phase of the Proposed Development

Project	MDS	Source of EMFs	Reference
Proposed Development	397 km	See Table 9.15	N/A
Offshore Wind Projects and Associated Cables			
Kincardine OWF	O&M: 60 km	IACs and Export Cables.	Kincardine OWF Limited (2016)
Berwick Bank Wind Farm	O&M: 2,097 km	IACs and offshore Export Cables.	SSE Renewables (2022)
Seagreen Phase 1A OFTO	O&M: 110 km	Export Cable.	Seagreen 1A (2021)
Seagreen 1 OWF	O&M: 1,200 km	IACs cables and offshore Export Cable.	Seagreen Wind Energy Limited (2012); Seagreen Wind Energy Limited (2018)
Aberdeen OWF	O&M: 39 km	IACs and offshore Export Cable.	(European Offshore Wind Deployment Centre, 2011a); European Offshore Wind Deployment Centre (2011b); European Offshore Wind Deployment Centre (2011c)
Hywind Scotland OWF	O&M: 50 km	IACs and offshore Export Cable.	Statoil (2015)
Ossian OWF	O&M: 1,524 km	IACs and Interconnector Cables.	Ossian OWFL (2024)
Berwick Bank OFTO	O&M: 160 km (in Scottish waters)	Four 40 km HVDC cables (symmetrical monopole) or two 40 km HVDC cables (bipole)	SSE Renewables (2023)
Cables and Pipelines			
Eastern Green Link 2	O&M: 436 km	Interconnector Cable.	(National Grid, 2022)
Total cable length (Proposed Development and Tier 2 projects)	**6,073 km**		

9.12.188 The cumulative impact is predicted to be of local spatial extent, long term duration, continuous, and high reversibility (as cables will be removed and/or de-powered during the decommissioning phase). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.189 The sensitivity of the receptor is as defined in Paragraphs 9.10.271 to 9.10.291 above for the alone assessment.

Significance of effect

9.12.190 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effects is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.191 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 3

O&M phase

Magnitude of impact

9.12.192 In addition to the Tier 2 projects, there were four Tier 3 projects with the potential for cumulative EMF impacts during the O&M phase of the Proposed Development:

- Morven Hawthorn Pit Grid Connection Project (O&M phase);
- Ossian Transmission Infrastructure (O&M phase);
- Eastern Green Link 3 (O&M phase); and
- CNSE Project (O&M phase) (Table 9.49).

9.12.193 As Tier 3 projects, there were no specific cable parameters publicly available to inform the cumulative assessment (e.g. lengths of cables, burial depths, cable protection). However, cable burial and/or cable protection measures are likely to be included within these projects as industry standard, such as detailed in Table 9.15 for the Proposed Development.

9.12.194 EMFs emitted by subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. The intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is applicable to buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, the cumulative magnitude of impact with the Tier 3 projects is likely to be highly localised to within metres to tens of metres from cables.

9.12.195 The cumulative impact is predicted to be of local spatial extent, long term duration, continuous, and high reversibility (as cables will be removed and/or de-powered during the decommissioning phase). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

<u>Sensitivity of receptor</u>

9.12.196 The sensitivity of the receptor is as defined in Paragraphs 9.10.271 to 9.10.291 above for the alone assessment.

<u>Significance of effect</u>

9.12.197 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

<u>Additional Mitigation and residual effect</u>

9.12.198 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

Tier 4

O&M phase

<u>Magnitude of impact</u>

9.12.199 In addition to the Tier 3 project identified in Table 9.49, the O&M period of the Tier 4 project Flora Floating Wind Farm may overlap with that of the Proposed Development. There is potential for cumulative impacts associated with EMF during the operational phases of the Tier 4 project and the Proposed Development.

9.12.200 As with the Tier 3 project, there were no specific cable parameters publicly available to inform the cumulative assessment (e.g. lengths of cables, burial depths, cable protection). However, cable burial and/or cable protection measures are likely to be included within these projects as industry standard, such as detailed in Table 9.15 for the Proposed Development.

9.12.201 EMFs emitted by subsea cables are influenced by a variety of design and installation factors, including distance between cables, cable sheathing, number of conductors, and internal cable configuration. The intensity of EMF from subsea cables decreases at approximately the inverse square/power of the distance away from the cable (Hutchison *et al.*, 2021). This attenuation is applicable to buried, unburied, and dynamic cables (Hutchison *et al.*, 2021). Therefore, the cumulative magnitude of impact with the Tier 3 projects is likely to be highly localised to within metres to tens of metres from cables.

9.12.202 The cumulative impact is predicted to be of local spatial extent, long term duration, continuous, and high reversibility (as cables will be removed and/or de-powered during the decommissioning phase). It is predicted that the impact will affect the receptor directly. The magnitude of impact is, therefore, considered to be low.

Sensitivity of receptor

9.12.203 The sensitivity of the receptor is as defined in Paragraphs 9.10.271 to 9.10.291 above for the alone assessment.

Significance of effect

9.12.204 Overall, for all fish and shellfish IEFs, the cumulative magnitude of impact is deemed to be low and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of Negligible or Minor adverse significance. Applying a precautionary approach, the assessment concluded that the cumulative effect is **Minor** adverse and therefore not significant in EIA terms.

Additional Mitigation and residual effect

9.12.205 No Additional Mitigation is considered necessary because the likely effect in the absence of Additional Mitigation (beyond the Embedded Mitigation measures outlined in Section 9.9) is not significant in EIA terms.

9.13 Proposed Monitoring

9.13.1 There are no proposed monitoring commitments applicable to the identified potential significant adverse impacts related to fish and shellfish.

9.14 Transboundary Effects

9.14.1 A screening of transboundary effects has been carried out (see Volume 3, Technical Appendix 4.5: Transboundary Effects Screening) and has identified that there were no likely significant transboundary effects with regard to fish and shellfish ecology from the Proposed Development upon the interests of EEA states.

9.15 Summary of Impacts, Mitigation, Likely Significant Environmental Effects and Monitoring

9.15.1 Information on fish and shellfish ecology within the Fish and Shellfish Ecology Study Area was collected through a detailed desktop review and the results of site-specific surveys. This information is summarised in Table 9.8 and Table 9.9.

9.15.2 Table 9.59 presents a summary of the assessment of significance in respect to fish and shellfish ecology. Overall, it is concluded that there will be no likely significant environmental effects arising from the Proposed Development during the construction, O&M or decommissioning phases. Although a likely significant effect (moderate adverse) has been concluded for the herring IEF resulting from piling during the construction phase. Prior to the commencement of piling at the Proposed Development, appropriate Additional Mitigation measures will be discussed and agreed with stakeholders. These may include the use of noise abatement systems or site-specific surveys to determine key herring spawning periods. Appropriate mitigation will be secured through the Piling Strategy as a condition of the Section 36 Consent and Marine Licence. It is anticipated that following tailoring of Additional Mitigation measures as described above, the significance of this impact will be reduced to minor adverse for herring, which is not significant in EIA terms.

9.15.3 Table 9.60 presents a summary of the CEA on fish and shellfish ecology in EIA terms. Overall, it is concluded that there will be no likely significant cumulative effects from the Proposed Development alongside other projects/plans. As detailed in Paragraph 9.15.2 appropriate Additional Mitigation measures will be discussed and agreed with stakeholders to reduce the significance of the cumulative impact of subsea piling noise on herring to minor adverse, which is not significant in EIA terms.

9.15.4 No likely significant transboundary effects have been identified in regard to effects of the Proposed Development.

Table 9.59: Summary of Assessment of Significance

Description of Impact	Embedded Mitigation ID	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Mitigation	Significance of Residual Effect	Proposed Monitoring
Construction Phase							
Impact 1 - Temporary habitat loss and/or disturbance	N/A	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor Adverse	None required.	All IEFs – Minor Adverse	None.
Impact 2 - Long term habitat loss and/or disturbance	N/A	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor Adverse	None required.	All IEFs – Minor Adverse	None.
Impact 3 - Colonisation of hard structures	N/A	Low	All IEFs - Low	All IEFs – Minor Adverse	None required.	All IEFs – Minor Adverse	None.
Impact 4 - Increased SSCs and associated deposition	1	Low	Herring and sandeel IEFs – Medium All other IEFs – Low	All IEFs – Minor Adverse	None required.	All IEFs – Minor Adverse	None.

Description of Impact	Embedded Mitigation ID	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Mitigation	Significance of Residual Effect	Proposed Monitoring
Impact 5 - Subsea noise impacting fish and shellfish receptors	3	Low	Herring – High All other IEFs - Low	Herring – Moderate adverse (for piling only) All other IEFs (and herring for all other noise sources) – Minor adverse	Appropriate Additional Mitigation measures will be discussed and agreed with stakeholders. These may include the use of noise abatement systems or site-specific surveys to determine key herring spawning periods. Appropriate mitigation will be secured through the Piling Strategy as a condition of the Section 36 Consent and Marine Licence.	Herring IEF – Minor adverse (after application of appropriate Additional Mitigation)	None.
O&M Phase							
Impact 1 - Temporary habitat loss and/or disturbance	N/A	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Impact 2 - Long term habitat loss and/or disturbance	N/A	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.

Description of Impact	Embedded Mitigation ID	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Mitigation	Significance of Residual Effect	Proposed Monitoring
Impact 3 - Colonisation of hard structures	N/A	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Impact 4 - Increased SSCs and associated deposition	N/A	Low	Herring and sandeel IEFs – Medium All other IEFs – Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Impact 5 - Subsea noise impacting fish and shellfish receptors	N/A	Low	All IEFs – Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Impact 6 - Impacts to fish and shellfish receptors due to EMF	1	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Decommissioning Phase							
Impact 1 - Temporary habitat loss and/or disturbance	34	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Impact 2 - Long term habitat loss and/or disturbance	34	Low	Sandeel, herring and Norway Lobster IEFs – Medium	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.

Description of Impact	Embedded Mitigation ID	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Mitigation	Significance of Residual Effect	Proposed Monitoring
			All other IEFs - Low				
Impact 3 - Colonisation of hard structures	34	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Impact 4 - Increased SSCs and associated deposition	N/A	Low	Herring and sandeel IEFs – Medium All other IEFs – Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Impact 5 - Subsea noise impacting fish and shellfish receptors	34	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.

Table 9.60: Summary of CEA

Description of Impact	CEA Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Mitigation	Significance of Residual Effect	Proposed Monitoring
Construction Phase							
Temporary habitat loss and/or disturbance	Tiers 2 to 4	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Long term habitat loss and/or disturbance	Tiers 2 to 4	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Introduction of artificial habitat and subsequent colonisation	Tiers 2 to 4	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Increased SSCs and associated deposition	Tiers 2 and 3	Low	Herring and sandeel IEFs – Medium All other IEFs – Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.

Description of Impact	CEA Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Mitigation	Significance of Residual Effect	Proposed Monitoring
Subsea noise impacting fish and shellfish receptors	Tiers 2 to 4	Low	Herring – High All other IEFs - Low	Herring – Moderate adverse (for piling only) All other IEFs (and herring for all other noise sources) – Minor adverse	Appropriate Additional Mitigation measures to be discussed and agreed with stakeholders and secured as part of a Piling Strategy post consent to reduce the significance of the cumulative impact of subsea piling noise on herring to minor adverse, which is not significant in EIA terms.	Herring IEF – Minor adverse (after application of appropriate Additional Mitigation)	None.
O&M Phase							
Temporary habitat loss and/or disturbance	Tiers 2 to 4	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Long term habitat loss and/or disturbance	Tiers 2 to 4	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Introduction of artificial habitat and subsequent colonisation	Tiers 2 to 4	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Subsea noise impacting fish	Tiers 2 to 4	Low	All IEFs – Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.

Description of Impact	CEA Tier	Magnitude of Impact	Sensitivity of Receptor	Significance of Effect	Additional Mitigation	Significance of Residual Effect	Proposed Monitoring
and shellfish receptors							
Impacts to fish and shellfish receptors due to EMF	Tiers 2 to 4	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Decommissioning Phase							
Temporary habitat loss and/or disturbance	Tiers 2 to 4	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None proposed.
Long term habitat loss and/or disturbance	Tiers 2 to 4	Low	Sandeel, herring and Norway Lobster IEFs – Medium All other IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Introduction of artificial habitat and subsequent colonisation	Tiers 2 to 4	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.
Subsea noise impacting fish and shellfish receptors	Tiers 2 to 4	Low	All IEFs - Low	All IEFs – Minor adverse	None required.	All IEFs – Minor adverse	None.

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