Environmental Impact Assessment Report
Volume 1, Chapter 13: Fish Ecology

MarramWind Offshore Wind Farm

December 2025

MarramWind

Document code:	MAR-GEN-ENV-REP-WSP-000008
Contractor document number:	852346-WEIS-IA-O1-RP-F4-285191
Version:	Final for Submission
Date:	08/12/2025
Prepared by:	WSP UK Limited
Checked by:	WSP UK Limited
Accepted by:	MarramWind Limited

Contents

Volume 2, Figures:

13. Fish Ecology

13.1 Introduction

13.1.1.1 This Chapter of the Environmental Impact Assessment (EIA) Report presents the results of the assessment of the likely significant effects on fish ecology that may arise from the construction, operation and maintenance (O&M) and decommissioning of the offshore Project seaward of Mean High Water Springs (MHWS). It should be read in conjunction with the project description provided in **Chapter 4: Project Description** and the relevant parts of the following Chapters:

- **Chapter 6: Marine Geology Oceanography and Physical Processes:** Changes to marine geology, oceanography and physical processes have the potential to directly or indirectly impact fish species and habitats due to the reliance on physical processes during certain stages of their lifecycle. Therefore, the information from the marine geology, oceanography and physical processes assessment has informed this Chapter.
- **Chapter 7: Marine Water and Sediment Quality**: Changes to marine water and sediment quality have the potential to impact sensitive fish species and habitats. The information from the marine water and sediment quality chapter has informed this Chapter.
- **Chapter 8: Underwater Noise:** Changes to underwater noise has the potential to directly and indirectly impact fish receptors principally through displacement, barrier effects or potentially being lethal to fish species. Therefore, the information from this assessment has been used to inform this Chapter.
- **Chapter 9: Electromagnetic Fields (EMF)**: EMF emissions from the Project have the potential to impact fish receptors. EMF is emitted from cables and could potentially cause behavioural changes or create a barrier effect to fish species. Therefore, information from the EMF assessment has informed this Chapter.
- **Chapter 10: Benthic, Epibenthic and Intertidal Ecology**: The fish receptor species are sensitive to possible changes on prey resource habitats. Shellfish and potential impacts are considered in that chapter. Additionally, some fish species live within the benthic and intertidal environment as part of their life cycle and therefore there is a degree of overlap with aspects covered in that chapter. Therefore, the benthic, epibenthic and intertidal ecology chapter has informed this Chapter.
- **Chapter 11: Marine Mammals**: Marine mammals considered within this EIA Report include species that rely on fish species as part of their diet and therefore, impacts to fish could potentially indirectly impact marine mammals. The information from this Chapter will be used to inform the marine mammals assessment.
- **Chapter 12: Offshore and Intertidal Ornithology**: The offshore and intertidal ornithology chapter includes some species that rely of fish species as part of their diet and therefore, impacts to fish could potentially impact offshore and intertidal ornithology. The information from this Chapter will be used to inform the offshore and intertidal ornithology assessment.
- **Chapter 14: Commercial Fisheries**: The commercial fisheries chapter includes commercially important species and fisheries data and there is an overlap between these chapters. Commercial fisheries has the potential to directly and indirectly impact fish ecology. Information and data from the commercial fisheries assessment has informed the fish ecology assessment.

- **Chapter 23: Terrestrial Ecology and Ornithology:** This Chapter includes fish species that spend some of their life cycle within both inland waters and the marine environment. Therefore, there is potential for species to overlap between the onshore and offshore environment. Information from the terrestrial ecology and ornithology chapter has been used to inform the assessment on diadromous fish.

13.1.1.2 The shellfish receptor group was originally included in the fish and shellfish section within the Scoping Report (MarramWind Limited, 2023). Consideration of shellfish is now incorporated within **Chapter 10: Benthic, Epibenthic and Intertidal Ecology** as the pressures that shellfish experience, impacts they are susceptible to and responses they exhibit are comparable to other benthic invertebrates. As a result, the amendment to include shellfish within **Chapter 10: Benthic, Epibenthic and Intertidal Ecology** is deemed suitable.

13.1.1.3 This Chapter describes:

- the legislation, planning policy, guidance and other documentation that has informed the assessment (**Section 13.2: Relevant legislative and policy context**);
- the outcome of consultation and engagement that has been undertaken to date, including how matters relating to fish ecology have been addressed (**Section 13.3: Consultation and engagement**);
- the scope of the assessment for fish ecology (**Section 13.4: Scope of the assessment**);
- the data sources and methods used for gathering baseline data including surveys where appropriate (**Section 13.5: Methodology for baseline data gathering**);
- the overall environmental baseline (**Section 13.6: Baseline conditions**);
- the basis for the EIA Report (**Section 13.7: Basis for the EIA Report**);
- methodology for the EIA Report (**Section 13.8: Methodology for the EIA Report**);
- the assessment of fish ecology effects (**Section 13.9: Assessment of effects: construction** ; **Section 13.10: Assessment of effects: operation and maintenance stage; Section 13.11: Assessment of effects: decommissioning**);
- summary of effects (**Section 13.12: Summary of effects**);
- consideration of transboundary effects (**Section 13.13: Transboundary effects**);
- consideration of inter-related effects and cumulative effects (**Section 13.14: Inter-related effects** and **Section 13.15: Cumulative effects assessment**);
- a summary of residual effects for fish ecology (**Section 13.16: Summary of residual likely significant effects**);
- a reference list is provided (**Section 13.17: References**); and
- a glossary and abbreviations is provided (**Section 13.18: Glossary of terms and abbreviations**).

13.1.1.4 This Chapter is also supported by the following figures in **Volume 2**:

- **Figure 13.1: Fish ecology study area**;
- **Figure 13.2: Pelagic fish spawning and nursery grounds**;
- **Figure 13.3: Demersal spawning and nursery grounds**;
- **Figure 13.4: Lesser sandeel probability of occurrence and predicted density**;

- **Figure 13.5: Elasmobranch spawning and nurseries grounds**; and
- **Figure 13.6: Designated sites of relevance to fish ecology**.

13.2 Relevant legislative and policy context and technical guidance

13.2.1 Legislative and policy context

13.2.1.1 This Section identifies the relevant legislation and policy context that has informed the scope of the fish ecology assessment. Further information on policies relevant to the EIA and their status is set out in **Volume 1, Chapter 2: Legislative and Policy Context**, which provides an overview of the relevant legislative and policy context for the Project. **Volume 1, Chapter 2: Legislative and Policy Context** is supported by **Volume 3, Appendix 2.1: Planning Policy Framework**, which provides a detailed summary of international, national, marine and local planning policies of relevance to the EIA. Individual policies of specific relevance to this assessment and associated appendices have been taken into account.

13.2.1.2 This summary provides a foundation for understanding the specific requirements that this Chapter must address in terms of assessing and mitigating impacts on receptors and relevant environmental issues.

13.2.1.3 The legislation and international agreements relevant to fish ecology include:

- Kunming-Montreal Global Biodiversity Framework 2022;
- The European Biodiversity Strategy for 2030, (2020);
- The Aichi Biodiversity Targets 2020;
- The Environment (EU Exit) (Scotland) (Amendment etc.) Regulations 2019;
- The Conservation of Offshore and Marine Habitats and Species Regulations 2017;
- Wildlife and Natural Environment (Scotland) Act 2011;
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011;
- Marine (Scotland) Act 2010;
- The Marine Strategy Regulations 2010;
- Marine and Coastal Access Act 2009;
- Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive (MSFD));
- Nature Conservation (Scotland) Act 2004;
- Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003;
- Water Environment and Water Services (Scotland) Act 2003;
- EC Directive (2000/60/EC) establishing a framework for Community action in the field of water policy (Water Framework Directive (WFD);
- The Conservation (Natural Habitats, &c.) Regulations 1994;
- European Commission (EC) Directive (92/43/EEC) on the conservation of natural habitats and of wild fauna and flora;

- Convention on Biological Diversity 1992;
- Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) 1992;
- Electricity Act 1989;
- The Convention on the Conservation of Migratory Species of Wild Animals (the 'Bonn Convention') 1983;
- Wildlife and Countryside Act 1981;
- Convention on the Conservation of European Wildlife and Natural Habitats (the 'Bern Convention') 1979; and
- Convention on Wetland of International Importance especially as Waterfowl Habitat 1971 (the 'Ramsar Convention').

13.2.1.4 The policy relevant to fish ecology include:

- Draft Updated Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2025a);
- Environment Strategy: progress report – March 2024 (Scottish Government, 2024);
- National Planning Framework 4 (NPF4) 2023 (Scottish Government, 2023a);
- Tackling the Nature Emergency – Scottish biodiversity strategy to 2045 (Scottish Government, 2023b);
- Sectoral Marine Plan for Offshore Wind Energy (Scottish Government, 2020a);
- The Environment Strategy for Scotland: vision and outcomes (Scottish Government, 2020b);
- Scottish National Marine Plan (Scottish Government, 2015a); and
- UK Marine Policy Statement 2011 (Department for Environment, Food and Rural Affairs (Defra, 2011).

13.2.2 Relevant technical guidance

13.2.2.1 Other information and technical guidance relevant to the assessment undertaken for fish ecology include:

- Marine licensing and consenting: offshore renewable energy projects (Scottish Government, 2025b)'
- NatureScot advice on Marine non-native species (NatureScot, 2025a);
- Scottish Government's Feature Activity Sensitivity Tool (FeAST) (Scottish Government, 2025c);
- Marine Evidence-based Sensitivity Assessment (MarESA) – Guidance Manual (Tyler-Walters *et al*., 2023);
- Scottish Wild Salmon Strategy (Scottish Government, 2022);
- Sectoral Marine Plan: regional locational guidance (Scottish Government, 2020c);
- Guidelines for Ecological Impact Assessment in the UK and Ireland – Terrestrial, Freshwater, Coastal and Marine (Chartered Institute for Ecology and Environmental Management (CIEEM), 2018);

- Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options (Boyle and New, 2018);
- Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments (Benjamins *et al*., 2014a);
- Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report (Popper *et al*., 2014);
- Scottish Natural Heritage (SNH) Identification of Priority Marine Features (PMF) (Howson *et al*., 2012);
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy Project (Judd, 2012);
- SNH Guidance on Survey and Monitoring in Relation to Marine Renewables Deployments in Scotland (Saunders *et al*., 2011);
- A Review of Assessment Methodologies for Offshore Wind Farms (Maclean *et al*., 2009); and
- Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR Commission, 2008).

13.3 Consultation and engagement

13.3.1 Overview

13.3.1.1 This Section describes the consultation and stakeholder engagement undertaken on the Project in relation to fish ecology. This includes early engagement, the outcome of and response to the Scoping Opinions (Scottish Government, 2023c; Aberdeenshire Council, 2023) in relation to the fish ecology assessment, non-statutory consultation, and the findings of the Project's Statutory Consultation. An overview of engagement undertaken for the Project as a whole can be found in Section 5.5 of **Chapter 5: Approach to the EIA**.

13.3.2 Key issues

13.3.2.1 A summary of the key issues raised during statutory and non-statutory consultation, specific to fish ecology, is outlined below in **Table 13.1**, together with how these issues have been considered in the production of this EIA Report.

Table 13.1 Stakeholder issues responses – fish ecology

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
NatureScot	210	29 September 2022 NatureScot Meeting.	*"NatureScot asked if the Project could look at the effect that development will have on the entirety of the ecosystem as well as individual receptors. NatureScot cannot provide guidance on how to do this but NatureScot will be looking for it going forward on future Projects. NatureScot also raised concern that in the past impacts can be considered in silo without addressing cascading impacts between chapters."*	On 22 May 2025 the Project provided NatureScot a 'Post-Scoping Clarifications' note that set out MarramWind Limited's (hereafter, referred to as 'the Applicant's') position on ecosystem assessment and asking key questions relating to ecosystem assessment. On 12 June 2025 NatureScot provided a response on the Applicant's position stating "*We are not at the stage where we can recommend a specific methodology for ecosystem assessments in offshore wind Projects. However, we advise that the assessment should focus on potential impacts across key trophic levels, particularly in relation to the availability of prey species*". Therefore, Section 32.6 of **Chapter 32: Inter-Related Effects** includes an ecosystem assessment.
NatureScot	445	12 May 2023 Marine Directorate – Licensing Operations Team (MD-LOT) Scoping Opinion Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Ecosystem assessment* *Increasingly, there is a need to understand potential impacts holistically at a wider ecosystem scale in addition to the standard set of discrete individual receptor assessments. This assessment should focus on potential impacts across key trophic levels particularly in relation to the availability of prey species. This will enable a better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance from the development of the wind farm on seabird and marine mammal (and other top predator) interests and what influence this may have on population level impacts."*	
MD-LOT	302	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.4.2* *Regarding the impulsive underwater noise assessment as noted in Section 5.3.12 of the Scoping Report, the Scottish Ministers advise that this assessment includes vibration (particle motion) for fish and shellfish, which is supported by the SFF. In line with NatureScot's advice, the Scottish Ministers would expect to see, if appropriate to the study area, sandeel, cod, and herring eggs as part of the assessment. In addition, the Scottish Ministers highlight the*	The Project provided a position statement to MD-LOT on 19 January 2024 acknowledging that the issue of particle motion sensitivity in many fish species is recognised and of concern to the wider research community. While recent research papers (for example, Popper and Hawkins, 2018,

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
			representation from Dee DSFB noting the potential form marine renewables to have an impact on salmon through underwater noise."	'The importance of particle motion to fishes and invertebrates') make clear that the detection of the particle motion component of some species (including salmon) is important, there remains a lack of data both in respect of predictions of the particle motion level as a consequence of a noise source such as piling, and a lack of knowledge of the sensitivity of a fish, or a wider category of fish, to a particle motion value. In short, it is insufficient to simply recognise that a species is sensitive to particle motion, we must know how sensitive. Currently, this is absent from the knowledgebase, and therefore there is no practical way to assess the impact of vibration (particle motion) on any species of fish. Popper and Hawkins (2019) acknowledges this, stating that "*since there is an immediate need for updated criteria and guidelines on potential effects of anthropogenic sound on fishes, we recommend, as do our colleagues in Sweden (Andersson et al., 2017), that the criteria proposed by Popper et al. (2014) should be used*". Therefore the use of sound pressure as a proxy for these species remains the best available science for this study and is our intended approach for undertaking the assessment.
NatureScot	522	12 May 2023 MD-LOT Scoping Opinion Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Underwater noise and vibration* *We note that Section 5.3.12 (Underwater noise and vibration) states that impulsive underwater noise will be assessed for relevant fish (and marine mammal) species. We advise that this should also include vibration (particle motion) for fish and shellfish. Sensitive fish species have not been specified but we would expect to see sandeel, cod and herring eggs if appropriate to the study area."*	

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
				MD-LOT responded on 20 February 2024 stating "*MD-LOT has reviewed MarramWind's position statements in response to the Scoping Opinion and notes the update provided by MarramWind. As noted above, the information provided here should be detailed and included within MarramWind's EIA report.*" Particle motion is addressed in this Chapter via the proxy of sound pressure. Further detail on particle motion and the referenced information is provided in **Volume 3, Appendix 8.1: Underwater Noise Modelling Assessment**.
MD-LOT	307	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.5.1 The Scottish Ministers welcome the Developer's proposal to include an EMF assessment as an appended technical report to the EIA Report, which is a view supported by NatureScot. The Scottish Ministers highlight the representation from Dee DSFB and emphasise the importance of including the effects of EMF against salmon within any EMF assessment. The Scottish Ministers are broadly content with the EMF effects noted across the receptor groups, but in line with the NatureScot advice, the Scottish Ministers advise that further consideration should be undertaken in respect of EMF effects on elasmobranchs."*	**Chapter 9: Electromagnetic Fields** has analysed the extent to which EMF emissions could occur in the marine environment as a result of the Project. These findings have then been interpreted in relation to sensitive fish species including salmon and elasmobranchs in **Section 13.10.7**.
MD-LOT	335	12 May 2023 MD-LOT Scoping Opinion	*"5.9.1 The Scottish Ministers are broadly content with the study area as defined in Section 5.8.6 and Figure 5.8.1 of the Scoping Report.*	The sediment modelling output from **Volume 3, Appendix 6.3: Marine Geology, Oceanography and**

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		(Scottish Government, 2023c).	*The Scottish Ministers advise that the NatureScot representation regarding noise modelling outputs and suspended sediment modelling outputs are considered when determining the boundary during further refinement of the Project envelope."*	**Physical Processes Baseline Report** has informed the fish ecology assessment, see **Sections 13.9.3** and **13.10.5**. The underwater noise modelling output from **Volume 3, Appendix 8.1** has informed the fish ecology assessment see **Sections 13.9.4**, **13.10.6** and **13.11.4**.
MD-LOT	336	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.2 Regarding baseline characterisation, the Scottish Ministers advise that the additional technical guidance, baseline data sets, and data sources identified by NatureScot must be used in the assessment in the EIA Report. The Scottish Ministers acknowledge that the Developer has noted the relevance of invasive non-native species ("INNS") throughout the technical guidance and data sets but advise that the EIA Report must provide details on how INNS will be considered, monitored, and recorded. Additionally, biosecurity plans for each phase of the development should be considered in full regarding INNS."*	The additional technical guidance, baseline data sets and data sources identified by NatureScot with relevance to shellfish have been used in the Fish Ecology assessment. The **Outline Offshore Invasive Non-Native Species Plan** is detailed within **Volume 4**.
MD-LOT	337	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.3 Regarding the identification of key species, in line with the NatureScot representation, the Scottish Ministers advise that the Developer must fully implement in NatureScot advice regarding, pelagic fish, elasmobranchs, migratory fish, diadromous fish, and shellfish. Additionally, Table 5.8.14 of the Scoping Report should be updated to include the minke whale feature of the Southern Trench Marine Protected Areas ("MPA") as there may be impacts to this protected feature via impacts on prey fish species."*	The NatureScot advice in relation to fish receptor groups has been utilised within the fish ecology assessment. Impacts on prey fish species are considered, for interpretation of effects on features of the Southern Trench Nature Conservation Marine Protected Area (NCMPA) in **NCMPA Assessment**.
MD-LOT	338	12 May 2023 MD-LOT Scoping Opinion	*"5.9.4 Additionally, any connectivity these species have back to natal rivers must be considered and assessed through the EIA Report*	Diadromous fish are considered as a receptor within the Fish Ecology Chapter, with Potential activities in the

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		(Scottish Government, 2023c).	*rather than the HRA Report. The Scottish Ministers are aware of ongoing research in this area which may later change this advice and may change conclusions on how diadromous fish are treated in both EIA and HRA going forward."*	Offshore Red Line Boundary that could indirectly or directly impact these fish species or their migratory pathways appropriately assessed. Onshore activities and potential effects on natal rivers and diadromous fish in a freshwater setting are assessed in **Chapter 23: Terrestrial Ecology and Ornithology.**
MD-LOT	339	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.5* *Potential impacts proposed to be scoped into the EIA Report are outlined in Table 5.8.16 of the Scoping Report. The Scottish Ministers agree that habitat loss and disturbance is a key impact pathway for the construction, operation and maintenance, and decommissioning stages of the Proposed Development. In addition to these phases, the Scottish Ministers advise in line with the NatureScot representation that relevant pre-construction seabed preparation works are also included in the EIA Report. Additionally, the advice provided in Section 5.4 of the Scoping Opinion regarding impacts from underwater noise and vibration on fish and fish and shellfish should be implemented in the EIA Report."*	This Chapter assesses the impacts stated, including habitat loss and disturbance, pre-construction seabed preparation works and underwater noise and vibration, across each stage of the Project for all fish receptors. See **Sections 13.9, 13.10** and **13.11**.
MD-LOT	340	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.6* *Scottish Ministers welcome the Developer's decision to scope in the loss of suitable substrate or sensitive habitats of importance to fish receptors via the introduction of the Proposed Development. Given the uncertainty of the effects caused by introducing floating WTGs, anchoring systems, and cabling, the Scottish Ministers advise in line with the NatureScot representation that colonisation of hard structures is also scoped into the EIA Report."*	This Chapter assesses the impacts stated, including loss of habitat, introduction of hard substrate and colonisation of hard structures, across each stage of the Project for all fish receptors. See **Sections 13.9, 13.10** and **13.11**.
MD-LOT	341	12 May 2023 MD-LOT	*"5.9.7*	See response to stakeholder issue ID 528.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Scoping Opinion (Scottish Government, 2023c).	*Regarding changes in prey species availability and INNS, the Developer should ensure that the NatureScot response in this regard is fully addressed in the EIA Report."*	
MD-LOT	342	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.8 The Scottish Ministers agree with the remaining impacts scoped into and out of the EIA Report. For the avoidance of doubt, The Developer must fully address the representation from NatureScot in the EIA Report."*	Noted. See responses to NatureScot representation.
MD-LOT	343	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.9 The Scottish Ministers are broadly content with the approach to assessment set out in Sections 5.8.15 to 5.8.17 of the Scoping Report. In line with the Natural England representation, the Scottish Ministers agree with the Developer's decision to scope impacts to the River Tweed SAC and the Tweed estuary SAC into the EIA Report as these designated sites may have connectivity to the Proposed Development."*	Potential impacts to designated sites are considered in this Chapter. The River Dee SAC is within the study area and therefore activities associated with the Project that may impact the SAC or its features are assessed. It is recognised that stock from other salmon rivers (including the River Tweed SAC) located further afield along the east of Scotland may have potential for connectivity with the activities associated with the Project. However, due to the larger distance from the Offshore Red Line Boundary and potential for greater dispersion of individuals from those rivers, it is deemed likely that effects would be lesser than that to populations from the Dee. An assessment has been undertaken for the River Dee and any outcome are considered the maximum effect for other SAC rivers with

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
				migratory fish. See **Sections 13.9.7, 13.10.10** and **13.11.7** for assessment of potential impacts on designates sites across the construction, O&M and decommissioning stages of the Project.
MD-LOT	344	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.10 The Scottish Ministers, in line with the NatureScot representation, advise that the assessment should quantify where possible the likely impacts on PMFs and consider whether this could lead to a significant impact on the national status of the PMFs being considered."*	This Chapter assesses potential impacts on PMF fish species. PMFs likely to be present in the study area are listed in **Section 13.6.**
MD-LOT	345	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.11 With regards to cumulative effects, the Scottish Ministers advise in line with the NatureScot representation that the Developer must consider the cumulative effects of key impacts such as habitat loss or change, especially concerning diadromous fish as well as key fish and shellfish species that contribute to ecological importance as a prey resource."*	**Chapter 33: Cumulative Effects Assessment** includes an assessment of cumulative effects of habitat loss and considers diadromous fish and other key fish species as impact receptors and includes consideration of their ecological importance as a prey resource.
MD-LOT	346	12 May 2023 MD-LOT Scoping Opinion (Scottish Government, 2023c).	*"5.9.12 With regards to mitigation and monitoring, the Scottish Ministers agree with the NatureScot representation that the full range of mitigation techniques and published guidance should be considered and discussed in the EIA Report as well as further information on proposed monitoring."*	This Chapter references the published guidance on mitigation and monitoring. Information on embedded mitigation measures relevant to Fish Ecology is provided in **Table 13.17.**
Dee District Salmon Fishery Board (DSFB)	403	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation	*"Designations & Conservation Status As statutory body charged with the protection of Atlantic salmon and sea trout (Salmo trutta) stock within its district, the Dee DSFB has a duty to ensure that there are no significant adverse impacts upon the populations of these species.*	The designation of the River Dee as a SAC has been recognised in this report, and activities that have a potential impact on its features are assessed. See **Sections 13.9.7, 13.10.10** and

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Responses & Advice (Scottish Government, 2023c).	*The Dee has been designated as a Special Area of Conservation under the EC Habitats Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna for Atlantic Salmon (the principal species for which it receives this designation). The Dee District also supports populations of trout, eels and brook, river and sea lampreys.(Petromyzon marinus).* *Sea trout, common to all the rivers within the Dee District, are a priority species under the United Kingdom's Biodiversity Action Plan (UKBAP).* *All lamprey species are protected under the EC Habitats Directive whilst river and sea lampreys are additionally protected under the UKBAP priority list.* *Eels are a UKBAP priority species, critically endangered under the IUCN red list and protected under CITES."*	**13.11.7** for assessment of potential impacts on designated sites across the construction, O&M and decommissioning stages of the Project. Potential impacts from offshore activities across the construction, O&M and decommissioning stages on migratory species including Atlantic salmon, sea trout, European eel and lamprey have been assessed within the diadromous fish receptor group. See **paragraph 13.6.1.79** for baseline information.
Dee DSFB	404	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Wild Salmon Strategy and Conservation regulations Furthermore, the Conservation of Salmon (Scotland) Regulations 2016 has led to the production of stock assessments for all Scottish salmon rivers, based on catch data. The assessments estimate whether the number of adults returning to the river in each of the previous five year will produce enough eggs to keep the population size above a critical threshold."*	This Chapter uses stock assessments based on catch data to inform the baseline for salmonid fish, alongside other data sources. See **Section 13.6**.
Dee DSFB	405	12 May 2023 MD-LOT Scoping Opinion. Appendix 1:	*"Wild Salmon Strategy and Conservation regulations In January 2022, the Scottish Government released its Wild Salmon Strategy which gave a clear message that there is sadly now unequivocal evidence that populations of Atlantic Salmon are*	This Chapter references the Scottish Wild Salmon Strategy (Scottish Government, 2022) and considers the key pressures identified, with potential

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Consultation Responses & Advice (Scottish Government, 2023c).	*at crisis point. The Strategy calls on government agencies, as well as the private sector, to prioritise the protection and recovery of Scotland's wild Atlantic salmon populations.* *One of the key pressures identified in the strategy is marine development, with marine renewables highlights as having the potential to impact salmon through noise, water quality and effects on electromagnetic fields (EMFs) used by salmon for migration."*	impacts to salmon through noise, water quality and EMF assessed for each stage of the Project.
Dee DSFB	406	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Wild Salmon Strategy and Conservation regulations* *For the Dee, like other north-east rivers, the assessments have shown a declining trend in catches since 2011. Nonetheless, the Dee has been categorised as a Grade 1 river, meaning that the stocks have most likely been above the critical threshold - the Conservation Limit - over the last five years."*	This Chapter uses stock assessments based on catch data to inform the baseline for salmonid fish, alongside other data sources. See **Section 13.6**.
Dee DSFB	407	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Wild Salmon Strategy and Conservation regulations* *Assessment of the juvenile salmon stocks in the Dee through the National Electrofishing Programme for Scotland (NEPS) has evaluated juvenile stocks in the Dee as Grade 2, suggesting that there are significant issues with recruitment and survival within the catchment (Malcolm et al., 2020). With greater pressures on marine survival such that only approximately 3% of smolts return to the river as adults, we need to address any pressures within the freshwater and marine environments to protect Dee salmon stocks."*	Atlantic salmon (*Salmo salar*) within the marine environment are considered as a receptor within this Chapter, with potential activities in the Offshore Red Line Boundary that could indirectly or directly impact these fish species or their migratory pathways are appropriately assessed. Onshore activities and potential effects on natal rivers and diadromous fish in a freshwater setting are assessed in **Chapter 23: Terrestrial Ecology and Ornithology**.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
Dee DSFB	408	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"The Dee DSFB welcomes the opportunity to respond to the scoping opinion and would wish to be consulted further during this process with specific interest in the migratory fish species Atlantic salmon and sea trout."*	Further engagement with the Dee DSFB relating to migratory fish species is welcomed.
Dee DSFB	409	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"We note that the location of the proposed site, cable corridor and landfall are out with the Dee District Salmon Fishery Board district and that the Dee SAC is approximately 39km southwest from the fish scoping boundary. However, due to the migratory nature of Atlantic salmon and sea trout we are pleased to see that these migratory fish have been considered and 'scoped in' to the assessment on a range of 'activities and impacts' at this stage. The likelihood of encountering stock from the Dee within the proposed development site boundary is unknown, but evidence suggests that the proposed development site is within typical migration routes for adult and juvenile life stages of both species."*	The River Dee SAC is found within the study area and activities that have a potential impact on its features are assessed. See **Sections 13.9.7**, **13.10.10** and **13.11.7** for assessment of potential impacts on designates sites across the construction, O&M and decommissioning stages of the Project. The migratory nature of salmon has also been considered, including potential pathways through the Offshore Red Line Boundary, and assessment of salmon under the diadromous fish receptor group are appropriately undertaken.
Dee DSFB	410	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish	*"Table 5.4.3 in the 'Consultation' section of the report refers to the ScotMER Diadromous Fish Specialist Receptor Group. We note that this is the only reference to this group, and we would therefore suggest that further consultation takes place with Marine Scotland Science and Fisheries Management Scotland with reference to broadening our understanding of any potential impact upon diadromous fish as a result of this proposed development."*	Pre-application information has been provided to Marine Scotland Science and Fisheries Management Scotland in 2025 on the approach to assessing potential impacts to diadromous fish in the EIA.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Government, 2023c).		
NatureScot	502	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"We are broadly content with the fish and shellfish study area as defined in Section 5.8.6 and Figure 5.8.1, which comprises:* • *the offshore Scoping Boundary together with the Zone of Influence (ZOI) up to the MHWS mark;* • *the ZOI is based on the tidal excursion, coastal processes and potential spread of underwater noise;* • *the ZOI buffer encompasses the area over which suspended sediments may travel following disturbance as a result of the Project's activities, extending 15km around the array Scoping Boundary and a distance of 15km surrounding the offshore cable corridor; and* • *noting that species which require a larger study area will be considered as appropriate."*	Noted. For the fish ecology assessment, the study area has been extended to 50km due to modelling from **Volume 3, Appendix 8.1** showing potential behavioural impacts for fish up to 50km from impact piling activities resulting in noise and vibration effects. Additionally, this larger study area includes impacts on diadromous fish species which are features of the River Dee SAC (see **Volume 2, Figure 13.6**).
NatureScot	504	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"We note that further refinement of the study area will be reviewed and amended in response to refinement of the Project envelope, identification of impact pathways and feedback from consultation. We therefore advise that underwater noise modelling outputs and suspended sediment modelling outputs may help determine the boundary."*	The study area has been extended to 50km due to modelling from **Volume 3, Appendix 8.1** showing potential behavioural impacts for fish up to 50km from impact piling activities resulting in noise and vibration effects. Additionally, this larger study area includes impacts on diadromous fish species which are features of the River Dee SAC (see **Volume 2, Figure 13.6**). Suspended sediment modelling outputs (**Volume 3, Appendix 6.3**) have been considered but did not result in a requirement to extend the study area.
NatureScot	506	12 May 2023 MD-LOT	*"We are content that Table 5.8.1 correctly identifies the relevant legislation and policy for this topic."*	This comment is acknowledged. **Section 13.2** provides a list of the

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).		legislation and policy relevant to fish ecology.
NatureScot	507	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Table 5.8.2 correctly identifies most of the relevant technical guidance for this topic. We recommend inclusion of the NatureScot Commissioned Report 791 "Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments"* (Benjamins *et al.*, 2014a). *Other guidance that may become applicable later in the EIA process will likely include: JNCC guidance on underwater noise* (JNCC, 2024)*, unexploded ordnance clearance - joint interim position statement* (Department for Environment Food and Rural Affairs *et al*., 2021) *and the Scottish Marine Wildlife Watching Code* (NatureScot, 2017*). We also confirm that Table 5.3.2 correctly identifies the most relevant technical guidance on underwater noise and fish receptors."*	This Chapter references and uses the NatureScot Commissioned Report 791 (Benjamins *et al.,* 2014a) to inform assessment of entanglement risk. While primarily relating to marine mammals, JNCC guidance on underwater noise, UXO clearance and the Scottish Marine Wildlife Watching Code have been considered in this Chapter.
NatureScot	508	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"We are content that Table 5.8.8 captures most of the relevant baseline datasets, but recommend inclusion of "Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland"* (Franco et al., 2022) *developed by the Scottish Marine Energy Research (ScotMER) programme, which is due for publication shortly.* *We also recommend inclusion of the Feature Activity Sensitivity Tool (FeAST)* (Scottish Government, 2025c)*, which is due to be updated with fish and shellfish information by the end of March 2023.*	The Scottish Marine Energy Research (ScotMER) published 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' (Franco *et al.*, 2022) has been used to inform the baseline of this Chapter. The FeAST tool (Scottish Government, 2025c) has been used to inform the fish ecology assessment.
NatureScot	509	12 May 2023 MD-LOT	*"With regard to data sources relating to fish and EMF, we recommend that a recent MSc paper by Lucie Hervé "An evaluation*	The recommended paper (Hervé, 2021) has been used to inform the

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*of current practice and recommendations for environmental impact assessment of electromagnetic fields from offshore renewables on marine invertebrates and fish" is included as a data source in Table 5.4.4. We can supply a copy of this paper on request."*	assessment of EMF in **Chapter 9: Electromagnetic Fields** and subsequently informs this Chapter.
NatureScot	510	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"We support the proposed approach of carrying out a desk-based review of existing fish and shellfish ecology data, focusing on sourcing data that has been collected within or in close proximity to the study area. This will be supplemented by fish and shellfish information obtained from site-specific benthic ecology surveys, although no direct fish survey will be completed for this development site."*	A desk-based review of existing fish ecology data, including data collected within or in close proximity to the study area and information from site-specific surveys on sediments, DAS, catch data and other data sources has been undertaken to appropriately inform the baseline of this Chapter. For data sources, see **Table 13.5.** For site specific surveys, see **Table 13.6.**
NatureScot	511	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Pelagic fish* *Table 5.8.9 lists pelagic fish, this should be updated to identify blue whiting (Micromesistius poutassou) as a Scottish PMF species."*	Blue whiting has been added to the pelagic fish baseline section of this Chapter (see **Section 13.6.1**) and identified as a Scottish PMF species, see **Table 13.8.**
NatureScot	512	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation	*"Demersal fish* *We support the specific consideration of sandeel as a key prey species (Sections 5.8.38-39) and note the presence of high intensity spawning grounds for this species within the study area, as well as low intensity spawning grounds for cod, plaice, saithe*	Sandeel and their importance as a key prey species, and presence of high intensity spawning grounds in the study area have been considered in the fish ecology assessment.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Responses & Advice (Scottish Government, 2023c).	*(Pollachius virens) and whiting (Section 5.8.37). All of these species are sensitive to impacts caused by offshore wind developments."*	Cod (*Gadus morhua*), plaice (*Pleuronectes platessa),* saithe and whiting and their ecological and commercial importance has been considered, alongside presence of spawning grounds to inform the fish ecology assessment.
NatureScot	513	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Elasmobranchs Further consideration of this group should be undertaken in respect of dynamic cabling and EMF effects."*	Elasmobranchs and consideration of potential impacts from dynamic cabling and EMF has been considered in this Chapter. See **Section 13.10.7**.
NatureScot	514	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Migratory/ diadromous fish Table 5.8.12 correctly identifies European eel as a conservation priority across several criteria. However very little is known about their migratory pathways, either as juveniles or adults. Malcolm et al. (2010) contains a review of available data in relation to migration routes and behaviour, and Gill & Bartlett (2010) on effects of noise and electromagnetic fields (EMF) on European eel as well as sea trout."*	The ecological importance and conservation priority plus the limited understanding of migratory pathways of European eel (*Anguilla Anguilla)* is considered in the Fish ecology assessment. Both Malcolm *et al*. (2010) and Gill and Bartlett (2010) have been used to inform the assessment of impacts (including underwater noise and EMF) on diadromous fish receptors. See **Sections 13.9.4 and 13.10.7** respectively.
NatureScot	515	12 May 2023 MD-LOT	*"Migratory / diadromous fish*	This Chapter references the Scottish Wild Salmon Strategy (Scottish

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*Atlantic salmon are undergoing a significant decline across their global range, and numbers in Scotland have declined dramatically since 2010. This has led to the recent publication of the Scottish Wild Salmon Strategy (Scottish Government, 2022)35, and continuing high levels of mortality at sea is a significant issue."*	Government, 2022) and considers the key pressures identified, with potential impacts to Atlantic salmon through noise, water quality and EMF assessed for each stage of the Project. See **Sections 13.9, 13.10 and 13.11**.
NatureScot	516	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Migratory / diadromous fish Sea trout support a number of fisheries in Scotland and many of these fisheries have undergone declines in the last 25 years. Note that juvenile Atlantic salmon and trout (including those that will become sea trout) can also be a host species for freshwater pearl mussel Margaritifera margaritifera."*	Freshwater pearl mussel (*Margaritifera margaritifera*) have been included as a receptor as detailed in **Section 13.6.1**. Freshwater pearl mussel are also considered in this Chapter as a feature of the River Dee SAC and where impacts to Atlantic salmon and sea trout are assessed due to its life stage dependence on these diadromous fish species.
NatureScot	517	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Migratory / diadromous fish Due to uncertainty on where migratory fish (Atlantic salmon, sea trout and sea and river lamprey) go within marine waters and any connectivity back to natal rivers we consider these species should be considered and assessed through EIA only and not through HRA. We are aware of work being led by ScotMER on the Review of Evidence of Diadromous Fish, and this is an area of research which may change conclusions on how diadromous fish are treated in both EIA and HRA going forward."*	Diadromous fish are considered as a receptor within this Chapter, with Potential activities in the Offshore Red Line Boundary that could indirectly or directly impact these fish species or their migratory pathways appropriately assessed. Onshore activities and potential effects on natal rivers and diadromous fish in a freshwater setting are assessed in **Chapter 23: Terrestrial Ecology and Ornithology**.
NatureScot	519	12 May 2023 MD-LOT Scoping Opinion.	*"Designated sites Table 5.8.14 should be updated to include the minke whale feature of the Southern Trench MPA (currently only burrowed mud is*	Impacts on prey fish species are considered in this Chapter, for interpretation of effects on features of

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*included). Minke whale prey on sandeel, herring and mackerel they are sensitive to prey depletion and this predator/ prey relationship should be explored for this development site."*	the Southern Trench NCMPA in **NCMPA Assessment**. Impacts on prey species in relation to marine mammals are also considered in **Chapter 32: Inter-Related Effects**.
NatureScot	520	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Habitat loss and disturbance* *Habitat loss and disturbance (temporary and long-term) is a key impact pathway identified for the construction, operation and maintenance, and decommissioning stages. We recommend that any relevant pre-construction seabed preparation works are also included in assessment."*	Pre-construction seabed preparation works are included for assessment as a potential impact pathway in this Chapter. See Impact C1, assessed in **Section 13.9.2**.
NatureScot	521	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Underwater noise and vibration* *We support scoping in the effect of underwater noise during construction and decommissioning stages, and the effects of UXO clearance. We support scoping in the effects of underwater noise during the operation and maintenance phase. These effects arising from floating wind turbine generators, their anchoring systems and cabling are not well understood at present. This will require further discussion and agreement with Marine Scotland and NatureScot."*	**Volume 3, Appendix 8.1** provides the modelling results. The Project had further engagement with MD-LOT and NatureScot in September 2025 regarding the findings of the underwater noise assessment. The possibility of an early review of the underwater noise chapter by NatureScot was discussed. NatureScot confirmed they will await to review the final version in the EIA Report.
NatureScot	523	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation	*"Increased hard substrate and structural complexity* *We support scoping in the loss of suitable substrate or sensitive habitats of importance to fish receptors via the introduction of Project elements. The effects of introducing floating wind turbine generators, anchoring systems and cabling are not well understood*	Colonisation of hard structures has been scoped into assessment for fish ecology receptors in this Chapter. See Impact O3, **Section 13.10.4**.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Responses & Advice (Scottish Government, 2023c).	*at present, and so we recommend that colonisation of hard structures is scoped into assessment. This potential impact is also linked to the potential need to remove marine growth, and methods for achieving this."*	
NatureScot	524	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"EMF* *We welcome the scoping in of EMF effects on fish and shellfish receptors as another impact pathway that is not well understood at present, to increase our understanding of the effects of dynamic cables, particularly as floating wind becomes an established technology."*	Noted. Consideration of potential impacts from dynamic cabling and EMF has been considered in **Chapter 9: Electromagnetic Fields**, and subsequently in this Chapter in **Section 13.10.7**.
NatureScot	525	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"EMF* *We note that cable burial/ Cable Burial Risk Assessment are listed as embedded environmental measures (Table 5.8.15).* *However we highlight research by Hutchinson et al. (2020) which establishes that cable burial may actually generate a response from sensitive species, as it reduces EMF levels to the 'normal' range that species use to hunt prey or navigate.*	The recommended paper has been used to inform the assessment of EMF on marine invertebrates and fish in **Chapter 10: Benthic, Epibenthic and Intertidal Ecology** and this Chapter.
NatureScot	526	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Potential impacts on Southern Trench MPA* *There may be impacts on the minke whale protected feature of the Southern Trench MPA via impacts on prey fish species from the export cable route and we recommend this is scoped into assessment."*	Impacts on prey fish species are considered in this Chapter, for interpretation of effects on features of the Southern Trench NCMPA in **NCMPA Assessment**. Impacts on prey species in relation to marine mammals are also considered in **Chapter 32: Inter-Related Effects.**

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
NatureScot	527	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*“Changes in prey species availability More consideration is required in the EIA Report to ensure that impacts to key prey species (such as sandeel, herring, mackerel and sprat) and their habitats are considered for this development and in combination with other wind farms. As mentioned above we recognise that most EIA Reports concentrate on receptor specific impacts. However, increasingly we need to understand impacts at the ecosystem scale. Therefore, consideration across key trophic levels will enable better understanding of the consequences (positive or negative) of any potential changes in prey distribution and abundance on marine mammal (and other top predator) interests and how this may influence population level impacts. 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. In addition, the PrePARED (Predators and Prey Around Renewable Energy Developments).* *Project will also assist in the understanding of predator-prey relationships in and around offshore wind farms which started in 2022 and will run for five years.”*	Impacts on prey fish species are considered in this Chapter. The PrePARED Project has been reviewed to inform the impact assessment associated with predator-prey relationships associated with new infrastructure associated with the Project. For inter-related effects and the ecosystem assessment, see **Chapter 32: Inter-Related Effects**.
NatureScot	528	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Invasive non-native species (INNS) We advise that the EIA Report should provide details on how INNS will be considered, monitored and recorded as well as being taken into account of in biosecurity plans for each phase of the development."*	INNS are considered as a potential impact on fish ecology receptors in this Chapter. For assessment of effects, see **Sections 13.9.8**, **13.10.11** and **13.11.8**. An **Outline Offshore Invasive Non-Native Species Management Plan** has been submitted with this Application (**Volume 4**).

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
NatureScot	529	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"Impacts to be scoped out* *We agree with the proposed impacts to be scoped out for fish and shellfish: accidental pollution, and collision risk and entanglement."*	This comment is acknowledged. **Section 13.4.6** provides effects scoped out and associated justification.
NatureScot	530	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"We broadly support the approach to assessment set out in Sections 5.8.15-17.* *Priority Marine Features (PMFs)* *We recommend that the assessment should quantify, where possible, the likely impacts to key fish and shellfish PMFs. It should assess whether these could lead to a significant impact on the national status of the PMFs being considered."*	This Chapter assesses potential impacts on PMF fish species. PMFs likely to be present in the study area are listed in **Section 13.6**.
NatureScot	531	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"We note the anticipated list of impacts likely to be scoped into cumulative assessment in Section 5.8.66. The cumulative assessment should consider the cumulative effect of key impacts such as habitat loss/ change particularly in relation to diadromous fish, as well as key fish and shellfish species that contribute ecological importance as a prey resource. This may differ depending on the life stage being considered."*	**Chapter 33: Cumulative Effects Assessment** includes an assessment of cumulative effects of habitat loss and considers diadromous fish and other key fish species as impact receptors and includes consideration of their ecological importance as a prey resource with 'other developments'.
NatureScot	532	12 May 2023 MD-LOT Scoping Opinion. Appendix 1:	*"We welcome the embedded environmental measures described in Table 5.8.15. We advise that the full range of mitigation measures and published guidance is considered and discussed in the EIA Report."*	**Section 13.7.2** provides embedded environmental measures relevant to fish ecology. Technical guidance used to

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
		Consultation Responses & Advice (Scottish Government, 2023c).		inform this Chapter are listed in **Section 13.2.2**.
NatureScot	533	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"No specific monitoring for fish and shellfish is mentioned in the Scoping Report, although the list of embedded environmental measures includes a commitment to implement a Project Environmental Monitoring Plan which will set out commitments to environmental monitoring. Further information on proposed monitoring should be discussed in the EIA Report."*	It is not anticipated that additional monitoring will be required specific to fish receptors as result of activities associated with this project. However, **Volume 4: Outline Project Environmental Monitoring Programme** details commitments to environmental monitoring.
Scottish Fishermen's Federation	618	12 May 2023 MD-LOT Scoping Opinion. Appendix 1: Consultation Responses & Advice (Scottish Government, 2023c).	*"For P5.8.19, para 5.4.35, the SFF would expect the Project to adhere to the guidelines for protection of spawning herring."*	This will be covered within the **NCMPA Assessment** if an NCMPA near the Project is protected by herring spawning.
Marine Science Scotland	660	30 September 2022, Meeting.	*"Marine Science Scotland asked will the scoping area be reviewed for migratory fish as there is significant migratory flow in a Northerly direction through the scoping boundary?"*	For this Chapter, the study area has considered migratory fish and the potential for migratory movement north along the Aberdeenshire coastline and through the Offshore Red Line Boundary. The study area is defined in **Section 13.4.2**.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
NatureScot	661	30 September 2022, Meeting.	*"NatureScot recommended that the Project uses the ScotMER Essential Fish Habitat Mapping Report."*	The Scottish Marine Energy Research (ScotMER) published 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' (Franco *et al.*, 2022) has been used to inform the baseline of this Chapter.
Marine Science Scotland	662	30 September 2022, Meeting.	*"Marine Science Scotland raised that existing data indicates that there a significant concentration of Smolt that use the area. MN said that WSP should consider that changes to migration routes can lead to an increase in prey and predator interaction."*	It is acknowledged that existing data indicates significant concentrations of smolt may use the habitats in and in close proximity to the Offshore Red Line Boundary. Consideration of potential changes to migration routes and the effect on prey and predator reactions are considered in this Chapter and both **Chapter 33: Cumulative Effects** and **Chapter 32: Inter-Related Effects**.
MD-LOT	674	16 June 2023 Email.	*"Update on ScotMER* *The updated evidence maps were published in late January 2023 and are available via the ScotMER webpage: https://www.gov.scot/policies/marine-renewable-energy/science-and-research/* *Work continues with the ScotMER Receptor Groups to review and refine the evidence maps. Management of developer representation on ScotMER Receptor Groups is through Scottish Renewables.* *Since our last update in October 2022, we have published the outcomes of 3 research Projects. The research Projects published are:*	The Scottish Marine Energy Research (ScotMER) published 'Essential Fish Habitat Maps for Fish and Shellfish Species in Scotland' (Franco *et al.*, 2022) has been used to inform the baseline of this Chapter. The published research projects referenced: France *et al.* (2022) and have been reviewed and used to inform this Chapter. Deakin *et al.* (2022) and the Sectoral Marine Plan reference primarily relate to seabirds and therefore not relevant to this Chapter.

Stakeholder	Stakeholder issue ID	Date, document, forum	Stakeholder comment	How is this addressed in the EIA Report
			• *Developing essential fish habitat maps for fish and shellfish species in Scotland (May 2023) https://www.gov.scot/publications/developing-essential-fish-habitat-maps-fish-shellfish-species-scotland-report/* • *A review to inform the assessment of the risk of collision and displacement in petrels and shearwaters from offshore wind developments in Scotland (December 2022) https://www.gov.scot/publications/review-inform-assessment-risk-collision-displacement-petrels-shearwaters-offshore-wind-developments-scotland/* • *Sectoral Marine Plan roadmap actions (December 2022).”*	

13.4 Scope of the assessment

13.4.1 Overview

13.4.1.1 This Section sets out the scope of the EIA for fish ecology. This scope has been developed as the Project's design has evolved and responds to stakeholder feedback received to-date, as set out in **Section 13.3**.

13.4.2 Spatial scope and study area

13.4.2.1 The spatial scope of the fish ecology assessment is defined as the Option Agreement Area (OAA) and offshore export cable corridor up to MHWS (see **Volume 2, Figure 4.2: Offshore Red Line Boundary**) plus a 50 kilometres (km) Zone of Influence (ZOI). Together, these areas define the study area presented in this Section and illustrated in **Volume 2, Figure 13.1**.

13.4.2.2 To ensure a precautionary approach, a buffer zone extending 50km beyond the Offshore Red Line Boundary has been applied. This has taken account of potential direct and indirect impacts on fish species, including, but not limited to, disturbance or injury resulting from underwater noise from piling, temporary habitat loss and increased suspended sediment concentrations (SSC) and associated deposition. The use of 50km as a precautionary ZOI for underwater noise aligns with both the noise modelling conducted for the Project (see **Volume 3, Appendix 8.1**) for more information), and that of other offshore wind Projects such as CENOS (Xodus, 2024) and Berwick Bank Offshore Wind Farm (SSER, 2022), which identified behavioural impacts within this range. Furthermore, this ZOI accounts for fish mobility and their spawning / nursery grounds, along with capturing coastal waters to accommodate diadromous fish and their movements.

13.4.2.3 A wider regional context has been considered for diadromous fish species. Given the extensive open ocean and near shore migrations undertaken by these species, there is the potential for activities associated with the Project to affect stocks within natal waters at some distance from the Project. The River Dee Special Area of Conservation (SAC) and its features are included within the study area. However, it is recognised that stock from other salmon rivers located further afield along the east of Scotland may have potential for connectivity with the activities associated with the Project.

13.4.3 Temporal scope

13.4.3.1 The temporal scope of the assessment of fish ecology is the entire lifetime of the Project, which therefore covers the pre-construction, construction, O&M, and decommissioning stages of the Project. It is anticipated that the construction of the Project will commence in 2030, with the first phase becoming fully operational by 2037. It is anticipated that the second phase of the Project would become fully operational by 2040 and the third phase by 2043. The operational lifetime of the Project for each phase is expected to be 35 years.

13.4.4 Identified receptors

13.4.4.1 The spatial and temporal scope of the assessment enables the identification of receptors that may experience a change as a result of the Project. The receptors identified that may experience likely significant effects for fish ecology are outlined in **Table 13.2**.

13.4.4.2 Where sensitivity or significance of effect are consistent across pelagic fish, demersal fish, and elasmobranchs, these receptor groups will collectively be referred to as 'marine fish'.

13.4.4.3 Where individual species or habitats represent a feature of a designated site or hold significance (for example, species of conservation importance), these will be identified within each receptor group.

Table 13.2 Identified receptors requiring assessment for fish ecology

Receptor group	Receptors included within group
Pelagic fish	Mobile fish species that spend the majority of their lifecycle within the water column, with extremely variable distribution. Key species likely to be found in the study area are listed in **Section 13.6.1**.
Demersal fish	Fish species that spend the majority of their lifecycle on or near the seabed. Key species likely to be found in the study area are listed in **Section 13.6.1**. Turbot Bank MPA (of which sandeel are a designated interest feature) is included within this receptor group.
Elasmobranchs	Includes sharks, skates, and rays. Key species likely to be found in the study area are listed in **Section 13.6.1**.
Diadromous fish	Diadromous fish that spend part of their life cycle in freshwater and part in sea water, migrating between the two. Key species likely to be found in the study area are listed in **Section 13.6.1**.

13.4.5 Potential effects

13.4.5.1 Potential effects on fish ecology that have been scoped in for assessment are summarised in **Table 13.3**.

13.4.5.2 Potential impacts on the Southern Trench MPA during pre-construction, construction, O&M and decommissioning stages are considered in the **NCMPA Assessment**. The Southern Trench MPA features are not assessed further in this Chapter.

13.4.5.3 Where receptors are a feature of a designated site, the feature will be assessed in detail for each potential effect, with a summary assessment of effects on designated sites provided for each stage (see **Sections 13.9.7**, **13.10.10** and **13.11.7**).

Table 13.3 Potential effects on fish ecology

Receptor	Activity or impact	Potential effect
Pre-construction and construction stage		
All fish ecology receptor groups	Impact C1: Pre-construction seabed preparation works.	Potential effect on feeding and spawning patterns through temporary / permanent, direct habitat loss and disturbance through pre-construction activities.
All fish ecology receptor groups	Impact C2: Temporary habitat loss and / or disturbance.	Potential effect on feeding and spawning patterns through temporary / permanent, direct

Receptor	Activity or impact	Potential effect
		habitat loss and disturbance through construction activities.
All fish ecology receptor groups	Impact C3: Temporary localised increases in suspended sediment concentrations (SSC) and smothering.	Potential effect through smothering of species from the placement of infrastructure and associated construction activities within the marine environment.
All fish ecology receptor groups	Impact C4: Mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion for example, UXO clearance.	Potential effect through mortality, injury, behavioural changes and auditory masking for sensitive receptors.
All fish ecology receptor groups	Impact C5: Direct and indirect seabed disturbances leading to the release of sediment contaminants.	Potential effect through contamination resulting in ecological or behavioural changes in sensitive receptors.
All fish ecology receptor groups	Impact C6: Changes in water quality.	Potential effect resulting from construction activity (both on land and offshore), which could cause changes in water quality.
All fish ecology receptor groups	Impact C7: Potential impacts on designated sites.	Potential effect on features of designated sites via construction activities.
All fish ecology receptor groups	Impact C8: Increased risk of introduction and / or spread of marine INNS.	Potential effect on fish receptors through changes in prey availability resulting from the introduction of INNS or colonisation of new structures.
Operation and maintenance stage		
All fish ecology receptor groups	Impact O1: Temporary habitat loss and disturbance.	Potential effect on feeding and spawning patterns through temporary / permanent, direct habitat loss and disturbance.
All fish ecology receptor groups	Impact O2: Long-term habitat loss and / or disturbance due to presence of offshore substation foundations, scour protection and cable protection.	Potential effect on feeding and spawning patterns through temporary / permanent, direct habitat loss and disturbance through operational and maintenance activities.
All fish ecology receptor groups	Impact O3: Introduction / colonisation of hard substrate.	Potential effect on fish receptors through habitat changes resulting from the introduction of new structures.
All fish ecology receptor groups	Impact O4: Temporary localised increases in SSC and smothering.	Potential effect through smothering of species by SSC resulting from the placement,

Receptor	Activity or impact	Potential effect
		maintenance and removal of infrastructure within the marine environment.
All fish ecology receptor groups	Impact O5: Effects arising from underwater noise, vibration and particle motion.	Potential effect through mortality, injury, behavioural changes and auditory masking in sensitive receptors.
All fish ecology receptor groups	Impact O6: EMF effects arising from cables.	Potential effect through behavioural changes in receptors that are receptive to EMF.
All fish ecology receptor groups	Impact O7: Heat effects arising from cables.	Potential effect through behavioural changes in sensitive receptors.
All fish ecology receptor groups	Impact O8: Direct and indirect seabed disturbances leading to the release of sediment contaminants.	Potential effect through contamination resulting in ecological or behavioural changes in sensitive receptors.
Elasmobranchs	Impact O9: Secondary entanglement risk.	Potential effect on elasmobranchs through secondary entanglement to abandoned fishing gear caught on mooring lines or cables.
All fish ecology receptor groups	Impact O10: Potential impacts on designated sites.	Potential effect on features of designated sites due to operational and maintenance activities.
All fish ecology receptor groups	Impact O11: Increased risk of introduction and / or spread of INNS.	Potential effect on fish receptors through changes to prey availability resulting from the introduction of INNS or the colonisation of new structures.
Decommissioning stage		
All fish ecology receptor groups	Impact D1: Temporary habitat loss and / or disturbance.	Potential effect on feeding and spawning patterns through temporary / permanent, direct habitat loss and disturbance.
All fish ecology receptor groups	Impact D2: Temporary localised increases in SSC and smothering.	Potential effect through smothering of species from the removal of infrastructure within the marine environment.
All fish ecology receptor groups	Impact D3: Mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion for example, UXO clearance.	Potential effect through mortality, injury, behavioural changes and auditory masking in sensitive receptors.

Receptor	Activity or impact	Potential effect
All fish ecology receptor groups	Impact D4: Direct and indirect seabed disturbances leading to the release of sediment contaminants.	Potential effect through contamination resulting in ecological or behavioural changes in sensitive receptors.
All fish ecology receptor groups	Impact D5: Changes in water quality.	Potential effect resulting from decommissioning activities (such as removal of structures), which could cause changes in water quality.
All fish ecology receptor groups	Impact D6: Potential impacts on designated sites.	Potential effect on features of designated sites due to decommissioning activities.
All fish ecology receptor groups	Impact D7: Increased risk of introduction and / or spread of INNS.	Potential effect on fish receptors through changes in prey availability resulting from the introduction of INNS.

13.4.5.4 Potential for reduced fishing and the potential effects on fish ecology receptors is assessed within **Chapter 32: Inter-Related Effects**.

13.4.6 Effects scoped out of assessment

13.4.6.1 A number of potential effects have been scoped out from further assessment, resulting from a conclusion of no likely significant effect. These conclusions have been made based on the knowledge of the baseline environment, the nature of planned works and the professional judgement on the potential for impact from such Projects more widely. The conclusions follow (in a site-based context) existing best practice. Each scoped out activity or impact is considered in turn in **Table 13.4**.

Table 13.4 Activities or effects scoped out of assessment

Activity or impact	Rational for scoping out
Accidental pollution	There is a risk of pollution being accidentally released during the construction, O&M, and decommissioning stages from sources including vessels and equipment. However, accidental pollution events are not considered to result in a significant effect on fish ecology. The magnitude of an accidental spill will be limited by the size of chemical or oil inventory on construction vessels. In addition, release of hydrocarbons (in this case marine fuels) would be subject to rapid evaporation, dispersion and biodegradation. The limited quantities involved in such a scenario would be unlikely to persist in the marine environment. The likelihood of an incident will be reduced as all vessels on the Project will be required to comply with strict environmental controls with the implementation of a Project Environmental Monitoring Programme (PEMP) (embedded measure M-049) and Marine Pollution Contingency Plan (MPCP) (embedded measure M-033), which will be approved by the relevant stakeholders and secured through s.36 conditions, marine licence conditions and EMP (embedded measure M-122). These plans include planning for

Activity or impact	Rational for scoping out
	accidental spills, address all potential contaminant releases and include key emergency contact details. The plans will also set out industry good practice including OSPAR and International Convention for the Prevention of Pollution from Ships (MARPOL) guidelines for preventing pollution at sea. Due to the implementation of control measures and small quantities of hydrocarbons and chemicals, this impact has been scoped out of further consideration within the EIA.
Collision risk with vessels (construction, O&M and decommissioning)	Basking sharks (*Cetorhinus maximus*) typically feed very close to the surface and at slow speeds (Sims *et al*., 2000) and are therefore at risk from collision with vessel traffic. It has been assumed that individuals may be present in very low numbers within the Offshore Red Line Boundary during the lifecycle of the Project. There is considerable uncertainty regarding population-level consequences of basking shark from ship-strikes, because little is known about them, especially in the North Sea. The Marine Conservation Society (MCS) reported 63 sharks suffering from ship strike or entanglement in fishing gear between 1992 and 2013 (Solandt and Chassin, 2013). In severe cases, these collisions can result in fatal wounds (Chilton and Speedie, 2008), but this is most likely to occur with fast moving vessels. While there is potential for collision during the construction stage of the Project and to a lesser extent during O&M and decommissioning stages (due to reduce vessel movement comparatively), most of the vessels will be slow moving, and a low-speed ship strike is less likely to result in serious injury or death. Furthermore, the potential for interaction between vessels and basking sharks will likely be limited to certain times of year when the sharks are foraging at the surface (i.e. in summer) and potentially breeding. Otherwise, they are more likely to be found at depths below the hull or propulsion system of most vessels. Finally, given the limited presence of basking shark in the North Sea (relative to the seas off western Scotland), the likelihood of a vessel collision is very low. Therefore, this impact has been scoped out of further consideration within the EIA.
Primary entanglement (construction, O&M and decommissioning)	Entanglement with Project infrastructure (known as primary entanglement) is likely to be the highest for basking sharks due to their size and feeding behaviour. There have been some records of basking sharks being entangled in ropes from stationary gear (Benjamins *et al.,* 2014a). However, any associated cables or chains with this Project are likely to be taut within the water column. There have been no records of basking shark entanglement or collision from cables or midwater chains. The risk of this impact is therefore considered to be low and further reduced by the relative scarcity of basking sharks in this part of the North Sea. Therefore, in agreement with NatureScot, this impact has been scoped out of further consideration within the EIA. The potential effect of secondary entanglement or ghost fishing, where individuals are caught in lost fishing nets or other equipment snagged on mooring lines or cables, with respect to elasmobranchs, remains in scope. As these effects are not yet well understood, they have been included for assessment in the O&M stage.

13.5 Methodology for baseline data gathering

13.5.1 Overview

13.5.1.1 Baseline data collection has been undertaken to obtain information over the study area described in **Section 13.4**. The current and future baseline conditions are presented in **Section 13.6**.

13.5.2 Desk study

13.5.2.1 Information on fish ecology within the study area was gathered through a comprehensive desktop review of existing studies and datasets. For the purpose of assessment, fish have been categorised into the following ecological groups:

- pelagic fish species;
- demersal fish species;
- elasmobranchs species; and
- diadromous fish species.

13.5.2.2 Rare and / or legally protected marine species that were identified, including those listed in the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (IUCN, 2025) have been addressed in their respective ecological group as defined above.

13.5.2.3 Where individual species or habitats represent a feature of a designated site, these will be identified within each receptor group.

13.5.2.4 The data sources that have been collected and used to inform this Chapter are summarised in **Table 13.5**.

13.5.2.5 Data from the International Council for the Exploration of the Seas (ICES), that are referred to as ICES statistical rectangles have been used in this Chapter to provide more detail on which species are likely to be present in the study area. A full commercial fisheries impact assessment is presented in **Chapter 14: Commercial Fisheries**. Data from the ICES statistical rectangles that intersect the Offshore Red Line Boundary (**Volume 2, Figure 13.1**), specifically 44E8, 44E9, 45E8 and 45E9 have been used to inform the fish ecology baseline, based on commercial catches and fish surveys that are commonly reported at ICES rectangle scale.

Table 13.5 Data sources used to inform the fish ecology chapter

Source	Summary	Coverage of study area
SAC designation documents by JNCC	SAC designation documents and site management plans.	Designated site-specific data.
Natura 2000 standard data forms by JNCC (Various publications)	Natura 2000 standard data forms published by the JNCC.	Designated site-specific data.
Fish data maintained by Marine Data Exchange (2025)	Fish ecology survey data from surveys in 2013 and reports previously undertaken.	Hywind Offshore Wind Farm Pre-Construction Geophysical survey Regional context. Partial coverage to study area.
North Sea fish data held by MarLIN (2025)	North Sea fish data.	Full coverage of the study area.
North Sea data by National Biodiversity Network (NBN) Gateway (2025)	The NBN Gateway is a database that holds species.	Partial coverage of the study area.
North Sea benthic and intertidal habitats held by Multi-Agency Geographic Information for the Countryside (Defra, 2025)	Online geographical information system that provides data from the natural environment from across government.	Full coverage of the study area.
International Council for Exploration of the Sea (ICES) data and reports (2025a)	ICES has data from fish trawl surveys and catch data, which provide an understanding of the species found throughout the North Sea.	Full coverage of the study area.
International Bottom Trawl Survey (ICES, 2025b)	The International Bottom Trawl Survey Working Group (IBTSWG) fishery-independent multispecies bottom-trawl surveys by ICES rectangle (2020-2025).	Full coverage of the marine fish study area.
Eggs and Larvae Database (ICES, 2025c)	The IBTSWG fishery-independent multispecies egg and larvae surveys by ICES rectangle (2020-2025).	Full coverage of the marine fish study area.

Source	Summary	Coverage of study area
OSPAR list of threatened and declining fish species (OSPAR Commission, 2025)	List of threatened and declining fish species identified in need of protection. (OSPAR Commission, 2025).	Full coverage of the fish study area.
Marine Protected Areas by NatureScot (NatureScot, 2025b)	Marine Protected Area Reports from NatureScot.	Partial coverage of the study area.
Priority Marine Habitats by NatureScot (NatureScot, 2025c)	Priority marine habitats information from NatureScot.	Partial coverage of the study area.
North Sea habitats (NatureScot, 2025d)	NatureScot Habitat Map of Scotland will publish all available habitat data and manage a programme to survey those areas for new information.	Full coverage of the study area.
Landings statistics data for UK-register vessels, Marine Management Organisation (MMO), (2024).	Detailed information on landings (tonnage and value) of fish species by ICES rectangle (2012 to 2023)	Full coverage of the marine fish study area.
North East Scotland Biological Records Centre (NESBReC, 2025)	Provides data on fish species and observations / records of different species from the.	Partial coverage of the study area.
ScotMER: Developing essential fish habitat maps (Franco *et al*., 2022)	Distribution of Essential Fish Habitat (those waters and substrate necessary for spawning, breeding, feeding, or growth) of key fish species in Scottish waters.	Full coverage of the marine fish study area.
Marine Scotland Information for fisheries sensitivity maps, spawning and nursery grounds (Marine Scotland, 2022)	Marine Scotland Information has a range of species-specific information as well as downloadable data in the form of Geographical Information System layers. The information covers the UK and includes the Project area.	Marine Scotland Information for fisheries sensitivity maps, spawning and nursery grounds.
Ocean Biodiversity Information System (OBIS, 2022)	Has a range of different species from various sources. It includes the original data sets, which can be downloaded as layers for various species. It has a global coverage, but some areas do have less data points than others.	Partial coverage of the study area.
Sandeel models (Langton *et al*., 2021)	Species distribution models developed to predict the occurrence and density of these species in parts of the Celtic Sea. This 'hurdle' model	Partial coverage of the marine fish study area.

Source	Summary	Coverage of study area
	considers a number of factors including sediment silt and sand component percentage, seabed slope, and a depth range of 30m-50m as predictors of sandeel presence and density.	
Distribution of spawning and nursery grounds defined by Coull *et al*. (1998) and Ellis *et al*. (2012)	Distribution of potential nursery and spawning grounds for several key fish species in UK waters.	Full coverage of the marine fish study area.
Updating Fisheries Sensitivity Maps in British Waters (Aires *et al*., 2014)	Distribution of 'sensitive areas' of key commercial species based on evidence of aggregations of non-grouped fish and / or larvae.	Full coverage of the marine fish study area.
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 (Malcolm *et al*., 2010)	This report outlines major spawning routes and behaviours of Atlantic salmon *Salmo salar*, brown trout *Salmo trutta*, and European eel in and around the study area.	Full coverage of the Diadromous fish study area.

13.5.3 Site surveys

13.5.3.1 The surveys that have been conducted to inform this fish ecology assessment are summarised in **Table 13.6**.

Table 13.6 Site surveys undertaken

Survey type	Scope of survey	Coverage of study area
Geophysical and Environmental Export Cable Corridor Survey – Volume 1 of 8: Environmental Field Report Galaxy (Fugro, 2024a)	Geophysical, geotechnical and environmental data acquisition along the Project's proposed offshore export cable corridor. Surveys included sediment samples, water samples and photographic data. Fish observed in the survey area were dominated by flatfish (Pleuronectiformes including plaice and Gadoid fish including haddock (*Melanogrammus aeglefinus*). Hagfish (*Myxine glutinosa*), dragonettes (Callionymidae), gurnards (Triglidae) and an octopus (Octopoda) were also observed.	Partial coverage of study area. Full coverage of offshore export cable corridor at select sampling stations.
Volume 3, Appendix 10.3: Confidential Geophysical and Environmental Export Cable Corridor Survey – Benthic Survey Interpretative Report 2024	Geophysical and environmental survey along the Project's proposed offshore export cable corridor. Surveys included camera transects and grab sampling. Surveys identified the following species: • sand eels (both *Ammodytes marinus* and *A. tobianys*); • plaice; • whiting (*Merlangius merlangus*); • Atlantic herring (*Clupea harengus*); • common ling (*Molva molva*); • anglerfish (*Lophius piscatorius*); • mackerel (*Scomber scombrus*); • saithe (*Pollachius virens*); • Norway pout (*Trisopterus esmarkii)*; • brown /sea trout (*Salmo trutta*); and • Atlantic salmon (*Salmo salar*).	Partial coverage of study area. Full coverage of offshore export cable corridor at select sampling stations.
Volume 3, Appendix 10.4: Geophysical and Environmental Offshore Windfarm Survey Volume 2 of 11: Benthic Survey Interpretative Report	Geophysical and environmental survey along the proposed OAA. Surveys included 80 grab sampling stations and video / photographs from eight camera stations. Surveys identified the following fish species: • Atlantic cod (*Gadus morhua);* • Haddock (*Melanogrammus aeglefinus);* • witch flounder *(Glyptocephalus cynoglossus);* • rays *(Rajidae); and* • American plaice *(Hippoglossoides platessoides).*	Partial coverage of study area. Full coverage of the OAA at select sampling stations.
Geophysical and Environmental Offshore Windfarm Survey Volume 4: MMO Report – Valkyrie (Fugro, 2024c)	Marine mammal mitigation was carried out onboard the MV Valkyrie during the survey period 18 April to 28 June 2023 at the MarramWind Floating Offshore Windfarm. The onboard marine mammal observer (MMO) carried out dedicated monitoring for marine mammals, turtles and basking	Partial coverage of study area. Full coverage of offshore export cable

Survey type	Scope of survey	Coverage of study area
	sharks within 500 metres (m) of the vessel prior to the commencement of geophysical operations. No basking sharks were observed.	corridor at select sampling stations.
MarramWind site – specific aerial surveys between April 2021 and March 2023 (APEM, 2024)	Three Atlantic bluefin tuna (*Thunnus thynnus*) were recorded in August 2022 within the western area of the OAA. No basking sharks or other marine fish were observed during Digital Aerial Surveys (DAS) from 2021 to 2023.	Partial coverage of study area.

13.5.4 Data limitations

13.5.4.1 Observations from camera transects and marine mammal observations are limited to presence / absence observations, and misidentification of a species is possible. No context of abundance, life stage or activity of the species identified is provided. These surveys were also not undertaken for the primary purpose of informing the fish ecology baseline. Due to the limitations of this survey method, the data has not been relied upon to inform the assessment; however, where species have been identified the assessment acknowledges this.

13.5.4.2 There is limited information regarding diadromous migratory pathways in this area of the North Sea. There are uncertainties around migratory routes, specific timings of migration, post-smolt behaviour and river origins of diadromous fish within the study area. Tagging studies have been conducted in rivers in the east of Scotland (Main, 2021), and data is also available via Marine Directorate's epipelagic trawl surveys for post-smolts at sea, yet the migratory patterns of Atlantic salmon remain relatively unknown and research is ongoing (ScotMER, 2024).

13.5.4.3 The commercial landings data acquired from selected ICES statistical rectangles cannot provide an accurate representation of species composition, as the data is influenced by factors, such as the fishing methods used, seasonality, quotas, by-catch, and Total Allowable Catch (TAC) limits.

13.5.4.4 These data limitations do not affect the robustness of the assessment of this EIA Report.

13.6 Baseline conditions

13.6.1 Current baseline

13.6.1.1 This Section outlines the existing environment in relation to fish ecology. This includes the Offshore Red Line Boundary, which incorporated the OAA, offshore export cable corridor and landfall(s) (further information is provided in **Chapter 4: Project Description**) and the fish ecology ZOI.

Designated sites

13.6.1.2 The Project Red Line Boundary does not directly overlap with any sites designated for the protection of fish species. However, the study area overlaps with two protected sites with fish as designated features: Turbot Bank MPA and River Dee SAC (**Volume 2, Figure 13.6**).

In addition, the Offshore Red Line Boundary directly overlaps the Southern Trench MPA, which is designated for minke whales and a number of protected habitats. The trench functions as a nursery ground for juvenile fish, with extensive soft mud substrates (NatureScot, 2020c). Potential effects on prey fish species are considered, for interpretation on effects on minke whales as detailed in **Chapter 11: Marine Mammals** and **NCMPA Assessment**. The designated features of each site are listed in **Table 13.7**.

13.6.1.3 It is noted that additional designated sites outside of the 50km study area may be affected by impacts on mobile features (such as migratory fish), including some River SACs. The approach for assessment of those sites is considered and further detailed in **paragraph 13.6.1.82**.

Table 13.7 Marine nature conservation designations with relevance to fish ecology

Site	Location relative to the Offshore Red Line Boundary	Features or description
River Dee SAC	Approximately 45km south-west of the Offshore Red Line Boundary.	Designated for Atlantic salmon and freshwater pearl mussel.
Turbot Bank MPA	Approximately 25km south of the Offshore Red Line Boundary.	Turbot bank is designated for the protection of sandeels, which play an important role in the wider North Sea ecosystem, providing a vital source of food for larger fish, seabirds and marine mammals. Turbot Bank has the potential to act as a source of young sandeels for maintain and restocking surrounding areas. The Conservation Objectives for the Turbot Bank MPA is that the protected feature (sandeels) should: • *“so far as already in favourable condition, remain in such condition; and* • *so far as not already in favourable condition, be brought into such condition, and remain in such condition.* *With respect to the sandeels, this means that the quality and quantity of its habitat and the composition of its population are such that they ensure that the population is maintained in numbers which enable it to thrive.* *Any temporary reduction of numbers is to be disregarded if the population of sandeels is thriving and sufficiently resilient to enable its recovery from such reduction. Any alteration to that feature brough about entirely by natural processes is to be disregarded.*” (JNCC, 2018).
Southern Trench MPA	Overlaps with the offshore export cable corridor route and western section of the Offshore Red Line Boundary.	The Southern Trench MPA is located off the Aberdeenshire coast and is designated to protect marine mammals (minke whales), burrowed mud, fronts and shelf deeps. The offshore cable route Red Line Boundary passes through the MPA (see **Volume 2, Figure 13.6**). The Southern Trench MPA is a 250m deep trench that runs parallel to the coastline. The dynamic mixing zone of warm and cold waters attracts shoals of Atlantic herring, Atlantic

Site	Location relative to the Offshore Red Line Boundary	Features or description
		mackerel and Atlantic cod to the area, with the soft sands providing abundant habitat for sandeels (NatureScot, 2020c). The burrowed mud habitat (EUNIS code: A5.361) PMF present in the Southern Trench MPA is characterised by the presence of Norway lobster (*Nephrops norvegicus)*, crabs, seapens and anemones. The burrowed mud habitat is in favourable condition but is listed by OSPAR as a threatened and declining habitat. Burrowed mud habitats are highly sensitive to physical disturbance; disturbances to water flow, wave, exposure; and siltation. The conservation objectives of the site for burrowed mud include: *"Conserve the diversity, abundance and distribution of typical species associated within the burrowed mud (including N. norvegicus, Pennatula phosphorea, Virgularia mirabilis."*

Pelagic species

13.6.1.4 Pelagic species spend most of their life cycle within the mid to upper portions of the water column. They are highly mobile and often make seasonal migrations driven by spawning and food availability. Their distribution and abundance can be further influenced by hydrographic conditions, which can be extremely variable. Hydrographic factors are important for pelagic species due to their egg and larval stages, which rely on ocean currents for distribution to nursery grounds. Some pelagic species such as Atlantic herring, also rely on specific habitat and substrate for egg laying, making them particularly vulnerable to habitat loss. Pelagic species are typically mobile when tracking food and can make extensive seasonal migrations, resulting in a highly variable distribution through time. Demersal spawning behaviour increases sensitivity to pressures such as seabed disturbance, as the suspension and subsequent resettlement of sediments can result in the smothering of eggs deposited on or near the seabed. As such, greater consideration is given to Atlantic herring and in subsequent sections, as it is a key commercially and ecologically important pelagic species identified within the study area that exhibits this spawning behaviour.

13.6.1.5 Within the vicinity of the Project, several key pelagic species are expected to be present. These include commercially valuable fish such as Atlantic herring, Atlantic mackerel (*Scomber scombrus*), along with ecologically significant species like European sprat (*Sprattus sprattus*), which play a crucial role as prey for marine mammals, birds, and larger fish.

13.6.1.6 Some species of ecological or commercial importance, identified from baseline searches within the study area, along with their conservation status, are shown in **Table 13.8.** These species are either known to occur in the area (based on MarLIN data) or are listed as Scottish PMFs, Annex II species under the Bern Convention, or as UK Post-2010 Biodiversity Framework species (Coull *et al*., 2009; Ellis *et al*., 2012). Some of these species have nursery and spawning grounds within the study area and are discussed further below.

Table 13.8 Key pelagic species identified within the region of the Project with their conservation International Union for Conservation of Nature (IUCN) and UK conservation status

Species	Overlap with the study area		UK BAP species	IUCN Red List	Scottish PMF	Scottish Biodiversity List	OSPAR
	Spawning Ground	Nursery Ground					
Atlantic herring	Y	Y	Y	Least concern	Y	N	N
Atlantic mackerel		Y	Y	N	Y	N	N
Horse mackerel		Y	Y	N	Y	N	N
Blue whiting		Y	Y	N	N	N	N
European sprat	Y	Y	N	N	N	N	N
Atlantic bluefin tuna			Y	Least concern	N	N	Y
Black scabbardfish			Y	N	Y	N	N
Orange roughy			Y	N	Y	N	Y
Roundnose grenadier			Y	Critically endangered	Y	N	N

Atlantic herring

13.6.1.7 Atlantic herring are widely distributed across UK and Irish waters, including the North Sea, the English Channel, the Irish Sea, and the North Atlantic. Outside of their spawning season, they typically form extensive near-surface shoals in offshore waters, avoiding nearshore coastal areas.

13.6.1.8 As shown in Plate 5.2 in **Volume 3, Appendix 14.1: Commercial Fisheries Technical Report**, from 2012 to 2023 the landed weight of herring (2,100 tonnes average) dominated landings in the local study area (ICES rectangles 44E8-E9 and 45E8-E9), far exceeding other species, with the exception of mackerel and haddock.

13.6.1.9 Herring are demersal spawners, laying adhesive eggs on coarse sand and gravel substrates, making their spawning grounds particularly vulnerable to physical disturbances. Spawning occurs in shallow waters, when large shoals of females form, depositing dense layers of eggs. Each female can produce between 10,000 to 80,000 eggs. Males fertilise the eggs by releasing milt that settles on top of the eggs on the sea floor. In the North Sea, three major herring populations can be identified, all of which spawn at different times of year. The Buchan / Shetland herring population spawn off the Scottish and Shetland coasts during August and September, the Banks / Dogger herring spawn in the Central North Sea and off the English coast from August to October. The Bight / Downs population spawn in the English Channel between November and January.

13.6.1.10 The distribution of sediment types in the study area is shown in Figure 3 of **Volume 3, Appendix 6.3**. Substrates of the preferred geophysical characteristics for herring spawning, i.e. coarse sand and gravel, are predominantly present in the coastal areas along the offshore export corridor cable, with the OAA limited to ‘fine to medium sand silt’ to ‘very silty fine to medium sand’. Optimal substrate is therefore limited to the offshore export corridor cable, with available substrate to the north and south, with sub-optimal but still potential spawning sediment present across the wider Offshore Red Line Boundary and study area.

13.6.1.11 Particle size distribution (PSD) results indicated that the majority of sample sites along the offshore export cable corridor evidenced unsuitable habitat for herring spawning, with sand the dominant fraction of the sediment at all stations with percentages ranging from 33.89% (station ST51) to 99.98% (station ST44_a), with a mean of 81.41% and a median of 84.29%.

13.6.1.12 Gravel was absent from 15 stations and where it occurred, gravel content ranged from 0.01% at 4 stations to 64.73 % (station ST51), with a mean of 8.21 % and a median of 1.06 %. Where present, fines content ranged from 0.24% (station ST50_a) to 35.09% (station STA2_05), with a mean of 10.38% and a median of 4.93%. Of the fines, silt content was consistently higher than the clay content, whilst 7 stations were devoid of fines (**Volume 3, Appendix 10.3**).

13.6.1.13 The potential for herring spawning at each sample site has used methodology devised by Reach *et al*. (2013) and recently updated by Kyle-Henney *et al.* (2024). Using the sediment composition, locations were classified as either ‘preferred’, ‘marginal’ or ‘unsuitable’ habitat for herring spawning, as presented in **Table 13.9**.

Table 13.9 Partitioning of herring spawning habitat using sediment characteristics (Reach *et al*., 2013; Kyle-Henney *et al*., 2024)

% Particle contribution (muds = <63µm; gravel = 63 to 2000µm)	Habitat preference	Folk sediment unit	Habitat classification
<5% mud, >50% gravel	Prime	Gravel and part sandy; Gravel.	Preferred
<5% mud, >25% gravel	Sub-prime	Part sandy gravel and part gravelly sand.	Preferred
<5% mud, >10% gravel	Suitable	Part gravelly sand.	Marginal
>5% mud, <10% gravel	Unsuitable	Everything excluding gravel, part sandy gravel and part gravelly sand.	Unsuitable

13.6.1.14 The Folk sediment classification system (Folk, 1954) describes and classifies sediment by the relative proportion of sediment fractions (gravel, sand and fines). The Folk (BGS modified) classification described 31 stations as ‘sand’, 22 stations as ‘muddy sand’, 16 stations as ‘gravelly sand’, 7 stations as ‘sandy gravel’ and 1 station as ‘gravelly muddy sand’. Further interpretation found that of 77 sample sites along the offshore export corridor cable, one station (ST51), was prime habitat, 6 sub-prime, 11 suitable and the remained unsuitable, as per classifications shown in **Table 13.9**.

13.6.1.15 Within the OAA, PSD results indicated that the majority of sample sites evidenced unsuitable habitat for herring spawning, with sand the dominant fraction of the sediment at all stations with percentages ranging from 57.50% (station A14) to 94.96% (station A20_a), with a mean of 79.95%. Fines (or mud) were recorded at all stations and had a content ranging from 4.72% (station A15_a) to 42.48% (station A14), with a mean of 19.97%. Gravel was absent from 31 stations and at the remaining stations gravel content ranged from 0.01 % at 11 stations to 2.17% (station A9), with a mean of 0.08% (Fugro, 2023).

13.6.1.16 Further interpretation found that all 79 sample sites within the OAA were classified as unsuitable habitat, due to the low gravel percentage composition.

13.6.1.17 Overall, both model and site-specific data indicates that the majority of the offshore export corridor cable and all of the OAA is of unsuitable sediment classification to support herring spawning.

13.6.1.18 Eggs hatch within one to three weeks, with pelagic larvae transported by currents toward nursery areas in the north and east of Scotland. Juveniles mature into large, migratory shoals, travelling between spawning, feeding, and overwintering grounds. Low intensity nursery grounds are identified across most of the Offshore Red Line Boundary with a small nearshore area being mapped as high intensity (Ellis *et al.*, 2012). In addition to this, a review of International Herring Larvae Surveys (IHLS) conducted in the North Sea (ICES, 2025a) further suggests that the wider study area may provide spawning habitat for herring, with herring larvae detected at high abundances across the region between 2017 and 2024. While listed as Least Concern by the IUCN, Atlantic herring are designated as a UK Biodiversity Action Plan (BAP) species and a Scottish PMF.

Atlantic mackerel

13.6.1.19 As shown in Plate 5.2 in **Volume 3, Appendix 14.1**, from 2012 to 2023 the landed weight of mackerel (3,800 tonnes average) dominated landings in the local study area, exceeding all other species.

13.6.1.20 Atlantic mackerel are widely distributed throughout the continental shelf waters surrounding the British Isles and Northern Europe. In the North Sea, they are most often found in waters shallower than 200m during the warmer months, with overwintering populations occupying deeper areas to the north and east of Shetland and the Norwegian Deep.

13.6.1.21 In spring and summer, adult mackerel undertake extensive migrations to spawning grounds in the central and southern North Sea, typically between May and July. These movements are driven by changes in water temperature and food availability. Spawning activity peaks between May and August, with eggs released into surface waters. Mackerel are fast-swimming, migratory predators that feed on pelagic zooplankton, crustaceans, and small fish. Their migratory behaviour and diet link them closely to ecosystem dynamics and make them a key species for both ecological monitoring and commercial fisheries.

13.6.1.22 While listed as Least Concern by the IUCN, Atlantic mackerel are designated as a UK BAP species and a Scottish PMF. There are no suggested nursery sites or spawning areas within the study area. Although it is considered likely that the region is likely frequented by both juvenile and adults.

European sprat

13.6.1.23 The European sprat is a widely distributed pelagic fish species found across the Northeast Atlantic, North Sea, Baltic Sea, Black Sea and northern regions of the Mediterranean Sea

(McKeown *et al*., 2020). The species holds significant ecological importance, acting as a keystone species in many marine food webs, feeding an abundance of fish, seabirds and marine mammals (Cushing *et al*.,2018). In the North Sea, sprats are most abundant south of the Dogger Bank and in the Kattegat. Populations also extend into the Firth of Forth and Moray Firth. The European sprat is a commercially important species in the UK, with stocks managed as a single unit within the Greater North Sea ecoregion. Spawning occurs from May to August, typically peaking between May and June (Wahl and Alheit, 1988). The pelagic eggs are generally found in surface waters at depths of 25m to 30m, both in coastal and offshore areas. Dispersed by ocean currents, eggs and larvae remain in the water column until hatching occurs after approximately five to six days (Valenzuela and Vargas, 2002).

13.6.1.24 Traditional winter fisheries in coastal areas suggest seasonal inshore migration for overwintering, although older individuals may remain in offshore habitats. Sprat shoals also exhibit diel vertical migration, which is a daily vertical movement of biomass in the oceans with species ascending to surface waters at dusk and descending to deeper waters during daylight hours (Wahl and Alheit, 1988).

13.6.1.25 In northern European waters (North and Baltic Seas), peak spawning occurs at water temperatures between 8°C and 15°C. However, the onset and duration of spawning may vary due to temperature and feeding conditions. As a multiple batch spawner, sprat release several egg batches throughout the spawning season (up to ten in some areas) (Peck *et al*., 2012).

13.6.1.26 Recorded nursery and spawning grounds for sprat cover large areas of the west coast of Scotland, including the majority of the study area and the entirety of the Offshore Red Line Boundary, evidencing their wide distribution, abundance and mobility as a pelagic shoaling fish.

Atlantic bluefin tuna

13.6.1.27 Atlantic bluefin tuna are large, highly migratory fish that range throughout the Atlantic Ocean and are being increasingly observed within the Northeast Atlantic (Horton *et al.,* 2025). Atlantic bluefin tuna is an important species for commercial fisheries, and stocks have previously experienced over-exploitation. Atlantic bluefin tuna forage in the Northeast Atlantic between the months of August and December, where they feed at the surface (Atlantic bluefin tuna follow a diel diving pattern, where daily vertical migrations follow the movements of prey species).

13.6.1.28 Atlantic bluefin tuna have previously been a regular occurrence along the coasts of western Ireland, however in 2005 became regionally scarce. In recent years, Atlantic bluefin tuna have reappeared in UK and Irish coastal and offshore waters, with Japanese longline fleets working in the Northeast Atlantic also indicating increased catches of the species (Horton *et al.,* 2020). Observations of tuna in the North Sea have been reported regularly in recent years having been absent since the 1950s (Righton, 2018). DAS surveys in August 2022 recorded three Atlantic bluefin tuna within the western area of the OAA.

Horse mackerel

13.6.1.29 Around the UK horse mackerel are typically managed as two stocks: a western stock and a North Sea stock. The latter spends much of the year in the Central North Sea, Skagerrak, and Kattegat, migrating south in Summer to spawn. Adults form large shoals and feeding on fish and other invertebrates.

13.6.1.30 In summer, the species shows a more limited distribution, with peak densities in the southeastern North Sea and along the northern shelf edge. It is largely absent from the Central North Sea during this time and tends to disappear from the region in Winter (Smith-

Vaniz *et al*., 2015). The Atlantic horse mackerel (*Trachurus trachurus*) is currently listed as Vulnerable on the IUCN Red List (2013). The status of the North Sea stock remains uncertain, though landings have declined – likely due to reduced fishing effort.

Pelagic species spawning and nursery grounds

13.6.1.31 Atlantic herring and European sprat are known to use the region as both spawning and nursery grounds (as shown in **Volume 2, Figure 13.2**). In addition, established nursery grounds for blue whiting have also been identified within the study area. **Table 13.10** illustrates the key spawning periods for species with spawning grounds within the study area.

13.6.1.32 Aires *et al.* (2014) use the findings of Coull *et al.* (1998) and Ellis *et al*. (2012) together with International Bottom Trawl Survey (IBTS) data, beam trawl survey data, IHLS and other standalone surveys to summarise the probability of aggregations of individuals in the first year of their life, referred to as 0-group, and/or larvae of key commercial species. The probability of 0-group aggregations within the study area is low to moderate for herring, horse mackerel, mackerel and sprat (Aires *et al.,* 2014).

Table 13.10 Spawning activity in the study area

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Herring												
Sprat												

NB: Light green indicates spawning period, and dark green indicates peak spawning periods.

Demersal species

13.6.1.33 Demersal species live on or near the seabed, and whilst the egg and larval stages are often subject to passive dispersal (advection), distribution of juvenile and adult life stages are principally determined by hydrography and sediment type (abiotic factors). However, biotic factors such as competition and predator-prey interactions may also influence abundance and distribution (Drazen and Haedrich, 2012). This group includes several important commercial species such as Atlantic cod, haddock and plaice. Epibenthic species include important keystone species such as sandeels (*Ammodytes* spp).

13.6.1.34 Species afforded protection in Scotland, identified from baseline searches and / or field surveys conducted in support of the Project within the study area, along with their conservation status, are shown in **Table 13.11**. Some of these key species have nursery and spawning grounds within the study area (Coull *et al.,* 1998; Ellis *et al*., 2012) and are discussed in **paragraph 13.6.1.59**.

13.6.1.35 Other common species and groups not listed in **Table 13.11** but may be present in the study area (or have been observed / captured by non-specific surveys), include gurnards, dragonettes, hagfish, common dab, plaice, turbot and common goby (*Pomatoschistus microps*).

Table 13.11 Key demersal fish species identified in the vicinity of the MarramWind Project with their IUCN and conservation status

Species	Overlap with the study area		UK BAP species	IUCN Red List	Scottish PMF	Scottish Biodiversity List	OSPAR	Bern Convention
	Spawning Ground	Nursery Ground						
European hake		Y	Y	N	N	Y	N	N
Anglerfish		Y	Y	N	Y	N	N	N
European plaice	Y	Y	Y	N	N	Y	N	N
Ling		Y	Y	N	Y	Y	N	N
Lemon sole	Y	Y	N	N	N	N	N	N
Atlantic cod	Y	Y	Y	Vulnerable	Y	Y	Y	N
Sandeel	Y	Y	Y	N	Y	Y	N	N
Norway pout	Y	Y	N	N	Y	Y	N	N
Haddock		Y	N	Vulnerable	N	N	N	N
Saithe		Y	N	N	Y	N	N	N

Species	Overlap with the study area		UK BAP species	IUCN Red List	Scottish PMF	Scottish Biodiversity List	OSPAR	Bern Convention
	Spawning Ground	Nursery Ground						
Atlantic halibut			Y	Endangered	Y	N	N	N
Whiting	Y	Y	Y	Y	N	Y	Y	N
Blue ling			Y	N	Y	N	N	N
Common goby			N	Least Concern	N	N	N	Y
Common sole			Y	N	N	N	N	N
Greenland halibut			Y	N	Y	N	N	N
Sand goby			N	N	Y	N	N	Y

Sandeel

13.6.1.36 Sandeel species are of high conservation importance (Engelhard *et al*., 2008; Régnier *et al*., 2024; Sharples *et al*., 2009) and are designated as a feature of the Turbot Bank MPA (located approximately 25km south of the Offshore Red Line Boundary) (**Volume 2, Figure 13.6**). A total of five species of sandeel are found within Scottish waters, with Raitt's sandeel (*Ammodytes marinus*), and the lesser sandeel (*Ammodytes tobianus*) the most common.

13.6.1.37 Sandeel are of high ecological importance as a food source for a wide variety of predators, including many fish (Engelhard *et al*., 2008), seabirds (Régnier, 2024) and some mammals (Sharples *et al*., 2009). While industrial fishing of sandeel in all Scottish waters has been banned – with a full ban on non-UK vessels now in force as of April 2024 under the Sandeel (Prohibition of Fishing) (Scotland) Order 2024 – the species remains a commercially important species across Europe. The Offshore Red Line Boundary is located within the Northeast UK sandeel closure, established for nature conservation purposes of sandeels. The area is subject to year-round closure on sandeel fishing.

13.6.1.38 Sandeel typically spawn between November to February. Eggs are demersal and are deposited on sandy substrate (Wright *et al*., 2000). Larvae hatch after several weeks (usually between February and March), and drift in the water column as pelagic larvae for one to three months. After this period, they settle on sandy seabed habitat. Typically, Raitt's sandeel's settle in deeper water between depths of 20m-x (Wright *et al*., 2000) whilst the lesser sandeel is rarely observed deeper than 20m (Langton *et al*., 2021). Both species typically settle in areas characterised by sandy substrate with limited fine particles of silt and clay (Holland *et al*., 2005). Sandeels prefer sediment with a high percentage of medium to coarse grained sand (particle size 0.2 millimetres (mm) to 2mm) and have been shown to avoid sediment containing >4 per cent silt (particle size <0.063mm) and >20 per cent fine sand (particle size 0.063mm to 0.25mm) (Wright *et al*., 2000; Holland *et al*., 2005). Once settled in appropriate habitat, adult sandeels bury into sediment when not feeding in the water column (Engelhard *et al*., 2008). Adult sandeels also remain dormant (referred to as 'overwintering') in the sediment over the Winter period (van Deurs *et al*., 2012; Winslade, 1974); aside from emerging briefly to spawn between November to February (Wright *et al*., 2000).

13.6.1.39 Species distribution models have been developed to predict the occurrence and density of these species in parts of the North Sea (Langton *et al*., 2021). These maps in the context of the study area are shown in **Volume 2, Figure 13.4**. This 'hurdle' model considered a number of factors including sediment silt and sand component percentage, seabed slope, and a depth range of 30m to 50m. The OAA is indicated as having a predicted density of zero sandeel per square metre (m²). An area of increased predicted density is, however, present along the coast in the offshore export cable corridor route up to 10km off the coast of Aberdeenshire, with the highest density recordings 7km north of Peterhead. Where presence is predicted, density is predicted to be between 10 to 30 per m², with some discrete points up to 60 per m². A small patch of higher predicted density of 60 to >120 per m² is also present within the study area within the area north of Peterhead. Some areas along the coastal reach have no data available for predicted density or presence.

13.6.1.40 A small patch of suitable habitat was also identified within the Turbot Bank MPA, 25km south of the offshore export cable corridor route, with a probability less than 0.25 (on a scale of zero – less probable, to one – more probable). It is acknowledged that small pockets of suitable habitat may exist elsewhere across the Offshore Red Line Boundary that support localised populations.

13.6.1.41 The distribution of sediment types in the study area are shown in Figure 3 of **Volume 3, Appendix 6.3**. Substrates of the preferred geophysical characteristics for sandeel are predominantly present in the coastal areas along the offshore export corridor cable, with the OAA limited to 'fine to medium sand silt' to 'very silty fine to medium sand'. Optimal substrate is therefore limited to the offshore export corridor cable, with available substrate to the north and south, with sub-optimal but still potential spawning sediment present across the wider Offshore Red Line Boundary and study area.

13.6.1.42 PSD results indicated that the majority of sample sites along the offshore export cable corridor evidenced preferable habitat for sandeel spawning, with sand the dominant fraction of the sediment at all stations with percentages ranging from 33.89% (station ST51) to 99.98% (station ST44_a), with a mean of 81.41% and a median of 84.29%. Where present, fines content ranged from 0.24% (station ST50_a) to 35.09% (station STA2_05), with a mean of 10.38% and a median of 4.93%. Of the fines, silt content was consistently higher than the clay content, whilst 7 stations were devoid of fines (**Volume 3, Appendix 10.3**).

13.6.1.43 As previously described, the Folk (BGS modified) classification described 31 stations as 'sand', 22 stations as 'muddy sand', 16 stations as 'gravelly sand', 7 stations as 'sandy gravel' and 1 station as 'gravelly muddy sand'. Therefore, in accordance with Reach *et al.* (2024) sediment divisions (where sand, slightly gravelly sand and gravelly sand is 'preferred', sandy gravel is 'marginal' and all other Folk sediment divisions are 'unsuitable'), 49 stations evidenced preferred habitat, 7 stations marginal and 23 stations unsuitable, with a trend of suitability reducing moving away from shore.

13.6.1.44 Within the OAA, PSD results indicated that the majority of sample sites evidenced preferable habitat for sandeel spawning, with sand the dominant fraction of the sediment at all stations with percentages ranging from 57.50% (station A14) to 94.96% (station A20_a), with a mean of 79.95%. Fines (or mud) were recorded at all stations and had a content ranging from 4.72% (station A15_a) to 42.48% (station A14), with a mean of 19.97%. (Fugro, 2023).

13.6.1.45 The Folk description (BGS modified) classified 68 stations as muddy sand and 11 stations as sand. Therefore, in accordance with Reach *et al*. (2024) sediment divisions, 11 stations evidenced preferred habitat, with 68 stations evidencing unsuitable habitat due to the high fines percentage.

13.6.1.46 The minimum depth detected within the OAA was 87.8m LAT (Lowest Astronomical Tide), which is outside the depth range at which most sandeel species are usually found (20m for less sandeel and 80m for Raitt's sandeel), although this does not rule out their presence.

13.6.1.47 Overall, both model and site-specific data indicates that the majority of the offshore export corridor cable is of suitable sediment to support sandeel with a high potential for presence. The majority of habitat within the OAA is of low suitability for sandeel species.

Haddock

13.6.1.48 Haddock, a member of the cod family, is a valuable commercial species, exploited commercially in both mixed trawl and seine fisheries. It is also bycaught in langoustine fisheries (Hedger *et al*., 2004). Spawning runs from February until early May and occurs in the majority of the North Sea.

13.6.1.49 As shown in Plate 5.2 in **Volume 3, Appendix 14.1**, from 2012 to 2023 the landed weight of haddock (2,600 tonnes average) dominated landings in the local study area, exceeding all other species with the exception of mackerel.

Atlantic cod

13.6.1.50 Atlantic cod are productive breeders. Spawning occurs between February and April when many millions of buoyant eggs are released, often forming great swarms that can be transported miles by ocean currents before hatching after 12 days. The larval stage of this species is also planktonic and will be carried by currents for up to two months before settling on the seabed where the Atlantic cod spend most of their life (Dipper, 2001).

13.6.1.51 Juvenile Atlantic cod feed mainly on copepods but become increasingly dependent on fish as they age, eating the likes of herring, capelin, haddock and even other cod (Dipper, 2001; Wheeler, 1969).

13.6.1.52 As shown in Plate 5.2 in **Volume 3, Appendix 14.1**, from 2012 to 2023 the landed weight of cod (180 tonnes average) was relatively limited in the local study area.

Norway pout

13.6.1.53 Norway pout are a benthopelagic to pelagic species found over muddy substrates between 100m to 200m. Spawning occurs from January to July off the northern coast of Scotland, Faroes, Iceland and the Norwegian coast. Norway pout are an important food item for several species including hake, cod, whiting and pollack (*Pollachius pollachius*), and is a highly commercial species caught mainly for fishmeal (Sweet, 2008).

Saithe

13.6.1.54 Saithe is a member of the pollack family, reaching up to 1.2m in length. It is commonly found off the northeast coast of Scotland, entering coastal waters in Spring, before returning to deeper waters (up to 350m) in Winter (Barnes, 2008a).

13.6.1.55 Saithe are an active, gregarious fish, that forages by schooling behaviour in the water column and its diet indicates pelagic feeding on capelin, krill, blue whiting, herring and sandeel. It is believed that the spawning period takes place from January to April near the continental shelf (Scottish Government, 2015b), with key areas for spawning found off the east coast of Scotland and off the west coast of the Shetland Islands. No spawning areas are recorded in the North Sea.

13.6.1.56 As shown in Plate 5.2 in **Volume 3, Appendix 14.1**, from 2012 to 2023 the landed weight of saithe (100 tonnes average) was relatively limited in the local study area.

Whiting

13.6.1.57 Whiting is a cod-like fish that can grow up to 70 centimetres (cm). It is found around off the coast of most of the British Isles, usually found at depths of 30m to 100m (Barnes, 2008b).

13.6.1.58 Spawning occurs from January to July, with the species laying pelagic eggs. Extensive areas of the North Sea including the study area are suitable for spawning and nursery grounds (Coull *et al.,* 1998, Ellis *et al*., 2012) with springtide identified as a key physical determinant of whiting spawning distribution, which may be linked to the need for larvae to be advected offshore (Gonzalez-Irusta and Wright, 2017).

Demersal species spawning and nursery grounds

13.6.1.59 High intensity spawning grounds for sand eel, Norway pout overlap with the study area. Low intensity spawning grounds for Atlantic cod, whiting, European plaice, lemon sole and sandeel overlap with the study area. Nursery grounds for Atlantic cod, haddock, saithe, European hake, Norway pout, whiting, ling, European plaice, lemon sole, sandeel and anglerfish overlap with the study area (Coull *et al*., 1998; Ellis *et al.,* 2012).

13.6.1.60 Sandeel play a key role in the North Sea food web and many species rely on them as a source of food. Sandeel are particularly vulnerable as they require a specific substratum (mainly consisting of medium to coarse sand and low silt) for their habitat requirements

(Holland *et al*., 2005). Sandeel spend autumn and winter months lying dormant in the sediment, apart from a brief emergence to spawn. They are more active during the spring and summer months, moving between the seabed and water column diurnally. Sandeel that have settled are rarely found at depths greater than 30m (Jensen *et al*., 2011; Greenstreet *et al*., 2010; and Rowley, 2008). Due to sandeels' ecological importance and habitat preferences they are vulnerable to disturbance through direct habitat loss or indirect changes to the seabed (Coull *et al*.,1998).

13.6.1.61 Several demersal species have nursery and spawning grounds (Coull *et al*., 1998; Ellis *et al.,* 2012) within the fish study area as identified in **Table 13.12**. Overlap of spawning and nursery grounds with the offshore export cable corridor and the OAA are identified in **Table 13.12** and presented in **Volume 2, Figure 13.3**. The main spawning periods for these species have been identified in **Table 13.13** and are discussed in more detail below.

13.6.1.62 In addition to the above datasets, analysis of haddock and whiting likely distributions of spawning grounds (Gonzalez-Irusta and Wright, 2016, 2017) indicate high predictions of preference for both species overlapping areas of the OAA and offshore export cable, as presented in **Table 13.12.**

13.6.1.63 Aires *et al.* (2014) use the findings of Coull *et al.* (1998) and Ellis et al. (2012) together with International Bottom Trawl Survey (IBTS) data, beam trawl survey data, IHLS and other standalone surveys to summarise the probability of aggregations of individuals in the first year of their life, referred to as 0-group, and/or larvae of key commercial species. The probability of 0-group aggregations within the study area is low to moderate for anglerfish, cod, plaice, sole, and moderate to high for haddock, hake, Norway pout, and whiting (Aires *et al.* 2014).

Table 13.12 Key demersal species detected with spawning and / or nursery grounds that overlap the offshore export cable and / or the OAA

Species	Overlap with OAA		Overlap with offshore export cable corridor	
	Spawning	Nursery	Spawning	Nursery
Anglerfish		YY		Y
Atlantic cod	Y	Y	Y	Y
Haddock	YY	Y*	YY	Y*
European Hake		Y		Y
Sandeels (Ammodytidae spp.)	Y	Y	YY	Y
Ling		Y		Y
Norway pout	Y	Y*	YY(partial) and Y(partial).	Y*(partial)
Plaice			Y(partial)	Y(partial)
Saithe				Y*(partial)

Species	Overlap with OAA		Overlap with offshore export cable corridor	
	Spawning	Nursery	Spawning	Nursery
Whiting	YY	Y	YY	YY
Lemon sole	Y*		Y*	Y*
Y- low intensity spawning / nursery ground identified. YY- high intensity spawning / nursery ground identified. Y*- intensity not specified.				

Table 13.13 Main periods of spawning activity for key demersal fish species in the fish study area

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglerfish												
Atlantic cod												
Haddock												
European hake												
Sandeels												
Ling												
Norway pout												
Plaice												
Saithe												
Whiting												

Source: (Coull *et al*., 1998; Ellis *et al*., 2012)
NB: Light green indicates spawning period, and dark green indicates peak spawning periods

Elasmobranchs

13.6.1.64 The elasmobranchs consist of sharks, skates, and rays, all three of which generally feature low reproductivity, low fecundity and late maturity when compared to other marine fish. Many species are protected due to their declining numbers, sensitivity to disturbance and slow rate of recovery from population loss (McCully *et al*., 1998). Mobility varies between species, with some undergoing extensive migration (Doherty *et al*., 2017a) and others remaining more localised (Strong, 1989). Spawning behaviour is similarly diverse with egg laying (oviparous) and live birth (viviparous) strategies found within the group. The majority of benthopelagic and pelagic shark species are likely to move through the study area, as opposed to being resident, due to their widespread ranges.

13.6.1.65 Species afforded protection in Scotland, identified from baseline searches and / or field surveys conducted within the study area, along with their conservation status, are shown in **Table 13.14**. Some of these species have known or likely nursery grounds within the study area (Ellis *et al*., 2012) and are discussed further in **paragraph 13.6.1.78**.

Table 13.14 Elasmobranch species identified within the region of the Project with their IUCN and conservation status

Common name	Overlap with the study area		UK BAP species	IUCN Red List	Scottish PMF	Scottish Biodiversity List	OSPAR	The Wildlife & Countryside Act 1981	Berne Convention	Convention on migratory species
	Spawning Ground	Nursery Ground								
Spurdog	N/A	Y	Y	Vulnerable	Y	N	Y	N	N	N
Tope shark	N/A	Y(partial)	Y	Critically endangered	N	N	N	N	N	N
Common skate complex	N/A	Y(partial)	Y	Critically endangered	Y	Y	Y	Y	N	N
Thornback ray	N/A	Y(partial)	N	Near threatened	N	Y	Y	N	N	N
Spotted ray	N/A	Y	N	Least concern	N	N	Y	N	N	N
Angel shark	N/A	N/A	Y	Critically endangered	N	N	Y	Y	N	N
Basking shark	N/A	N/A	Y	Vulnerable	Y	Y	Y	Y	Y	Y
Blue shark	N/A	N/A	Y	Near threatened	N	N	N	N	N	N
Gulper shark	N/A	N/A	Y	Endangered	N	N	Y	N	N	N

Common name	Overlap with the study area		UK BAP species	IUCN Red List	Scottish PMF	Scottish Biodiversity List	OSPAR	The Wildlife & Countryside Act 1981	Berne Convention	Convention on migratory species
	Spawning Ground	Nursery Ground								
Kitefin shark	N/A	N/A	Y	N	N	N	N	N	N	N
Leafscale gulper shark	N/A	N/A	Y	Endangered	Y	N	Y	N	N	N
Porbeagle shark	N/A	N/A	Y	Vulnerable	Y	N	Y	N	N	N
Portuguese dogfish	N/A	N/A	Y	Near threatened	Y	N	Y	N	N	N
Sandy ray	N/A	N/A	Y	Endangered	Y	N	N	N	N	N

13.6.1.66 There are a number of other deep water species of shark that occasionally visit Scottish waters. Little is known about their population numbers or abundance. Additional species of sharks and rays not listed above may move through the study area. A full list of sharks and rays in Scottish waters can be found in Scotland's Marine Atlas (Scottish Government, 2011).

Basking shark

13.6.1.67 Basking shark (*Cetorhinus maximus*) is the second largest cartilaginous fish in the world. It is on the OSPAR list of threatened and declining species and classed as globally endangered by the IUCN. They are provided full legal protection in Scotland under the Wildlife and Countryside Act 1981, the Nature Conservation (Scotland) Act 2004, and the Marine (Scotland) Act 2010.

13.6.1.68 Basking sharks are present in UK coastal waters primarily between June to August and have been found to move to offshore shelf waters in winter months. Their distribution is linked to oceanographic features such as thermal fronts and productive chlorophyll patches which aggregate their plankton prey (Gore *et al*., 2023). Basking sharks are ram filter-feeders, and preferentially forage on zooplankton, predominately targeting energy rich calanoid copepods (for example, *Calanus finmarchicus* and *C.helgolandicus*) (Sims *et al.*, 2005)

13.6.1.69 Sightings of most individuals are made in shallow, coastal waters (Gore *et al*., 2023; Paxton *et al*., 2014), although more recent telemetry studies (Hawkes *et al*., 2020; Doherty *et al.*, 2017b) suggest that basking sharks also utilise deeper, offshore waters, and it is likely that the results of observational data is a function of observer effort. Statistical modelling of basking sharks in Scottish territorial waters has further improved understanding of the species movements, with surface sightings typically only reported where sea surface temperatures range between 15°C and 17.5°C (Paxton *et al*., 2014; Cotton *et al*., 2005). Basking sharks have also been recorded conducting extensive horizontal (up to 3,400km) and vertical migrations across both continental shelf areas and oceanic habitat (Sims *et al*., 2003; Doherty *et al.*, 2017b), suggesting a wide use of the water column and variety of marine habitats.

13.6.1.70 Few historical surface sightings of basking sharks have been recorded in the North Sea east of Scotland (Wilson *et al.*, 2020). Long-term monitoring (four years) of tagged basking sharks off the west coast of Scotland and the Isle of Man likewise provided evidence that basking sharks do not frequent the east coast of Scotland. One of three migration behaviours were exhibited in the 70 tagged individuals. Either they remained in waters along the west-coast of the UK, Ireland, and the Faroe Islands, migrated south to the Bay of Biscay or moved further south to waters off the Iberian Peninsula, and North Africa (Doherty *et al.*, 2017b).

13.6.1.71 No basking sharks were identified during DAS for the OAA from 2021 to 2023 (APEM, 2024). Aerial surveys conducted in support of other offshore wind farm Projects around the east coast of Scotland, including Hywind Offshore Wind Farm (located within the study area) (Statoil 2015) and Berwick Bank Wind Farm (150km south of the Project) (RPS, 2022) did not detect basking sharks.

13.6.1.72 As basking sharks are highly migratory and considering the study area has been identified as a region with potentially suitable habitat (Paxton *et al.*, 2014) it is possible that basking sharks may occur within the vicinity of the Project. It is considered unlikely, however that the species is found in significant numbers.

Spiny dogfish and tope shark

13.6.1.73 Spiny dogfish (or spurdog) (*Squalus acanthias*) and tope shark (*Galeorhinus galeus*) are both viviparous species. Spiny dogfish are typically born at a length of 19cm-30cm (Gauld, 1979), with the presence of individuals less than 48cm suggested to indicate the presence of primary and secondary nursery grounds (Ellis *et al.*, 2012). Spiny dogfish were detected across numerous years within the area reported in both DATRAS (ICES, 2025b) and Marine Scotland landing datasets (Marine Scotland, 2023). Size data provided in the DATRAS datasets for spiny dogfish further implies that spawning occurs within the study area, with individuals less than 48cm in length constituting over 50 per cent of the total catch between 2020 and 2025 (ICES, 2025b). It is considered highly likely that spiny dogfish pups may use the area as nursery grounds.

13.6.1.74 Tope sharks were not detected in either DATRAS (ICES, 2025b) or Marine Scotland landing data (Marine Scotland, 2023) sets. However, juvenile tope is caught sporadically in inshore areas of the North Sea (for example, Firth of Forth) (Ellis *et al*., 2012). Tope sharks are listed as critically endangered under the IUCN Red List (Walker *et al*., 2020) and the species has a particularly low biological productivity, reaching reproductive maturity late in life and exhibit a triennial reproductive cycle (Lucifora *et al*., 2004). Low fecundity of the species suggests the population may be particularly sensitive to the loss of spawning areas.

Common and flapper skate

13.6.1.75 Common skates including both the blue skate (*Dipturus batis*) and flapper skate (*D.intermedius*) are oviparous species, and although there is limited data on the distribution of egg-cases to define spawning areas, they are expected to overlap with nursery grounds (Ellis *et al*., 2012). Common skates have undergone extensive population declines (>80 per cent) over the past 60+ years due to exploitation as both a historical target species and as by-catch in multispecies trawl and tangle net fisheries (Ellis *et al*., 2021). In response, the species was listed as critically endangered on the IUCN Red List in 2006 and was listed on the OSPAR list of threatened and declining species in 2012.

13.6.1.76 Recent observations in the Orkney Isles indicate that flapper skate's favour egg-laying habitat categorised by boulder or cobbles in shallow waters (<20m) with moderate current (03 to 2.8 knots) and low sedimentation. Nursery grounds identified by Ellis *et al*. (2012) for the common skate complex suggests spawning is concentrated around the west coast of Scotland and Ireland, although a small area in the North Sea has been identified and intersects the southern nearshore extent of the study area (**Volume 2, Figure 13.5**). In addition to the identification of nursery sites for the common skate, the species was landed in 2020 and 2021 within the study area, albeit at low quantities (0.1441 tonnes over the two years) (Marine Scotland, 2023).

Spotted ray

13.6.1.77 Spotted ray (*Raja montagui*) is an oviparous species that is widespread around Scotland and considered to be a relatively abundant skate. In addition to nursery grounds identified over majority of the study area, the spotted ray was confirmed present in the study area, with the species reported in Marine Scotland landing datasets (Marine Scotland, 2023) between 2018 and 2022. Presence of juveniles measuring less than 18cm in length has been used to indicate the presence of nursery grounds (Ellis *et al*., 2012). Size data reported as part of the DATRAS dataset, however, did not suggest a large presence of young rays, with all individuals caught, but one measuring greater than 40cm in length. Nevertheless, it is possible that some spotted rays may use habitat in the study area for egg laying considering the findings of Ellis *et al.* (2012).

Spawning and nursery grounds

13.6.1.78 Low intensity nursing grounds for spiny dogfish, tope shark, common skate complex, spotted ray and thornback ray (*Raja clavate*) are mapped within the study area. The main spawning periods for these species are identified in **Table 13.15**.

Table 13.15 Main periods of spawning activity for key elasmobranch species in the fish study area.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spiny dogfish												
Tope shark												
Common skate												
Spotted ray												

NB: Light green indicates spawning period, and dark green indicates peak spawning periods. Where peak periods of spawning activity are unknown, a precautionary approach has been adopted with spawning assumed all year round.

Diadromous fish

13.6.1.79 Diadromous fish spend part of their life in both freshwater and sea water, migrating between the two. Some species are anadromous, spending most of their adult lives at sea and only returning to freshwater to spawn. Catadromous species conversely spawn at sea before migrating to freshwater. Given the extensive open ocean and near shore migrations undertaken by diadromous fish (Malcolm *et al*., 2010) there is potential for these species to migrate through the study area during certain periods of the year.

13.6.1.80 The following migratory species may be present within the fish study area:

- Atlantic salmon (*Salmo salar*);
- sea trout (*Salmo trutta*);
- twaite shad *(Alosa fallax);*
- European eel (*Anguilla Anguilla*);
- sea lamprey (*Petromyzon marinus*); and
- smelt *(Osmerus eperlanus*).

13.6.1.81 A review of conservation designations in the study area was undertaken to identify sites with migratory fish as qualifying features. The River Dee SAC is the only designated site present for diadromous fish (specifically Atlantic salmon and freshwater pearl mussel).

13.6.1.82 It is noted that other designated sites with the same qualifying features beyond the 50km buffer (such as the River Spey SAC and River Tay SAC) may be affected (**Volume 2, Figure 13.6**). However, due to the larger distance from the Offshore Red Line Boundary and potential for greater dispersion of individuals from those rivers, it is deemed likely that effects would be lesser than that to populations from the Dee. An assessment has been undertaken for the River Dee SAC and any outcomes are considered the maximum effect for other SAC rivers with migratory fish. Other non-designated salmonid rivers are also present in the study area, such as the Ugie, Deveron and Ythan (Malcolm *et al*., 2010).

13.6.1.83 Existing data for the migratory species listed above is limited, especially for juvenile salmonid migration from east coast rivers. There is also uncertainty regarding European eel migratory routes. For these species, there are also significant knowledge gaps on behaviour and swimming depths with regard to Scottish waters (Malcom *et al.,* 2010).

Atlantic salmon

13.6.1.84 Atlantic salmon are widely distributed in Scotland, with the Scottish population recognised as being of both national and international importance (Malcolm *et al*., 2010). In recent decades there has been a decline in the total reported rod catch for wild salmon across much of the species' range (Marine Scotland, 2023). In recognition of the European importance of Scotland's salmon populations, 11 rivers are designated as SACs for Atlantic salmon, and they are a qualifying feature at an additional six sites (JNCC, 2023a).

13.6.1.85 Across estuaries within the Outer Hebrides, Atlantic salmon spawning peaks between November and December (Ashley, 2019; Marine Scotland, 2023), however this may extend from October to late February (Webb and McLay, 1996). Juveniles typically remain within natal rivers between one to four years, before migrating down river as smolts. Smolts typically migrate downstream and enter coastal waters during the Spring, most often during April and May (Thorstad *et al*., 2012). Following entry into coastal waters, the fish are referred to as post-smolts until the Spring of the following year (Malcolm *et al*., 2010).

13.6.1.86 Current tracking findings from Rodger *et al.* (2024) show that, overall, post-smolts from the rivers Solway, Clyde, Boyne, Bush, and Foyle, which enter the Irish Sea and Firth of Clyde, tended to migrate in a northerly direction, being detected passing through the North Channel at the northern end of the Irish Sea. Post-smolt tracking on the east coast of Scotland in the River Dee indicate that in their initial stage of migration, post-smolts travel in an easterly direction, and the interim results of epipelagic trawling conducted by Marine Directorate on the north and east coasts of Scotland also indicate that post-smolts are widely distributed across offshore areas, with higher Catch Per Unit Effort (CPUE) off the east Grampian coast and lower catch rates in the outer Moray Firth (Main, 2021; Newton, 2021; Newton, 2023, personal communication).

13.6.1.87 Feeding grounds of Atlantic salmon are known to be in the in the Norwegian Sea and west Greenland (Thorstad *et al.,* 2012). Stomach analyses of post-smolts taken in fjords and coastal areas in Norway suggest however that fish start to extensively feed on marine organisms immediately after entrance to saltwater (Rikardsen *et al.,* 2004). Post-smolts are opportunistic feeders and have been reported to feed on a wide variety of fish and invertebrates (Rikardsen and Dempson, 2011), although crustacean and marine fish larvae constitute the vast majority of post-smolt diets (Utne *et al.,* 2022). Stomach content analyses suggests that 0-group sandeel (sandeel in the first year of their life) and blue whiting are the most important food source for post-smolts in the west and north of Scotland, and in the Faroe Shetland Channel (up to 62ºN) (Haugland *et al.,* 2006).

13.6.1.88 Atlantic salmon typically spend between two and six years at sea before returning to natal rivers to spawn. Their marine migration appears to involve two distinct phases: an initial phase of broad navigation from distant feeding areas toward the general vicinity of the home coast, followed by a coastal phase involving more precise orientation toward their natal rivers (Davidsen *et al.,* 2013). In the open ocean, navigation is thought to rely on mechanisms such as internal map-and-compass systems using geomagnetism (earth's magnetic field), visual cues and rheotaxis in relation to oceanic currents (Petersson, 2016). As salmon approach the coastline, evidence suggests that olfactory and visual cues become increasingly important for orientation (Bett and Hinch, 2015). Consequently, after reaching the coastal zone, Atlantic salmon typically adopt a coast-following behaviour, which is believed to reflect their reliance on nearshore sensory cues for final homing to their natal river systems (Davidsen *et al.,* 2013).

13.6.1.89 Returning adult salmon migrate close to the surface (0m to 40m) and typically remain within the top few metres of the water column (1m to 5m) (Godfrey *et al*., 2015). Diving behaviour (~13m to 118m) (Godfrey *et al*., 2015) has also been recorded in homing salmon, and although this behaviour is more frequent in offshore areas it has also been observed close to the coast (Hedger *et al*., 2022; Strøm *et al.,* 2018). A tracking study by Davidsen *et al*.

(2013) in a Norwegian fjord indicated that salmon movements during the latter part of their marine migration and river entry were unidirectional and relatively rapid, with a mean speed of 9.7km per day. However, as the salmon approached the estuary, their migratory speed slowed significantly, with much lower speeds recorded in the innermost areas of the estuary compared to the open fjord.

13.6.1.90 In many Scottish rivers, adult Atlantic salmon return to freshwater over an extended period (Sparholt *et al*., 2018). The earliest returning fish are older, multi-sea-winter (MSW) salmon, entering from the sea in late winter or early spring. Later in the season, from May onwards, grilse (1-sea-winter or 1sw salmon) enter the river, some returning only weeks before spawning, which takes place during late autumn and winter (Youngson *et al*., 1994).

13.6.1.91 Carlin tag studies undertaken from the 1930s to 1970s of Scottish and British adult salmon, as summarised by Malcolm *et al.* (2010), suggest that adult salmon may approach their spawning rivers from multiple directions, using different migratory pathways on their return migration. In some of the studies reviewed, adult salmon were reported to be recaptured up to 500km to 600km from their tagging site (Malcolm *et al.,* 2010). A review of tagged salmon undertaken more recently by Downie *et al*. (2018) further supports this notion. In this review, returning adult salmon to four major east coast river stocks (Tay, North Esk, Dee and Conon) were recorded over a widely dispersed area. For example, adult fish from the rivers Tay and North Esk (on the east coast of Scotland) were recaptured in both west coast and Solway fisheries (Downie *et al*., 2018).

13.6.1.92 Kelts refer to salmon that have completed their spawning and subsequently return to the marine environment. Male kelts often migrate downstream shortly after spawning (from October onwards). Depending on river conditions and post-spawning condition, female kelts, may instead overwinter in pools within natal rivers and begin their descent in Spring (March to May) (Bardonnet and Baglinière, 2000; Simmons *et al*., 2024)). In some cases, particularly in rivers with extensive estuarine zones, kelts may remain in the estuary for extended periods before migrating onwards to the ocean. For example, in the LaHave River (Canada), a study found that some kelts remained in the estuary for up to five weeks before migrating out to the ocean (Hubley *et al*., 2008).

13.6.1.93 In consideration of this behaviour, it is necessary to consider that adult salmon may migrate through the study area as grilse, kelts and repeat spawners, and may include fish from rivers along the east coast of Scotland such as the Ugie, Deveron, Ythan, Dee, South Esk and Tay.

13.6.1.94 Salmon stock in Scottish rivers are graded annually. The conservation status of each stock is defined by the probability of the stock meeting its conservation limit (CL) over a five-year period. Stocks are allocated to one of three grades, each with its own recommended management actions (Scottish Government, 2025e):

- 1 (Good) – At least 80% probability of meeting the CL. Exploitation is sustainable therefore no additional management action is currently required.
- 2 (Moderate) – Between 60% to 80% probability of meeting the CL. Management action is necessary to reduce exploitation. Catch and release should be promoted strongly in the first instance. The need for mandatory catch and release will be reviewed annually.
- 3 (Poor) – Less than 60% probability of meeting the CL. Exploitation is unsustainable. Catch and release fishing is mandatory to reduce exploitation of the stocks.

13.6.1.95 Rivers within the study area have been graded as follows (Scottish Government, 2023d, 2025d, 2025e):

- The River Ythan and River Ugie have been graded 3 from 2021 to 2026, indicating continued issues with recruitment and survival.

- The River Deveron and River South Esk SAC have been graded 2, indicating some issues where additional management intervention is required.
- The River Dee SAC, River Spey SAC, River Tay SAC have been graded 1, suggesting a more sustainable stock (Scottish Government, 2023d, 2025d, 2025e).

13.6.1.96 In recent decades, there has been a decline in the total reported rod catch for wild salmon across much of the species' range (Middlemas and Hanson, 2025). Rod catches of Atlantic salmon adults in the Rivers Deveron, Ythan, South Esk, and Tay have remained relatively consistent since the 1950s, although there has been evidence of declines in recent years. Catches in the Dee have declined since 1952, whilst catches in the Tweed have increased since 1952. Rod catches were highest in the Tweed and the Tay, which are two notable rivers for salmon populations and salmon fishing in Scotland. More recently, however, decreases in rod catches have been reported (Marine Scotland, 2023). Rivers such as the Deveron show a stable period of catch records from 1952 to the 1980s, averages increasing until 2012 before falling steeply and not recovering significantly in recent years (RDDSFB, 2025). While rod catch data can provide useful insights on salmonid populations, it should be noted that considered alone, rod catches are limited in their reliability as indicators of stock levels.

Sea trout

13.6.1.97 Sea trout are widely distributed in Scotland's freshwater environments and exhibit diverse life history strategies. Some remain in freshwater for their entire lives as resident or 'brown' trout, while others migrate to estuaries (semi-anadromous) or out to sea (anadromous). The anadromous form, referred to as sea trout, is the focus of this Section, as freshwater-resident trout will not be present within the offshore Red Line Boundary. Information on freshwater fish is presented in **Chapter 23: Terrestrial Ecology and Ornithology.**

13.6.1.98 Sea trout are recognised as a species of principal importance in England (Defra, 2022), a PMF in Scotland (NatureScot, 2020a), and the species is listed on the Scottish biodiversity list (NatureScot, 2020b). Despite these local listings, it is globally listed as "*Least Concern*" by the IUCN (IUCN, 2024a). Sea trout spend a variable amount of time in freshwater before migrating to sea, and like salmon, are referred to as post-smolts upon entry to the sea, and until spring of the following year.

13.6.1.99 Marine dispersal of sea trout post-smolts differs from that of salmon. Post-smolts move from rivers to sea lochs or estuaries primarily between April and early June and subsequently move to the open sea in late June and July (Pemberton, 1976). Sea trout tend to remain in coastal and estuarine environments rather than dispersing widely across the marine environment (Main *et al*., 2023; Middlemas *et al.,* 2009; Thorstad *et al*., 2004). Acoustic tracking studies provide insight into this behaviour. For instance, research on Scotland's west coast found that only 36 per cent of tagged post-smolts travelled more than 6km from their release sites (Middlemas *et al*., 2009). A more recent study on sea trout from the Rivers Dee and Don observed similar patterns, with post-smolts either remaining in estuaries or staying close to the shore (within 3.5km on the shore). Those that ventured into marine waters were predominantly recorded near the surface (down to depths of 3.4m), with no evidence of diving behaviour (Main *et al*., 2023).

13.6.1.100 Adult sea trout exhibit varied marine behaviour. Some spend summers at sea and winters in freshwater, while others remain at sea year-round, returning to freshwater only to spawn. Like Atlantic salmon, sea trout demonstrate strong natal homing, migrating back to their rivers of origin for spawning. For those returning from the sea, the peak migration period occurs in August and September (Pemberton, 1976). Most adult sea trout remain within 80km of their natal rivers, but longer-distance coastal migrations exceeding 500km have been recorded (Thorstad *et al.,* 2016). Adults typically occupy near-surface waters (less than 3m), although they have been observed diving to depths of 10m to 90m in coastal environments (Kristensen *et al*., 2018).

13.6.1.101 It is likely that sea trout post-smolts may pass through or utilise habitats within the Offshore Red Line Boundary, specifically the coastal areas around the offshore export cable corridor route. As post-smolts typically remain close to their natal rivers, those near the Red Line Boundary are expected to originate from local populations – specifically, from rivers and estuaries along the Aberdeenshire coastline. Adult sea trout however exhibit more variable marine distribution patterns and may undertake long-distance migrations. As such, it is possible that adult trout from rivers across the broader east coast of Scotland could transiently pass through or, on occasion, utilise habitats within the Offshore Red Line Boundary.

13.6.1.102 Recorded rod catches have decreased since 1952 in the Rivers Ythan and Ugie, remained stable on the Tay and increased in the Dee and Tweed (Marine Scotland, 2023). Reports from the Deveron show annual variations from 1952 to the 2003, where catches dropped significantly to the lowest catch on record of 317 fish. Since 2003, catches have remained low, mirroring a similar recent decline across many Scottish rivers (RDDSFB, 2025).

Freshwater pearl mussel

13.6.1.103 Freshwater pearl mussels are a freshwater mollusc, requiring cool, well oxygenated soft water that is free of pollution. Freshwater pearl mussels can be found in rivers throughout the UK, with the majority of the population found in Scotland (Moorkens *et al*., 2024; NatureScot, 2023), it is listed as Endangered on the IUCN Red List. The mussel spends its larval, or glochidial, stage attached to the gills of salmonid fishes (NatureScot, 2023). For this reason, and for their selection as features of designated sites within the study area, indirect effects on freshwater pearl mussels are considered following assessment of effects on salmonid fish.

13.6.1.104 The River Dee supports a functional population of freshwater pearl mussels. Juveniles make up approximately 30 per cent of the recorded population, among the highest proportions recorded in Scotland, indication strong recruitment and therefore importance (JNCC, 2025b). The River Spey has an equally strong population, estimated at several million individuals.

Twaite shad

13.6.1.105 Twaite shad is distributed across the west coast of Europe, from southern Norway to the eastern Mediterranean Sea, and is found in the lower reaches of large accessible rivers along these coasts. In Scotland, shad are most commonly associated with the Solway Estuary (on the west coast of Scotland), although little is known about the distribution of adults in the marine environment (Maitland and Hatton-Ellis, 2003). In response to declining spawning populations, the species is listed in Annexes II and V of the EU Habitats and Species Directive, Appendix III of the Bern Convention, and as a Priority Species in the UK BAP.

13.6.1.106 Twaite shad spawn in freshwater rivers along the coast of the UK, with eggs lodged on gravel. After hatching, the young inhabit the slow-flowing reaches of the lower parts of rivers until they move into the estuary, where they remain until the end of their second Summer (Bracken and Kennedy, 1967). Marine habitat requirements of adult twaite shad are poorly understood but it is thought the species is generally centred around coastal areas adjacent to known spawning rivers (La Mesa *et al*., 2015; Nachón *et al*., 2016), although recent acoustic tagging studies have indicated the species can make extensive migrations (950km) (Davies *et al*., 2020).

13.6.1.107 Twaite shad is considered unlikely to be found in significant numbers within the vicinity of the fish study area considering known spawning rivers are at a distance from the fish study area, generally along the west coast of Scotland (Maitland and Hatton-Ellis, 2003). Within the study area, no records of twaite shad being caught by trawls have been recorded since 2020 (ICES, 2025b) and there are no records of landings in Marine Scotland landing datasets (Marine Scotland, 2023). It is possible, however that twaite shad may migrate through, or intermittently use habitat within the fish study area.

Smelt

13.6.1.108 European smelt (*Osmerus eperlanus*), also known as sparling, occur around the western coasts of Europe. They are found in coastal waters and estuaries and migrate to large, clean rivers to spawn. Historically, populations of sparling were recorded in 15 Scottish rivers ranging from the Almond and Annan to the Fleet and Forth. Smelt in Scotland are now only found in the rivers Cree, Forth and Tay.

13.6.1.109 Within the study area, no records of smelt being caught by trawls have been recorded since 2020 (ICES, 2025b) and there are no records of landings in Marine Scotland landing datasets (Marine Scotland, 2023).

13.6.1.110 Smelt is also a UK BAP priority fish species and a conservation feature in two of Scotland's Sites of Special Scientific Interest (SSSI) (the Cree Estuary SSSI and Forth of Forth SSSI), giving them protection under the Wildlife and Countryside Act 1981 (as amended). However, these SSSI are not within the fish ecology study area.

European eel

13.6.1.111 European eel is widely distributed across Scotland, and is found within Scottish freshwater rivers, estuaries and marine environments. European eel is listed in Appendix II of the Bonn Convention (The Convention on Migratory Species), Appendix II of Convention on International Trade in Endangered Species (CITES) and is considered critically endangered globally (IUCN, 2024) and locally across Great Britain (JNCC, 2023b).

13.6.1.112 European eel is also recorded on the OSPAR list of threatened and / or declining species and habitats (OSPAR, 2025). Assessment by OSPAR in 2022 indicates that the status of European eel remains very poor across all OSPAR regions where the species occurs. While glass eel (i.e. juvenile European eel) recruitment has remained stable since 2010, it is still at a very low level, with no clear indication of recovery (OSPAR, 2025). Although commercial fishing pressure has decreased during the 2010 to 2021 period, other significant threats, such as dams, turbines, habitat destruction, pollution, poaching, diseases, pathogens, and climate change continue to pose considerable risks to the species (OSPAR, 2025). Similarly, ICES assessment indicates that the eel stock remains in a critical state, with recruitment levels well below historical averages. In 2024, the "*Elsewhere Europe*" index series, which includes the Celtic Sea, recorded a glass eel recruitment rate of 7.2 per cent, slightly lower than recorded in 2023 (7.4 per cent). Yellow eel (i.e. mid-age eels) recruitment was similarly low in 2023 (11.4 per cent) (ICES, 2024b).

13.6.1.113 European eels are catadromous and based on the distribution and size of eel larvae caught in Atlantic trawls, spawning is thought to occur in the vicinity of the Sargasso Sea (Miller *et al*., 2019). Satellite tagging has also provided direct evidence of European eels migrating to Sargasso Sea from the Azores (Wright *et al*., 2022) and the Scotian Shelf in Canada (Béguer-Pon *et al*., 2015).

13.6.1.114 European eels undergo an autumn migration (Sandlund *et al*., 2017). However, individuals may begin to leave the rivers at almost any point of the year, with much variation between peak migration periods at particular sites (Righton *et al*., 2016). Very little is known about the migration route of adult European eels traveling to spawning grounds from the east coast of Scotland. Tracking studies of European eel released from the Swedish west coast, the west coast of Ireland (Celtic Sea) and the Bay of Biscay (France) suggest that European eels typically follow routes that converge on the Azores region (Righton *et al*., 2016). The last segment of the migration route was confirmed by Wright *et al*. (2022) who satellite tagged and tracked the movements of 21 adult European eel in the Azores, demonstrating that the eels migrate towards the Sargasso Sea along the Mid-Atlantic Ridge. Considering the migration route taken by the Scandinavian populations and Irish populations, eel populations along the east coast of Scotland may head towards the Azores (Righton *et al*., 2016).

13.6.1.115 During migration, eels exhibit a diurnal depth cycle, swimming at greater depths during daylight hours and moving to shallower water during the night. Even with this diurnal behaviour however, European eels typically remain in deep water (>140m depth) throughout their entire migration.

13.6.1.116 Once hatched, larval eels cross the Atlantic Ocean and, by the time they reach the European continental shelf, metamorphose into post-larvae referred to as glass eels. Although there is some debate about the reliance of larval eels on oceanic currents as opposed to activity swimming, it appears that migration is primarily driven by oceanic currents, including the Gulf Stream and its extension, the North Atlantic Drift (Adams *et al*., 2013; Knights, 2003). As they near land, typically during the period from September to November (Tesch, 2003), the northerly flowing Continental Shelf Current and wind-driven coastal currents are thought to influence their final approach. Given these oceanographic conditions – particularly the exposure to the North Atlantic Drift, Continental Shelf Current, and prevailing south-westerly winds – the west of the British Isles, and especially western Scotland, is likely to be a key region of first landfall for a significant proportion of the oceanic migrating eel population in most years (Adams *et al*., 2013).

13.6.1.117 Glass eels either ascend rivers around Europe, remain at sea or move back and forth between freshwater, estuarine and marine environments (Daverat *et al*., 2006). Eventually, all glass eels become yellow eels. Yellow eels exhibit a similar behaviour as glass eels, either settling and remaining in marine, estuarine or freshwater, or shifting between the habitats (Rohtla *et al*., 2023a). However, it is thought that European eels predominantly reside in estuarine habitats and / or shift between freshwater and estuarine environments, with the coastal and marine zones used to a lesser extent, primarily as migratory corridors (Denis *et al*., 2023). Following a continental growth phase (ranging from three to 60 years) they begin their return migration to the spawning grounds in the Sargasso Sea.

13.6.1.118 Given the variability in migratory patterns exhibited by European eels (Daverat *et al*., 2006; Rohtla *et al*., 2023b), and the findings of Adams *et al*. (2013), it is considered likely that European eels may pass through the Offshore Red Line Boundary during migration, both as adults on their way to the Sargasso Sea and as 'landing' glass eels. In addition to these migratory movements, marine residents – including both glass and yellow eels – may infrequently inhabit and utilise the coastal areas around the Offshore Red Line Boundary.

Sea lamprey

13.6.1.119 Sea lamprey (*Petromyzon marinus*) is a widely distributed species, found across the UK (Boulêtreau *et al*., 2020). Populations of sea lamprey, however, have been continuously deteriorating across most of the species range (OSPAR, 2009). Several Scottish SAC rivers are designated for its protection (JNCC, 2023a), although none of these are in the study area for fish ecology.

13.6.1.120 Sea lamprey is an ectoparasitic species in its adult phase. They attach and feed off various fish species including salmonids, clupeids, gadoids as well as megafauna such as basking sharks (OSPAR, 2009). Although rarely captured in coastal and estuarine waters, sea lamprey have been caught at depths over 4,000m suggesting that they can feed in deeper offshore waters (Haedrich, 1977).

13.6.1.121 Due to their dispersal in the marine environment, they are not philopatric (they do not return to their natal rivers to spawn), however, research suggests that spawning occurs in streams where ammocoete larvae are present due to olfactory cues (OSPAR, 2009). Spawning occurs in freshwater over coarse gravel and cobbles between end of April and end of May in water depths over 50cm. Juveniles may remain within freshwater for up to seven years before migrating to sea.

13.6.1.122 The species ectoparasitic adult phase means the species distribution is ultimately depended on the home range and migratory behaviour of the host species. Considering the wide range of host species targeted by sea lamprey, it is considered highly likely that the species may pass through and / or utilise habitat across the full extent of the study area.

13.6.2 Future baseline

13.6.2.1 In the absence of the Project, the marine environment in the study area is likely to experience changes associated with long-cycle natural variations and anthropogenic climate change. Studies have demonstrated that long-term change in the fish community is likely to result from a combination of climatic (for example, rising sea temperatures) (Dulvy *et al*., 2008) and non-climatic factors (for example, changes in fishing patterns) (Jones *et al*., 2023a), with potential effects including geographical range shifts, habitat reduction, altering food webs and increased disease outbreaks. Studies in the North Sea have demonstrated that long-term change in the fish community is likely to result from a combination of climatic (for example, rising sea temperatures (Dulvy *et al*., 2008) and non-climatic factors (for example, changes in fishing patterns).

13.6.2.2 Response of the fish community to changes in the climate and / or changes in non-climatic factors will be dependent on individual species characteristics, including physiology (for example, thermal preference or tolerance to ocean acidification), ecology, biogeography, and susceptibility to human impact (for example, fishery target, by-catch).

13.6.2.3 One potential effect of increased sea surface temperatures is that some fish species will extend their distribution into deeper, colder waters (Poloczanska *et al*., 2016). In these cases, however, habitat requirements are likely to become important, with some shallow water species having specific habitat requirements which are not available in these deeper areas. For example, sandeel is less likely to be able to adapt to increasing temperatures as a result of its specific habitat requirements for coarse sandy sediment and declining recruitment in sandeel in parts of the UK has been correlated with increasing temperature (Macdonald *et al.,* 2019). Using ocean temperature projections, Cote *et al*. (2021) illustrated a poleward shift of suitable spawning areas for Atlantic cod under forecasted emission scenarios. Increasing ocean temperature was correlated with earlier emergence of sandeels from winter dormancy (Henriksen *et al*., 2021). Even where direct effects do not occur, climate change may affect prey resources which may in turn drive changes in fish distribution. Projected warming scenarios indicated regime shifts between sandeel and their copepod prey, resulting in sandeel recruitment declines (Regnier *et al*., 2019). Increased sea surface temperatures in the North Sea may lead to an increase in the relative abundance of species associated with more southerly areas. For example, data that was collected as part of the IHLS indicate a trend for increased herring spawning with colder winters, while warm winters were associated with large catches of sardine (Alheit and Hagen, 1997).

13.6.2.4 Given the long-term nature of such processes, changes are not likely to be significant between now and the commencement of the Project. It is therefore considered that an assessment based on the current baseline would be adequately representative of any conditions pertaining at the commencement of construction activities. Baseline verification may be required prior to decommissioning.

13.6.2.5 In addition, the variations and trends in commercial fisheries activity are an important aspect of the future baseline, considered in **Chapter 14: Commercial Fisheries**.

13.7 Basis for the EIA Report

13.7.1 Maximum design scenario

13.7.1.1 The process of assessing using a parameter-based design envelope approach means that the assessment considers a maximum design scenario whilst allowing the flexibility to make improvements in the future in ways that cannot be predicted at the time of submission of the planning application, marine licence applications and s.36 consent.

13.7.1.2 The assessment of the maximum adverse scenario for each receptor establishes the maximum potential adverse effect and as a result effects of greater adverse significance would not arise should any other scenario (as described in **Chapter 4: Project Description**) to that assessed within this Chapter be taken forward in the final Project design.

13.7.1.3 The maximum design scenario parameters that have been identified to be relevant to fish ecology are outlined in **Table 13.16** and are in line with the Project design envelope (**Chapter 4: Project Description**).

Table 13.16 Maximum design scenario for impacts on fish ecology

Impact / activity	Maximum design scenario parameter	Justification
Construction		
Impact C1: Pre-construction seabed preparation works	**Seabed Preparation:** • geophysical surveys; • UXO clearance; • pre-lay grapnel run across entire length or all cables; • boulder clearance campaign; and • bedform clearance (e.g. sandwaves).	Greatest extent of seabed preparation or disturbance activities.
Impact C2: Temporary habitat loss and / or disturbance	**Wind turbine generators (WTGs): 6.75km²** • up to 225 WTGs; • mooring concepts: catenary; • maximum seabed displacement: Anchor type: drag embedment[1] fully buried (breadth 12.5m). 300m drag length. Seabed impact of 3,750m² per anchor; and • total anchor disturbance (assuming 225 WTGs, each with 8 anchors) is 6.75km². **Array cables: 20.4km²** • 225 array cables; • 680km total array cable length; • assumed jet trenching installation method as worst-case for sediment mobilisation with 30m disturbance width; • temporary construction disturbance assumed 100% of total array cable length is buried by jet trenching; 680km x 0.03km = 20.4km² **Subsea distribution centres (SDC): 125,280m2** • up to 45 SDCs; • assumed worst-case is gravity base foundations; • SDC construction footprint: 58m x 48m, footprint is 2,784m² per SDC; and	This is the maximum area of temporary disturbance required for the installation of WTG anchors; offshore substations and RCPs jacket foundations; SDCs; and offshore cables (array and export). Catenary mooring and drag-embedment anchors are considered the worst-case design options in terms of habitat disturbance, due to maximising the area of seabed swept by chains / cables, in addition to the direct footprint of the anchor. Offshore substations are considered the worst-case design scenario over subsea substations due to having the largest construction footprint.

[1] Should the drag embedment end point be out of tolerance then it would be required to lift the anchor and re-lay increasing the seabed displacement by the same amount. At the design stage, it is not possible to accurately determine the level of installation failure or damage when laying the anchors. There will remain a residual risk that some anchors may need to be re-laid as they are out of tolerance or moved during service. This will depend on seabed conditions and other factors associated with offshore operations of the install vessels.

Impact / activity	Maximum design scenario parameter	Justification
	• total disturbance is 125,280m^2 for 45 SDCs. **Offshore substations: 57,200m^2** • 4 offshore substations with jacket foundations secured with suction caisson; • offshore substation construction footprint: 130m x 110m = 14,300m^2 per offshore substations; and • total disturbance is 57,200m^2 for four offshore substations. **Offshore export cables: 21km^2** • 5 offshore export cable trenches; • 140km offshore grid transmission route length per trench; • assumed jet trenching installation method as worst-case for sediment mobilisation with 30m disturbance width, • temporary construction disturbance assumed 100% of total export cable length is buried by jet trenching of 140km x 0.03km = 4.2km^2 per cable; and • total disturbance is 21km^2 for five cables. **Cable crossings: 714,000m^2** • 6 cable crossings per trench within the OAA with construction footprint of 170m x 30m = 5,100m^2, total of 153,000m^2 for 6 cable crossings for 5 cable trenches; and • 22 cable crossings along the offshore export cable corridor with construction footprint of 170m x 30m =5,100m^2, total of 561,000m^2 for 22 cable crossings for 5 cable trenches. **Reactive compensation platforms (RCPs): 14,450m^2** • 2 RCPs with jacket foundations secured with suction caisson; construction footprint: 85m x 85m = 7,225m^2 (per RCP); and • total disturbance is 14,450m^2 for 2 RCP's. **Landfall(s): 80m^2** • Scotstown, Lunderton North and Lunderton South;	For offshore substation and RCP, jacket foundations secured by suction caissons have been considered as the wors t-case design scenario due to having the largest footprint of all the foundation types. Jet trenching is considered the worst-case cable installation method as it has to penetrate to achieve the same burial depth and disturbs a greater amount of sediment, therefore affecting a greater area of habitat. It also tends to resuspend a greater portion of sediment, increasing total suspended sediment and the area prone to redeposition.

Impact / activity	Maximum design scenario parameter	Justification
	• 8 horizontal directional drilling (HDD) (or similar trenchless technique)[2] cable bore exit pits and ducts with sub-tidal location for punch-out; • HDD exit pit dimensions: assumed 5m x 2m as worst-case, 10m² per exit pit; and • total disturbance is 80m² for 8 exit pits. **Total temporary habitat disturbance = 49,110,010m² (49.11km²).**	
Impact C3: Temporary localised increases in SSC and smothering	**Seabed preparation for wind turbine anchors** • 225 WTGs each with 8 anchors, total of 1,800 anchors; • Anchor type: driven pile anchor; and • bedform clearance (for example sandwaves). **Seabed preparation for array cables** • Bedform clearance (or example sandwaves). **Installation activities for array cables** • Jet trenching up to 530km of array cables with trench dimensions of 30m wide, 2m deep. **SDCs** • 45 SDCs; and • bedform clearance (or example sandwaves). **Seabed preparation for subsea substation** • 4 subsea substations; and • bedform clearance (or example sandwaves). **Seabed preparation for offshore substations** • 4 offshore substations; and • bedform clearance (or example sandwaves).	The maximum design scenario corresponds to (a combination of) the greatest amount of material disturbed and the greatest geographical extent of the impact. **Seabed preparation** Seabed preparation, specifically sandwave clearance / levelling, may be undertaken using a range of techniques – mass flow excavator and suction hopper dredging are considered the worst case. Dredge spoil release is assumed to be an instantaneous release at the water surface, with 10% of the hopper volume (typically 11,000m³) assumed to form the passive phase of the sediment plume. Other seabed preparation such as boulder clearance does not represent the maximum design scenario in terms of potential increases in SSC and associated changes to seabed substrate. **Installation activities for cables**

[2] In relation to trenchless cable burial techniques, HDD has been presented in the EIA. Whilst other trenchless methods are available, HDD is presented herein as it is likely to have the largest construction impact.

Impact / activity	Maximum design scenario parameter	Justification
	Piling for substation foundation installation • 56 drilled piles (12 driven piles per offshore substation and 4 driven piles per reactive compensation platform (RCP)) with 94.5m drill penetration depth and 3m drill diameter, creating 667.7m^3 of drill arisings per pile. **Seabed preparation for offshore export cables** • bedform clearance (or example sandwaves); and • 35,000m^3 of sandwave clearance from the offshore export cable. **Installation activities for export cables** • Jet trenching up to 5 offshore export cable trenches, with trench dimensions of 30m wide, 2m deep, along 140km offshore export cable corridor length. **Landfall installation activities** • 8 HDD cable bore exit pits and ducts with sub-tidal location for punch-out; and • 1,000 HDD duct length.	Pre-lay trenching may be undertaken using a range of techniques – jetting, ploughing and trenching. Jetting will give maximum design scenario for sediment disturbance. 100% fluidisation of material expelled from trench is conservatively assumed. In reality, pre-lay jetting will move a proportion of material rather than bringing it fully into suspension. **Piling** Based on the greatest amount of material disturbed in a drilling event, considering the largest driven pile dimension and largest driven pile penetration depth. **Landfall installation activities** Other stages of drilling (pilot hole drilling and stages of reaming) may result in smaller release events separated in time. But the maximum design scenario is considered as a release of drilling mud (Bentonite) from a single conduit. The parameters are supported by modelling within **Volume 3, Appendix 6.1: Physical Processes Modelling**, which simulates sediment dispersion, deposition and SSC levels. Figure 3 within **Volume 3, Appendix 6.1** further illustrates the spatial footprint of the construction activities.
Impact C4: Mortality, injury and behavioural changes resulting from	Construction window of up to 12 years. **WTG anchor installation with driven piles:**	Impulsive noise created during pile driving for the installation of the WTG anchors; offshore substation and RCP

Impact / activity	Maximum design scenario parameter	Justification
underwater noise, vibration and particle motion	• 8 driven pile anchors per floating unit, total 1,800 driven piles; • maximum pile length: 30m; • maximum pile diameter: 3m; • maximum hammer energy: 3,500kJ; • maximum number of driven piles per day per location is 2; • maximum number of concurrent piling locations is 2; • maximum hours of piling per driven pile is 2.35; and • maximum number of piling days is 1,800 (assuming one driven pile installed per day). **Offshore substation foundation installation with driven piles:** • 4 offshore substations with jacket foundations secured by driven piles; • 48 driven piles (12 per offshore substation); • maximum pile diameter: 3m; • maximum pile length: 95m; • maximum hammer energy: 3,500kJ; • maximum number of driven piles per day per location is 2; • maximum number of concurrent piling locations is 2; • maximum hours of piling per driven pile is 2.35; and • maximum number of piling days is 48 (assuming one pile installed per day. **RCP foundation installation with driven piles:** • 2 RCPs with jacket foundation secured by driven piles; • 8 driven piles (4 per RCP); • maximum pile diameter: 3m; • maximum pile length: 95m; • maximum hammer energy: 3,500kJ; • maximum number of driven piles per day per location is 2; • maximum number of concurrent piling locations is 2; • maximum hours pilling per driven pile is 2.35; and • maximum number of piling days is 8 (assuming one pile installed per day). Maximum number of piling days: 1,800 (WTG anchors) + 48 (offshore substations) + 8 (RCPs) = 1,856 days.	jacket foundations; and UXO have the potential to result in has the potential to cause injury or disturbance in fish receptors. This can affect migratory routes spawning, eggs, foraging, and larvae. The scenario with the maximum number of piling days represents the temporal worst-case. Other seabed clearance and installation activities such as cable laying, dredging and vessel movements may create pathways for underwater noise to effect sensitive receptors. However, these activities are established as producing low levels of noise, in the case of vessel movement no greater than the existing baseline of regional vessel noise, affecting a relatively small area in the immediate vicinity of activities. These general activities are therefore considered to not fall within the worst-case scenario. UXO clearance will be licensed under a separate marine licence but is included in the EIA Report for illustrative purposes

Impact / activity	Maximum design scenario parameter	Justification
	The type, size and number of possible UXO that might require clearance is currently unknown. The primary method of clearance will be low-order, with high-order being assessed as the worst-case scenario.	
Impact C5: Direct and indirect seabed disturbances leading to the release of sediment contaminants	Refer to Impact C3.	The worst-case scenario represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during construction activities.
Impact C6: Changes in water quality	Refer to Impact C3.	Maximum seabed disturbance is the scenario with greatest implications for water quality.
Impact C7: Potential impacts on designated sites	Refer to all other construction impacts for maximum scenario.	Maximum scenario for all construction impacts appropriate for impacts on designated sites. Features of designated sites (e.g. Atlantic salmon) will be assessed within each receptor group throughout.
Impact C8: Increased risk of introduction and / or spread of marine INNS	Construction window of up to 12 years. It is anticipated that approximately 10 vessels would be on site at any one time during the construction of the Project. It is estimated that approximately 3,838 individual vessel transits would be required during the construction of the Project. **Total volume of introduced hard substrates: 2,399,000m^3** • 225 WTGs; • 1,122,000m^3 of rock for array cable protection; • 500m^3 scour protection per offshore substation platform, total 2,000m^3 for four offshore substations; • 500m^3 scour protection per RCP, total 1,000m^3 for two RCPs;	Vessel movements associated with the construction of the Offshore Windfarm can lead to an increased risk of introduction or spread of marine INNS. These parameters are considered the worst-case in terms of vessel movements. This scenario represents the maximum area of hard substrate introduced that could be introduced on the seabed. Hard substrates offer ideal settlement surfaces

Impact / activity	Maximum design scenario parameter	Justification
	• 140km offshore export cable with 1,155,000m³ of cable protection; and • 28 cable crossings per cable trench (140 cable crossings total) total 850m³ x 140 = 119,000m³ of cable protection. • Total introduced hard substrate = 2,399,000m³.	for species that are typically absent from soft sediment environment. The introduction of hard substrate can act as a stepping stone for the spread of INNS, particularly those that are opportunistic and thrive on artificial substrate. The maximum design scenario is used to ensure a precautionary approach in assessing risk of introduction or spread of INNS, capturing the worst-case extent of habitat alteration and associated biosecurity concerns.
Operation and maintenance		
Impact O1: Temporary habitat loss and disturbance	Each phase will be operational for 35 years. **Maintenance of:** • replacement of mooring line components; • replacement of mooring or anchors using the same process as construction; • replacement or repair of array cables including routine inspection (recovery and reburial); • SDC and subsea substations includes routine inspections and scour protection repair / replacement; • offshore substations and RCPs including routine inspections, removal of marine growth and replacement of scour protection; and • offshore export cables including routine inspection and cable repair (recovery and reburial).	These are the activities likely to result in temporary disturbance of seabed habitats during O&M. The frequency of these activities is currently unknown. Therefore, the temporary disturbance of seabed habitat cannot but quantified in relation to each of the maintenance activities stated. Any temporary habitat disturbance during O&M is expected to be of the same or lower magnitude than that assessed for the construction stage.
Impact O2: Long-term habitat loss and / or disturbance	Each phase will be operational for 35 years. **WTGs: 270,000m²** • 8 anchors per floating unit, total number of anchors 8 x 225 =1,800; • worst-case assumed: drag embedment anchor; and	The maximum design scenario is defined by the maximum area of seabed lost by the footprint of the anchors on the seabed, offshore substation and RCP jacket foundations, scour and cable protection and cable crossings.

Impact / activity	Maximum design scenario parameter	Justification
	• maximum total area of seabed covered by 1 anchor: 12m x 12.5m = 150m^2, total 270,000m^2 for 1,800 anchors. **Array cables: 2.04km^2** • 225 array cables; • secondary protection rock placement, localised: concrete mattresses and bags; • 680km total array cable length; • 136km length of unburied cable; • conservative cable corridor swathe width of 15m assumed for areas of cable protection, and; • maximum total area of seabed covered by cable protection based on conservative 136km x 0.015km = 2.04km^2. **SDCs: 47,880m^2** • 45 SDCs; • assumed worst-case is gravity base foundations; and • dimensions of SDC including cable protection: 38m x 28m, footprint is 1,064m^2 and total 47,880m^2 for 45 SDCs. **Offshore substations: 39,600m^2** • 4 offshore substations with jacket foundations secured by suction caisson; • maximum seabed footprint (including scour protection): 110m x 90m, footprint is 9,900m^2 and total 39,600m^2 for 4 offshore substations. **Offshore export cables: 10.5km^2** • 5 offshore export cable trenches; • 140km offshore grid transmission rout length per trench; • conservative cable corridor swathe width of 15m assumed for areas of cable protection, and; • maximum seabed footprint (including cable protection): 140km x 0.015km = 2.1km^2 per cable trench and total 10.5km^2 for 5 cable trenches. **Cable crossings: 231,000m^2** • 6 cable crossings per trench within the OAA with construction footprint of 150m x 11m = 1,650m^2, total of 49,500m^2 for 6 cable crossings for 5 cable trenches; and	Four offshore substations are considered the maximum design scenario over subsea substations due to having the largest seabed footprint. Maximum design scenario footprints for cable protection have been determined based on: • 20% of total cable length requiring cable protection for the array cables; and • 20% of total cable trench length requiring cable protection for the offshore export cables.

Impact / activity	Maximum design scenario parameter	Justification
	• 22 cable crossings along the offshore export cable corridor with construction footprint of 150m x 11m = 1,650m², total of 181,500m² for 22 cable crossings for 5 cable trenches. **RCPs: 8,450m²** • 2 RCPs with jacket foundations secured by suction caisson; and • maximum seabed footprint (including scour protection): 65m x 65m = 4,225m² and total 8,450m². **Maximum long-term habitat loss = 13,136,930m² (13.137km²).**	
Impact O3: Colonisation of hard substrate	**Total volume of introduced hard substrates:** • 225 WTGs; • 1,122,000m³ of rock for array cable protection; • 500m³ scour protection per offshore substation platform, total 2,000m³ volume for four offshore substations; • 500m³ scour protection per RCP, total 1,000m³ for 2 RCPs; • 140km offshore export cable with 1,155,000m³ of rock for cable protection; and • cable crossings with 850m³ x 140 = 119,000m³ of cable protection. **Total introduced hard substrate = 2,399,000m³.**	This scenario would result in the largest amount of permanent hard structure and associated scour protection, which would provide the largest potential area for colonisation.
Impact O4: Temporary localised increases in SSC and smothering	Refer to Impact O2.	Refer to Impact O1.
Impact O5: Effects arising from underwater noise, vibration and particle motion	Peak of up to 7 O&M vessels offshore with up to 364 round trips to port per year. **WTGs:** • up to 225 WTGS; • 1,800 moorings lines in total (8 mooring lines per WTG); • 800m radius per individually moored floating unit (maximum mooring footprint of 2,010,619.298m² or 2.011km²; • catenary mooring lines; and • mooring line material of rope, links, chain buoyancy and / or clump weights.	Maximum number of ship movements. The design, number and capacity of the WTGs and the design, dimension and maximum spatial extend of the mooring lines, will lead to the maximum UWN that represents the maximum design scenario for noise-related impacts.

Impact / activity	Maximum design scenario parameter	Justification
	The operational lifetime of the Project is 35 year per phase.	There are no reliable noise thresholds that would be recommended to identify disturbance for rare / intermittent impulses of this type. Mooring lines associated with floating WTGs have been described as producing a 'snapping' noise related to tension release. As any snapping occurs at an average rate of less than one snap per hour, disturbance leading to avoidance behaviour is considered unlikely. The semi-submersible floating unit are the worst-case scenario in this instance as it is not a taut system.
Impact O6: EMF effects arising from cables	See Table 9.5 of **Chapter 9: Electromagnetic Fields** for the detailed design parameters for the maximum design scenarios for the array and offshore export cables. EMF analysis has determined that these parameters will create the maximum design scenario: • 8 buried 66kV array cables in close proximity to each will emit EMF at 50 micro tesla (μT) over a distance of approximately 0.8m from each array cable. • for dynamic sections of the array cables in the water column, EMF will also be attenuated to background levels of 50μT within 0.8m, and to 0.1μT over 40m and 0.05μT by 60m distance from the cable; • 5 HVDC offshore export cables will emit EMF at 50μT zone to approximately 1.1m around a monopole cable, and approximately 11m around any single pole of the bipole cable; and • 5 HVAC offshore export cables will emit EMF at 50μT zone to approximately 1.15m around the cable.	The scenario generates the maximum field that might affect fish species. The design, number and maximum spatial extent of the array and export cables represent the worst-case scenario for EMF impacts on fish receptors. The maximum length and operating current of the array and offshore export cables will result in the greatest potential for EMF effects. The minimum target cable burial depth represents the worst-case scenario as EMF exposure will be reduced with greater burial depth. Dynamic array cables represent the worst-case scenario for EMF due to being suspended in the water column and having a greater attenuation of EMF compared to buried cables.

Impact / activity	Maximum design scenario parameter	Justification
Impact O7: Heat effects arising from cables	Refer to Impact O6	Maximum scenario for heat effects same or less than EMF effects.
Impact O8: Direct and indirect seabed disturbances leading to the release of sediment contaminants	Refer to Impact O1.	Largest spatial extent of seabed interaction during O&M. The maximum design scenario represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during O&M activities.
Impact O9: Secondary entanglement risk	**Mooring lines:** • 1,800 moorings lines in total (8 mooring lines per WTG); • 800m radius per individually moored floating unit (maximum mooring footprint of 2,010,619.298m^2 or 2.011km^2; • catenary mooring line; and • mooring line material of rope, links, chain buoyancy and / or clump weights. **Array cables:** • up to 225 array cables • 136km of unburied array cable (assuming a worst case of 20% of cable length cannot be buried). The operational lifetime of the Project is 35 years per phase.	The design, dimensions and maximum spatial extent of the mooring lines and array cables represent the maximum potential for entanglement.
Impact O10: Potential impacts on designated sites	Refer to all other operation impacts for maximum scenario.	Maximum design scenario for all O&M impacts is appropriate for impacts on designated sites. Features of designated sites (e.g. Atlantic salmon) will be assessed within each receptor group throughout.

Impact / activity	Maximum design scenario parameter	Justification
Impact O11: Increased risk of introduction and / or spread of INNS	Peak of up to 7 O&M vessels offshore with up to 364 round trips to port per year.	Vessel movements associated with the operation and maintenance of the OAA can lead to an increased risk of introduction or spread of marine INNS. These parameters are considered the worst-case in terms of vessel movements.
Decommissioning		
Impact D1: Temporary habitat loss and / or disturbance	Equal to (or less than) that of the construction stage. Refer to Impact C1 and C2.	Refer to Impact C2 justification.
Impact D2: Temporary localised increases in SSC and smothering	Equal to (or less than) that of the construction stage. Refer to Impact C3.	Refer to Impact C3 justification.
Impact D3: Mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion	Equal to (or less than) that of the construction stage. Refer to Impact C4.	Refer to Impact C4 justification.
Impact D4: Direct and indirect seabed disturbances leading to the release of sediment contaminants	Equal to (or less than) that of the construction stage. Refer to Impact C6.	Refer to Impact C6 justification.
Impact D5: Changes in water quality	Equal to (or less than) that of the construction stage. Refer to Impact C8.	Refer to Impact C8 justification.

Impact / activity	Maximum design scenario parameter	Justification
Impact D6: Potential impacts on designated sites	Equal to (or less than) that of the construction stage. Refer to Impact C10.	Refer to Impact C10 justification.
Impact D7: Increased risk of introduction and / or spread of INNS	Equal to (or less than) that of the construction stage. Refer to Impact C10.	Refer to Impact C10 justification.

13.7.2 Embedded environmental measures

13.7.2.1 As part of the Project design process, a number of embedded environmental measures have been adopted to reduce the potential for adverse impacts on fish ecology. These embedded environmental measures have evolved over the development process as the EIA has progressed and in response to consultation.

13.7.2.2 These measures also include those that have been identified as good or standard practice and include actions that would be undertaken to meet existing legislation requirements. As there is a commitment to implementing these embedded environmental measures, and also to various standard sectoral practices and procedures, they are considered inherently part of the design of the Project and are set out in this EIA Report.

13.7.2.3 **Table 13.17** sets out the relevant embedded environmental measures within the design and how these affect the fish ecology assessment.

13.7.2.4 Further detail on the embedded environmental measures in **Table 13.17** is provided in the **Volume 3, Appendix 5.2: Commitments Register**, which sets out how and where particular embedded environmental measures will be implemented and secured.

Table 13.17 Relevant fish ecology embedded environmental measures

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Relevance to fish ecology assessment
M-028	An **Outline Scour Protection Plan** has been submitted within **Volume 4** and includes details of the need, type, quantity and installation methods for scour protection. A Final Scour Protection Plan will be completed prior to construction commencing and will include measures during the O&M stage such as period inspection and maintenance requirements and will be submitted to MD-LOT for approval.	Scoping Amended at EIA Report.	s.36 conditions and marine licences conditions.	This measure will help minimise habitat disturbance, sediment resuspension and smothering of sensitive communities that provide a resource for fish.
M-029	An **Outline Cable Plan** has been submitted within this Application (**Volume 4**), and includes details of the need, type, quantity and installation methods for cabling. A Final Cable Plan will be completed prior to construction commencing and submitted to MD-LOT for approval. The Final Cable Plan will include: a) the vessel types, location, duration and cable laying techniques for export and array cables; b) the finalised location of the export cable route; c) the results of monitoring or data collection work (including geophysical, geotechnical and benthic surveys); d) technical specification of the cables, including a desk based assessment of attenuation of electromagnetic field strengths and shielding; e) a CBRA, to ascertain burial depths and where necessary alternative protection measures; f) methods to be used to mitigate the effects of EMF; g) methodologies and timetable for post-construction and operational surveys (including inspection, over trawl, post-lay) for the cables through its operational life; h) measures to address and report to the Licensing Authority any exposure of cables or risk to users of the sea from cables; and	Scoping Amended at EIA Report.	s.36 conditions and marine licences conditions.	This measure will help minimise habitat disturbance, and alteration of communities that provide a resource for fish.

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Relevance to fish ecology assessment
	g) methodologies for cable inspection with measures to address and report to Scottish Ministers, any exposure of array cables.			
M-032	An **Outline Marine Mammal Mitigation Protocol** (MMMP) has been submitted with this Application (**Volume 4**). The Final MMMP will be completed prior to construction and submitted to MD-LOT for approval. The MMMP will be adhered to and subsequently mitigate potential impacts from underwater noise on marine mammals and fish through good or standard practice actions in order to meet legislative requirements.	Scoping Amended at EIA Report.	s.36 conditions and marine licences conditions.	Certain procedures for the protection of marine mammals will also apply to species such as basking sharks.
M-033	An **Outline Marine Pollution Contingency Plan** (MPCP) (Appendix to the **Environmental Management Plan** (EMP)) has been submitted with this Application (**Volume 4**). This Outline MPCP outlines details of procedures to protect personnel working and to safeguard the marine environment and mitigation measures in the event of an accidental pollution event arising from offshore operations relating to the Project. The Final MPCP will be completed prior to construction commencing and submitted to MD-LOT for approval and will include relevant key emergency contact details.	Scoping Amended at EIA Report.	s.36 conditions and marine licences conditions	This measure will minimise the risk of accidental pollution associated with the Project on sensitive receptors.
M-049	**An Outline Project Environmental Monitoring Programme** (PEMP) has been submitted with this Application (**Volume 4**). The Final PEMP will be completed prior to construction commencing and submitted to MD-LOT for approval. The Final PEMP will set out commitments to environmental monitoring in pre-, during and post-construction stages of the Project.	Scoping Amended at EIA Report.	s.36 conditions and marine licences conditions.	This measure will provide environmental benefits, detect any unforeseen effects and inform adaptive management if required.

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Relevance to fish ecology assessment
M-054	A detailed Cable Burial Risk Assessment (CBRA) will be undertaken to enable informed judgements about burial depth. This should reduce the risk of buried cables reemerging whilst also limiting the amount of sediment disturbance to that which is necessary. The array and export cables will typically be buried at a target burial depth between 1m to 2m below the seabed surface. The final depth of the cable will be dependent on the seabed mobility and CBRA. The CBRA will manage and mitigate risks from loading and sediment transport across the seabed. The CBRA will be included within the Final Cable Plan.	Scoping Amended at EIA Report.	s.36 conditions and marine licences conditions.	This measure will minimise impacts for temporary habitat disturbance, permanent habitat loss and EMF / heat exposure to fish.
M-055	Key sensitive habitats will be avoided, where known, through pre-construction surveys and micro-siting of proposed offshore Project infrastructure.	Scoping	s.36 conditions and marine licences conditions.	This measure will minimise the impacts for temporary and permanent habitat loss and knock on effects on fish using those habitats.
M-056	To reduce environmental impact of the landfall, a trenchless solution (for example, HDD) is to be implemented to install ducts at landfall. Determination of the most suitable trenchless landfall crossing method will be undertaken during the detailed design stage of the Project, following geotechnical investigations of the onshore and nearshore areas.	Scoping Amended at EIA Report.	Project design s.36 conditions and marine licences conditions.	This measure will minimise habitat loss and reduce the generation of suspended sedimentation, thereby minimising impacts to fish in nearshore subtidal areas.
M-057	Burial of the cables where possible and / or use of external cable protection such as rock placement and / or concrete mattressing. Concrete mattresses only used in isolation in non-fished areas to ensure no snagging issues for fisheries industry. Where appropriate, nature-inclusive design options will be considered in the selection and placement of cable protection measures.	Scoping Amended at EIA Report.	Project description.	This measure will minimise impacts for temporary habitat disturbance, permanent habitat loss and EMF / heat exposure to fish.

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Relevance to fish ecology assessment
M-059	Micro-siting will be applied to proposed offshore Project infrastructure such as cables (trenched or ploughed in), or WTG anchor structures, to minimise mobilisation of contaminants from any areas of significantly contaminated sediment detected during pre-construction surveys.	Scoping	s.36 conditions and marine licences conditions.	This measure minimises the risk of exposure to pollutants, thereby minimising ecological harm.
M-060	Turbidity in the water column caused by sediment mobilisation during construction will be controlled by selection of best practice construction methods.	Scoping	s.36 conditions, marine licences conditions and EMP.	This measure minimises the risk and duration of exposure to elevated SSC as well as reducing the risk of smothering of benthic resources that fish may require.
M-061	Minimise potential for creation of a temporary barrier to fish migration in any river adjacent to cable landfall(s) due to a plume of mobilised sediment obstructing the river entrance by appropriate timing of operations close to the shore regarding tidal flows and fish migration seasons	Scoping Amended at EIA Report.	s.36 conditions, marine licences conditions and EMP.	Minimises impacts to freshwater life stages of diadromous fish.
M-062	Minimise adverse effects on water and sediment quality from loss of drilling muds when using HDD across the littoral zone by employment of a site-specific best practice protocol, including drilling, reaming and cleaning the majority of the hole from the land before drilling the final few metres to breakout using non-polluting drill fluid containing the least toxic drilling fluid additives.	Scoping	s.36 conditions, marine licences conditions and EMP.	Minimises adverse effects on water and sediment quality and therefore impacts on fish ecology receptors.
M-064	The Project will ensure that any material to be deposited in the sea (metal components, rock for armour, concrete mattresses) does not contain toxic materials that could leach into the sea water and result in toxic effects.	Scoping	s.36 conditions, marine licences conditions and EMP.	This measure minimises the risk of exposure to pollutants, thereby minimising ecological harm.

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Relevance to fish ecology assessment
M-102	An **Outline Offshore Invasive Non-Native Species** (INNS) **Management Plan** has been submitted with this Application (**Volume 4**). The Final INNS Management Plan will be completed prior to construction commencing and submitted to MD-LOT for approval. The Final INNS Management Plan will include management measures to limit the risk of INNS being introduced to the marine environment.	Scoping Amended at EIA Report.	s.36 conditions and marine licences conditions.	This measure will reduce where possible the risk of introducing INNS into the region.
M-105	An **Outline Piling Strategy** has been submitted with this Application (**Volume 4**). The Final Piling Plan will be completed prior to construction commencing and submitted to MD-LOT for approval. It will detail the method of pile installation and associated underwater noise levels. It will describe any mitigation measures to be implemented (e.g. soft start and ramp up measures, or the use of acoustic deterrent devices) prior to and during pile installation to manage the effects of underwater noise.	Scoping Amended at EIA Report.	Required under Section 105 (Energy Act 2004) and marine licence conditions.	This measure will set out procedures for piling, therefore reducing the noise exposure to fish receptors.
M-106	The development of and adherence to a Decommissioning Programme. The Decommissioning Programme will outline measures for the decommissioning of the Project. The Decommissioning Programme would be submitted prior to construction commencing to MD-LOT and approved by Scottish Ministers prior to construction.	Scoping Amended at EIA Report.	Required under Section 105 (Energy Act 2004) and marine licence conditions.	This measure will minimise environmental impacts during the decommissioning stage.
M-114	The Project will use ‘low order’ techniques such as deflagration for UXO disposal, where possible and required.	Scoping	HRA and marine licences conditions.	This measure will minimise impacts of underwater noise to fish.
M-120	An **Outline Construction Method Statement** (CMS) has been submitted with this Application (**Volume 4**). The Final CMS will be completed prior to construction commencing and submitted to MD-LOT for approval. The Final CMS will include:	EIA Report.	s.36 conditions and marine licences conditions.	This measure will minimise impacts of construction activities to fish.

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Relevance to fish ecology assessment
	a) details of the commence dates, duration and phasing of key elements of construction, working areas, the construction procedures and good working practices; b) details of the roles and responsibilities; and c) details of how the construction related mitigation step proposed are to be delivered.			
M-121	An **Outline Environmental Management Plan** (EMP) has been submitted with this Application (**Volume 4**) and includes the following Appendix: - **Outline Marine Pollution Contingency Plan**. The Final EMP will be completed prior to construction commencing and submitted to MD-LOT for approval. The Final EMP will be implemented by the contractor(s). The contractor(s) will ensure that the relevant environmental measures within the EMP and health and safety procedures are implemented. The Final EMP will identify the project management structure roles and responsibilities with regard to managing and reporting on the environmental impact of the construction and O&M stages. Other measures that feed into the EMP include: - A Waste Management Plan (WMP) will be developed as an Appendix of the EMP post-submission to manage all waste generated during the construction and operation stages of the Project. The WMP will be appended to the Environmental Management Plan. The WMP will follow the principles of the waste hierarchy (Department for Environment, Food & Rural Affairs, 2001) which consists of: prevention, re-use, recycle, other recovery and disposal. - The Final Environmental Management Plan will include a Chemical Risk Assessment to identify, evaluate and mitigate potential environmental and health risks associated with the	EIA Report.	s.36 conditions and marine licences conditions.	This will ensure delivery of measures designed to minimise ecological impacts, including to fish.

ID	Environmental measure proposed	Project stage measure introduced	How the environmental measures will be secured	Relevance to fish ecology assessment
	use, storage and disposal of hazardous substances during O&M and decommissioning stages of the Project. The EMP will be the securing mechanism for many measures.			
M-122	Development of and adherence to a Offshore Operations and Maintenance Plan, which will confirm the Project's operations and maintenance activities. This will be submitted to MD-LOT for approval post-consent.	EIA Report.	s.36 conditions and marine licences conditions.	This measure will minimise impacts of operation and maintenance activities to fish.

13.8 Methodology for the EIA Report

13.8.1 Introduction

13.8.1.1 The Project-wide approach to assessment is set out in **Chapter 5: Approach to the EIA**. Whilst this has informed the approach that has been used in this fish ecology assessment, it is necessary to set out how this methodology has been applied, and adapted as appropriate, to address the specific needs of the fish ecology assessment.

13.8.2 Significance evaluation methodology

Overview

13.8.2.1 The significance level attributed to each effect has been assessed based on the value of the affected receptor and the magnitude of change resulting from the Project. The level of significance has then been determined by the combination of value and magnitude.

13.8.2.2 The sensitivity and value of the features and the magnitude of impact specific to fish ecology are provided in the following sections. This assessment is also conducted with reference to Guidelines for Ecological Impact Assessment in the UK and Ireland – Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018).

Sensitivity

13.8.2.3 Scales for the sensitivities of fish species and habitats have been developed using a four-point scale (high, medium, low or very low). These scales have been developed with reference to the Marine Life Information Network (MarLIN) MarESA (Tyler-Walters, 2018). The scales for tolerance and resilience are provided in **Table 13.18** and **Table 13.19** and the matrix of sensitivity scores is provided in **Table 13.20**.

13.8.2.4 Scottish Government's FeAST has also been used to provide additional information on the sensitivity of certain species to pressures in the marine environment[3].

13.8.2.5 The sensitivity of a feature is dependent upon its adaptability (the degree to which a feature can avoid or adapt to a change), tolerance (the ability of a feature to absorb stress or disturbance without changing character) and recoverability (the temporal scale and extent to which a feature will recover following an effect).

Table 13.18 Assessment scale for resistance (tolerance) to a defined intensity of pressure

Resistance	Definition
High	No significant effects on the physicochemical character of habitat and no effect on population viability of key / characterising species but may affect feeding, respiration and reproduction rates.

[3] It is noted that a programme of updates to FeAST commenced during Summer 2025. At the time of writing, many of the sensitivity assessments are not available.

Resistance	Definition
Medium	Some mortality of species (can be higher where these are not keystone structural / functional and characterising species) without change to supporting habitats. Relates to the loss <25% of the species or habitat component.
Low	Significant mortality of key and characterising species with some effects on the physicochemical character of habitat. A significant decline / reduction relates to the loss of 25% to 75% of the extent, density or abundance of the selected species or habitat component for example, loss of 25% to 75% of the substratum.
None	Key functional, structural, characterising species severely decline and / or physicochemical parameters are also affected for example, removal of habitats, causing a change in habitat types. A severe decline / reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat component for example, loss of 75% substratum (where this can be reasonably applied).

Table 13.19 Assessment scale for resilience (recovery)

Resilience	Definition
High	Full recovery back to baseline levels within two years.
Medium	Full recovery back to baseline levels within 2 to 10 years.
Low	Full recovery back to baseline levels within 10 to 25 years.
Very low	Negligible or prolonged recovery possible, at least 25 years to recover structure and function.

Table 13.20 Definitions of sensitivity levels for fish ecology

	Resistance			
Resilience	**None**	**Low**	**Medium**	**High**
Very low	High	High	Medium	Low
Low	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
High	Medium	Medium	Low	Very Low

13.8.2.6 Where several sensitivity levels are given for features against a potential impact, professional judgement will be used for the assessment.

Value of receptor

13.8.2.7 In addition, for some assessments the 'value' of a receptor may also be an element to add to the assessment where relevant – for instance if a species is protected, has an economic value or provides an important ecological service or function. While it is predominantly an expert judgement, the definitions of value levels have been developed using a four-point scale and example definitions are provided in **Table 13.21**.

Table 13.21 Definitions of value levels for fish ecology

Value	Definition
High	Nationally important / rare with limited potential for offsetting / compensation. Habitats and species protected under international law (for example, Annex I habitats within a SAC boundary). Keystone species or habitats that provide critical ecological functions / services.
Medium	Regional important / rare with limited potential for offsetting / compensating. Habitats protected under national law (for example, Annex I habitats not within an SAC boundary). UK BAP priority habitats and species). Species / habitats that may be rare or threatened in the UK. Provides important but non-critical ecological functions / services.
Low	Locally important / rare; regional UK BAP priority habitats. Habitats or species that interact with species of higher value but do not provide important ecological functions / services.
Negligible	Habitats and species which are not protected or rare and are not economically important and do not appreciably support ecosystem functions / services.

13.8.2.8 It should be noted that high value and high sensitivity are not necessarily linked within a particular impact. A feature could be of high value (for example, an Annex II species) but have a low or negligible physical / ecological sensitivity to an effect. It is important not to inflate the significance of a potential effect just because a feature is 'valued'. This is where the narrative behind the assessment is important; the value can be used where relevant as a modifier for the sensitivity assigned to the feature.

Magnitude of change

13.8.2.9 The magnitude of impact relates to the level of change compared to the baseline conditions, using the duration, timing, scale, size and frequency to determine the magnitude of the impacts to each receptor. Magnitude is evaluated in accordance with the definitions set out in CIEEM's Guidelines for Ecological Impact Assessment, summarised in **Table 13.22**.

13.8.2.10 The following characteristics inform the definition of the magnitude of potential impacts on fish ecology:

- extent or spatial scope of the impact;
- reversibility of impact – whether the impact is naturally reversible or reversible through mitigation measures;
- timing and frequency of the impact, in relation to ecological changes; and
- likely duration of the impact – short term (< five year), medium term (five to ten years) or long term (ten or more years).

Table 13.22 Fish ecology definitions of impact magnitude

Magnitude of Impact	Definition
Very low	Changes to baseline conditions within the range of natural variability.
Low	Partial loss and / or recoverable alteration to the extent, composition or character of a habitat / community, or population of a species, with recovery expected within less than 5 years. Recovery largely through natural processes.
Medium	Partial loss and / or recoverable alteration in extent, composition or character of a habitat / community, or population of a species, with recovery expected within 5 to 10 years. Recovery typically through natural processes.
High	Changes to natural conditions that, either singly or through recurrence, alter the extent, composition or character of a habitat / community, or population of a species beyond the ability of the receptor to recover within a period of 10 years. Recovery likely requires some targeted mitigation.

13.8.2.11 Where several magnitude values are given for features against a potential impact, professional judgement will be used and justified for the assessment.

Significance evaluation

13.8.2.12 Following the identification of a features value, sensitivity and magnitude of the impact, it is possible to determine the significance of the impact. The significance of the effect on fish ecology receptors will be determined by correlating the sensitivity of the receptor and the magnitude of the impact. The method employed for this preliminary assessment is presented in **Table 13.23**.

13.8.2.13 During the assessment of effects for each identified receptor, the value in **Table 13.21** will be combined with the magnitude of change from **Table 13.22** to produce an overall significance rating based on the evaluation matrix shown in **Table 13.23**. As a general rule, **Major** and **Moderate** effects are considered to be **Significant** and **Minor** and **Negligible** effects are considered to be **Not Significant**. However, professional judgement is applied, where appropriate, to determine significance of effect. Where effects are assessed, according to the matrix in **Table 13.23** to **be Potentially Significant** in EIA terms, professional judgement is applied to determine whether they are **Significant** or **Not Significant**.

Table 13.23 Significance assessment matrix for the significance of residual effect

		Magnitude of change			
		High	**Medium**	**Low**	**Very Low**
Value / Sensitivity	**High**	**Major (Significant)**	**Major (Significant)**	**Moderate (Potentially Significant)**	**Minor (Not Significant)**
	Medium	**Major (Significant)**	**Moderate (Potentially Significant)**	**Minor (Not Significant)**	**Minor (Not Significant)**
	Low	**Moderate (Potentially Significant)**	**Minor (Not Significant)**	**Minor (Not Significant)**	**Negligible (Not Significant)**
	Very Low	**Minor (Not Significant)**	**Minor (Not Significant)**	**Negligible (Not Significant)**	**Negligible (Not Significant)**

13.9 Assessment of effects: construction stage

13.9.1 Introduction

13.9.1.1 This Section provides an assessment of the effects for fish ecology from the construction of the offshore elements of the Project.

13.9.1.2 The assessment methodology set out in **Section 13.8** has been applied to assess effects to fish ecology from the Project.

13.9.2 Impact C1: pre-construction seabed preparation works and Impact C2: temporary habitat loss and / or disturbance

Overview

13.9.2.1 The maximum design scenario relating to pre-construction seabed preparation works, habitat loss and / or disturbance is presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8.2**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.9.2.2 Temporary habitat loss / disturbance of seabed habitats within the Offshore Red Line Boundary during the pre-construction and construction stages will occur as a result of the use of jack-up vessels during installation, WTG anchors, offshore substation, SDC and RCP foundations, installation of array cables or offshore export cables (including seabed clearance operations prior to cable installation) and anchor placements associated with these activities. Excavated material resulting from seabed preparations, such as boulders will be disposed of within the Offshore Red Line Boundary. The assessment therefore also includes habitat loss / disturbance associated with disposal of excavated material from this activity and pre-construction seabed preparation works.

13.9.2.3 Disturbance to these habitats has the potential to affect identified fish receptors directly (for example, removal or injury of individuals, particularly benthic species) and indirectly (for example, loss of, or damage to important fish habitats, such as spawning grounds and / or reduction in food resource).

Sensitivity of receptor

13.9.2.4 Fish species potentially most sensitive to temporary habitat loss within the study area are those that spawn on or near the seabed. Seabed disturbance during spawning periods may lead to egg mortality and reduced spawning opportunities for demersal spawners. Notable benthic / demersal spawners include Atlantic herring, sandeel, and oviparous elasmobranchs such as the common skate complex.

Demersal spawning species

Atlantic herring

13.9.2.5 Atlantic herring are demersal spawners that depend on suitable seabed substrates, such as gravel or sand, for egg deposition (Frost and Diele, 2022). The species is considered to have low tolerance to seabed disturbance during spawning, as habitat alteration can result in egg mortality when spawning grounds are affected during active spawning periods. Disturbance may also reduce the success of spawning events if adult herring avoid disturbed areas (Frost and Diele, 2022). Recovery potential is considered medium, as Atlantic herring populations can replenish relatively quickly following disturbance, supported by pelagic larval dispersal and relatively short generation times. Accordingly, Atlantic herring are considered to have low resistance and medium resilience and to be of medium value. Therefore, their overall sensitivity is considered to be **medium**.

Sandeel

13.9.2.6 The Scottish Government's FeAST tool identifies sandeel as highly sensitive to sub-surface abrasion and penetration, and of medium sensitivity to surface abrasion (Scottish Government, 2025c) due to their habit of burying themselves in the substrate. Temporary seabed habitat loss or disturbance may result in direct impacts to adult and juvenile sandeel, such as increased mortality, particularly where individuals are unable to relocate to suitable sandy habitats nearby, or where alternative habitats are at or near carrying capacity (Wright *et al*., 2000). Sandeel are particularly vulnerable during their spawning period, and during the overwintering period, when they are buried in the seabed and less able to avoid disturbance.

13.9.2.7 Sandeel recolonisation of temporarily disturbed areas with suitable sediment is expected to begin shortly after construction activities cease. Long-term and short-term monitoring at the Horns Rev and Nysted Offshore Wind Farms in Denmark (Jensen *et al*., 2004; van Deurs *et al*., 2012; Danish Energy Group, 2013) found no long-term impacts on sandeel populations due to construction or operation. Similarly, post-construction monitoring at the Beatrice Offshore Wind Farm (BOWL, 2021) showed sandeel abundance either increased or remained stable between 2014 and 2020, despite construction beginning in 2017. These findings support the conclusion that sandeel populations are capable of recovering quickly following temporary seabed disturbance, provided suitable habitat conditions are restored.

13.9.2.8 Sandeel are considered to be of nationally important being listed as a PMF and protected within the Turbot Bank MPA (located approximately 25km south of the Offshore Red Line Boundary) and a high value prey species and are also considered to have a high vulnerability to habitat loss and disturbance. Sandeel are considered to have low resistance and high resilience to this impact and are therefore considered to have **medium** sensitivity, despite their high value.

Oviparous elasmobranchs

13.9.2.9 The study area overlaps with nursery grounds of spiny ray, spiny dogfish (or spurdog), common skate and spotted ray (**Volume 2, Figure 13.5**). These species exhibit demersal egg-laying behaviours, which makes them vulnerable to seabed disturbance that may damage deposited egg cases. However, after hatching they become mobile and are subsequently considered to be less vulnerable. Due to the species life-history traits – slow growth, late maturity and low fecundity (Ellis *et al*., 2021), these species are considered to have low recoverability to potential loss of egg cases from temporary seabed loss / disturbance.

13.9.2.10 This group of species have a wide distribution throughout UK waters (Barnes, 2008c; Gibson-Hall, 2018; Neal and Pizzolla, 2006) so any localised, temporary seabed disturbance is unlikely to have long-term effects to the functioning of their populations as a whole.

13.9.2.11 However, considering the conservation value of this species and potential presence within the area affected by this impact, oviparous elasmobranchs are considered of high value, medium resistance and low resilience. Based on these attributes, the sensitivity of oviparous elasmobranchs to this impact is considered to be **medium**.

Diadromous fish

13.9.2.12 Diadromous fish species including Atlantic salmon, sea trout, and European eel are highly mobile and exhibit broad migratory ranges between marine and freshwater environments. Due to their mobility, these species generally have a high tolerance to temporary and spatially limited habitat disturbance in offshore environments, particularly where such areas are not essential to critical life stages (for example, spawning or feeding). The Red Line Boundary does not appreciably overlap with any known important foraging areas for diadromous species, with the exception of the coastal export cable corridor area, which has a higher sandeel expected presence, and therefore may provide an important food resource.

13.9.2.13 Indirect effects may occur through changes in prey availability. Species, including post-smolt Atlantic salmon forage on sandeel or other small pelagic species shortly after entry to the marine environment (Haugland *et al*., 2006) that could be temporarily displaced by construction. However, prey species in this region, particularly sandeel, are expected to recover rapidly following temporary seabed loss / disturbance. Diadromous species are opportunistic feeders and have the capacity to adjust feeding strategies or relocate foraging activity across broad spatial scales (Rikardsen and Dempson, 2011).

13.9.2.14 The Offshore Red Line Boundary does not overlap any known freshwater breeding grounds or designated sites for twaite shad or European smelt. For this reason and the likely high dispersion of individuals if present within the study area, these species are expected to have high tolerance to this impact.

13.9.2.15 Given their ability to avoid disturbed areas, opportunistic feeding behaviour, and the resilience of prey populations, diadromous fish species exhibit high tolerance to temporary habitat loss and indirect ecological change and are considered to have high recoverability to this impact. Whilst these species are of high value, their overall sensitivity to this pressure is considered **low**.

Other marine fish

13.9.2.16 Marine fish species not discussed individually are considered to have a lower likelihood of exposure to temporary seabed habitat loss and disturbance. These include (but are not limited to) gadoids (e.g. haddock, whiting), flatfish (e.g. European plaice), pelagic species (e.g. Atlantic mackerel), viviparous elasmobranchs or those oviparous species within no known nursery ground within the Red Line Boundary (for example, tope shark, basking shark).

13.9.2.17 Where exposure does occur, these species are considered to have high tolerance due to their broad ecological niches, generalist feeding behaviours, mobility, and limited reliance on specific benthic habitats for key life stages. Many do not exhibit high site fidelity and can readily avoid or adapt to temporary changes in habitat structure. In terms of recoverability, these species are expected to recover rapidly following periods of temporary seabed habitat loss and / or disturbance. As such, all other marine fish, of low to high value are considered to be of high tolerance and medium to high recoverability. Therefore, the sensitivity of these remaining receptor groups is considered to be **low**.

Magnitude of impact

13.9.2.18 Construction activities within the Red Line Boundary will lead to temporary seabed habitat loss / disturbance. The total maximum area of temporary habitat disturbance due to construction activities is approximately 49.11km^2 and 3.9% of substrate present within the Offshore Red Line Boundary. **Table 13.24** outlines the subtidal area disturbed by activity.

Table 13.24 The area of subtidal habitat likely to be disturbed as a result of each construction activity

Activity	Subtidal area disturbed
Installation of drag embedment anchors	6.75km^2
Installation of array cables	20.4km^2
Installation of SDCs	0.12528km^2
Installation of offshore substations	0.0572km^2
Installation of offshore export cable corridor	21km^2
Installation of cable crossings	0.714km^2
Installation of RCPs	0.01445km^2
HDD exit pits	0.00008km^2

Seabed preparation

13.9.2.19 Seabed preparation activities can be necessary to clear and stabilise the seabed in advance of construction activities. Works can include the removal of boulders, sand wave levelling, and the removal of debris such as lost fishing gear. Depending on the density of boulders, these will typically be relocated to a nearby position on the seabed and a safe distance from the planned construction activities. Boulder clearance will be using plough and / or grab methods. The maximum volume of offshore export cable corridor sandwave clearance is expected to be 35,000m^3.

13.9.2.20 The existing programme anticipates activities to be complete in three phases over a period of 12 years. These activities will be localised and temporary in nature, causing temporary disturbance of sediments and localised disturbances to fish receptors.

Anchors

13.9.2.21 Anchors and mooring lines will be transported to the OAA by vessels prior to the installation of the WTG floating units. Given likely weather window and storage constraints, anchors may be installed year-round and up to several years in advance of the mooring lines and WTG floating units. Mooring lines would be installed in advance (within the same installation year) and wet stored on the seabed awaiting the installation of WTG floating units. Total anchor disturbance is expected to cause 6.75km^2 temporary habitat disturbance.

13.9.2.22 The existing programme anticipates activities to be complete in three phases over a period of ten years. These activities will be localised and temporary in nature, with the exception of the permanent footprint of the anchors and lines. There will be temporary disturbance of sediments and localised disturbances to fish receptors over an intermittent period.

Offshore export cables and array cables

13.9.2.23 Cable burial techniques are described further in Section 4.6.10 in **Chapter 4: Project Description**, with jet trenching installation as a worst case due to maximum sediment mobilisation.

13.9.2.24 The offshore export cables will be installed in three phases, with a maximum temporary disturbance footprint of 21km^2. Cables will be buried 1m to 2m below the seabed for most of their length to the landfall(s), except where localised site conditions prevent burial.

13.9.2.25 Array cables will be used to connect the WTGs to the SDCs and offshore substations it is assumed 100% of total array cable length of 680km is buried by jet trenching. The maximum temporary habitat disturbance is 20.4km^2.

13.9.2.26 The existing programme anticipates export cable installation activities to be complete in three phases over a period of nine years. For the array cables, this will be completed in three phases over ten years. These activities will be localised and temporary in nature, temporary disturbance of sediments, but rapid infilling and recovery. Localised, temporary disturbances to fish receptors are expected.

13.9.2.27 A review commissioned by the Crown Estate examined the environmental recovery of subtidal sediments following cable installation, drawing on post-construction monitoring data from over 20 UK offshore wind farms. The findings indicated that sandy sediments tend to recover rapidly, with cable trenches typically infilling soon after installation and leaving little observable disturbance in subsequent years. In contrast, residual trench features in coarse, mixed, or muddy sediments were found to persist for longer, sometimes remaining visible for several years post-installation. However, these features were generally shallow (on the order of tens of centimetres deep), and the associated horizontal extent was limited to a few metres, meaning they did not represent a substantial deviation from baseline conditions (RPS, 2019).

Offshore substation, RCP and SDC installation

13.9.2.28 There will be up to four offshore substations located within the OAA. The location and extent of the offshore substations will be confirmed through detailed design process but will be located within the Offshore Red Line Boundary. There will be a maximum temporary disturbance footprint of 57,200m^2, with jacket foundations secured by suction caisson assumed as a worst-case methodology.

13.9.2.29 Up to 45 SDCs may be constructed, with a maximum temporary habitat disturbance footprint of 125,280m^2.

13.9.2.30 Up to two RCPs may be constructed located within the offshore export cable corridor, with a maximum temporary habitat disturbance of 14,450m^2, with jacket foundations secured by driven piles assumed as a worst-case methodology. The foundations are lowered to the seabed at a prepared location. The foundation is then secured to the seabed by the driven piles.

Cable crossings

13.9.2.31 It is anticipated that there could be up to six crossings per cable trench required (total of 30 cable crossings) within the Project's OAA. There are currently 16 known cable crossings per cable trench required along the offshore export cable corridor. The applicant has included an additional six crossings per cable trench as a contingency (total 110 cable crossings). There will be a maximum temporary disturbance footprint of 0.714km^2.

Disposal of excavated material

13.9.2.32 Any sediment displaced during seabed preparation for jackets with suction caissons would be deposited within the OAA. Should this not be possible, any marine licensing requirements for spoil removal or disposal will be identified and applied for by the Applicant under the Marine and Coastal Access Act 2009 for activities beyond 12nm.

13.9.2.33 This activity is localised (to within the OAA or appropriate disposal site), with disturbance expected to be temporary, with no loss of subtidal habitat.

Overall magnitude of impact

13.9.2.34 Overall, the impact from pre-construction seabed preparation works and temporary habitat disturbance is assessed as being highly localised and of a short duration, reversible, and of a low frequency (intermittent over construction stages), and therefore is defined as being of **low** magnitude.

Significance of residual effect

Atlantic herring

13.9.2.35 Construction activities and disturbance may overlap with the spring (February to April) and autumn spawning period (August to October), therefore localised effects or disturbance of spawning herring may occur. The spatial extent of the impact is limited considering the availability of recorded spawning grounds across the broader region, with the area of herring spawning ground affected by temporary seabed habitat loss and / or disturbance limited to the coastal areas near the offshore export cable corridor landfall. Construction activities in the OAA do not overlap with herring spawning or nursery grounds. Disturbance is considered reversible, with recovery of spawning habitats and populations expected to commence immediately post-construction. Overall, Atlantic herring are considered to be of **medium** sensitivity and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA Terms.

Sandeel

13.9.2.36 There are potential localised impacts to sandeel along cable routes in areas close to shore. Effects are spatially limited, as only a small proportion of suitable habitats will be affected, especially when considering the availability of habitats across the broader region and embedded environmental measures. Disturbance is considered reversible, and sandeel populations are expected to recover rapidly following construction. Despite their high value, as a population sandeel are considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

Oviparous elasmobranchs

13.9.2.37 Typically, elasmobranchs reach sexual maturity after a number of years, exhibit relatively low fecundity, and have long gestational periods. Therefore, it is likely that oviparous elasmobranchs have slow recovery times following disturbance or loss of spawning grounds. However, there is little evidence that the marine area within the Offshore Red Line Boundary is important for spawning of any oviparous elasmobranch species.

13.9.2.38 Species disturbed by construction are likely to recover and return to the area once construction activities have ceased. suitable egg-laying habitats in the North Sea for these species are extensive. As these areas constitute only a small proportion of the area affected by temporary habitat loss and / or disturbance, the extent of potential impact on spawning habitats is very limited. Disturbance is considered reversible, with natural recovery of egg-laying habitats and populations occurring post-construction. Overall, elasmobranchs are considered of **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

Diadromous fish

13.9.2.39 Diadromous fish are considered to be of **low** sensitivity and the magnitude of impact is **low**. Consequently, the effect is **Minor** (**Not Significant**). As effects to Atlantic salmon and sea trout are considered **Minor** (**Not Significant**), effects on freshwater pearl mussels are likewise considered to be **Minor Adverse** (**Not Significant**) in EIA terms.

Other marine fish

13.9.2.40 All other marine fish species across the three receptor groups (demersal fish, pelagic fish and elasmobranchs) not specifically mentioned are considered to have a lower likelihood of exposure to pre-construction seabed preparation works and temporary seabed habitat loss and disturbance. This is primarily due to their infrequent presence within the affected area or limited reliance on specific benthic habitats for key life stages. Many of these species either spawn pelagically or are not strictly reliant on specific benthic habitats for key life stages (for example, egg depositing), reducing their vulnerability to seabed disturbance (Coull *et al.,* 1998; Ellis *et al.*, 2012). Overall, these species are considered to have **low** sensitivity due to their reduced reliance on seabed habitats. Because the magnitude of impact is **low**, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.9.3 Impact C3: temporary localised increases in suspended sediment concentrations and smothering

Overview

13.9.3.1 The maximum design scenario relating to temporary localised increases in SSC and smothering are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8.2**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.9.3.2 Temporary increases in SSC and subsequent sediment deposition are predicted to occur during construction activities, which include:

- seabed preparation and installation for anchors;
- seabed installation activities for array cables;
- seabed preparation and installation for subsea distribution centre;
- seabed preparation and installation for offshore substations with jacket foundation secured by suction caisson;
- seabed preparation and installation for RCPs with jacket foundation secured by suction caisson;
- seabed preparation activities (levelling, sandwave clearance) which may lead to a requirement for spoil disposal elsewhere creating elevated suspended sediment and potential smothering deposition;
- seabed preparation and installation activities for offshore export cables; and
- landfall installation activities including release of drilling fluid.

13.9.3.3 These activities have been subject to desk-based analyses which are detailed in **Chapter 6: Marine Geology, Oceanography and Physical Processes**. An assessment of the physical characteristics of the above, including the methodological approach used to assess the characteristics of sediment plumes and associated changes in bed level arising from settling of material is set out in **Volume 3, Appendix 6.1** and **Volume 3, Appendix 6.3**.

13.9.3.4 Elevated SSC may cause direct physiological impacts to fish, including gill irritation or damage, impaired respiration, and, in extreme cases, mortality. Fish may also exhibit behavioural responses, either avoiding areas of high SSC or in some cases, using turbid water to aid avoidance of predators. By the same token, increased turbidity associated with elevated SSC also has the potential to reduce foraging efficiency by impairing prey detection by visual predators.

13.9.3.5 The resettlement of suspended material (deposition) may result in the smothering of less-mobile species or vulnerable life stages (for example, demersal eggs and larvae where present), as well as the temporary degradation of benthic feeding habitats. These effects may indirectly influence fish condition, reproduction, or recruitment if important habitats are affected during sensitive periods. Impact pathways are detailed in **paragraph 13.9.3.18**.

Sensitivity or value of receptor

13.9.3.6 Eggs and larvae are considered the most sensitive life stages to elevated SSC and sediment deposition, due to their limited or absent mobility and prolonged contact with affected substrates or turbid waters. Pelagic spawners are generally less affected by deposition; however, larvae may still be exposed to elevated SSC in the water column.

Atlantic herring

13.9.3.7 Demersal spawners, such as Atlantic herring, deposit eggs directly onto the seabed, making them more susceptible to smothering by resettled sediment. If the deposited sediment is not dispersed quickly by tidal currents sediment accumulation may impede gas exchange or result in physical abrasion of developing embryos, and hatching success may be reduced (Kjelland *et al*., 2015). Appleby and Scarratt (1989) found that egg and larval development may be impaired at concentrations exceeding 1,000mg/L. However, Kiørboe *et al*., 1981) found no impact on Atlantic herring eggs from exposure to concentrations of 5mg/L to 300mg/L over ten days, and short-term exposure to 500mg/L also produced no measurable effects - indicating some natural tolerance, at least for this species.

13.9.3.8 In terms of recoverability, this species exhibits high fecundity, broad distribution ranges, and relatively short generation times, often coupled with pelagic larval dispersal, which supports recovery. However, repeated or prolonged disturbance events may reduce the potential for recovery by limiting opportunities for population regeneration. While these biological characteristics indicate a high capacity for recovery following potential egg or larval losses, recoverability is assessed as medium, reflecting the possibility that sustained disturbance could constrain full population recovery. Atlantic herring are deemed to be high value, low tolerance and high recoverability. Therefore, the sensitivity of Atlantic herring is considered to be **medium**.

Sandeel

13.9.3.9 Species that rely on the seabed for key life functions, such as burrowing or overwintering, are also sensitive to sediment deposition. Sandeel are a key example, as they are strongly associated with sandy seabed habitats throughout their life cycle. Deposition of fine sediments may reduce oxygen availability or change substrate composition, thereby reducing habitat suitability. The Scottish Government’s FeAST tool identifies sandeel as highly sensitive to heavy deposition (5cm to 30cm of fine material), and of medium sensitivity to light deposition (≤5cm) (Scottish Government, 2025c). On this basis, sandeel are deemed to be of high value, low tolerance and high recoverability. Therefore, the sensitivity of sandeel is considered to be **medium**.

Spawning and nursery grounds

13.9.3.10 Juvenile fish, while still capable of some avoidance, have more limited mobility than adults and are thus considered to have lower tolerance to elevated SSC and associated deposition. Physiological and physical effects are also more likely at this life stage. Species known to use nursery grounds within the study area affected by elevated SSC and deposition impacts include Atlantic herring, European sprat, Atlantic mackerel, blue whiting, anglerfish, Atlantic cod, haddock, European hake, sandeels, ling, Norway pout, lemon sole, plaice, saithe, and whiting. While these species may be exposed during sensitive life stages, their presence in coastal and shelf areas characterised by Winter storms and tidal currents and associated naturally elevated SSC indicates a degree of natural tolerance. In terms of recoverability, these species exhibit high fecundity, broad distribution ranges, and relatively short generation times. Such biological traits support a strong capacity for recovery from both lethal and sub-lethal impacts (for example, injury leading to reduced fitness and increased predation risk, temporary reductions in foraging efficiency).

13.9.3.11 Species with spawning and / or nursery grounds within the area affected by elevated SSC and deposition (including Atlantic herring, European sprat, Atlantic cod, lemon sole, Norway pout, common skate complex, and spotted ray), are considered to have low tolerance and medium recoverability and are of medium to low value. Therefore, the overall sensitivity of these species is considered to be **medium**.

Diadromous fish

13.9.3.12 Diadromous fish species including Atlantic salmon, sea trout, European eel, shad, smelt and lamprey are highly mobile and undertake broad-scale migrations between freshwater and marine environments. These species typically migrate through estuarine and nearshore coastal habitats where SSC are naturally elevated due to fluvial input and hydrodynamic processes. As such, diadromous species are considered to exhibit high tolerance to temporary increases in SSC and localised sediment deposition within offshore environments.

13.9.3.13 Indirect effects may arise through changes in prey availability. For example, post-smolt life-stages of Atlantic salmon forage on sandeel or other small pelagic species at sea (Haugland *et al*., 2006) that could be affected by temporary increases in SCC and subsequent resettlement. However, prey species, especially sandeel, are expected to recolonise disturbed habitats quickly following cessation of construction, supported by evidence from post-construction monitoring (for example, Jensen *et al*., 2004; BOWL, 2021). Diadromous species are also opportunistic feeders (or in the case of lampreys, opportunistic parasites) and capable of altering foraging patterns across broad spatial scales (Rikardsen and Dempson, 2011), thereby reducing the likelihood of foraging disruption.

13.9.3.14 Given their ability to avoid disturbed areas, opportunistic feeding behaviour, and the resilience of prey populations, diadromous fish species exhibit high tolerance to temporary increases in SSC and deposition and indirect ecological change and are considered to have high recoverability to this impact. Whilst these species are of high value, their overall sensitivity to this pressure is considered to be **low**.

Other marine fish

13.9.3.15 Mobile adult fish are typically considered to have relatively high tolerance to temporary increases in SSC, as they can detect and actively avoid turbid areas, thereby limiting exposure to potential physiological effects such as gill irritation or respiratory stress (Messieh *et al*., 1981). Most pelagic and demersal adult fish are therefore unlikely to experience significant sublethal or lethal effects from short-term exposure. Sediment deposition is also unlikely to impact mobile adults directly, though it may temporarily reduce foraging efficiency if prey becomes obscured or displaced.

13.9.3.16 Marine fish species not discussed individually – such as those without identified spawning or nursery grounds within the area affected by SSC and sediment deposition, and species that do not rely on the seabed for key life functions such as burrowing, or overwintering – are considered to have a higher tolerance to temporary increases in SSC and sediment deposition. Many of these species are also capable of avoiding unfavourable conditions, reducing the likelihood of prolonged exposure. In terms of recoverability, these species have a high capacity to recover following exposure to elevated SSC and associated deposition.

13.9.3.17 As such, all other marine fish, of low to high value are considered to be of high tolerance and have medium to high recoverability to this impact. Therefore, the overall sensitivity of these receptor groups is considered to be **low**.

Magnitude of impact

13.9.3.18 Installation of infrastructure within the Red Line Boundary may lead to increased SSC and associated sediment deposition. Under the maximum design scenario for SSC and sediment deposition, the following activities were considered, and used for the purpose of sediment transport modelling:

- installation for offshore substation and RCP jacket foundation secured by suction caisson;
- seabed preparation by dredging for WTG anchors, subsea distribution centres (SDCs), offshore substations and RCP jacket foundations;

- sandwave clearance prior to cable burial;
- offshore export and array cable burial; and
- drilling fluid release during HDD at the landfall.

13.9.3.19 Further details of the modelling undertaken to inform this assessment is presented in **Volume 3, Appendix 6.1**, including the individual activities considered and assumptions within these and modelling outputs for suspended sediments and associated sediment deposition.

13.9.3.20 Sediment deposition associated with the Project is predicted to fall within four main zones of effect, based on the distance from the activity causing sediment disturbance. A summary of these findings is presented within **paragraph 13.9.3.21** to **paragraph 13.9.3.24**.

13.9.3.21 The zone of highest suspended sediment concentration (SSC) increases and greatest likely thickness of deposition is within 25m of the activity. All gravel sized sediment likely deposited in this zone, also a large proportion of sands that are not resuspended high into the water column, and also most or all dredge spoil in the active phase. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released and the manner in which the deposit settles.

- During the activity that generates the disturbance, SSC may increase by several orders of magnitude, resulting in SSC of tens to hundreds of thousands of mg/l for the duration of active disturbance.
- This will persist for approximately 30 minutes following the end of disturbance before redeposition. Sands and gravels may deposit in local thicknesses of tens of centimetres to metres depending on the degree of seabed intervention. Fine sediment is unlikely to deposit in measurable thickness.
- More than one hour after the end of active disturbance, SSC will no longer be elevated and with no measurable ongoing deposition.

13.9.3.22 The wider zone of 25m-250m will show measurable SSC increases and measurable but lesser thickness of deposition, mainly sands that are released or resuspended higher in the water column and resettling to the seabed whilst being advected by ambient tidal currents. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released, the height of resuspension or release above the seabed, and the ambient current speed and direction at the time.

- At the time of active disturbance SSC may increase (hundreds to low thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following the end of the activity. Sands and gravels may deposit in local thicknesses of up to tens of centimetres; fine sediment is unlikely to deposit in measurable thickness.
- More than one hour after the end of active disturbance no change to SSC will be evident, with no measurable ongoing deposition.

13.9.3.23 Beyond 250m to the tidal excursion buffer distance is a zone of lesser but measurable SSC increase and no measurable deposition. Suspended material comprises mainly fines that are maintained in suspension for more than one tidal cycle and are advected by ambient tidal currents. Plume dimensions and SSC are primarily controlled by the volume of sediment released, the patterns of current speed and direction at the place and time of release and where the plume moves to over the following 24 hours.

- At the time of active disturbance, low to intermediate SSC increase occurs within a narrow plume (tens to a few hundreds of metres wide). SSC may be elevated to tens to low hundreds of mg/l solely as a result of any remaining fines in suspension. SSC decreases rapidly by dispersion to ambient values within one day after the end of active disturbance and fine sediment is unlikely to deposit in measurable thickness.

- One to six hours after end of active disturbance – decreasing to low SSC increase (tens of mg/l); fine sediment is unlikely to deposit in measurable thickness.
- Six to 24 hours after the end of active disturbance – decreasing gradually through dispersion to background SSC (no measurable local increase); fine sediment is unlikely to deposit in measurable thickness. No measurable change from baseline SSC after 24 hours to 48 hours following cessation of activities.

13.9.3.24 Beyond the tidal excursion buffer distance, or anywhere not tidally aligned to the active sediment disturbance activity there is no expected change to SSC nor a measurable sediment deposition.

13.9.3.25 **Chapter 6: Marine Geology, Oceanography and Physical Processes** considers the maximum scenario for each activity, and therefore the maximum zone of SCC and sediment deposition. With the zone of highest SSC increase and greatest likely thickness of deposition limited to 25m, and the zone of measurable SSC increase and lesser measurable thickness of deposition limited to 250m, the impact area for all construction activities is very localised, especially for those receptors highly sensitive to deposition.

13.9.3.26 The embedded environmental measures M-120 and M-121 from **Table 13.17** means a construction method statement and EMP will be produced as part of the Project, ensuring construction methods align with good practice, implement agreed embedded environmental measures and are appropriately managed.

13.9.3.27 Overall, elevated SSCs during the construction stage are adverse, expected to be medium-term (intermittently over a period of 12 years through three phases). Elevated SCC and associated deposition are predicted to be highly localised and naturally reversible through tidal processes. As such, the magnitude of impact is assessed as **very low**.

Significance of residual effect

13.9.3.28 Peak SSC and sediment deposition associated with the Project during the construction stage are predicted to be spatially limited, intermittently over 12 years, with maximum levels confined to the immediate vicinity of construction activities. Increases in SSC and temporary increases in sediment loads from deposition are unlikely to persist at levels or for durations sufficient to interfere with the use of offshore nursery habitats, particularly given the broad distribution of these areas across the wider study area. Development of eggs and larvae in areas subject to sediment depositions in the immediate vicinity of the activity may be affected on a temporary and highly localised basis. The SSC and sediment deposition depths across much of the affected area are unlikely to be great enough or persist long enough to affect the development of eggs and larvae. Disturbance is considered temporary and reversible, with recovery of water quality and the seabed expected as sediments settle and disperse on successive tidal cycles.

13.9.3.29 Species with spawning grounds, or both spawning and nursery grounds, within the area affected by SSC and sediment deposition (including Atlantic herring, European sprat, Atlantic cod, lemon sole, Norway pout and oviparous elasmobranchs) are considered to have **medium** sensitivity, and the magnitude of impact is **very low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.9.3.30 Overall, sandeel are considered to have **medium** sensitivity, and the magnitude of impact is **very low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.9.3.31 All other marine fish receptors are considered to have **low** sensitivity, and the magnitude of impact is **very low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.9.3.32 Diadromous fish are considered to be of **low** sensitivity and the magnitude of impact is **very low**. Consequently, the effect is **Negligible** (**Not Significant**) in EIA terms. As effects on Atlantic salmon and sea trout are considered **Negligible** (**Not Significant**), in EIA terms effects on freshwater pearl mussels are likewise considered **Negligible** (**Not Significant**) in EIA terms due to its life stage dependence on these diadromous fish species.

13.9.4 Impact C4: mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion for example, UXO clearance

Overview

13.9.4.1 The maximum design scenario relating to mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion during the construction stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8.2**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.9.4.2 Sound exposure guidelines for fishes have been developed to reflect the varying sensitivity of species based on their auditory anatomy and mechanisms of sound detection. Fish detect sound through two main pathways: direct stimulation of the inner ear by particle motion, and indirect stimulation via re-radiated pressure waves from gas-filled organs such as swim bladders. The contribution of each pathway depends on the species' anatomy. Some fish have evolved specialised adaptations, such as swim bladder extensions or auditory bullae, that enhance their ability to detect sound pressure over a broader frequency range, while others rely solely on particle motion. Fish are thus broadly categorised into groups based on the presence and auditory function of swim bladders, and whether these adaptations enhance sensitivity and frequency detection range. This functional grouping is used in the application of threshold-based noise exposure guidelines.

13.9.4.3 The Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al*., 2014), expanded by Popper *et al*., 2019, are considered the most relevant framework for assessing the impacts of underwater noise on fish species. Further detail on these guidelines can be found in **Volume 3, Appendix 8.1**. These guidelines, agreed upon with NatureScot and MD-LOT during scoping (see stakeholder issue ID 522 in **Table 13.1**), group fish into categories based on hearing sensitivity and mechanisms of sound detection as follows:

- Group 1: Fishes with no swim bladder or other gas chamber. These species detect only particle motion and have narrow frequency sensitivity. They are considered the least sensitive to underwater noise. Relevant species within the Project area include flatfishes (for example, Atlantic halibut, common sole, European plaice), sandeels, anglerfish, and all sharks, skates, and rays (including basking shark).
- Group 2: Fishes with a swim bladder that does not aid in hearing. These fish are similarly limited to detecting particle motion and have a narrow hearing bandwidth. Relevant species include salmonids (Atlantic salmon, sea trout) and some pelagic species such as Atlantic bluefin tuna and Atlantic mackerel.
- Group 3: Fishes with swim bladders that are close, but not connected, to the ear (e.g. gadoids and eels). These fishes are sensitive to both particle motion and sound

pressure and show a more extended frequency range than Groups 1 and 2, extending to about 500 Hz.

- Group 4: Fishes that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring, sprat and shads). These fishes are sensitive primarily to sound pressure, although they also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in Groups 1, 2 and 3.
- Group 5: Fish eggs and larvae. These early life stages lack developed auditory structures and are therefore not able to actively detect sound in the same way as juveniles or adults. However, they can still be affected by physical injury from high-intensity sound exposure, particularly during construction activities. Species of relevance are those whose spawning grounds overlap with the marine fish study area and whose eggs and larvae may be present in the water column during construction.

Sensitivity of receptor

Groups 1 and 2

13.9.4.4 Because of their relative insensitivity to underwater sound, general community of marine fish within groups 1 and 2 are considered of **very low** sensitivity. Diadromous fish within Group 2, specifically salmonids (Atlantic salmon and sea trout) have relatively high tolerance to underwater noise as their swim bladder does not play a role in audition (Popper *et al.*, 2014). They are also able to move away from the source of noise, and are therefore at low risk from mortality and recoverable injury, although there remains potential for behavioural responses which may affect migration patterns. In terms of recoverability, although many of the potential behavioural effects are transient and reversible at the individual level, the depleted stocks of many salmonid populations means that even minor effects on survival, feeding success, or migration could have consequences at the population level.

13.9.4.5 Overall, fish species in groups 1 and 2 are considered to have a low vulnerability to mortality, potential mortal injury and recoverable injury to the underwater noise generated from piling activities. Therefore, groups 1 and 2 are assessed to have a **very low** sensitivity.

Groups 3 and 4

13.9.4.6 Groups 3 and 4 include gadoids, eels and clupeids, in which the swim bladder contributes to hearing. Of these, clupeids (Group 4) have the greatest hearing acuity due to the prootic auditory bullae, gas-filled ducts that extend from the swim bladder into the skull and connect directly to the inner ear. A total of three species of clupeid occur within the marine fish study area; Atlantic herring, Twaite shad and European sprat. Both herring and sprat are known to spawn and use the subtidal habitat as nursery grounds. This combination of anatomical sensitivity and extended frequency range makes clupeids among the most acoustically sensitive marine fishes. Despite their hearing ability, such species are highly mobile and wide ranging, and there for better able to avoid or vacate ensonified areas. Although behavioural effects or auditory masking in herring from piling are expected to be moderate in the far field, and high within the intermediate field (see **paragraph 13.9.4.27** for a definition of these terms), owing to their mobile nature, herring are considered to have low vulnerability to recoverable injury, for instance Temporary Threshold Shift (TTS), masking and behavioural disturbance associated with piling noise. Herring and sprat typically reproduce relatively rapidly thus have high tolerance and recovery to this temporary effect, and therefore a **low** overall sensitivity. Little is known about the migratory route of Twaite shad, and although they are of High conservation value (**Table 13.21**), they are also highly mobile and as the disturbance is not in close proximity to a natal river, it is unlikely to affect spawning activity.

13.9.4.7 European eel have moderate hearing sensitivity. They can respond to sound pressure but only after it is converted to particle motion by the swim bladder. Conversion of sound pressure to particle motion is inefficient due to the long distance between the swim bladder and the auditory organs. They have been found to have an upper auditory threshold of 300 Hertz (Hz), with greatest sensitivity to 90Hz and are considered to have a relatively high tolerance to underwater noise. Given poor recruitment in eel stocks throughout Europe reported by ICES (2023), recoverability is assessed as low. Though they exhibit a high degree of mobility, opportunistic foraging behaviour and relatively high tolerance to underwater noise, European eel are a PMF and listed by the IUCN as critically endangered. Despite their high conservation importance, their overall sensitivity to this impact is **low**.

Group 5

13.9.4.8 Fish eggs and larvae are not able to actively detect sound but are vulnerable to physical injury from high-intensity sound exposure, particularly during construction activities. Species of relevance are those whose spawning grounds overlap with the marine fish study area and whose eggs and larvae may be present in the water column during construction. The Popper criteria discussed previously are the same for Groups 5 and 2, and therefore they are assigned the same overall sensitivity of **very low**.

Magnitude of impact

13.9.4.9 Impulsive and continuous underwater noise and vibration will be generated during the construction stage of the Project. The most significant contributor to underwater noise is impact pile driving associated with the installation of offshore substation and RCP jacket foundations secured with driven piles; and WTG anchor installation with driven piles, which generates high-intensity impulsive sound. Additional, lower-level continuous noise sources include vessel operations, trenching for cable installation, cable laying, drag embedment anchors, dredging, drilling, rock placement, suction pile installation, UXO clearance and other general construction activities.

13.9.4.10 Fish perceive underwater noise through two main mechanisms: detection of particle motion and detection of sound pressure (see Section 2.2 of **Volume 3, Appendix 8.1** for more detail). The capacity of a fish species to detect and respond to underwater noise is determined by its specific hearing capabilities, which vary widely between species. Understanding these sensory mechanisms is essential to evaluating the potential biological impacts of underwater noise and underpins the sensitivity assessment of fish species to construction-related noise.

13.9.4.11 When assessing the potential impacts of underwater noise on fish, both the characteristics of the noise source and the exposure metrics used to quantify it are important. For impulsive sound sources such as pile driving, the two primary metrics used in impact assessments are Peak Sound Pressure Level (SPL_{peak}, or $L_{p,pk}$) and Cumulative Sound Exposure Level (SEL_{cum}, or $L_{E,p,t}$). These metrics are used because they are most strongly associated with the types of physical and behavioural impacts observed in fish from exposure to underwater noise. These two metrics are further described in **Volume 3, Appendix 8.1**.

13.9.4.12 Underwater sound can cause a range of biological effects in fish, from immediate physical injury to more subtle behavioural or ecological consequences. For the purpose of impact assessment, potential effects are classified into five main categories following the framework developed by Popper *et al*., 2014). These categories help distinguish relevant effects (those likely to influence population dynamics, ecological function, or long-term viability) from more transient or insignificant responses (for example, minor changes in behaviour such as startle responses):

- Mortality and potential mortal injury: Immediate or delayed death either due to injury or substantially reduced fitness. Mortality differs from potential mortal injury, with mortality used to describe injuries that directly cause death, whilst potential mortal injury is used to describe permeant injuries that substantially reduce fitness and increases the chance of predation or disease (indirect mortality).
- Recoverable injury: Injuries, that are unlikely to cause direct mortality. Recoverable injuries include injuries such as hair cell damage and minor internal or external bleeding.
- TTS: TTS refers to a temporary, reversible reduction in hearing sensitivity. TTS is defined as a measurable shift in hearing threshold of ≥6dB that persists beyond the exposure period. While TTS itself does not typically cause physical injury, it can impair a fish's ability to detect biologically relevant sounds (for example, predators, prey, or mates) and therefore has the potential to influence behaviour and survival.
- Masking: A reduction in the ability of fish to detect, recognise, or respond to biologically relevant sounds (for example, communication, prey, predator cues) due to the presence of other noise sources. Masking effects from underwater noise are only considered relevant when there is an impairment of hearing sensitivity by 6dB or greater, as smaller changes are typically indistinguishable from normal variation and are not considered ecologically significant.
- Behavioural changes: Substantial change in behaviour for the animals exposed to a sound. This may include long-term changes in behaviour and distribution, such as moving away from preferred foraging or breeding areas.

13.9.4.13 The underwater noise modelling has been developed to define the maximum spatial extent of underwater noise impacts that will not be exceeded during construction. Further details on how this has been defined, as well as details of the modelling input parameters are provided in Section 3 of **Volume 3, Appendix 8.1**.

Moving / mobile and stationary thresholds

13.9.4.14 In the context of underwater noise modelling, stationary and moving thresholds refer to 2 behavioural assumptions used to estimate cumulative sound exposure levels (SEL_{cum}) for marine animals:

- a stationary receptor is assumed to remain in place throughout the noise exposure, accumulating sound energy over time;
- a moving or mobile receptor, by contrast, is assumed to move away from the noise source during exposure, thereby reducing its cumulative exposure as distance from the source increases.

13.9.4.15 Fish are generally highly mobile species and will, in some cases, would be expected to move away from loud noise sources. However, there is relatively limited evidence for fish fleeing from high level noise sources in the wild. Whether an animal swims or remains stationary in response to a loud noise will differ between species, with species that are most likely to remain stationary expected to be benthic or species without a swim bladder, due to their reduced hearing capabilities, making these species the least sensitive to noise (for example, Goertner *et al*., 1994; Stephenson *et al.,* 2010; Halvorsen *et al*., 2012). In addition, sea trout and Atlantic salmon kelts (those that have spawned) are more akin to 'stationary' receptors because they use coastal habitats not just as a migratory pathway, but for feeding / general habitat and therefore tend to "*linger*" in an area (thus have increased residence time). Other species, particularly those with acute audition due to the use of their swim bladders and an accessory hearing organ (for example, herring) might be expected to move away rapidly from an ensonified area.

13.9.4.16 Accordingly, criteria for "*fleeing*" fish have been developed that take into account the tendency for an animal to move away from the noise source. Including only a stationary animal model as a worst-case scenario is likely to overestimate the potential risk to fish, while using only "*fleeing*" criteria may be unrealistic for some species. A combined approach has therefore been adopted for this assessment, which considers impact ranges to both moving and stationary receptors where appropriate.

13.9.4.17 Impact ranges for cumulative exposure (SEL_{cum}) are presented in the noise modelling for both stationary and moving receptors. The moving model incorporates a horizontal swimming speed of 1.5m/s (based on Hirata, 1999) and is considered a conservative speed at which to base the swim speed of salmon.

13.9.4.18 Further information regarding criteria and guidelines can be found in Section 2.3.4 of **Volume 3, Appendix 8.1**.

13.9.4.19 As per regulatory guidance and standard practice, the stationary receptor model has been used for the formal impact assessment, as it represents a precautionary worst-case scenario. However, results from the moving receptor model are also reported to provide a more realistic context and support a more nuanced interpretation of potential impacts on migrating salmon.

13.9.4.20 The outputs from these scenarios form the basis for assessing potential impacts on ecological receptors including marine and migratory fish species.

Impact piling

13.9.4.21 Quantified criteria for evaluating the magnitude of noise impacts have been developed by Popper *et al*. (2014) that distinguish between the types of fish and the type of potential injury caused as described in **paragraph 13.9.4.1**. **Table 13.25** summarises the fish injury criteria recommended for pile driving based on these guidelines.

Table 13.25 Criteria for onset of injury to fish due to impulsive piling (Popper *et al.*, 2014)

Group	Parameter	Mortality / potential mortal injury	Recoverable injury	TTS
1 (fish without a swimbladder)	$L_{E,p,24h}$	>219	>216	>186
	dB $L_{p,pk}$	>213	>213	N/A
2 (fish with swimbladder not involved in hearing)	$L_{E,p,24h}$	210	203	>186
	dB $L_{p,pk}$	>207	>207	N/A
3 and 4 (fish with swimbladder involved in hearing)	$L_{E,p,24h}$	207	203	186
	dB $L_{p,pk}$	>207	>207	N/A
5 (eggs and larvae)	$L_{E,p,24h}$	>210	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low
	dB $L_{p,pk}$	>207		

Group	Parameter	Mortality / potential mortal injury	Recoverable injury	TTS
Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near field (N; for instance, 10s of metres), intermediate (I; for instance, 100s of metres), and far field (F; for instance, 1,000s of metres) (Popper *et al.,* 2014).				

13.9.4.22 Impact piling modelling included single location modelling and multiple location modelling. Table 4.5 to Table 4.7 (within **Volume 3, Appendix 8.1**), present the impact piling modelling results for the Project, covering offshore substation and RCP foundations, and driven pile anchors. For fish, the largest recoverable injury ranges (203 dB LE,p,24h) are predicted at a range of 4.9km for a stationary receptor. These ranges reduce to less than 100m when a fleeing receptor is assumed. Impact ranges are detailed in **Table 13.26**.

Table 13.26 Summary of the unweighted $L_{E,p,24h}$ impact ranges for fish using the Popper *et al.* (2014) pile driving criteria covering the offshore substation driven pile installation modelling for two sequentially installed piles at the north corner modelling location

Popper *et al.* (2014) Unweighted $L_{E,p,24h}$		**Offshore substation driven piles (two sequentially installed piles)**			
		Area	**Maximum range**	**Minimum range**	**Mean range**
Pile driving (Fleeing 1.5m/s)	219dB	< 0.1km^2	< 100m	< 100m	< 100m
	216dB	< 0.1km^2	< 100m	< 100m	< 100m
	210dB	< 0.1km^2	< 100m	< 100m	< 100m
	207dB	< 0.1km^2	< 100m	< 100m	< 100m
	203dB	< 0.1km^2	< 100m	< 100m	< 100m
	186dB	2,700km^2	32km	27km	29km
Pile driving (Stationary 0.0m/s)	219dB	0.36km^2	350m	330m	340m
	216dB	0.99km^2	580m	550m	560m
	210dB	7.6km^2	1.6km	1.6km	1.6km
	207dB	21km^2	2.6km	2.6km	2.6km
	203dB	75km^2	4.9km	4.9km	4.9km
	186dB	5,500km^2	44km	39km	42km

13.9.4.23 Based on the fleeing receptor model mortality would occur within 100m of the piling source for all hearing groups, and over an area of <0.1km^2 (**Table 13.26**). For the stationary receptor model mortality for Group 1 species would occur at a maximum range of 350m from the noise source and at 2.6km for Group 3 and 4 species. TTS would occur at a maximum range of 32km, and over an area of 2700km^2 for a fleeing receptor and at a maximum range of 44km, and over an area of 5,500km^2 for a stationary receptor.

13.9.4.24 It is considered that the magnitude of impact due to noise that might cause mortality or recoverable injury is **very low**, due to the relatively limited extent of the ensonified area. However, since the areas over which TTS is likely to occur are considerably larger under either the stationary or moving receptor model this is considered to be an impact of **low** magnitude.

Unexploded ordnance clearance

13.9.4.25 A low-order methodology (typically less than 250g) is expected to be used for UXO clearance, with high-order being a last resort low-order clearance would produce a maximum impact range of 990m for mortality and potential mortal injury for fish (see **Volume 3, Appendix 8.1** for further detail).

13.9.4.26 For all other noise making activities, it has been surmised that there is a minimal risk of any injury or TTS with reference to the Lp guidance for continuous noise sources in Popper *et al.* (2014), with all sources listed producing much quieter levels than impact piling. Therefore, the magnitude of impact from unexploded ordnance clearance is considered to be **very low**. Further information regarding other noise sources can be found in Section 5 of **Volume 3, Appendix 8.1**.

Behavioural effects

13.9.4.27 Behavioural effects in response to construction related underwater noise include a wide variety of responses including startle responses (also known as C-turn responses), strong avoidance behaviour, changes in swimming or schooling behaviour or changes of position in the water column. Masking may occur where a masking noise exceeds the absolute hearing thresholds of an animal. The Popper *et al*. (2014) guidelines provide qualitative behavioural and masking criteria for fish from a range of noise sources. These categorise the risks of effects in relative terms as "*high*", "*moderate*" or "*low*" at three distances from the source: "*near*" (for instance, 10s of metres), "*intermediate*" (for instance,100s of metres) or "*far*" (for instance, 1,000s of metres). The behavioural criteria for piling operations are summarised in **Table 13.27**.

Table 13.27 Potential risk for the onset of behavioural effects in fish from piling (Popper *et al*., 2014)

Group	Masking	Behaviour
1	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
2	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
3 and 4	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate

Group	Masking	Behaviour
Eggs and larvae	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low
Relative risk (high, moderate, low) is given for animals at 3 distances from the source defined in relative terms as near field (N; for instance, 10s of metres), intermediate (I; for instance, 100s of metres), and far field (F; for instance, 1,000s of metres)).		

13.9.4.28 The criteria detailed in **Table 13.27** indicate a variable degree of impact risk in the far field (1,000s of m) depending on the auditory acuity of the particular species. For all groups, behavioural effects are high in the near field, with the exception of eggs and larvae, with masking effects moderate in the near field, with the exception of groups 3 and 4. In the intermediate field behavioural effects are moderate for group 1 and group 2, high, for groups 3 and 4, and low for eggs and larvae. Masking is low for all groups except Groups 3 and 4, which is high. In the far field, behavioural and masking effects are low for all groups except groups 3 and 4, which is moderate.

13.9.4.29 Therefore, it is considered that behavioural effects are generally higher for groups 3 and 4, with higher risk of effects in the near field (10s of meters), suggesting a semi-localised effect on behaviour. It is therefore considered that the impact due to noise that might cause behavioural changes is **low** for Groups 3 and 4, and Impact C4: mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion for example, UXO clearance **low** for all other groups.

Significance of residual effect

13.9.4.30 Injury and / or mortality for all fish species may occur within very close proximity to piling operations (either 100m based on the fleeing model, or 350m for the stationary model), and is therefore anticipated to affect very small numbers of fish. Impacts would be mitigated using soft start procedures (M-105) allowing individuals in close proximity to flee the area prior to experiencing maximum hammer energy levels that otherwise might cause injury.

Groups 1 and 2

13.9.4.31 These groups (which include species that are features of designated sites) have a high tolerance and **low** sensitivity to underwater noise activities. The magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

Groups 3 and 4

13.9.4.32 These groups have a high tolerance and **medium** sensitivity to underwater noise activities. The magnitude of impact is **very low** (mortality / injury) and **low** (TTS / behavioural). Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

Group 5

13.9.4.33 These groups have a high tolerance and **low** sensitivity to underwater noise activities. The magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.9.5 Impact C5: direct and indirect seabed disturbances leading to the release of sediment contaminants

Overview

13.9.5.1 The direct and indirect disturbances associated with the construction stage of the Project may lead to the release of sediment contaminants into the water column, causing deterioration of water quality and subsequently the health of the fish receptors.

13.9.5.2 The maximum design scenario relating to direct and indirect seabed disturbances leading to the release of sediment contaminants during the construction stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8.2**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

Sensitivity of receptor

13.9.5.3 Seabed disturbances during construction may result in temporary increases in contaminants which may affect the respiration mechanisms of some fish and reduce the success of pelagic spawning events (Hylland and Vethaak, 2020).

13.9.5.4 For all fish receptor groups, the most sensitive individuals will be those with pelagic spawning and gill sensitivity (Singh and Sharma, 2024). As this includes a broad range of species, it is considered that sensitivity for all groups to this impact is **medium**.

Magnitude

13.9.5.5 Trenchless techniques used for export cable installation at the landfall; jet trenching along the export cable route and drilling for jacket foundations of the offshore substations and RCPs during the construction stage may release drilling muds into the water column, contributing to temporary increases in SSC and subsequently any release of contaminants.

13.9.5.6 Results of the sediment metals analysis for the core samples within the OAA can be seen in the survey report from the surveys carried out during 2021 (Fugro 2022).

13.9.5.7 Across the OAA survey area, PAH concentrations were below Marine Scotland’s Action Level 1 (AL1), indicating no ecological concern. Metal concentrations in grab samples were also below AL1 and AL2 thresholds, while core samples showed isolated exceedances of AL1 for arsenic and chromium, though all remained below AL2. PCBs and organotins (dibutyltin and tributyltin) were consistently below detection limits or AL1 values, suggesting minimal contamination risk throughout the site.

13.9.5.8 Results of the sediment metals analysis for the core samples within the offshore export cable corridor can be seen in the survey report from the surveys carried out during 2023 (Fugro 2023a and b).

13.9.5.9 All PAH concentrations in grab samples were below Marine Scotland Action Level 1 (AL1), indicating no ecological concern. One core sample (MRW_ECC_47-3) exceeded AL1 for multiple PAHs, though adjacent layers did not, suggesting a localised anomaly. Metal concentrations in grab samples were also below AL1 and AL2 thresholds, while some core samples exceeded AL1 for arsenic, cadmium, chromium, copper, and nickel, but remained below AL2. PCB and tributyltin (TBT) concentrations were consistently below AL1 across all samples, indicating minimal contamination risk.

13.9.5.10 Disturbance of sediment will be temporary and highly localised (as described in **Section 13.9.3**) and therefore the release of any contaminants will be limited to the area of disturbance. It is anticipated that rapid dilution and spread of any contaminants will reduce toxicity to negligible levels. As survey results from the area indicate low contaminant risk throughout the Offshore Red Line Boundary, in addition with adherence to embedded environmental measures, specifically M-033, M-049, M-059, M-060, M-062, M-064 as detailed in **Table 13.17**, the magnitude of change is **very low**.

Significance or residual effect

13.9.5.11 All fish receptors have a high tolerance and **medium** sensitivity to release of sediment contaminants. The magnitude of impact is **very low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.9.6 Impact C6: changes in water quality

Overview

13.9.6.1 The maximum design scenario relating to direct and indirect seabed disturbances leading to the release of sediment contaminants during the construction stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8.2**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.9.6.2 Changes in water quality may arise from a number of sources during preconstruction and construction activities, namely sediment disturbance and oil release from drilling machinery. Deterioration of water quality can affect the health of the fish receptors. For example, low dissolved oxygen concentrations leading to fish mortality (hypoxia) may occur as a result of sediment releases.

Sensitivity of receptor

13.9.6.3 Changes in water quality during construction may affect the respiration mechanisms of some fish, reduce the success of spawning events, and potentially cause other effects such as mortality or disrupted predator detection (*Dixson et al.,* 2009).

13.9.6.4 Impacts from water quality are varied and will be dependent on the substance, concentration, toxicity and other factors such as dilution and tidal cycles (Cereja *et al.*, 2022). As impacts are broad, the species that could be affected are also broad, although some species and life stages (e.g larval) are more sensitive to changes in water quality than other, more tolerant groups and adult fish. Therefore, for a precautionary approach, it is considered that sensitivity for all groups to this impact is **medium.**

Magnitude

13.9.6.5 Trenchless techniques used for export cable installation at the landfall; jet trenching along the export cable route and drilling for jacket foundations of the offshore substations and RCPs during the construction stage may release drilling muds into the water column, contributing to temporary increases in SSC and subsequently any release of contaminants which may result in changes in water quality. The magnitude of impact from release of contaminants from seabed disturbance (as described in **Section 13.9.3**) is **very low**.

13.9.6.6 With adherence to embedded environmental measures, specifically M-033, M-049, M-059, M-060, M-061, M-062, M-064 as detailed in **Table 13.17**, the magnitude of change is **very low**.

Significance or residual effect

13.9.6.7 All fish receptors have a high tolerance and **medium** sensitivity to change in water quality. The magnitude of impact is **very low**. As the embedded measures minimises the likelihood of significant release of contaminants, pollution events or accidental releases to the marine environment, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.9.7 Impact C7: potential impacts on designated sites

Overview

13.9.7.1 The maximum design scenario relating to potential impacts on designated sites during the construction stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8.2**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.9.7.2 This Section summarises the potential impacts on designated sites from pre-construction and construction activities associated with the Project. The fish ecology assessment has concluded that there are no significant effects on fish species during construction. Therefore, there will be no significant implications for prey species due to changes in predators, and no significant effects on predator species due to changes in prey availability. There will also be no significant effects on fish species that are features of designated sites, specifically:

- sandeel (Turbot Bank MPA);
- Atlantic salmon (River Dee SAC); and
- freshwater pearl mussel (River Dee SAC).

Sensitivity of receptor

Turbot Bank

13.9.7.3 Turbot Bank MPA is located approximately 25km south of the Offshore Red Line Boundary. No impacts from construction activities are expected at this distance, with the exception of behavioural disturbances associated with impact piling activity. No direct impacts on habitats within the Turbot Bank MPA are expected.

13.9.7.4 Sandeel are features of the Turbot Bank MPA, therefore the sensitivity of Turbot Bank MPA is directly related to the sandeel population and their sensitivity to potential impacts. At this distance the only potential impact considered is behavioural disturbances associated with impact piling activity. However, sandeel have no swim bladder and therefore are within the group of fish (group 1) considered to be the least sensitive to underwater noise (see **Section 13.9.4**).

13.9.7.5 Therefore, despite the high value of sandeel and the Turbot Bank MPA, the sensitivity of this designated site to impacts associated with the pre-construction and construction stages are **low**.

River Dee SAC

13.9.7.6 As described in the baseline (see **paragraph 13.6.1.2**), the River Dee SAC is located approximately 45km south-west of the Offshore Red Line Boundary. The River Dee SAC is designated for Atlantic salmon and freshwater pearl mussels. No direct impacts on habitats within the River Dee SAC are expected.

13.9.7.7 Atlantic salmon, individuals possibly associated with the SAC, can be expected to pass through the Offshore Red Line Boundary during migration. Therefore, potential impacts on salmon (and freshwater pearl mussels due to life cycle association) can be interpreted as potential impacts on features of the SAC. However, it is not possible to identify the quantity, congregation or timing of individual salmon associated with the SAC passing through the study area during activities, so there is a high degree of uncertainty around their sensitivity to impacts.

13.9.7.8 The assessment of all potential impacts from the pre-construction and construction activities associated with the project highlighted a **medium** sensitivity to be the highest sensitivity to the impacts listed during pre-construction or construction activities, therefore as a precaution, the sensitivity associated with features of the River Dee SAC (Atlantic salmon and freshwater pearl mussels) is **medium.**

Magnitude of impact

13.9.7.9 No potential impacts are anticipated from any pre-construction or construction activities a range that might affect any designated sites, as described in each impact assessment. In addition, the implementation of environmental measures, including M-061 which minimise impacts to freshwater life stages of Atlantic salmon associated with the River Dee SAC is assumed. Therefore, the overall magnitude of impact is **low**.

Significance of residual effect

13.9.7.10 Turbot Bank MPA has a **low** sensitivity to construction activities. The magnitude of change is **low**. Therefore, a **Minor Adverse** (**Not Significant**) in EIA terms has been concluded for this impact.

13.9.7.11 River Dee SAC has a **medium** sensitivity to construction activities. The magnitude of change is **low**. Therefore, a **Minor Adverse** (**Not Significant**) in EIA terms has been concluded for this impact.

13.9.8 Impact C8: increased risk of introduction and / or spread of marine INNS

Overview

13.9.8.1 The maximum design scenario relating to increased risk of introduction or spread of marine INNS during the construction stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.9.8.2 During construction and pre-construction, the following activities may pose a risk of introducing or facilitating the spread of INNS:

- wet storage of Project infrastructure components[4];
- presence of new structures in the water column;
- installation of WTGs, including floating units, and mooring and anchoring systems;
- installation of offshore substation and RCP jacket foundations;
- installation of SDCs;
- installation of array and offshore cables;
- installation of cable crossings; and
- vessel movements for the construction stage.

13.9.8.3 The introduction of INNS through changes to habitat type and construction of infrastructure as well as increased vessel traffic has the potential to directly impact benthic, epibenthic and intertidal ecology receptors, as detailed in **Chapter 10: Benthic, Epibenthic and Intertidal Ecology**, with indirect effects to fish receptors. The introduction of INNS has the potential to result in changes in prey availability. No INNS were detected in the intertidal surveys (APEM, 2024), though two INNS were found in the offshore surveys of the offshore export cable corridor:

- *Goniadella gracilis* (detected at 19 locations along the offshore export cable corridor) is a small (approximately 3cm) polychaete worm that was first described from the northeastern United States and has since been found in European waters including the North Sea.
- *Monocorophium sextonae* (detected at one location along the offshore export cable corridor) is a small burrowing amphipod crustacean, native to New Zealand. It was introduced near Plymouth in the 1930s and had spread to Ireland by the late 1970s. It can now be found along the European coast from southern Norway to the Mediterranean and is considered naturalised.

13.9.8.4 It should be noted that no specific information is available to suggest that reefs associated with offshore wind farms will provide uniquely beneficial opportunities not currently available to alien species to assist their invasion in UK waters (Linley *et al.*, 2007).

13.9.8.5 INNS establishment depends on multiple factors, including salinity, depth, current strength, and the presence of suitable substrates. Fully marine salinities can support a wider range of INNS (Evans, 1980), while strong currents may reduce larval settlement but aid dispersal. Sites with stable, submerged surfaces (natural or artificial) are more susceptible to colonisation, especially if structures remain undisturbed for extended periods.

Sensitivity of receptor

13.9.8.6 The sensitivity of fish receptors to INNS spread relates to their dependence on artificial reefs and native species. The study area is dominated by pelagic, open water and soft sediment habitats, and so the species composition is not dependent on reef structures and food sources provided, although they may congregate and benefit from them (see **Section 13.10.4** for assessment of colonisation of hard substrate and the effects of FADs).

[4] The Offshore Red Line Boundary does not include areas that may be used for the temporary floating storage of Project components (commonly referred to as 'wet storage') as these have not yet been identified. The consent and assessment of wet storage areas is outside the remit of the Project EIA and will be considered as part of any necessary separate consents (for example harbour development works).

13.9.8.7 There may be localised reductions in available demersal spawning habitats (for example, colonisation of soft sediment by INNS), although the impact is expected to be localised, with extensive available habitat for spawning in the surrounding area.

13.9.8.8 It is considered that, due to the mobile and pelagic / demersal ecology of fish receptors in the study area, and the low dependency on artificial structures, the sensitivity of all fish receptors to this impact is **low**.

Magnitude of impact

13.9.8.9 As discussed in **Chapter 10: Benthic, Epibenthic and Intertidal Ecology**, once established, INNS are difficult to eradicate, so their introduction will result in an irreversible impact, therefore making prevention critical. The Applicant is committed to producing and adhering to an INNS Management Plan (see **Volume 4: Outline Offshore Invasive Non-Native Species Management Plan** and M-102 detailed within **Section 13.7.2**) to prevent and reduce impacts from the introduction of INNS. The **Volume 4: Outline Offshore Invasive Non-Native Species Management Plan** identifies all Project activities as presenting a low risk of INNS introduction. This, combined with the mitigation measures set out in the INNS plan and M-102, are expected not to result in any increase in the rate of introduction of INNS into Scottish waters, or to their spread within the Project area. The magnitude of impact to fish ecology receptors is thus classed as **very low**.

Significance of residual effects

13.9.8.10 The Project embedded environmental measures (as show in **Table 13.17**) include the adherence to an INNS Management Plan (M-102) to prevent and reduce impacts to receptors from the introduction of INNS. Considering the **low** sensitivity of all fish receptors and the **very low** magnitude of impact, the overall effect of potential introduction and spread of INNS on all fish species during O&M is considered to be **Negligible** (**Not Significant**) in EIA terms.

13.10 Assessment of effects: operation and maintenance stage

13.10.1 Introduction

13.10.1.1 This Section provides an assessment of the effects for fish ecology from the O&M of the offshore elements of the Project.

13.10.1.2 The assessment methodology set out in **Section 13.8** has been applied to assess effects to fish ecology from the Project.

13.10.2 Impact O1: temporary habitat loss and / or disturbance

Overview

13.10.2.1 The maximum design scenario relating to temporary habitat loss and / or disturbance during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.2.2 Temporary habitat loss and / or disturbance are predicted to occur during maintenance activities, which include:

- replacement of mooring line components;
- replacement of mooring or anchors using the same process as construction;
- replacement or repair of array cables including routine inspection and cable repair (recovery and reburial);
- SDC and subsea substations includes routine inspections, cable and scour protection repair / replacement;
- offshore substations and RCPs including routine inspections, removal of marine growth and replacement of scour protection; and
- offshore export cables including routine inspection and cable repair (recovery and reburial).

13.10.2.3 Disturbance to these habitats has the potential to affect identified fish receptors directly (for example, removal or injury of individuals, particularly benthic species) and indirectly (for example, loss of, or damage to important fish habitats, such as spawning grounds and / or reduction in food resource).

Sensitivity or value of receptor

13.10.2.4 The explanation of values and sensitivity of receptors to temporary habitat disturbance of seabed habitat is provided in **Section 13.9.2**. The sensitivity of receptors to this impact is **medium** to **low**.

Magnitude of impact

13.10.2.5 If the anchors require replacing, the lifting of the anchor and re-lay will increase the seabed displacement.

13.10.2.6 Where a fault is detected on the export or array cables, the damaged section of cable will be recovered and repaired by splicing in a new section or replaced in its entirety. For buried cable, it will be necessary to expose the cable prior to recovery where testing will be conducted to establish the extent and type of repair required. After repairs are complete, the cable will again be buried below the seabed using one of the same techniques as used for the initial construction. New cable protection material may need to be installed over the repaired section. Where cable protection was in place, this would need to have been displaced to allow recovery of the cable and then replaced. The activities along with cable preventative maintenance will result in increased SSC and an increase in sediment deposition.

13.10.2.7 The impacts from these operational works will be spread over the life span of the Project (35 years per phase) with only a limited number of activities occurring with any single year.

13.10.2.8 The magnitude of temporary habitat disturbance from maintenance activities relating to the Project is predicted to be of small spatial extent, short-term duration, intermittent and reversible, therefore the magnitude of the impact is deemed to be **low**.

Significance of residual effect

13.10.2.9 Overall, it is predicted that the effect upon all fish receptor groups is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.3 Impact O2: long-term habitat loss and / or disturbance

Overview

13.10.3.1 The maximum design scenario relating to long-term habitat loss or disturbance during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.3.2 Long-term habitat loss will result from the presence of the anchors for the floating unit; the cable protection for the unburied array cables and export cables, and cable crossings; the SDCs and scour protection; and the offshore substations and RCPs scour protection on the jacket foundations.

13.10.3.3 Habitat loss and disturbance have the potential to degrade or remove sensitive fish habitats, including foraging, spawning, and nursery areas. Direct effects on fish receptors may include injury or displacement of individuals during maintenance activities. Indirect effects may arise from the alteration or loss of benthic habitats that support key prey species or provide ecological functions critical to early life stages.

Sensitivity or value of receptor

13.10.3.4 Marine fish may be indirectly affected by permanent seabed habitat loss or long-term disturbance through changes in prey availability or benthic community structure. Many demersal and benthopelagic species feed on infaunal and epifaunal invertebrates associated with seabed habitats. However, most fish exhibit generalist feeding strategies and can adapt to localised long-term or temporary changes by shifting foraging areas or prey preferences.

13.10.3.5 Species considered most sensitive to direct seabed habitat loss or disturbance are those with strong associations to specific benthic habitats and / or demersal spawning strategies. This includes Atlantic herring, sandeel, and oviparous elasmobranchs (for example, the common skate complex). These species are considered in more detail below.

Demersal spawning species

Atlantic herring

13.10.3.6 Atlantic herring are demersal spawners that depend on suitable seabed substrates, such as gravel or sand, for egg deposition (Frost and Diele, 2022). The species has low tolerance to permanent seabed loss, as this results in a long-term reduction in the availability of spawning habitat. In addition, episodic or temporary disturbance during the O&M stage may lead to direct egg mortality if it coincides with critical spawning periods and may reduce spawning success if adults avoid disturbed areas (Frost and Diele, 2022). Recovery potential is considered medium, supported by the species' use of broad and spatially dispersed spawning grounds, pelagic larval dispersal, and relatively short generation times (Wright *et al.,* 2000). Accordingly, Atlantic herring are assessed as being of medium value, with low tolerance and medium recoverability. Overall, the sensitivity of Atlantic herring to permanent seabed loss is considered **medium**.

Sandeel

13.10.3.7 Sandeel are highly sensitive to both physical seabed disturbance and substratum change (FeAST, 2025). They rely on specific sediment types for burrowing and overwintering. Permanent habitat loss may reduce the extent of suitable habitat, while temporary disturbance (for example, jack-up vessel deployment, cable reburial) may lead to localised displacement or mortality. Monitoring from other developments (for example, Horns Rev I, Beatrice Offshore Wind Farm) suggests potential for recovery (van Deurs *et al*., 2012; BOWL, 2021). However, habitat in the Celtic Sea is more fragmented, likely limiting recovery potential from permanent loss of suitable habitats, whereas the North Sea exhibits a large expanse of suitable substrates, improving potential for recovery. Sandeel are assessed as having medium value, low tolerance, and medium recoverability. Sensitivity is therefore **medium**.

Oviparous elasmobranchs

13.10.3.8 Oviparous elasmobranchs such as spiny ray, spiny dogfish, common skate, spotted ray and spurdog (**paragraph 13.6.1.64**) have identified nursery grounds within the Red Line Boundary and lay demersal egg cases. Demersal egg-laying behaviour makes these species more vulnerable to permeant seabed disturbance that may result in the permanent loss of spawning habitats and / or damage deposited egg cases. FeAST and MarLIN categorise adult elasmobranchs as having low sensitivity to substratum loss and moderate sensitivity to abrasion, due to their mobility (FeAST, 2025, Tyler-Walters, 2023). However, egg-cases are immobile and are therefore considered more sensitive than their adult counterparts. Habitat range for species present in the study area has broad coverage in the wider area. Overall, oviparous elasmobranchs are considered of high value, medium tolerance, and low recoverability. Sensitivity is therefore **medium**.

Diadromous fish

13.10.3.9 Diadromous fish species, including Atlantic salmon, sea trout, and European eel, are highly mobile and undertake broad marine migrations between freshwater and oceanic habitats. Given this mobility and the absence of known critical habitats (for example, spawning or key foraging areas) within the Red Line Boundary (see **paragraph 13.6.1.79**), these species have limited direct reliance on benthic habitats affected by permanent seabed loss. As such, direct impacts are expected to be **negligible**.

13.10.3.10 However, indirect effects may arise through long-term changes in prey availability, particularly sandeel and other small forage fish, which may be more persistently affected by permanent habitat change compared to temporary disturbance. Post-smolt Atlantic salmon, for example, feed on sandeel shortly after entering the marine environment (Haugland *et al.,* 2006). While diadromous species are generalist predators and capable of shifting foraging strategies across broad spatial scales (Rikardsen and Dempson, 2011), longer-term localised reductions in prey availability may lead to some energetic or behavioural impacts.

13.10.3.11 Given their high value, moderate tolerance to indirect ecological change, and high recoverability due to their wide range and flexible foraging strategies, the overall sensitivity of diadromous fish species to permanent seabed habitat loss and / or disturbance is considered to be **medium**.

Other marine fish

13.10.3.12 Other marine fish species not specifically mentioned – including (but not limited to) gadoids, flatfish, pelagic species, and viviparous elasmobranchs – are considered less sensitive to this impact. These species typically do not rely on specific benthic substrates for key life stages and exhibit higher tolerance to habitat change and physical disturbance. Many also possess life-history traits (for example, high fecundity, mobility) that support faster recovery. These receptors are of low to high value and are considered to have high tolerance and low to moderate recoverability. Sensitivity is therefore **low**.

Magnitude of impact

13.10.3.13 Permanent seabed habitat loss will result from the installation of infrastructure within the Offshore Red Line Boundary. **Table 13.16** provides the maximum seabed footprint (long-term habitat loss) for floating unit anchors, array cables, SDCs, offshore substations, offshore export cables, cable crossings and RCP. With a total maximum long-term habitat loss of 13,136,930m^2 (13.137km^2).

13.10.3.14 The seabed within the OAA can be generally described as a widely distributed but thin veneer of relatively sandy sediment. The seafloor sediments mainly comprise a combination of sand and silt, varying from slightly silty fine to medium sand to fine to medium sandy silt. Within the offshore export cable corridor, the seafloor sediments mainly comprise a combination of silt, sand, and gravel. Based on the results from the environmental grab samples, sand is the predominant main soil type with gradual changes in grain size across the route. Bedrock is observed outcropping at the seafloor in nearshore areas including at the landfall zones. The surficial Holocene sediments are generally between 0m to 1m thick. However, they reach a thickness of >5m in places (see Section 10.6.1 of **Chapter 10: Benthic, Epibenthic and Intertidal Ecology**).

13.10.3.15 Silty fine to medium sand is the predominant seafloor sediment. Long-term losses of this habitat will be limited to physical footprints of infrastructure and unburied cables. In these areas, the change represents a shift from softer sediment to artificial hard substrate (for example, concrete or rock scour protection).

13.10.3.16 The areas subject to permanent change will be spatially discrete and localised, either in the immediate vicinity of the floating unit anchors, offshore substation and RCP jacket foundations and SDCs (including scour protection); along narrow, linear stretches of the array and export cable routes; or at cable crossings. As such, the footprint of habitat loss (see **paragraph 13.10.3.13**) or conversion is small in proportion to the extent of similar habitats in the wider region. While the change from natural to artificial substrate does not constitute complete functional loss, it alters physical structure and ecological character, which may affect associated benthic communities, and thereby affecting fish species indirectly through changes in prey availability or habitat structure. However, the benthic, epibenthic and intertidal ecology (including shellfish) assessment concluded that impacts from this impact-pathway were **Minor Adverse** (**Not Significant**) in EIA terms for subtidal habitats, species and shellfish (**Chapter 10: Benthic, Epibenthic and Intertidal Ecology**). As such, any secondary effects on fish via reduced availability of epifaunal or infaunal communities are assumed to be minimal.

13.10.3.17 Although differing in permanence and mechanism, both the long-term habitat will affect only a small proportion of available habitat relative to the wider marine area. Permanent impacts are spatially limited within the Offshore Red Line Boundary and, in many areas, involve a change in substrate type rather than complete removal, with some potential for colonisation on artificial hard structures and diversification of habitats.

13.10.3.18 The magnitude of impact on long-term habitat loss / disturbance on fish receptors is predicted to be of local spatial extent and of long-term duration, continuous and irreversible (35 years per phase). As such, considering the adverse nature of the impact, its limited spatial extent, partial reversibility, intermittent frequency, and long-term duration, the overall magnitude of impact is assessed as **low**.

Significance of residual effect

13.10.3.19 Atlantic herring are demersal spawners that may be affected by the permanent loss of localised coarse substrate. Effects are, however considered spatially limited due to the restricted extent of suitable spawning substrate within the area affected by permanent seabed habitat loss and / or disturbance, especially when considering the availability of suitable spawning grounds across the broader study area and wider region. Overall, Atlantic herring are considered to be of **medium** sensitivity and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.3.20 For sandeel, effects are also spatially limited, as only a small proportion of suitable habitats within the area affected by this impact-pathway will be affected, relative to available habitats across the wider marine fish study area. Overall, sandeel are considered to have **medium** sensitivity and the magnitude of impact is **low**. The effect is assessed as **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.3.21 Oviparous elasmobranchs are considered to have **medium** sensitivity, owing to their conservation importance and vulnerability to habitat disturbance but broad habitat range. Importantly, while the species may utilise the affected area, suitable egg-laying habitats are spatially restricted, being limited to shallow nearshore waters (<20m depth). These shallow habitats represent only a small proportion of the area subject to permanent seabed loss and / or disturbance associated with the O&M stage (see **Table 13.16**). As such, the potential impact on key reproductive habitat is limited. Given their **medium** sensitivity and the **low** magnitude of impact, the effect is assessed as **Minor** (**Not Significant**).

13.10.3.22 Diadromous fish are considered to be of **medium** sensitivity and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms. As effects on Atlantic salmon and sea trout are considered minor (not significant), effects on the freshwater pearl mussels that depends on these species are likewise considered **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.3.23 All other marine fish receptors are considered to have **low** sensitivity due to their reduced reliance on seabed habitats, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.4 Impact O3: colonisation of hard substrate

Overview

13.10.4.1 The maximum design scenario relating to colonisation of hard substrates are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.4.2 The introduction of the hard substrates on the seabed and the foundations of floating wind turbine foundations, mooring lines and dynamic cables of wind turbines within the water column may potentially affect the established fish community providing new habitat and ecosystem function. These hard substrates include:

- mooring lines and anchors on the seabed;
- array and interconnector cable protection and cable crossing protection; and
- floating wind turbine foundations in the water column.

13.10.4.3 Infrastructures associated with offshore wind farms may provide shelter and new habitats for fish and shellfish species as they can act as artificial reefs. The introduction of hard infrastructure in the marine environment alters previously soft sediment habitat areas with hard structures, which can attract new species to the area, therefore, potentially increasing habitat complexity and biodiversity of the area (Degraer *et al*., 2020).

Sensitivity of receptor

13.10.4.4 In sand-dominated environments, fish aggregation around hard substrate and structures is likely to boost local biodiversity and have positive impacts upon populations of key fish species such as Atlantic cod and pouting (*Trisopterus luscus*) (Reubens *et al*., 2013). However, given the scale of the Project in the context of the wider Central North Sea, aggregations as a result of the Project are not expected to result in population-level effects. For well-established artificial reef structures, aggregation of predatory species may have a localised negative impact upon small prey species (Leitão *et al*., 2008). However, the potential for aggregation is dependent on a number of variables relating to the size, complexity, material, location, and age of the artificial structure, in addition to seasonal distributions of fish driven by abiotic conditions (Glarou *et al*., 2020; Wright *et al*., 2020).

13.10.4.5 Generally, pelagic, demersal and diadromous fish species have a high degree of mobility and agility. While they may aggregate in areas of high productivity (around FADs), they are considered to exhibit a level of adaptability to aggregation effects. Therefore, all fish receptor groups are deemed to be of low vulnerability and overall, a **low** sensitivity to this impact.

Magnitude of Impact

13.10.4.6 Subsea, floating structures, associated moorings, and substation jacket foundations have the potential to act as artificial reefs and FADs, which attract fish from other areas and group individuals together into a smaller area. The introduction of hard structures in the marine environment will likely become inhabited by marine organisms, creating new habitats and demonstrating an artificial reef effect. These hard structures become known as a FAD, if fish become attracted to these artificial reefs. It is thought that fish stocks concentrate around FADs, rather than actually increasing productivity and biodiversity (Inger *et al*., 2009). Evidence suggests, however, that hard structures, which may act as artificial reefs, provide food and refuge, and therefore may increase the productivity of an area (Langhamer and Wilhelmsson, 2009; Wilhelmsson *et al*. 2006; Linley *et al*. 2007). Early results of the PrePARED Project, which consisted of Baited Remove Underwater Video monitoring at operational offshore wind farms on the east coast of Scotland in 2022 to assess the presence, abundance and size of demersal fish species close to offshore wind farm turbines, indicate an increased abundance, size and mean energy content of fish near to turbines when compared to reference sites further from turbine foundations. The results indicated 2.5 times more flatfish within 30m of turbines at the Beatrice Offshore Wind Farm and three times more haddock. Results at the Moray East Offshore Wind Farm were less pronounced with no increase in flatfish and two times more haddock (PrePARED, 2024). It is not possible to say whether similar changes to those observed in the PrePARED Project monitoring would be reflected at this Project, or whether those effects would be significant, or even whether there would be positive, negative or neutral effects on the fish community.

13.10.4.7 The installation of jacket foundations (including mud mats), array cables, anchors, mooring lines, clump weights and remedial protection on the seabed within the OAA, will provide surfaces that have the potential to be colonised. As detailed in **Table 13.16**, the combined total introduced hard substrate for the Project is 2,399,000m^3. Cables will be buried except where localised site conditions prevent burial, to reduce the footprint of additional remedial protection. Where burial is not possible, typically rock placement, would be installed.

Biofouling will occur on hard surfaces, if there is no antifouling treatment applied to foundations, floating substructures, mooring lines, anchors or cables. Furthermore, biofouling will also occur on any remedial protection along the cable route.

13.10.4.8 The potential impact regarding benthic species colonising the installed structures has been assessed in **Chapter 10: Benthic, Epibenthic and Intertidal Ecology**. Comparatively, the scale of the fish aggregation effect is expected to be lower for floating offshore wind developments, than other offshore industries which are characterised by foundations on the seabed (Linley *et al.,* 2007). Additionally, the potential impact of INNS colonisation and spread as result of introduced hard substrate is considered in **Section 13.10.11**.

13.10.4.9 Overall, there is likely to be a highly localised impact and it is unlikely to significantly increase productivity in the area. The total area of potential new habitat is small, but this still represents a minor shift away from baseline conditions. The impact is defined as being of a local spatial extent, long-term and continuous and is judged to be of a **low** magnitude. Any impacts are unlikely to affect long-term functioning of the baseline fish species.

Significance of residual effects

13.10.4.10 Many of the fish predicted to utilise the study area are of a high conservation status and therefore considered to be nationally or internationally important. However, due to their high mobility and extensive available alternative habitat in the wider area, all fish receptor groups are considered to have **low** sensitivity to this impact, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.5 Impact O4: temporary localised increases in suspended sediment concentrations and smothering

Overview

13.10.5.1 The maximum design scenario relating to temporary localised increases in suspended sediment concentrations and smothering during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.5.2 Temporary increases in SSC and subsequent associated sediment deposition are predicted to occur during the O&M stage, from activities such as repair, replacement or reburial of cable and mooring line components. Elevated SSC may cause direct physiological impacts to fish, including gill irritation or damage, impaired respiration, and, in extreme cases, mortality. In high concentrations SSC may also cause reductions in dissolved oxygen concentrations leading to fish mortality (hypoxia). Fish may also exhibit behavioural avoidance, either avoiding areas of high SSC or in some cases, using turbid water to aid avoidance of predators. By the same token, increased turbidity associated with elevated SSC also has the potential to reduce foraging efficiency by impairing prey detection by visual predators.

13.10.5.3 The resettlement of suspended material (deposition) may result in the smothering of less-mobile species or vulnerable life stages (for example, demersal eggs and larvae where present), as well as the temporary degradation of benthic feeding habitats. These effects may indirectly influence fish condition, reproduction, or recruitment if important habitats are affected during sensitive periods.

Sensitivity or value of receptor

13.10.5.4 Sensitivity (tolerance and recoverability) of marine fish species to SSC and subsequent deposition has been assessed for seabed preparation, foundation installation, and the laying of array cables and export cables for the construction stage in **Section 13.9.3**. As the impacts during the O&M stage are the same – namely, increases in SSC and subsequent deposition – sensitivity is considered equivalent. No further discussion of species-specific sensitivity rankings is provided here. For clarity, sensitivity statements are repeated below.

Spawning and nurseries grounds

13.10.5.5 Species with nursery grounds of medium to low value within the area affected by increased SSC and sediment deposition (including Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling, and whiting) are considered to have low tolerance and high recoverability. Therefore, the overall sensitivity of these species is considered to be **medium**.

13.10.5.6 Species with spawning grounds, or both spawning and nursery grounds, within the area affected by elevated SSC and deposition (including Atlantic herring, European sprat, Atlantic cod, lemon sole, Norway pout, common skate complex, and spotted ray), of medium to low value are considered to have low tolerance and medium recoverability. Therefore, sensitivity of these species is considered to be **medium**.

Sand eel

13.10.5.7 Sandeel are deemed to be of medium value, low tolerance and high recoverability. Therefore, the sensitivity of sandeel is considered to be **medium**.

Other Marine Fish

13.10.5.8 As such, all other marine fish, of low to high value are considered to be of high tolerance and medium to high recoverability to this impact. Therefore, the sensitivity of these species is considered to be **low**.

Diadromous fish

13.10.5.9 As for marine fish, the sensitivity (tolerance and recoverability) of diadromous species to SSC and subsequent deposition has already been assessed for seabed preparation, foundation installation, and cable laying for the construction stage in **Section 13.9.3**. As the impacts during the O&M stage are the same (increases in SSC and subsequent deposition), the sensitivity of the receptors is considered equivalent.

13.10.5.10 Given their ability to avoid disturbed areas, opportunistic feeding behaviour, and the resilience of prey populations, diadromous fish species exhibit high tolerance to temporary increases in SSC and deposition. Whilst these species are of high value, their overall sensitivity to this pressure is considered **low**.

Magnitude of impact

13.10.5.11 O&M activities within the Red Line Boundary are expected to result in increases in SSC and localised sediment deposition during cable and mooring line repair, replacement and reburial operations. This assumes array cables and offshore export cables extending from WTGs to landfall with a total combined length of approximately 670km. The necessary frequency of repair or replacement is unknown but will happen over the Project lifetime, with each Project phase operational for up to 35 years. Associated cable reburial is expected to be undertaken using the same methods as those used during installation, with jet trenching representing the worst-case scenario in terms of sediment disturbance and resulting increases in SSC and associated deposition.

13.10.5.12 Any increases in SSC and associated deposition during O&M are expected to be of the same or lower magnitude than those assessed for the construction stage. This reflects that, under the maximum design scenario (and associated modelling of sediment dispersion, SSC, and deposition), construction allowed for more intensive and concurrent activities, namely the installation of driven piles, anchors and the jet trenching of cables. Such combined, large-scale works will not occur during the O&M stage, and therefore, sediment disturbance will be comparatively lower. It is acknowledged that reburial and repair works could occur up to six times over the Project's operational life which would result in a greater frequency of localised sediment disturbance events compared to the construction stage.

13.10.5.13 Elevated SSC during the O&M stage is expected to be short-term, intermittent, and spatially limited. Deposition is predicted to be highly localised and naturally reversible through tidal processes. Although reburial works may occur more frequently than during construction (up to six events over the Project lifetime), each is expected to be of short duration. The impact is adverse but temporary, localised, and reversible. As such, the magnitude of impact is assessed as **low**.

Significance of residual effect

13.10.5.14 Peak SSC and sediment deposition associated with the Project during the O&M stage are predicted to be spatially limited and of short duration, with maximum levels confined to the immediate vicinity of construction activities. Increases in SSC and deposition on seabed environments are unlikely to persist at levels or for durations sufficient to interfere with the use of offshore nursery habitats, particularly given the broad distribution of these areas across the wider marine fish study area. Development of eggs and larvae in areas subject to peak SCC and peak sediment deposition thickness may be affected. However, the SCC and sediment deposition thickness across much of the affected area is unlikely to be high enough or persist long enough to affect the development of eggs and larvae.

13.10.5.15 Species with nursery grounds within the area affected by SSC and sediment deposition (including Atlantic mackerel, blue whiting, anglerfish, European hake, haddock, ling, and whiting) are considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.5.16 Species with spawning grounds, or both spawning and nursery grounds, within the within the area affected by SSC and sediment deposition (including Atlantic herring, European sprat, Atlantic cod, lemon sole, Norway pout, common skate complex, and spotted ray) are considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.5.17 Sandeel are considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.5.18 All other marine fish receptors are considered to have **low** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.5.19 Diadromous fish are considered to be of low sensitivity and the magnitude of impact is low. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms. As effects on Atlantic salmon and sea trout are considered **Minor Adverse** (**Not Significant**) in EIA terms, effects on the freshwater pearl mussels are likewise considered **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.6 Impact O5: effects arising from underwater noise, vibration and particle motion

Overview

13.10.6.1 The maximum design scenario relating to noise and vibration during the operational and maintenance stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.6.2 During the O&M stage of the Project, maintenance activities have the potential to generate underwater noise during cable burial replacement and maintenance.

13.10.6.3 Underwater noise generated during the operational stage will predominantly be mechanically-generated vibration from the rotating machinery in the WTGs, which is subsequently transmitted into the water column. It has also been suggested that floating offshore windfarms generate additional operational noise due to the flexible mooring lines that consist of steel cables, chains or wired ropes, which may produce 'snaps' or 'bangs' during short periods of tension (Risch *et al*., 2023). Underwater noise may also result from the presence of vessels, as described for construction.

Sensitivity or value of receptor

13.10.6.4 A detailed assessment of sensitivity of each receptor group to noise and vibration, along with threshold values and impact ranges is provided in **paragraph 13.9.4.1**.

13.10.6.5 The effects of operational noise on fish is deemed significantly less than noise generated during the construction stage (**Section 13.9.4**). Continuous noise generated from mechanically generated vibration is likely to be slightly above ambient noise levels, but not much more than fixed offshore wind turbines, with some louder 'snaps' or 'bangs' during periods of mooring tension. Popper *et al.* (2014) assesses that the threshold at which individuals will experience TTS for 12 hours is 158dB and recoverable injury (recoverable after 48 hours) is 170dB. Both of these thresholds are higher than the broadband source sound pressure levels recorded at floating wind farms and reported by Risch *et al*. (2023).

13.10.6.6 Many of the fish predicted to utilise the study area are regionally to internationally important. As assessed in **Section 13.9.4**, fish receptors have a medium sensitivity to the high-amplitude underwater noise generated from construction activities and would likely have low sensitivity to relatively low amplitude operational noise within the OAA. Fish are also mobile and have the ability to flee the area if they are disturbed. The overall sensitivity of all fish receptor groups to underwater noise is considered to be **low**.

Magnitude of impact

13.10.6.7 The impact is expected to be equal to or lower magnitude than that generated during the construction stage of the Project (see **Section 13.9.4**). For the O&M stage vessel presence will be reduced in comparison to activities during the construction stage. It is likely that vessel presence will be limited to ad hoc maintenance activities.

13.10.6.8 The impact is expected to be localised, reversible and long-term in nature with an overall magnitude of **low**.

Significance of residual effect

13.10.6.9 Overall, all fish receptor groups are considered to have **low** sensitivity, and the magnitude of impact is **low**. Consequently, the significance of the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.7 Impact O6: electromagnetic field arising from cables and Impact O7: heat effects arising from cables

Overview

13.10.7.1 The maximum design scenario relating to EMF or heat effects arising from cables during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.7.2 The installation of array cables, interconnector and offshore export cables will result in High Voltage Alternating Current (HVAC) under the maximum design scenario (see **Table 13.16**). EMF are generated by two main components: electric fields (E-fields) and magnetic fields (B-fields). The strength of these fields depends on the amount of current and voltage flowing through the cables.

13.10.7.3 Magnetic fields (measured in Tesla (T) or µT) are not shielded by cable insulation and can extend into the surrounding water. The strength of these fields varies depending on the amount of current flowing through the cable and can be detected by species sensitive to magnetic fields (magneto-sensitive species). Unlike magnetic fields, electric fields generated by subsea cables (measured in microvolts per metre (µV/m)) are usually contained within the cable's insulation, so under normal conditions, marine species are not directly exposed to the electric field itself. However, when a conductor (like a fish or seawater from tidal movement) moves through the produced magnetic field, it can induce a secondary electric field, called an induced electric field (iE-fields). Induced electric fields are detectable by species sensitive to electric fields (electrosensitive species). Alternating current (AC) cables have the potential to produce weak induced electric fields in the range of µV/m. Background measurements of the magnetic field are approximately 50µT in the North Sea, and the naturally occurring electric field in the North Sea is approximately 49µV/m (National Oceanic Atmospheric Administration (NOAA), 2025). The calculated background magnetic field in the OAA is approximately 50µT (NOAA, 2025).

13.10.7.4 As such, the localised EMF (both the induced electric field and the magnetic field) produced by array cables, interconnector and offshore export cables has the potential to disrupt electrosensitive and magneto-sensitive fish.

13.10.7.5 With respect to thermal emissions, water has a high specific heat capacity, meaning it is able to absorb and dissipate thermal energy originating from infrastructure such as subsea cables. Therefore, thermal emissions from the array cables and export cables will not substantially heat the surrounding seawater, other than immediately adjacent to the cable surface where heat will rapidly dissipate. With regards to buried sections of cables, sediments within the OAA, adjacent to the array cables and export cables may be subject to localised heating (Taormina *et al*., 2018), meaning only species that depend on the seabed for spawning or shelter could have the potential to be affected by thermal emissions.

Sensitivity of receptor

13.10.7.6 Elasmobranchs are generally considered the most electro-sensitive species group due to their highly developed electro-sensory systems. For this reason, elasmobranchs are discussed separately from other marine fish below in terms of their sensitivity to EMF.

Elasmobranchs

13.10.7.7 Elasmobranchs (sharks, skates, and rays) are generally considered to be the most electro-sensitive species group due to their possession of a highly sensitive electro-sensory system known as the ampullae of Lorenzini. These systems allow for the detection of extremely weak electric fields emitted by prey and possibly other animals and may also aid magnetic orientation and navigation behaviours.

13.10.7.8 Elasmobranchs are capable of detecting electric fields as low as 1nV/cm to 5nV/cm (Normandeau *et al.,* 2011) and magnetic fields within the natural range of the earth's geomagnetic field (approximately 25μT to50μT). These sensory systems are used in a variety of ecological functions including foraging, predator detection, and long-range navigation (Gill *et al*., 2009; Normandeau *et al*., 2011).

13.10.7.9 A range of laboratory and mesocosm studies have demonstrated behavioural responses of elasmobranchs to EMF produced by subsea cables. **Table 13.28** summarises available evidence for elasmobranch species detected within the baseline marine fish survey area or closely related taxa.

Table 13.28 Elasmobranch species for which information on sensitivity to electric or magnetic fields has been suggested or studied, relevant to the species or family groups found in the study area

Species	Reference(s)	Detection of magnetic and / or electric fields
Family Scyliorhinidae		
Spiny dogfish (spurdog) ***Squalus acanthias***	Gill *et al.* (2009).	No response observed to exposure to 36kV AC cables.
Small-spotted catshark ***Scyliorhinus canicular***	Gill *et al.* (2009), Gill & Taylor (2001), others.	Behavioural and physiological response observed at electric fields of 0.01 to 0.1μV/cm.
Family Triakidae		
Smooth dogfish ***Mustelus asterias***	Dawson *et al*. (1980), Kalmijn 1982.	Behavioural response observed at electric fields of 0.005 to 0.01μV/cm.
Family Carcharhinidae		
Blue shark ***Prionace glauca***	Heyer *et al.* (1981), Kalmijn (1982), Klimley *et al*. (2002).	Behavioural response observed at electric fields of 0.005μV/cm.
Family Rajidae		
Little skate ***Leucoraja erinacea***	Hutchison *et al.* (2020).	Behavioural response to 49.7μT and 52.6μT electric fields

Species	Reference(s)	Detection of magnetic and / or electric fields
		produced from 300 and 500kV DC cables.
Family Platyrhynidae		
Thornback ray ***Raja clavata***	Gill *et al.* (2009), Kalmijn (1971).	Behavioural and physiological response observed at electric field of 0.01μV/cm, and a magnetic field of 35μT. Response also observed at an induced field electric field of 160μV/cm.

13.10.7.10 Field studies have shown variable responses among elasmobranchs. For instance, a Collaborative Offshore Wind Research into the Environment sponsored mesocosm study found that some individuals of thornback ray and lesser-spotted dogfish exhibited increased searching behaviour when cables were energised (Gill *et al.,* 2009), but these responses were not consistent across all individuals. Spiny dogfish showed avoidance to electric fields of 10μV/cm (Gill and Taylor, 2001), though this exceeds typical field strengths generated by buried AC cables and exceeds the predicted fields in all areas of the Project except in the immediate vicinity (within 10s of cm) of unburied cables converging on the offshore substation as explained in **paragraph 13.10.7.25**.

13.10.7.11 Despite the limited field evidence of major ecological effects as a result of anthropogenic EMF, there remains the potential for some elasmobranchs to be influenced by EMFs, particularly during migration or feeding activities when those activities occur near the seabed. The cable route also passes through known low intensity nursery grounds for spurdog, tope shark and spotted ray (**Volume 2, Figure 13.5**). In light of the available evidence and the specialised sensory systems of elasmobranchs, the proximity of the cable to potentially sensitive nursery habitats, these species are assessed to have low tolerance to EMF generated by subsea cables. In terms of recoverability, although many of the observed behavioural effects are transient and reversible at the individual level, elasmobranchs are generally characterised by life history traits that confer low population resilience. These include slow growth rates, late sexual maturity, and low fecundity. As a result, disruptions affecting survival, feeding success, or reproductive behaviour could have longer-term consequences at the population level, and recovery from sustained or repeated disturbances is likely to be delayed. On this basis, recoverability is assessed as Medium. Elasmobranchs, which are of low to medium value, exhibit low tolerance and medium recoverability to EMF exposure. Therefore, the overall sensitivity of elasmobranchs to EMF generated by subsea cables is assessed as **medium**.

Diadromous fish

13.10.7.12 Salmonid species and European eel are believed to use the earth's magnetic field to help navigate during their long migrations, a sense known as magneto-reception. Research has identified iron-rich particles, such as magnetite, in their tissues – particularly around the lateral line and nervous system – supporting their ability to detect geomagnetic cues. Behavioural studies further confirm this, with both species showing orientation changes in response to magnetic fields. As a result, EMF generated by subsea cables could potentially interfere with these natural navigation processes during migration. Current knowledge suggests that EMFs from subsea cables and cabling orientation may interact with migrating eels (and possibly salmonids) if their migration or movement routes take them over the cables, particularly in shallow waters (<20m). The effect, if any, could be a relatively trivial temporary change in swimming direction, or potentially a more serious avoidance response or delay to migration. Whether this will represent a biologically significant effect cannot yet be determined (Gill & Bartlett, 2010).

13.10.7.13 A study by Armstrong *et al*. (2015) examined the response of captive Atlantic salmon to activated Helmholtz coils and found no significant reaction, such as alarm behaviour, avoidance, or changes in swimming speed, when exposed to magnetic fields up to 95μT. Similar research conducted in Sweden on the impact of High Voltage Directional Current (HVDC) cables on fish migration, including salmonids, found no effect (Wilhelmsson *et al.,* 2010). Likewise, a study of the Trans Bay cable near San Francisco, California, found no impact on the migration success or survival of chinook salmon *Oncorhynchus tshawytscha*, although some behavioural changes were noted, such as salmon lingering near the cable for longer periods (Kavet *et al*., 2016). Further evidence from the Dee Estuary in the UK, where several buried subsea cables have been present for several years, has not indicated any disruption to historic salmonid or European eel migrations (Gill *et al.,* 2005). Collectively, these studies indicate that while short-term behavioural changes may occur when Atlantic salmon or sea trout encounter EMF from subsea cables, there is no evidence that these effects interfere with overall migration success or population viability. On this basis, these species are considered to have high tolerance.

13.10.7.14 In terms of recoverability, although many of the observed behavioural effects are transient and reversible at the individual level, considering the depleted stocks of many salmonid populations, even minor disruptions affecting survival, feeding success, or migrations could have longer-term consequences at the population level. On this basis, recoverability is assessed as **low** on a precautionary basis. Based on these attributes, sensitivity is assessed as **low** for both species. However, considering the high conservation value of Atlantic salmon and data that indicates significant concentrations of smolt in the study area (as stated by Marine Science Scotland, see stakeholder issue ID 662, **Table 13.1**), but otherwise limited confidence in known migratory routes in the North Sea, the overall sensitivity of Atlantic salmon has been increased to **medium** on a precautionary basis.

13.10.7.15 Studies tracking European eels in the southern Baltic Sea have revealed that migratory eels may experience temporary deviations in swimming speed due to magnetic anomalies caused by subsea cables. Specifically, Westerberg and Lagenfelt (2008) observed that eels exhibited a significant reduction in swimming speed when approaching a 130kV AC subsea power cable. However, this slowdown was temporary, with an average delay of approximately 40 minutes. The authors noted that such a brief delay is unlikely to impact the eels' overall fitness during their extensive 7,000km migration to the Sargasso Sea. Other studies have reported similar short-term behavioural changes, such as reduced swim speeds around subsea cables, but no long-term effects on migration patterns have been documented. Orpwood *et al.,* (2015) observed no significant changes in movement or behaviour of European silver eels exposed to an AC magnetic field of approximately 9.6μT in a controlled laboratory setting. On this basis, European eel is considered to have medium tolerance. Although many of the observed behavioural effects are transient and reversible at the individual level, the population status of the European eel is critically depleted. Therefore, even relatively minor disruptions affecting survival, feeding success, or migration could have wider implications. Due to this, the species' recoverability is assessed as low, and overall sensitivity is **medium**.

Other Marine Fish

13.10.7.16 In contrast to elasmobranchs, most teleost (bony) fish lack specialised electroreceptors and their ability to detect and respond to EMF is considered limited. Some species have been reported to detect magnetic fields which they use for orientation or navigation, but the evidence for behavioural or physiological responses to EMF generated by subsea cables is inconsistent.

13.10.7.17 Field observations from AC power cable installations in California found no evidence of fish being attracted to or repelled by 35kV to kV cables (Love *et al*., 2016). Likewise, in controlled laboratory studies, juvenile flounder (*Platichthys flesus*) exposed to magnetic fields up to 3.7μT over a three month period showed no effect on survival (Bochert and Zettler, 2004). Similarly, exposure of Atlantic halibut (*Hippoglossus hippoglossus*) to magnetic fields between 1,000μT to 1,200μT over 72 hours revealed no conclusive evidence of EMF-induced responses (Woodruff *et al.,* 2013). Further, laboratory studies on Atlantic herring and lesser sandeel larvae found no detectable effects of AC-generated EMF on larval behaviour or orientation (Cresci *et al*., 2020; 2022).

13.10.7.18 Laboratory studies on Atlantic haddock *Melanogrammus aeglefinus* larvae, which are known to rely on the earth's magnetic field for orientation during dispersal, found no alteration in spatial distribution or directional preference when exposed to magnetic fields ranging from 50μT to 150μT. While some larvae exhibited changes in swimming speed, suggesting that magnetic field exposure may elicit selective responses depending on individual behavioural phenotypes (for example, proactive vs reactive behaviours), these effects were not considered ecologically significant (Cresci *et al*., 2019).

13.10.7.19 Field studies at the Nysted Offshore Wind Farm investigated the potential behavioural effects of EMF from a high-voltage AC subsea cable buried approximately 1m beneath the seabed. Although the primary focus was on eel migration, additional assessments were conducted on five other species. No effects were recorded for eelpout (*Zoarces viviparus*) or short-spined sea scorpion (*Myoxocephalus Scorpius*). Some behavioural changes were observed in European eel, cod, and Atlantic herring. However, these responses could not be conclusively attributed to EMF exposure. Visual cues along the cable corridor and increased prey availability were considered more likely drivers. European flounder was the only species to show a statistically significant response, with individuals observed crossing cable routes more frequently in areas with lower electromagnetic field intensity. This suggests a potential sensitivity to EMF in this species, although confounding environmental factors could not be entirely ruled out (Hal, Volwater and Neitzel, 2022).

13.10.7.20 Further evidence from a study in the North Sea found no significant differences in the abundance or size distribution of flatfish species (European plaice, common sole, dab) in proximity to HVAC subsea cables compared with control areas. Notably, a higher abundance of whiting and dragonet was recorded near cables. These patterns, however, could not be conclusively linked to EMF exposure, and the authors suggested that environmental factors, such as prey availability or, were more likely to have influenced the observed distributions (Hal, Volwater and Neitzel, 2022).

13.10.7.21 The physiological and behavioural sensitivity of most marine teleost fish to EMF is considered low. While some species may detect weak EMF, observed responses are generally inconsistent, short-lived, and often attributable to other environmental factors. Most teleosts lack specialised electroreceptors, which reduces their capacity to detect or respond to EMFs from operational subsea cables. On this basis, teleost fish are considered to exhibit high tolerance to EMF exposure. Where behavioural responses do occur (for example, changes in swimming speed or orientation), these are typically reversible and unlikely to result in long-term impairment of key life functions such as feeding or reproduction. Consequently, recoverability from EMF exposure is also considered to be high. On the basis, marine fish (excluding elasmobranchs) of low to high value, exhibit high tolerance, and high recoverability. Therefore, the overall sensitivity is assessed as **low**.

Magnitude of impact

Electromagnetic fields

13.10.7.22 The installation of array cables and export cables will include HVAC cables under the maximum design scenario. EMF are generated by two main components: electric fields (E-fields) and magnetic fields (B-fields). The strength of these fields depends on the amount of current flowing through the cable and the potential difference (voltage) across it.

13.10.7.23 Magnetic fields are not shielded by cable insulation and can extend into the surrounding water. The strength of these fields varies depending on the amount of current flowing through the cable and can be detected by species sensitive to magnetic fields (magneto-sensitive species).

13.10.7.24 Unlike magnetic fields, electric fields generated by subsea cables are usually contained within the cable's insulation, so under normal conditions, marine species are not directly exposed to the electric field itself. However, when a conductor (like a fish, or seawater from tidal movement) moves through the produced magnetic field, it can induce a secondary electric field, called an induced electric field (iE-fields). Induced electric fields can be detectable by electrosensitive species. AC cables have the potential to produce weak induced electric fields in the range of µV/m. Background measurements of the magnetic field are approximately 50µT across the North Sea (similar to the global average), and the naturally occurring electric field in the North Sea is approximately 49µV/m (NOAA, 2025). The calculated background magnetic field in the OAA is approximately 50µT (National NOAA, 2025).

13.10.7.25 FeAST gives a benchmark of elevated local electric field of 1V/m above ambient, or local magnetic field of 10µT due to anthropogenic means. The potential EMF produced by the Project has been modelled and is reported in **Chapter 9: Electromagnetic Fields**. The modelling results are detailed within Table 9.7 of **Chapter 9: Electromagnetic Fields** and indicate that the 525 kV voltage scenario would be the worst-case as the field extends horizontally for 11m before being attenuated to the 50µT background level, and the vertical field extends 7m around any single pole of the 525 kV bipole cables. The duration of impact will be long-term during the operational stage (35 years per Project phase), but reversible upon decommissioning. Considering the limited spatial extent of the field around each cable, and that the cable will be buried, the magnitude of impact is considered to be **low**.

Heat

13.10.7.26 Even within seabed sediments, thermal emissions are highly localised to the immediate surroundings of the cable. Taormina *et al*. (2018) found that a maximum increase of 2.5°C occurs 50cm directly below an AC cable buried at 1m deep. Sediment temperature increases above the cables were reduced, due to the influence of the seawater interacting with the seabed. Additionally, Emeana *et al*. (2016) determined that heat transfer was dependent on sediment type, with coarse silts experiencing the greatest temperature change. Coarser sediments had a lower temperature change but were affected over a greater distance. As sediment types change throughout the Offshore Red Line Boundary, the extent of thermal emissions within the sediments may vary across the Offshore Red Line Boundary. However, as cable thermal emissions are relatively low, the degree of heating is not likely to change perceptibly throughout the OAA and offshore export cable corridor.

13.10.7.27 Due to the high heat capacity of water, thermal emissions in the water column associated with dynamic cables will not result in a discernible increase in surrounding water temperatures.

13.10.7.28 The duration of impact will be long-term, and reversible on decommissioning. Considering the limited spatial extent, and that the cable will mostly be buried, the magnitude of impact is considered to be **low**.

Significance of residual effect

13.10.7.29 The Project's embedded environmental measures (as show in **Table 13.17**) include cable burial to a depth typically of up to 2m (M-054), which is greater than the vertical extent of most fields with the exception of the 525kV bipole cable area where the field extends a vertical distance of 7m and therefore intersects the seabed surface.

13.10.7.30 As a result, the majority of the cable fields will not interact with fish ecology receptors near the seabed surface apart from the 525kV bipole cable which will affect an area of approximately 4.48km^2, primarily affecting benthic elasmobranchs. Considering the geographic range of elasmobranchs and habitats available in the area, this is not an appreciable proportion.

Elasmobranchs

13.10.7.31 In general, the strength of EMF decrease rapidly with distance from the cable and attains background levels within a metre, limiting the spatial scale of exposure. Demersal elasmobranchs may encounter higher exposure levels due to proximity to the seabed, whereas pelagic species are less likely to be exposed. Despite their physiological sensitivity, there is limited evidence of population-level impacts in the field (CSA, 2019; Love *et al.,* 2016). The most likely behavioural responses include attraction, avoidance, or temporary disorientation, particularly in juvenile or benthic species that may encounter cables more closely. However, the evidence reviewed (Normandeau *et al.,* 2011) suggests that observed effects are often subtle and species-specific, with some individuals showing little to no behavioural alteration. Overall, elasmobranchs are considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

Diadromous fish

13.10.7.32 Atlantic salmon, an anadromous species, is expected to cross the proposed cable corridor during both seaward (post-smolt) and return (adult and kelt) migrations. Tracking data indicates that adults typically migrate through coastal waters near the surface, although occasional deeper dives may occur. As the EMF attenuates with distance from the source, these vertical movement patterns reduce the likelihood of significant exposure. Additionally, both post-smolts and returning adults migrate rapidly through coastal waters, limiting the duration of any potential interaction. Overall, Atlantic salmon is considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.7.33 Unlike Atlantic salmon, sea trout spend extended periods within coastal and estuarine habitats during their marine phase. This behaviour, combined with their use of shallow nearshore areas for foraging, increases their potential for exposure to EMF. However, studies have not shown any adverse effects on migration success or population viability. Reflecting this, sea trout is considered to have **low** sensitivity, and the magnitude of change is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.7.34 As effects on Atlantic salmon and sea trout are considered **Minor Adverse** (**Not Significant**) in EIA terms, effects on freshwater pearl mussels are considered **Minor Adverse** (**Not Significant**) in EIA terms, due to its life stage dependence on these diadromous fish species.

13.10.7.35 The duration and frequency of European eel exposure to EMF generated by subsea cables is shaped by the species' migratory behaviour and habitat use. During migration, eels exhibit complex vertical movements, including diel and reverse vertical migrations and tidal-synchronized diving at varying depths (Verhelst *et al*., 2023). These behaviours mean that eels may intermittently encounter EMF generated by subsea cables when diving near the seabed. While the species is considered to have moderate tolerance to EMF, its recoverability is low due to its depleted conservation status. However, the brief and episodic nature of its presence within the Project Red Line Boundary during migration reduces the likelihood of sustained exposure. Overall, European eel is considered to have **medium** sensitivity, and the magnitude of change is **low**. Consequently, the effect of **Minor Adverse** (**Not Significant**) in EIA terms.

Other Marine Fish

13.10.7.36 The physiological and behavioural sensitivity of most marine teleost fish to EMF generated by subsea cables is considered to be low. Unlike some elasmobranchs and migratory species, most teleosts lack specialised electroreceptors and therefore have a limited capacity to detect or respond to EMF. Where responses have been observed, they are typically weak, inconsistent, and short-lived, with no evidence of adverse effects on individual fitness or population-level processes. Overall, marine fish (excluding elasmobranchs) are considered to have **low** sensitivity, and the magnitude of impact is **low**. Consequently, the significance of the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.8 Impact O8: direct and indirect seabed disturbances leading to the release of sediment contaminants

Overview

13.10.8.1 The maximum design scenario relating to direct and indirect seabed disturbances leading to the release of sediment contaminants during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.8.2 The direct and indirect disturbances associated with the O&M stage of the Project may lead to the release of sediment contaminants into the water column, causing deterioration of water quality and subsequently the health of the fish receptors.

Sensitivity of receptor

13.10.8.3 Seabed disturbances during the O&M stage may result in temporary increases in contaminants which may affect the respiration mechanisms of some fish and reduce the success of pelagic spawning events (Hylland and Vethaak, 2020).

13.10.8.4 For all fish receptor groups, the most sensitive individuals will be those with pelagic spawning and gill sensitivity (Singh and Sharma, 2024). As this includes a broad range of species, it is considered that sensitivity for all groups to this impact is **medium**.

Magnitude of impact

13.10.8.5 O&M activities within the Red Line Boundary that may release sediment contaminants include cable and mooring line repair, replacement and reburial operations.

13.10.8.6 The impact is expected to be equal to or lower magnitude that that generated during the construction stage of the Project (see **paragraph 13.9.6.5**). In addition, it is anticipated that rapid dilution and spread of any contaminants will reduce toxicity to negligible levels. Therefore, the magnitude of change is **very low**.

Significance or residual effect

13.10.8.7 All fish receptors have a high tolerance and **medium** sensitivity to release of sediment contaminants. The magnitude of impact is **very low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.9 Impact O9: secondary entanglement risk

Overview

13.10.9.1 The maximum design scenario relating to secondary entanglement risk during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.9.2 Secondary entanglement results when marine life, such as fish, becoming entangled in debris, such as fishing gear, that has been snagged on a mooring line or dynamic sections of cable. Abandoned, lost or discarded fishing gear is a recognised global issue, with fishing equipment entanglement on marine infrastructure presenting a potential pathway for injury and / or mortality of a range of marine species, including marine mammals. While commercial fisheries have a legal obligation to retrieve lost gear (MMO, 2016), it is not possible to retrieve all lost gear in every situation. The full extent of the risk secondary entanglement poses in floating offshore windfarms is poorly understood because of the relative infancy of the industry and lack of entanglement and marine debris monitoring for existing floating development (SEER, 2022).

13.10.9.3 Experience from the oil and gas and offshore wind industries suggest that there is a low risk of entanglement to marine fauna from mooring lines and cables associated with floating offshore windfarms (Garavelli, 2020). The Project infrastructure represents a small spatial footprint in comparison to the large spatial extent of the North Sea, which reduces the likelihood of discarded fishing gear snagging and contributing to secondary entanglement.

13.10.9.4 Within the OAA, there will be up to 680km of array cables (as a worst case under the 14MW WTG scenario), of which 136km would be unburied. The total length of mooring lines across the OAA is not yet known as it will be dependent on water depths at each WTG location, but there will be a total of up to 1,800 mooring lines across the OAA (based on a worst case scenario of up to 8 mooring liens for each of 225 14MW WTGs), which introduced the additional potential for derelict fishing gear to snag.

Sensitivity of receptor

13.10.9.5 Pelagic species and demersal species may be affected by secondary entanglement, depending on where in the water column fishing gear snags on Project infrastructure including the dynamic cabling for the array cables or mooring lines within the OAA. Therefore, the risk of secondary entanglement is not likely to be materially different between pelagic and demersal species. With respect to larger species, namely basking shark, there have been no reports of secondary entanglement with abandoned fishing gear and other marine debris in marine renewable energy systems since 2020 (Garavelli, 2020).

13.10.9.6 All fish receptor groups are assessed as **medium** sensitivity to this impact.

Magnitude of impact

13.10.9.7 As described in **Chapter 14: Commercial Fisheries**, fishing activity within the ICES rectangles in which the OAA sits (45E9), is dominated by demersal trawling for Norwegian lobster (*Nephrops norvigicus*). Low levels of demersal seine, pelagic trawls, pots and traps make up the remaining gear types. There is no reported gill or trammel netting within the ICES rectangles adjacent to the OAA and lost nets from these fisheries are typically recovered in the location in which they were lost (Oliveira *et al*., 2015). The risk of demersal trawl and seine nets being lost or fouled within the OAA is exceptionally low due to the fact that these are weighted nets that are dragged along the seabed and would likely remain on the seabed should they come loose or become ensnared on obstructions on the seabed. Pelagic trawl nets are unweighted, but the scale and material used in these nets still makes them negatively buoyant and it is not anticipated that they would remain within the pelagic water column long enough to be carried by currents into the OAA. Studies indicate that buoyant plastic fishing gear is a type of marine debris that poses a high risk of secondary entanglement and tends to remain near the surface (Gilman *et al*., 2021). The risk of secondary entanglement may therefore be highest in the first few meters of the water column close to floating platforms. However, this type of fishing gear (set and fixed gillnets and trammel nets, drift gillnets) is not common within the Offshore Red Line Boundary. Additionally, floats and polypropylene ropes associated with static fishing (creeling) could drift into the Offshore Red Line Boundary and become snagged on Project infrastructure. This type of fishing gear has been known to entangle marine mammals in Scottish waters, and it is plausible that through a similar mechanism, it could entangle other marine megafauna such as basking sharks. However, as with other types of fishing gear, this would likely be a rare occurrence.

13.10.9.8 The fishing gear types utilised in the Offshore Red Line Boundary do not lend themselves to becoming snagged on infrastructure and instead would remain on the seabed. Coupled with the low likelihood of such events occurring, it is reasonable to assume that the implications on fish species are limited.

13.10.9.9 The impact is considered to be highly localised, long-term and continuous, affecting a small spatial extent of a large maritime area used by fish species. Therefore, the impact for all fish receptor groups is defined as being of **low** magnitude.

Significance of residual effect

13.10.9.10 Considering the **medium** sensitivity of all fish receptors and the **low** magnitude of effect, the overall impact of secondary entanglement on all fish species during O&M is considered to be **Minor Adverse** (**Not Significant**) in EIA terms.

13.10.10 Impact O10: potential impacts on designated sites

Overview

13.10.10.1 The maximum design scenario relating to potential impacts on designated sites during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.10.2 This Section summarises the potential impacts on designated sites from pre-construction and construction activities associated with the Project. The fish ecology assessment has concluded that there are no significant effects on fish species during O&M. Therefore, there will be no significant implications for prey species due to changes in predators, and no significant effects on predator species due to changes in prey availability. There will also be no significant effects on fish species that are features of designated sites, specifically:

- sandeel (Turbot Bank MPA);
- Atlantic salmon (River Dee SAC); and
- freshwater pearl mussel (River Dee SAC).

Sensitivity of receptor

Turbot Bank

13.10.10.3 Turbot Bank MPA is located approximately 25km south of the Offshore Red Line Boundary. Impacts are not expected at this distance from any impact during O&M activities. No direct impacts on habitats within the Turbot Bank MPA are expected.

13.10.10.4 Sandeel are features of the Turbot Bank MPA, therefore the sensitivity of Turbot Bank MPA is directly related to the sandeel population and their sensitivity to potential impacts. At this distance no impacts are expected on sandeel populations present within the MPA.

13.10.10.5 Therefore, despite the high value of sandeel and the Turbot Bank MPA, the sensitivity of this designated site to impacts associated with the pre-construction and construction stages are **low**.

River Dee SAC

13.10.10.6 As described in the baseline (see **paragraph 13.6.1.2**), the River Dee SAC is located approximately 45km south-west of the Offshore Red Line Boundary. The River Dee SAC is designated for Atlantic salmon and freshwater pearl mussels. No direct impacts on habitats within the River Dee SAC are expected from O&M activities.

13.10.10.7 Atlantic salmon, individuals possibly associated with the SAC, can be expected to pass through the Offshore Red Line Boundary during the extended period of operation. Potential impacts on salmon (and freshwater pearl mussels due to life cycle association) can be interpreted as potential impacts on features of the SAC.

13.10.10.8 The assessment of all potential impacts from the O&M activities associated with the project highlighted a **medium** sensitivity to be the highest sensitivity to the impacts listed during O&M activities, therefore as a precaution, the sensitivity associated with features of the River Dee SAC (Atlantic salmon and freshwater pearl mussels) is **medium**.

Magnitude of impact

13.10.10.9 No potential effects are anticipated from any O&M activities at that range, as described in each impact assessment. In addition, the implementation of environmental measures, including M-061, which minimise impacts to freshwater life stages of Atlantic salmon associated with the River Dee SAC is assumed. Therefore, the overall magnitude of impact is **low**.

Significance of residual effect

13.10.10.10 Designated sites have a **low** (Turbot Bank MPA) and **medium** (River Dee SAC) sensitivity to O&M activities. The magnitude of change is **low**. Therefore, a **Minor Adverse** (**Not Significant**) in EIA terms has been concluded for this impact.

13.10.11 Impact O11: increased risk of introduction and / or spread of INNS

Overview

13.10.11.1 The maximum design scenario relating to increased risk of introduction and / or spread of INNS during the O&M stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.10.11.2 During O&M stages, the following activities may pose a risk of introducing or facilitating the spread of INNS:

- replacement of mooring line components;
- replacement or repair (recovery and reburial) of array cables;
- replacement of mooring or anchors using the same process as construction;
- subsea distribution centres and subsea includes routine inspections, cable and scour protection repair / replacement;
- offshore substation and reactive compensation platforms including routine inspections, removal of marine growth and replacement of scour protection; and
- offshore export cables including routine inspection and cable repair (recovery and reburial).

13.10.11.3 It is anticipated that the risk of introduction or spread of INNS is less than or equal to that of the construction stage, due to reduced vessel movement and limited introduction of new hard structures.

13.10.11.4 It should further be noted that a framework for managing the risk of INNS is included in **Volume 4: Outline Offshore Invasive Non-Native Species Management Plan**.

Sensitivity of receptor

13.10.11.5 The explanation of values and sensitivity of receptors to this impact is provided in **paragraph 13.9.8.6** The sensitivity of all fish receptors to this impact is **low**.

Magnitude of impact

13.10.11.6 The Applicant is committed to producing and adhering to an INNS Management Plan (see **Volume 4: Outline Offshore Invasive Non-Native Species Management Plan** and M-102 detailed within **Section 13.7.2**) to prevent and reduce impacts from the introduction of

INNS. Once established, eradication of INNS is difficult to achieve, therefore the introduction of INNS is likely to result in an irreversible impact. The impact is expected to be equal to or lower magnitude that that generated during the construction stage of the Project (see **Section 13.9.8**). Following the mitigation measures set out in the INNS plan and M-102, it is anticipated that the magnitude of impact to fish ecology receptors will be **very low**.

Significance of residual effect

13.10.11.7 The Project embedded environmental measures (as show in **Table 13.17**) include the adherence to an INNS Management Plan (M-102) to prevent and reduce impacts to receptors from the introduction of INNS. Considering the **low** sensitivity of all fish receptors and the **very low** magnitude of effect, the overall impact of potential introduction and spread of INNS on all fish species during O&M is considered to be **Negligible** (**Not Significant**) in EIA terms.

13.11 Assessment of effects: decommissioning stage

13.11.1 Introduction

13.11.1.1 This Section provides an assessment of the effects for fish ecology from the decommissioning of the offshore elements of the Project.

13.11.1.2 The assessment methodology set out in **Section 13.8** has been applied to assess effects to fish ecology from the Project.

13.11.1.3 The approach to decommissioning of the offshore infrastructure will be completed in line with any relevant guidance and legislation at the time of decommissioning. It is however expected that all infrastructure above the seabed will be removed. Any infrastructure below the seabed will be assessed to determine if less impactful (from an environmental perspective) to remove or leave in position. This is particularly relevant where new habitats have developed during the O&M stage of the Project.

13.11.1.4 A Decommissioning Programme will be developed post consent but prior to construction. It will be updated during the operational stage of the Project to account for any changes to industry best practice, relevant legislation, guidance and policy, or developments in technology. The detailed process expected to be followed for decommissioning the offshore components is detailed in Section 4.12 of **Chapter 4: Project Description**.

13.11.2 Impact D1: temporary habitat loss and / or disturbance

Overview

13.11.2.1 The maximum design scenario relating to temporary habitat loss and / or disturbance during the decommissioning stage is presented in **Table 13.6**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.11.2.2 Temporary habitat disturbance of seabed habitat will occur as a result of the removal of hard substrates during decommissioning. This has the potential to result in both adverse and beneficial effects on fish receptors.

13.11.2.3 The removal of scour protection and cable protection from areas with underlying soft sediment has the potential to increase areas of available habitat for demersal species such as sandeels and demersal spawning species such as herring, essentially restoring the pre-Project conditions and resulting in a beneficial effect. However, for species that benefit from FADs, due to protection from predation or increased food availability, or have colonised the areas of hard substrate during the projects operational life, it will result in adverse effects from habitat loss.

Sensitivity of value or receptor

13.11.2.4 The explanation of values and sensitivity of receptors to temporary habitat disturbance of seabed habitat is provided in **Section 13.9.2**. The sensitivity of receptors to this impact is **medium** to **low**.

Magnitude of impact

13.11.2.5 Decommissioning activities within the Red Line Boundary are expected to follow the reverse of the construction stage of the Project. As a precautionary approach, this assessment will assume that the removal of all hard substrate installed as part of the Project, including seabed structures, WTG anchors, rock armour and scour protection) will be removed.

13.11.2.6 The removal of hard substrate and structures will result in areas of substrates being returned to close to their pre-project natural state The impacts of this habitat alteration are likely be the same magnitude as during the construction stage. The Project commitments (as shown in **Table 13.17**) include the adherence to a decommissioning programme (M-106) to minimise disturbance to key sensitive receptors. Though the impact is long term, considering its limited spatial extent, the overall magnitude of impact is assessed as **low**.

Significance of residual effect

13.11.2.7 Overall, it is predicted that the effect upon all fish receptor groups is **Minor Adverse** (**Not Significant**) in EIA terms.

13.11.3 Impact D2: temporary localised increases in suspended sediment concentrations and smothering

13.11.3.1 The maximum design scenario relating to the temporary increase in suspended sediment deposition are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.11.3.2 Elevated SSC may cause direct physiological impacts to fish, including gill irritation or damage, impaired respiration, and, in extreme cases, mortality. Fish may also exhibit behavioural responses, either avoiding areas of high SSC or in some cases, using turbid water to aid avoidance of predators. By the same token, increased turbidity associated with elevated SSC also has the potential to reduce foraging efficiency by impairing prey detection by visual predators.

13.11.3.3 The resettlement of suspended material (deposition) may result in the smothering of less-mobile species or vulnerable life stages (for example, demersal eggs and larvae where present), as well as the temporary degradation of benthic feeding habitats. These effects may indirectly influence fish condition, reproduction, or recruitment if important habitats are affected during sensitive periods.

13.11.3.4 The following decommissioning activities could potentially give rise to increases in SSC and associated deposition of material within the OAAs and the offshore export cable corridor:

- removal of foundation structures;
- cutting off of piles at foundation legs / anchors; and
- removal of buried cables and/or protection.

Sensitivity or value of receptor

13.11.3.5 The explanation of values and sensitivity of receptors to temporary increases in suspended sediment and deposition is provided in **Section 13.9.3**. The sensitivity of receptors to this impact is **medium** to **low**.

Magnitude of impact

13.11.3.6 The removal of structures is expected to result in some localised seabed disturbance accompanied by temporary increases in SSC and subsequent re-deposition. Driven piles would be cut off at, or just below the seabed, potentially causing some localised disturbance of the bed and a temporary increase in SSC.

13.11.3.7 For the purposes of the EIA, it has been assumed that all cables will be removed during decommissioning although it is recognised that export cables may be left in-situ (see **Chapter 4: Project Description**). It is probable that equipment similar to that used to install the cables could be used to reverse the burial process and expose the cables. Accordingly, the area of seabed impacted during the removal of the cables would be similar as the area impacted during the installation of the cables.

13.11.3.8 For all of the above, the changes to bed levels associated with decommissioning activities are expected to be lesser than that associated with construction, as there is no requirement for seabed preparation works. Consequently, it is expected that the extent of sediment mobilisation will also be slightly less. In addition, the Project commitments (as shown in **Table 13.17**) include the adherence to a decommissioning programme (M-106) to minimise disturbance to key sensitive receptors.

13.11.3.9 It is expected that mobilised sediments will remain in suspension for same amount of time as during construction activities. This will likely result in a temporary, localised, adverse and reversible impact. As such, the magnitude of this impact is assessed as **low**.

Significance of residual effect

13.11.3.10 Species with spawning grounds, or both spawning and nursery grounds, within the within the area affected by SSC and sediment deposition (including Atlantic herring, European sprat, Atlantic cod, lemon sole, Norway pout and oviparous elasmobranchs) are considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.11.3.11 Overall, sandeel are considered to have **medium** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.11.3.12 Diadromous fish are considered to be of **low** sensitivity and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms. Effects on freshwater pearl mussels are likewise considered **Minor Adverse** (**Not Significant**) in EIA terms, due to its life stage dependence on diadromous fish species.

13.11.3.13 All other marine fish receptors are considered to have **low** sensitivity, and the magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.11.4 Impact D3: mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion

Overview

13.11.4.1 The maximum design scenario relating to noise and vibration during the decommissioning stage is presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.11.4.2 During the decommissioning stage of the Project, the removal of structures and cables will generate underwater noise and vibration.

13.11.4.3 The effects of underwater noise on fish receptors are detailed in **Section 13.9.4**.

Sensitivity or value of receptor

13.11.4.4 The explanation of values and sensitivity of receptors to noise and vibration is provided in **Section 13.9.4**. In summary Groups 3 & 4 (i.e. fish with a swim bladder or other gas-filled structure involved in hearing) have a **low** sensitivity. All other fish receptors have a **very low** sensitivity.

Magnitude of impact

13.11.4.5 The impact is expected to be significantly lower in magnitude that that generated during the construction stage of the Project due to the absence of any UXO clearance, piling or other impulsive noise.

13.11.4.6 Based on the results from **Volume 3, Appendix 8.1** it is concluded that noise from decommissioning activities, considering all embedded environmental measures, is likely to be relatively localised, reversible and of short duration at any given location. The overall magnitude is therefore assessed as **low**.

Significance of residual effect

Groups 1 and 2

13.11.4.7 These groups (which include species that are features of designated sites) have a high tolerance and **very low** sensitivity to underwater noise activities during decommissioning. The magnitude of impact is **low**. Consequently, the effect is **Negligible** (**Not Significant**).

Groups 3 and 4

13.11.4.8 These groups have a high tolerance and **low** sensitivity to underwater noise activities during decommissioning. The magnitude of impact is **low** Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

Group 5

13.11.4.9 These groups have a high tolerance and **very low** sensitivity to underwater noise activities during decommissioning. The magnitude of impact is **low.** Consequently, the effect is **Negligible** (**Not Significant**) in EIA terms.

13.11.5 Impact D4: direct and indirect seabed disturbance leading to the release of sediment contaminants.

Overview

13.11.5.1 The maximum design scenario relating to the temporary increase in suspended sediment deposition are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.11.5.2 The direct and indirect disturbances associated with the construction stage of the Project may lead to the release of sediment contaminants into the water column, causing deterioration of water quality and subsequently the health of the fish receptors.

13.11.5.3 The following decommissioning activities could potentially give rise to the release of sediment contaminants and associated within the OAAs and the offshore export cable corridor:

- removal of foundation structures;
- cutting off of piles at foundation legs / anchors; and
- removal of buried cables and protection.

Sensitivity or value of receptor

13.11.5.4 The explanation of values and sensitivity of receptors to the release of contaminants is provided in **Section 13.9.5**. The sensitivity of all fish receptors to this impact is **medium.**

Magnitude of impact

13.11.5.5 The impact is expected to be equal to or lower magnitude that that generated during the construction stage of the Project (see **Section 13.9.5**). The Project commitments (as shown in **Table 13.17**) include the adherence to a decommissioning programme (M-106) to minimise disturbance to key sensitive receptors. Therefore, the overall magnitude of impact is **low**.

Significance or residual effect

13.11.5.6 All fish receptors have a high tolerance and **medium** sensitivity to release of sediment contaminants. The magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.11.6 Impact D5: changes in water quality

Overview

13.11.6.1 The maximum design scenario relating to direct and indirect seabed disturbances leading to the release of sediment contaminants during the decommissioning stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.11.6.2 Changes in water quality can come from a number of sources during decommissioning activities, namely sediment disturbance (as assessed in **Section 13.11.3** and **Section 13.11.5**), accidental release from vessels and removal of infrastructure. Deterioration of water quality can affect the health of the fish receptors.

13.11.6.3 The following decommissioning activities could potentially give rise to the release of sediment contaminants within the OAAs and the offshore export cable corridor:

- removal of foundation structures;
- cutting off of piles at foundation legs / anchors; and
- removal of buried cables and protection.

Sensitivity or value of receptor

13.11.6.4 The explanation of values and sensitivity of receptors to changes in water quality is provided in **Section 13.9.6** The sensitivity of all fish receptors to this impact is **medium.**

Magnitude of impact

13.11.6.5 The impact is expected to be equal to or lower magnitude than that generated during the construction stage of the Project (see **Section 13.9.6**. The Project commitments (as shown in **Table 13.17**) include the adherence to a decommissioning programme (M-106) to minimise disturbance to key sensitive receptors. Therefore, the magnitude of change is **low**.

Significance or residual effect

13.11.6.6 All fish receptors have a high tolerance and **medium** sensitivity to changes in water quality. The magnitude of impact is **low**. Consequently, the effect is **Minor Adverse** (**Not Significant**) in EIA terms.

13.11.7 Impact D6: potential impacts on designated sites

Overview

13.11.7.1 The maximum design scenario relating to potential impacts on designated sites during the decommissioning stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures from **Table 13.17** have been implemented as part of the Project.

13.11.7.2 This Section summarises the potential impacts on designated sites from decommissioning activities associated with the Project. The fish ecology assessment has concluded that there are no significant effects on fish species during decommissioning. Therefore, there will be no significant implications for predator-prey interactions and dynamics, and no significant effects on fish species that are features of designated sites, specifically:

- sandeel (Turbot Bank MPA);
- Atlantic salmon (River Dee SAC); and

- freshwater pearl mussel (River Dee SAC).

Sensitivity of receptor

Turbot Bank

13.11.7.3 Turbot Bank MPA is located approximately 25km south of the Offshore Red Line Boundary. Impacts are not expected at this distance from any impact, with the exception of possible behavioural response of sensitive species associated with piling activity. No direct impacts on habitats within the Turbot Bank MPA are expected.

13.11.7.4 The sensitivity of Turbot Bank MPA is directly related to the sandeel population and its sensitivity to potential impacts. However, sandeel have no swim bladder and therefore are within the group of fish (group 1) considered to be the least sensitive to underwater noise.

13.11.7.5 Therefore, despite the high value of sandeel and the Turbot Bank MPA, the sensitivity of this designated site to impacts associated with decommissioning are **low**.

River Dee SAC

13.11.7.6 The River Dee SAC is located approximately 45km south-west of the Offshore Red Line Boundary. The River Dee SAC is designated for Atlantic salmon and freshwater pearl mussels. No direct impacts on habitats within the River Dee SAC are expected.

13.11.7.7 Atlantic salmon individuals possibly associated with the SAC can be expected to pass through the Offshore Red Line Boundary during migration. Therefore, potential impacts on salmon (and freshwater pearl mussels due to life cycle association) can be interpreted as potential impacts on features of the SAC. However, there is no evidence to suggest that salmon congregate offshore within the OAA or offshore export cable corridor, acknowledging there is a high degree of uncertainty around their presence and therefore exposure to sources of impact.

13.11.7.8 The assessment of all potential impacts from the decommissioning activities associated with the project highlighted a **medium** sensitivity to be the highest sensitivity to the impacts listed during pre-construction or construction activities, therefore as a precaution, the sensitivity associated with features of the River Dee SAC (Atlantic salmon and freshwater pearl mussels) is **medium**.

Magnitude of impact

13.11.7.9 No potential effects are anticipated from any decommissioning activities at a 45km range.

13.11.7.10 The Project commitments (as shown in **Table 13.17**) include implementation of environmental measures, including M-061, which minimise impacts to freshwater life stages of Atlantic salmon associated with the River Dee SAC and adherence to a decommissioning programme (M-106) to minimise disturbance to key sensitive receptors. Therefore, the overall magnitude of impact is **low**.

Significance of residual effect

13.11.7.11 Designated sites have a **low** (Turbot Bank MPA) and **medium** (River Dee SAC) sensitivity to decommissioning activities. The magnitude of change is **low**. Therefore, a **Minor Adverse** (**Not Significant**) in EIA terms has been concluded for both sites.

13.11.8 Impact D7: increased risk of introduction and / or spread of INNS

Overview

13.11.8.1 The maximum design scenario relating to the increased risk or introduction of spread to marine INNS during the decommissioning stage are presented in **Table 13.16**. Where predicted effects are identified, an assessment of the magnitude of change for each effect has been completed based on the methodology provided in **Section 13.8**. The magnitude of change, and hence the significance of potential effects has been assessed on the assumption that the embedded environmental measures **Table 13.17** have been implemented as part of the Project.

13.11.8.2 The removal of infrastructure will lead to increase vessel traffic, which has the potential to lead to the introduction of INNS and subsequently has the potential to result in changes to benthic species composition and therefore indirect effects on fish receptors.

Sensitivity or value of receptor

13.11.8.3 The explanation of values and sensitivity of receptors to increased risk of introduction or spread of marine INNS is provided in **Section 13.9.8**. The sensitivity of all fish receptors to this impact is **low.**

Magnitude of impact

13.11.8.4 The Applicant is committed to producing and adhering to an INNS Management Plan (see **Volume 4: Outline Offshore Invasive Non-Native Species Management Plan** and M-102 detailed within **Section 13.7.2**) to prevent and reduce impacts from the introduction of INNS. Once established, eradication of INNS is difficult to achieve, therefore the introduction of INNS is likely to result in an irreversible impact. The impact is expected to be equal to or lower magnitude that that generated during the construction stage of the Project (see **Section 13.9.8**). Following the mitigation measures set out in the INNS plan and **M-102**, it is anticipated that the magnitude of impact to fish ecology receptors will be **very low**.

Significance of residual effect

13.11.8.5 The Project's embedded environmental measures (as show in **Table 13.17**) include the adherence to an INNS Management Plan (M-102) to prevent and reduce impacts to receptors from the introduction of INNS. Considering the **low** sensitivity of all fish receptors and the **very low** magnitude of effect, the overall impact of potential introduction and spread of INNS on all fish species during O&M is considered to be **Negligible** (**Not Significant**) in EIA terms.

13.12 Summary of effects

13.12.1.1 A summary of the effects arising from the construction, O&M and decommissioning stages of the Project in relation to fish ecology are summarised in **Table 13.29**.

Table 13.29 Summary of effects on fish ecology

Receptor	Sensitivity	Activity and potential impact	Embedded environmental measures	Magnitude of impact	Significance of effects
Pre-construction and construction					
Atlantic herring Sandeel Oviparous Elasmobranchs	**Medium**	Impact C1: pre-construction seabed preparation works. Impact C2: temporary habitat loss and / or disturbance.	M-029 M-056 M-120 M-121	**Low**	**Minor Adverse** (**Not Significant**).
Diadromous fish Other marine fish	**Low**				
Atlantic herring Sandeel Spawning and nursery grounds (all receptor groups)	**Medium**	Impact C3: temporary localised increases in suspended sediment concentrations and smothering.	M-028 M-029 M-056 M-120 M-121	**Very low**	**Minor Adverse** (**Not Significant**).
Diadromous fish Other marine fish	**Low**				**Negligible** (**Not Significant**).
Groups 1 and 2	**Very low**	Impact C4: mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion for example, UXO clearance.	M-105 M-120 M-121	**Low**	**Negligible** (**Not Significant**).
Groups 3 and 4	**Low**			**Very low** (for mortality / injury). **Low** (for TTS / behavioural).	**Minor Adverse** (**Not Significant**).
Group 5	**Very low**			**Low**	**Negligible** (**Not Significant**).

Receptor	Sensitivity	Activity and potential impact	Embedded environmental measures	Magnitude of impact	Significance of effects
All fish receptors	**Medium**	Impact C5: direct and indirect seabed disturbances leading to the release of sediment contaminants.	M-029 M-033 M-049 M-059 M-060 M-061 M-062 M-064 M-120 M-121	**Very low**	**Minor Adverse** (**Not Significant**).
All fish receptors	**Medium**	Impact C6: changes in water quality.	M-029 M-033 M-049 M-059 M-060 M-061 M-062 M-064 M-120 M-121	**Very low**	**Minor Adverse** (**Not Significant**).
Turbot Bank MPA – sandeel	**Low**	Impact C7: potential impacts on designated sites.	M-028 M-029 M-120 M-121	**Low**	**Minor Adverse** (**Not Significant**).
River Dee SAC – Atlantic salmon and freshwater pearl mussel	**Medium**				
All fish receptors	**Low**	Impact C8: increased risk of introduction and / or spread of marine INNS.	M-102 M-120 M-121	**Very low**	**Negligible** (**Not Significant**).

Receptor	Sensitivity	Activity and potential impact	Embedded environmental measures	Magnitude of impact	Significance of effects
Operation and maintenance					
Atlantic herring **Sandeel** **Oviparous elasmobranchs** **Diadromous fish**	**Medium**	Impact O1: temporary habitat loss and disturbance.	M-028 M-029 M-054 M-122	**Low**	**Minor Adverse** (**Not Significant**).
Other marine fish	**Low**				
Atlantic herring **Sandeel** **Oviparous elasmobranchs** **Diadromous fish**	**Medium**	Impact O2: long-term habitat loss and / or disturbance.	M-028 M-029 M-054 M-122	**Low**	**Minor Adverse** (**Not Significant**).
Other marine fish	**Low**				
All fish receptors	**Low**	Impact O3: introduction / colonisation of hard substrate.	M-122	**Low**	**Minor Adverse** (**Not Significant**).
Atlantic herring **Sandeel** **Spawning and nursery grounds (all receptor groups)**	**Medium**	Impact O4: temporary localised increases in SSC and smothering.	M-028 M-029 M-122	**Low**	**Minor Adverse** (**Not Significant**).
Diadromous fish **Other marine fish**	**Low**				
All fish receptors	**Low**	Impact O5: effects arising from underwater noise, vibration and particle motion.	M-032 M-122	**Low**	**Minor Adverse** (**Not Significant**).

Receptor	Sensitivity	Activity and potential impact	Embedded environmental measures	Magnitude of impact	Significance of effects
Elasmobranchs **Diadromous fish**	**Medium**	Impact O6: EMF effects arising from cables. Impact O7: heat effects arising from cables.	M-029 M-054 M-057 M-122	**Low**	**Minor** (**Not Significant**).
Other marine fish	**Low**				
All fish receptors	**Medium**	Impact O8: direct and indirect seabed disturbances leading to the release of sediment contaminants.	M-033 M-049 M-059 M-060 M-061 M-062 M-064 M-122	**Very low**	**Minor Adverse** (**Not Significant**).
All fish receptors	**Medium**	Impact O9: secondary entanglement risk.	M-032 M-122	**Low**	**Minor Adverse** (**Not Significant**).
Turbot Bank MPA – sandeel	**Low**	Impact O10: potential impacts on designated sites.	M-028 M-029 M-055 M-122	**Low**	**Minor Adverse** (**Not Significant**).
River Dee SAC – Atlantic salmon and freshwater pearl mussel	**Medium**				
All fish receptors	**Low**	Impact O11: increased risk of introduction and / or spread of INNS.	M-102 M-122	**Very low**	**Negligible** (**Not Significant**).
Decommissioning					
Atlantic herring **Sand eel** **Oviparous** **Elasmobranchs**	**Medium** to **low**	Impact D1: temporary habitat loss and / or disturbance.	M-106	**Low**	**Minor Adverse** (**Not Significant**).

Receptor	Sensitivity	Activity and potential impact	Embedded environmental measures	Magnitude of impact	Significance of effects
Diadromous fish **Other marine fish**	**Low**				
Atlantic herring **Sand eel** **Spawning and nursery grounds (all receptor groups)**	**Medium**	Impact D2: temporary localised increases in SSC and smothering.	M-028 M-029 M-106	**Low**	**Minor Adverse** (**Not Significant**).
Diadromous fish **Other marine fish**	**Low**				
Groups 1 and 2	**Very low**	Impact D3: mortality, injury and behavioural changes resulting from underwater noise, vibration and particle motion.	M-032 M-106	**Low**	**Negligible** (**Not Significant**).
Groups 3 and 4	**Low**				
Group 5	**Very low**				
All fish receptors	**Medium**	Impact D4: direct and indirect seabed disturbances leading to the release of sediment contaminants.	M-028 M-029 M-033 M-049 M-059 M-060 M-062 M-064 M-106	**Low**	**Minor Adverse** (**Not Significant**).
All fish receptors	**Medium**	Impact D5: changes in water quality.	M-033 M-049 M-059 M-060 M-061 M-062	**Low**	**Minor Adverse** (**Not Significant**).

Receptor	Sensitivity	Activity and potential impact	Embedded environmental measures	Magnitude of impact	Significance of effects
			M-064 M-106		
Turbot Bank MPA – sandeel	**Low**	Impact D6: potential impacts on designated sites.	M-028 M-029 M-106	**Low**	**Minor Adverse** (**Not Significant**).
River Dee SAC – Atlantic salmon and freshwater pearl mussel	**Medium**				
All fish receptors	**Low**	Impact D7: increased risk of introduction and / or spread of INNS.	M-102 M-106	**Very low**	**Negligible** (**Not Significant**).

13.13 Transboundary effects

13.13.1.1 Transboundary effects arise when impacts from a development with one European Economic Area (EEA) State affects the environment of another EEA State(s). A screening of transboundary effects have been carried out and is presented in Appendix 4B of the Scoping Report (MarramWind Ltd., 2023).

13.13.1.2 The potential effects from construction, O&M and decommissioning on fish receptors are considered in Appendix 4A: Transboundary Screening Matrix. The potential for transboundary effects upon fish during the construction, O&M, and decommissioning of the Project has been identified as the same as those scoped in for this assessment (**Table 13.3**), with the exception of collision or entanglement risk.

13.13.1.3 Some fish can migrate over large geographic areas that cross into other territorial waters for key life stages. The assessment of potential effects from the Project, both alone and in combination with other developments, has been conducted based on the distribution of fish ecology receptors, which are not confined by national geographical boundaries. As a result, there are no potential significant transboundary effects on fish ecology receptors due to the construction, O&M and decommissioning of the Project. The potential impacts are localised and are not expected to affect other EEA states (other than insignificantly).

13.14 Inter-related effects

13.14.1.1 A description and assessment of the likely inter-related effects arising from the Project on fish ecology is provided in **Chapter 32: Inter-Related Effects**.

13.15 Assessment of cumulative effects

13.15.1.1 A description and assessment of the cumulative effects arising from the Project on fish ecology is provided in **Chapter 33: Cumulative Effects Assessment**.

13.16 Summary of residual likely significant effects

13.16.1.1 There are no residual likely significant effects on fish ecology receptors assessed in this Chapter have been identified.

13.17 References

Aberdeenshire Council, (2023). *Aberdeenshire Council's Scoping Opinion for Offshore Wind Farm Project at MarramWind Offshore Wind Farm.* [online] Available at: https://upa.aberdeenshire.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=RPB0TVCA04U00 [Accessed: 28 August 2025].

Adams, B., Taggart, J. B., Prodohl, P. A.., (2013). *Does genetic population structure of the European eel (Anguilla anguilla) persist from glass eel to silver eel?, Ecology and Evolution*, 3(14), pp. 4773-4786.

Aires, C., Gonzalez-Irusta, J. M., and Watret, R., (2014) *Updating Fisheries Sensitivity Maps in British Waters. Report to the Marine Management Organisation.*

Alheit, J. and Hagen, E., (1997). *Long-term climate forcing of European herring and sardine populations. Fisheries Oceanography*, 6(2), pp.130-139.

APEM Limited, (2024). *Ornithological and Marine Mammal Baseline Characterisation Surveys. APEM Final Report, MarramWind Option Area Agreement*. Shell New Energies UK Ltd, 02/02/24, Final Report, 274pp.

Appleby, J.P. and Scarratt, D.J., (1989). *Physical effects of suspended solids on marine and estuarine fish and shellfish, with special reference to ocean dumping: a literature review.*

Armstrong, J.D., Kemp, P.S., Yada, T., (2015). *Do power cables affect the behaviour of migrating Atlantic salmon smolts? Scottish Marine and Freshwater Science*, 6(11).

Ashley, K., 2019. *Wild Salmon – SPICe Breifing. Report for the Scottish Parliament.* Report No. SB 19-48. 77pp.

Bardonnet, A. and Baglinière J.L., (2000). Fre*shwater habitat of Atlantic salmon (Salmo salar)*. Canadian Journal of Fisheries and Aquatic Sciences, 57: pp. 497-506.

Barnes, M.K.S. (2008a). Pollachius virens Saithe. In Tyler-Walters H. and Hiscock K. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews.*. Plymouth: Marine Biological Association of the United Kingdom. [online] Available from: https://www.marlin.ac.uk/species/detail/84 [Accessed: 15 September 2025].

Barnes, M.K.S. (2008b). *Merlangius merlangus* Whiting. In Tyler-Walters H. and Hiscock K. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [online] Available at: https://www.marlin.ac.uk/species/detail/96 [Accessed: 15 September 2025].

Barnes, M.K.S. 2008c. *Squalus acanthias* Spiny dogfish. In Tyler-Walters H. and Hiscock K. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [online] Available at: https://www.marlin.ac.uk/species/detail/68 [Accessed: 15 September 2025].

Beatrice Offshore Wind, (2021). *Beatrice Offshore Wind Farm: Post-construction Sandeel Survey– Technical Report* (Document Reference: REP-BE-00723). [online] Available at: https://marine.gov.scot/sites/default/files/bowl_-_post-construction_sandeel_survey_-_technical_report_redacted.pdf [Accessed 15 September 2025]

Béguer-Pon, M., Benchetrit, J., Castonguay, M., (2015). *Shark Predation and Oceanic Migration of the European Eel. Journal of Experimental Marine Biology and Ecology*, 463, pp. 96–103.

Benjamin, L.R., Holst, M. and Olsen, E., (2014). *By-catch of basking sharks (Cetorhinus maximus) in the Norwegian coastal gillnet fishery*. *ICES Journal of Marine Science*, 71(6), pp. 1533-1540.

Benjamins, S., Harnois, V., Smith, H.C.M, Johanning, L., Greenhill, L., Carter, C. and Wilson, B., (2014a). *Understanding the potential for marine megafauna entanglement risk from renewable energy developments*. Scottish Natural Heritage Report No. 791. [online] Available at: https://www.nature.scot/sites/default/files/2017-07/Publication%202014%20-%20SNH%20Commissioned%20Report%20791%20-%20Understanding%20the%20potential%20for%20marine%20megafauna%20entanglement%20risk%20from%20renewable%20marine%20energy%20developments.pdf [Accessed 10 September 2025].

Bett, N. and Hinch, S., (2015). *Olfactory navigation during spawning migrations: a review and introduction of the Hierarchical Navigation Hypothesis. Biological Reviews Cambridge Philosophical Society*, 91(3).

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

Boulêtreau, S., Carry, L., Meyer, E., Filloux, D, Menchi, O., Mataix, V. and Santoul, F. (2020). *High predation of native sea lamprey during spawning migration. Sci Rep 10, 6122*. Available at: https://doi.org/10.1038/s41598-020-62916-w [Accessed: 11 September 2025].

Boyle, G., and New, P., (2018). *Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options*. [online] Available at: https://docslib.org/doc/10342075/orjip-piling-study-final-report-aug-2018-pdf [Accessed: 28 August 2025].

Bracken, J. and Kennedy, M. (1967). *Notes on some Irish estuarine and inshore fishes. Irish Fisheries Investigations B3*, pp. 1-28.

Cereja, R. Brotas, V. Nunes, S. Rodrigues, M. Cruz, J. Brito, A. (2022). *Tidal influence on water quality indicators in a temperate mesotidal estuary (Tagus Estuary, Portugal). Ecological Indicators,* Volume: 136, 2022, 108715, ISSN 1470-160X https://doi.org/10.1016/j.ecolind.2022.108715.

Chartered Institute for Ecology and Environmental Management (CIEEM), (2018). *Guidelines for Ecological Impact Assessment in the UK and Ireland - Terrestrial, Freshwater, Coastal and Marine*. [online] Available at: https://www.researchgate.net/publication/330535534_Guidelines_for_Ecological_Impact_Assessment_in_the_UK_and_Ireland_-_Terrestrial_Freshwater_Coastal_and_Marine_2018 [Accessed: 28 August 2025].

Chilton, L. and Speedie, C., (2008). *Basking shark hotspots in the UK: Results from The Wildlife Trusts' basking shark survey*. The Wildlife Trusts, 12 pp.

Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR), (1992). *Convention for the Protection of the Marine Environment of the North East Atlantic*. [online] Available at: https://www.ospar.org/site/assets/files/1169/ospar_convention.pdf [Accessed: 27 August 2025].

Convention on Biological Diversity, (1992). *Convention on Biological Diversity Text and Annexes.* [online] Available at: https://www.cbd.int/convention/text [Accessed: 27 August 2025].

Convention on Biological Diversity, (2020). *Aichi Biodiversity Targets 2020*. [online] Available at: https://www.cbd.int/sp/targets [Accessed: 27 August 2025].

Convention on Biological Diversity, (2024). *Kunming-Montreal Global Biodiversity Framework*. [online] Available at: https://www.cbd.int/article/cop15-final-text-kunming-montreal-gbf-221222 [Accessed: 27 August 2025].

Convention on Wetland of International Importance especially as Waterfowl Habitat 1971. [online]. Available at: https://www.ramsar.org/sites/default/files/documents/library/original_1971_convention_e.pdf [Accessed: 27 August 2025].

Cote, D., Konecny, C., Seiden, J., Hauser, T., Kristiansen, T. and Laurel, B.J. (2021). *Forecasted Shifts in Thermal Habitat for Cod Species in the Northwest Atlantic and Eastern Canadian Arctic. Marine Ecosystem Ecology*, 8.

Cote, D., Konecny, C., Seiden, J., Hauser, T., Kristiansen, T. and Laurel, B.J., (2021). *Forecasted Shifts in Thermal Habitat for Cod Species in the Northwest Atlantic and Eastern Canadian Arctic*. Marine Ecosystem Ecology, 8.

Coull, K. A., Johnstone, R. and Rogers, S. I., (1998). *Fisheries sensitivity maps in British waters*. [online] Available at: https://www.cefas.co.uk/media/o0fgfobd/sensi_maps.pdf [Accessed: 28 August 2025].

Cresci, A., Durif, C M.F., Browman, H.I., (2022). *Atlantic herring (Clupea harengus) larvae do not respond to the weak electromagnetic fields generated by submarine power cables*. Journal of the Royal Society Interface, 19(187), p. 20210842.

Cresci, A., Durif, C.M., Paris, C.B., (2019). *The relationship between the magnetic field and orientation in planktonic larvae of a marine temperate fish*. Communications Biology, 2(1), p. 227.

Cresci, A., Paris, C.B., Browman, H.I., (2020). *Lesser sandeel (Ammodytes marinus) larvae do not respond to the magnetic field of a subsea power cable*. Marine Environmental Research, 159, p. 104973.

Cushing, D., Shipley, O. and Siskey, M., (2018). *Pelagic fishes*. In: J.H. Steele, S.A. Thorpe and K.K. Turekian, eds. Encyclopedia of Ocean Sciences. 2nd ed. Academic Press, pp. 364–369. [online] Available at: https://doi.org/10.1016/B978-0-12-409548-9.10848-6 [Accessed 28 August 2025]

Danish Energy Group, (2013). *Horns Rev 2 Offshore Wind Farm Annual Environmental Monitoring Report 2012*.

Daverat, F., Limburg, K. E., Thibault, I., Shiao, J-C., Dodson, J.J., Caron, F., Tzeng, W-N., Iizuka, Y. and Wickström, H., (2006). *Phenotypic plasticity of habitat use by three temperate eel species, Anguilla anguilla, A. japonica and A. rostrata. Marine Ecology Progress Series,* 308, pp. 231-241.

Davidsen, J.G., Rikardsen, A.H., Thorstad, E.B., Halttunen, E., Mitamura, H., Præbel, K., Skarðhamar, J., and Næsje, T.F., (2013). *Homing behaviour of Atlantic salmon (Salmo salar) during final phase of marine migration and river entry. Canadian Journal of Fisheries and Aquatic Sciences*, 70(5).

Davies, P., Britton, R.J., Nunn, A.D., Dodd, J.R., Crundwell, C., Velterop, R., Ó'Maoiléidigh, N., O'Neill, R., Sheehan, E.V., Stamp, T. and Bolland, J.D. (2020). *Novel insights into the marine phase and river fidelity of anadromous twaite shad Alosa fallax in the UK and Ireland. Aquatic Conservation: Marine Freshwater Ecosystems,* 30(7), pp. 1297-1298.

Dawson, W.W., Gingerich, A.L., McClellan, J.M., *et al*. (1980). *Electroreception in the smooth dogfish Mustelus canis*. *Journal of Comparative Physiology A*, 138, pp. 319-323.

Deakin, Z, Cook, A., Daunt, F., McCluskie, A., Morley, N., Witcutt, E., Wright, L. and Bolton, M., (2022). *A review to inform the assessment of the risk of collision and displacement in petrels and shearwaters from offshore wind developments in Scotland. Report to the Scottish Government, December 2022.*

Degraer, S., Brabant, R., Rumes, B., *et al*. (2020). *Environmental impacts of offshore wind farms in the Belgian part of the North Sea: A continued move towards integration and quantification*. *Royal Belgian Institute of Natural Sciences, OD Natural Environment, Marine Ecology and Management Section.*

Denis, A., Cresson, P., Chouvelon, T., *et al*. (2023). *Evidence for multiple marine habitat use of the European eel (Anguilla anguilla) along the French Atlantic coast*. Aquatic Living Resources, 36, p. 2

Department for Environment, Food & Rural Affairs, Marine Management Organisation, Joint Nature Conservation Committee, Natural England and The Scottish Government, Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs (Northern Ireland), Department for Business, Energy & Industrial Strategy, Offshore Petroleum Regulator for Environment and Decommissioning, and Department for Energy Security and Net Zero, (2021). *Marine environment: unexploded ordnance clearance joint interim position statement.* [online] Available at: https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interimposition-statement [Accessed: 10 September 2025]

Department for Environment, Food and Rural Affairs (Defra), (2022). *List of habitats and species of principal importance in England.* [online] Available at: https://www.gov.uk/government/publications/habitats-and-species-of-principal-importance-in-england [Accessed: 28 August 2025].

Department for Environment, Food and Rural Affairs (Defra), (2025). *MAGIC: Multi-Agency Geographic Information for the Countryside*. [online] Available at: https://magic.defra.gov.uk/magicmap.aspx [Accessed: 28 August 2025].

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

Dixson, D.L., Munday , P.L., and Jones, G.P. (2009). *Ocean acidification disrupts the innate ability of fish to detect predator olfactory cues*. Ecological Letters 12:1 - 8.

Doherty, P.D., Baxter, J.M., Gell, F.R., Godley, B.J., Graham, R.T., Hall, G., Hall, J., Hawkes, L.A., Henderson, S.M., Johnson, L. and Speedie, C., (2017a). *Long-term satellite tracking reveals variable seasonal migration strategies of basking sharks in the north-east Atlantic. Scientific Reports*, 7*,* 42837. [online] Available at: https://doi.org/10.1038/srep42837. [Accessed 16 September 2025]

Doherty, P.D., Baxter, J.M., Godley, B.J., Graham, R.T., Hall, G., Hall, J., Hawkes, L.A., Henderson, S.M., Johnson, L., Speedie, C. and Witt, M.J., (2017b). *Testing the boundaries: Seasonal residency and inter-annual site fidelity of basking sharks in a proposed Marine Protected Area*. *Biological Conservation*, 209, pp. 68-75.

Downie, H., Hanson, N., Smith, G.W., Middlemas, S.J., Anderson, J., Tulett, D., and Anderson, H., (2018). *Using historic tag data to infer the geographic range of salmon river stocks likely to be taken by a coastal fishery*. *Scottish Marine and Freshwater Science*, 9(6).

Drazen, J. C. and Haedrich, R. L., (2012). *Physiochemical and biological characteristics of the world's oceans*. In: Deep-Sea Fishes. Cambridge University Press.

Dulvy, N. K., Rogers, S. I., Jennings, S., Stelzenmüller, V., Dye, S.R. and Skjoldal, H.R. (2008). *Climate change and deepening of the North Sea fish assemblage: a biotic indicator of warming seas*. *Journal of Applied Ecology*, 45(4), pp. 1029-1039.

Dulvy, N.K., Rogers, S.I., Jennings, S., Stelzenmüller, V., Dye, S.R. and Skjoldal, H.R., (2008). *Climate change and deepening of the North Sea fish assemblage: a biotic indicator of warming seas*. Journal of Applied Ecology, 45, pp. 1029-1039.

Eigaard, O. R., van Deurs, M., Behrens, J. W., *Bekkevold, D., Brander, K., Plambech, M., Plet-Hansen, K.S. and Mosegaard, H.,* (2014). *Prey or predator—expanding the food web role of sandeel Ammodytes marinus.* Marine Ecology Progress Series, 516, pp.267–273.

Electricity Act 1989 (1989 c.29). [online] Available at: https://www.legislation.gov.uk/ukpga/1989/29/contents [Accessed: 27 August 2025].

Ellis, C., Milligan, S., Readdy, L., Taylor, N. and Brown, M., (2012). *Spawning and nursery grounds of selected fish species in UK waters. Technical Report No. 147*. [online] Available at: https://tethys.pnnl.gov/sites/default/files/publications/Ellisetal2012.pdf [Accessed: 28 August 2025].

Ellis, J., McCully-Philipps, S.R., Sims, D., Derrick, D., Cheok, J. and Dulvy, N.K., (2021). *Dipturus batis. The IUCN Red List of Threatened Species 2021: e.T203364219A203375487*. [online] Available at: https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T203364219A203375487.en [Accessed: 11 September 2025]

Ellis, J., McCully-Philipps, S.R., Sims, D., Derrick, D., Cheok, J. and Dulvy, N.K. (2021b). *Dipturus batis. The IUCN Red List of Threatened Species 2021: e.T203364219A203375487*. Available at: https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T203364219A203375487.en [Accessed: 11 September 2025]

Emeana, C.J., Hughes, T.J., Dix, J.K., Gernon, T.M., Henstock, T.J., Thompson, C.E., and Pilgrim, J.A., (2016). *The thermal regime around buried submarine high-voltage cables*. *Geophysical Journal International*, 206 (2#), 1051-1064.

EMODnet, (2019). *EMODnet broad-scale seabed habitat map for Europe of physical habitats*. [online] Available at: https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/ [Accessed: 28 August 2025].

Energy Act 2004 (2004 c.20). [online] Available at: https://www.legislation.gov.uk/ukpga/2004/20/contents [Accessed: 02 September 2025].

Engelhard, G.H., van der Kooij, J., Bell, E.D., Pinnegar, J.K., Blanchard, J.L., Mackinson, S. and Righton, D.A., (2008). *Fishing mortality versus natural predation on diurnally migrating sandeels Ammodytes marinus*. Marine Ecology Progress Series, 369, pp. 213–227.

European Commission, (1979). *Convention on the Conservation of European Wildlife and Natural Habitats 1979*. (No. 104). [online] Available at: https://www.coe.int/en/web/bern-convention/texte-de-la-convention [Accessed: 27 August 2025].

European Commission, (1979). *Convention on the Conservation of Migratory Species of Wild Animals*. [online] Available at: https://www.cms.int/sites/default/files/instrument/CMS-text.en_.PDF [Accessed: 27 August 2025].

European Commission, (1992). *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora*. [online]. Available at: https://eur-lex.europa.eu/eli/dir/1992/43/oj/eng [Accessed: 27 August 2025].

European Commission, (2000*). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*. [online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02000L0060-20141120 [Accessed: 27 August 2025].

European Commission, (2008). *Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).* [online] Available at: https://eur-lex.europa.eu/eli/dir/2008/56/oj/eng [Accessed: 27 August 2025].

European Commission, (2020). *The European Biodiversity Strategy for 2030*. [online] Available at: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en [Accessed: 27 August 2025].

Evans, C.J., (1980). *The fouling of fixed offshore structures*. Report, Department of Energy.

Folk, R.L., (1954). *The Distinction Between Mud, Sand, and Gravel-Size Fractions in the Classification of the Common Sedimentary Rocks*. . *Journal of Sedimentary Petrology*, 24(2): 128-136.

Franco A., Smyth K., Thomson S., (2022). *Developing Essential Fish Habitat maps for fish and shellfish species in Scotland*. *Report to the Scottish Government*, December 2022.

Frost, M. and Diele, K., (2022). *Atlantic herring, Clupea harengus,* in *A Field Guide to the Southeast American Coast*. University of Georgia Press, pp. 176-177.

Fugro, (2023). *Geophysical and Environmental Offshore Windfarm Survey, Volume 2 of 12: Benthic Survey Interpretative Report*.

Fugro, (2024a). *Geophysical and Environmental Export Cable Corridor Survey - Volume 1 of 8: Environmental Field Report Galaxy 2024*.

Fugro, (2024b). *Geophysical and Environmental Export Cable Corridor Survey - Volume 2 of 8: Benthic Survey Interpretative Report 2024*.

Fugro, (2024c). *Geophysical and Environmental Export Cable Corridor Survey - Volume 2: Environmental Field Report Valkyrie 2024.*

Garavelli, L., (2020). *Encounters of Marine Animals with Marine Renewable Energy Device Mooring Systems and Subsea Cables*. In A.E. Copping and L.G Hemery (Eds.), OES-Environmental 2020 State the Science Report: Environmental Effects of Marine Renewable Energy Development Around the Word. Report for Ocean Energy Systams (pp. 147-153). DOI: 10.2172/1633184.

Gauld, J.A., (1979). *Reproduction and fecundity of the Scottish Norwegian stock of spurdogs, Squalus acanthias (L.)*. ICES Document CM 1979/H: 54.

Gibson-Hall, E., (2018). *Raja montagui* Spotted Ray. In Tyler-Walters H. and Hiscock K. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. [online]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/2321 [Accessed: 12 September 2025]

Gibson-Hall, E., (2018). *Raja montagui Spotted Ray*. In Tyler-Walters H. and Hiscock K. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. Plymouth: Marine Biological Association of the United Kingdom. [cited 15-09-2025]. [online] Available at: https://www.marlin.ac.uk/species/detail/2321 [Accessed: 17 September 2025].

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

Gill, A. B. and Taylor, H., (2001). *The potential effects of electromagnetic fields generated by sub-sea power cables on elasmobranch fishes*. in *Proceedings of the 1st International Conference on an Ecosystem Approach to Fisheries Management.*

Gill, A. B., Gloyne-Philips, I., Neal, K. J., (2009). *The potential effects of electromagnetic fields generated by sub-sea power cables on fish behaviour and migration*. ICES Journal of Marine Science, 66(5), pp. 1004-1005.

Gill, A., Gloyne-Philips, I., Neal, K. and Kimber, J. (2005). *COWRIE 1.5 The Potential Effects of Electromagnetic Fields Generated by Sub-Sea Power Cables Associated with Offshore Wind Farm Developments on Electrically and Magnetically Sensitive Marine Organisms - A Review* (Report No. COWRIE-EM FIELD 2-06-2004). Report by Centre for Marine and Coastal Studies Ltd (CMACS). Report for Collaborative Offshore Wind Research into the Environment (COWRIE). Gill, A., Bartlett, M. (2010). *Literature Review on the Potential Effects of Electromagnetic Fields and Subsea Noise from Marine Renewable Energy Developments on Atlantic Salmon, Sea Trout and European Eel* (Report No. 401). Report by Cranfield University. Report for Scottish Natural Heritage.

Gilman, E., Chopin, F., Suuronen, P., (2021). *Position paper: The role of the fishing sector in reducing ocean plastics pollution*. Marine Policy, 129, p. 104533.

Glarou, M., Zrust, M. and Papadatou, N., (2020). *Artificial reef and fish aggregating device (FAD) effects on the trophic ecology of fish: A case study from the eastern Mediterranean*. *Journal of Experimental Marine Biology and Ecology*, 523, p. 151276.

Godfrey, J. D., Stewart, D. C., Middlemas, S. J. and Armstrong, J.D., (2015). *Depth use and migratory behaviour of homing Atlantic salmon (Salmo salar) in Scottish coastal waters*. *ICES Journal of Marine Science*, 72(2), pp. 568-575.

Goertner, J.F., Wiley, M.L., Young, G. A. and McDonald, W.W., (1994). *Effects of underwater explosions on fish without swimbladders*. [online] Available at: https://apps.dtic.mil/sti/pdfs/ADA276407.pdf [Accessed: 17 September 2025].

Gonzalez-Irusta, J. M. and Wright, P. J. (2016). *Spawning grounds of whiting Merlangius merlangus in the North Sea*. *Fisheries Research*, 183, 180-191.

Gonzalez-Irusta, J. M. and Wright, P. J. (2017). Spawning grounds of haddock (Melanogrammus aeglefinus) in the North Sea and West of Scotland. *Journal of Fish Biology*, 90(1), pp. 198-217.

Gore, M., Camplisson, E. and Ormond, R. (2023). *Chapter Four - The biology and ecology of the basking shark: A review*. Advances in Marine Biology, 95, pp.113-257.

Green Volt Limited, (2025). *Baseline Benthic Survey Report*. Survey undertaken in 2021.

Greenstreet, S. P., Holland, G. J., Guirey, E. J. and Armstrong, E., (2010). *Combining hydroacoustic and grab sampling to assess the potential impact of a marine aggregate extraction operation on a sandeel (Ammodytidae) population*. ICES Journal of Marine Science, 67(5), pp. 993-1003.

Hal, R., Volwater, J.J.C. and Neitzel, P., (2022). *Ecological monitoring of flatfish, roundfish, and cartilaginous fish in offshore wind farm Egmond aan Zee and Offshore Wind farm near Noordwijk* (T-0 & T-1, 2011-2021).

Halvorsen, M.B., Zeddies, D.G., Ellison, W.T., Chicoine, D.R. and Popper, A.N., (2012). *Effects of mid-frequency active sonar on hearing in fish*. *The Journal of the Acoustical Society of America*, 131(1), pp. 599-607.

Haugland, M., Holst, J., Holm, M. and Hansen, L., (2006). *Feeding of Atlantic salmon (Salmo salar L.) post-smolts in the Northeast Atlantic*. ICES Journal of Marine Science, 63: pp. 1488-1500.

Hawkes, L.A., Exeter, O., Henderson, S.M., Kerry, C., Kukulya, A., Rudd, J., Whelan, S., Yoder, N. and Witt, M.J. (2020). *Autonomous underwater videography and tracking of basking sharks. Animal Biotelemetry*, 8.

Hedger, R., McKenzie, E., Heath, M., Wright, P., Scott, B., Gallego, A. and Andrews, J., (2004) *Analysis of the spatial distributions of mature cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) abundance in the North Sea (1980-1999) using generalised additive models. Fisheries Research* 70: 17-25.

Hedger, R.D., Kjellman, M., Thorstad, E.B., Strøm, J.F., and Rikardsen, A.H., (2022). *Diving and feeding of adult Atlantic salmon when migrating through the coastal zone in Norway*. *Environmental Biology of Fishes*, 105: pp. 589-604.

Henriksen, O., Rindorf, A., Mosegaard, H., Payne, M. R., and van Deurs, M. (2021). *Get up early: Revealing behavioral responses of sandeel to ocean warming using commercial catch data. Ecology and Evolution*, 11, pp.16786–16805.

Her Majesty's (HM) Government, (2011). *UK marine policy statement*. [online] Available at: https://www.gov.uk/government/publications/uk-marine-policy-statement [Accessed: 28 August 2025].

Hervé, L., (2021). *An evaluation of current practice and recommendations for environmental impact assessment of electromagnetic fields from offshore renewables on marine invertebrates and fish*. A dissertation submitted by Lucie Hervé to the Department of Civil & Environmental Engineering, University of Strathclyde, in part completion of the requirements for the Erasmus Mundus Joint Master's Degree Renewables Energy in the Marine Environment.

Heyer, G.W., Fields, M.C., Fields, R.D., *et al*. (1981). *Field evidence for electroreception in the shark Carcharhinus obscurus (abstract)*. Journal of the Elisha Mitchell Scientific Society, 97, p. 131.

Hirata, K., (1999). *Fishery biology of the sand lance, Ammodytes personatus, in the waters of northern Japan.* Report of Hokkaido National Fisheries Research Institute, 63, pp. 11-21.

Holland, G.J., Greenstreet, S.P.R. and Gibb, I.M., (2005). *The influence of commercial fishing on the structuring of marine fish communities in the north-east Atlantic*. ICES Journal of Marine Science, 62(2), pp. 245-252.

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

Horton, T.W., Binney, F.C.T., Birch, S., Block, B.A., Exeter, O.M., Garzon, F., Plaster, A., Righton, D., van der Kooij, J., Witt, M.J., and Hawkes, L.A., (2025). *Annual migrations, vertical habitat use and fidelity of Atlantic bluefin tuna tracked from waters off the United Kingdom*. Scientific Reports, 15.

Horton, T.W., Block, B.A., Drumm, A., Hawkes, L.A., O'Cuaig, M., Ó Maoiléidigh, N., O'Neill, R., Schallert, R.J., Stokesbury, M.J.W., and Witt, M.J., (2020). *Tracking Atlantic bluefin tuna from foraging grounds off the west coast of Ireland*. ICES Journal of Marine Science, pp. 2066-2077.

Howson, C.M., Hughes, K., and Narayanaswamy, B.E., (2012). *Identification of Priority Marine Features in Scottish territorial waters.* [online] Available at: https://www.nature.scot/sites/default/files/2022-08/final%20Publication%202012%20-%20SNH%20Commissioned%20Report%20388%20-%20Identification%20of%20Priority%20Marine%20Features%20in%20Scottish%20territorial%20waters.pdf [Accessed: 10 September 2025].

Hubley, P.B., Amiro, P.G., Gibson, A.J.F., Lacroix, G.L., and Redden, A.M., (2008). *Survival and behaviour of migrating Atlantic salmon (Salmo salar L.) kelts in river, estuarine, and coastal habitat*. ICES Journal of Marine Science, 65(9): pp. 1626-1634.

Hutchison, Z.L., Gill, A.B.Sigray, P., He, H. and King J.W. (2020). *Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species*. Scientific reports, 10(1), p. 4328.

Hylland, Ketil & Vethaak, Andre. (2012). *Impact of Contaminants on Pelagic Ecosystems.* 10.2174/978160805121211 0101#sthash.11GchPZG.dpuf.

International Council for Exploration of the Seas (ICES), 2023. *European eel (Anguilla anguilla) throughout its natural range - ICES Advice on fishing opportunities and conservation.* ICES Scientific Reports. Available at: 231101-ICES-Advice-on-fishing-opportunities-for-eel-2024.pdf

International Council for Exploration of the Seas (ICES), (2024a). *ICES Eggs and Larvae Database*. [online] Available at: https://www.ices.dk/data/data-portals/Pages/Eggs-and-larvae.aspx [Accessed: 17 September 2025].

International Council for Exploration of the Seas (ICES), (2024b). *European eel (Anguilla anguilla) throughout its natural range - ICES Advice on fishing opportunities and conservation*. ICES Scientific Reports.

International Council for Exploration of the Sea (ICES), (2025a). *ICES Data and Reports.* [online] Available at: https://www.ices.dk/data/data-portals/Pages/default.aspx [Accessed: 10 September 2025].

International Council for Exploration of the Sea (ICES), (2025b) *Internation Bottom Trawl Survey*. [online] Available at: https://ices-library.figshare.com/articles/report/International_Bottom_Trawl_Survey_Working_Group_I_BTSWG_outputs_from_2024_meeting_/28562888?file=52944146 [Accessed 10 September 2025].

Inger, R., Attrill, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M.J. and Godley, B.J.(2009). *Marine renewable energy: potential benefits to biodiversity? An urgent call for research*. Journal of applied ecology, 46(6), pp. 1145-1153.

International Council for Exploration of the Sea (ICES), (2025c). *Eggs a larvae database*. [online[Available at: https://eggsandlarvae.ices.dk/inventory [Accessed: 10 September 2025].

International Union for Conservation of Nature and Natural Resources (IUCN), (2025). *The IUCN Red List of Threatened Species*. [online] Available at: https://www.iucnredlist.org/en [Accessed: 28 August 2025].

Jensen, H., Rindorf, A., Wright, P. J. and Mosegaard, H.(2011). *Inferring the location and scale of mixing between habitat areas of lesser sandeel (Ammodytes marinus) from patterns in otolith chemistry*. Canadian journal of fisheries and aquatic sciences, 68(1), pp. 49-61.

Jensen, L.N., Kristensen, P.S., Christensen, K.M., *et al*. (2004). *The Horns Rev offshore wind farm: final report on the monitoring programme.*

Joint Nature Conservation Committee (JNCC), (2018). *Turbot Bank MPA*. [online] Available at: https://jncc.gov.uk/our-work/turbot-bank-mpa/ [Accessed: 10 September 2025].

Joint Nature Conservation Committee (JNCC), (2023a). *Special Areas of Conservation (SAC).* [online] Available at: https://jncc.gov.uk/our-work/special-areas-of-conservation. [Accessed: 11 September 2025].

Joint Nature Conservation Committee (JNCC), (2023b). *Red List in Great Britain. [online] Available at: https://jncc.gov.uk/our-work/red-lists-in-great-britain.* [Accessed 24 February 2025].

Joint Nature Conservation Committee (JNCC), (2024). *Marine Mammals and Noise Mitigation.* [online] Available at: https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation/ [Accessed: 10 September 2025].

Joint Nature Conservation Committee (JNCC), (2025a). *Special Areas of Conservation (SACs).* [online] Available at: https://jncc.gov.uk/our-work/special-areas-of-conservation/ [Accessed: 28 August 2025].

Joint Nature Conservation Committee (JNCC), (2025b). *River Dee.* [online] Available at: https://sac.jncc.gov.uk/site/UK0030251 [Accessed: 10 September 2025].

Jones, D.L., Meithe, T., Clarke, E.D., Marshall, T.C., (2023b). *Disentangling the effects of fishing and temperature to explain increasing fish species richness in the North Sea*. Biodiversity and Conservation, 32, pp. 3133-3155.

Judd. A., (2012). *Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy Project*. [online] Available at: https://tethys.pnnl.gov/sites/default/files/publications/CEFAS_2012_Eenvironmental_Assessment_Guidance.pdf [Accessed: 28 August 2025].

Kalmijn, A. J., (1971). *The electric sense of sharks and rays*. Journal of experimental biology, 55(2), pp. 371-383.

Kalmijn, A.J. (1982). *Electric and magnetic field detection in elasmobranch fishes*. Science, 218(4575), pp. 916-918.

Kavet, R., Wyman, M., and Klimley, A.P., (2016). *EMF from submarine power cables and the migration of salmon.* Bioelectromagnetics, 37(8), pp. 581-591.

Kiørboe, T., Frantsen, E., Jensen, C., *et al*. (1981). *Effects of suspended sediment on development and hatching of herring (Clupea harengus) eggs*. Estuarine, Coastal and Shelf Science, 13(1), pp. 107-111.

Kjelland, Ø., Woodley, C. M., Swann, C. P., *et al*. (2015). *An overview of the current knowledge and information gaps of the impacts of sediment on the early life stages of fish*. Reviews in Fisheries Science & Aquaculture, 23(3), pp. 247-280.

Klimley, A.P., Beavers, S.C., Curtis, T.H., *et al*. (2002). *Movements and swimming behavior of three species of sharks in La Jolla Canyon, California*. Environmental biology of fishes, 63, pp. 117-135.

Knights, B., (2003). *A review of the possible impacts of long-term oceanic and climate changes and fishing mortality on recruitment of anguillid eels of the Northern Hemisphere.* Science of the Total Environment, 310(1-3), pp. 237-269.

Knijn, R.J., Boon, T.W., Heessen, H.J.L. and Hislop, J.R.G., (1993). *Atlas of North Sea fishes: based on international research vessel surveys*. ICES Cooperative Research Report No. 194. Copenhagen: International Council for the Exploration of the Sea.

Kristensen, M.L., Righton, D., Del Villar-Guerra, D., Baktoft, H., (2018). *Temperature and depth preferences of adult sea trout Salmo trutta during the marine migration phase.* Marine Ecology Progress Series, 599: pp. 209-224.

Kyle-Henney, Reach, I., M., Barr, N., Warner, I., Lowe, S., and Lloyd Jones, D. (2024). *Identifying and Mapping Sandeel Potential Supporting Habitat: An Updated Method Statement.*

La Mesa, G., Annunziatellis, A., Filidei, E. and Fortuna, C.M. (2015). *Modeling environmental, temporal and spatial effects on twaite shad (Alosa fallax) by-catches in the central Mediterranean Sea. Fisheries Oceanography*, 24(2), pp. 107-117.

Langhamer, O. and Wilhelmsson, D., (2009). *Colonisation of fish and crabs of wave energy foundations and the effects of manufactured holes–a field experimen*t. Marine Environmental Research, 68(4), pp. 151-157.

Langton, R., Boulcott, P. and Wright, P. J., (2021). *A verified distribution model for the lesser sandeel Ammodytes marinus*. Marine Ecology Progress Series, 667, pp.145-159.

Leitão, F., Santos, M. N., and Monteiro, C. C., (2008). *Contribution of an artificial reef to the diet of the white sea bream (Diplodus sargus)*. Journal of the Marine Biological Association of the United Kingdom, 88(1), pp. 191-197.

Linley, E. A. S., Wilding, T. A., Black, K., Hawkings, S.J., Mangi, S., (2007). *Review of the reef effects of offshore wind farm foundations and the potential for enhancement and mitigation*. Pp. 132.

Love, M. S., Nishimoto, M. M. and Clark, S., (2016). *Do oil and gas platforms off California reduce fishing pressure on overfished rockfishes?* Bulletin of Marine Science, 92(1), pp. 87-104.

Lucifora, L., Menni, R. and Escalante, A., (2004). *Reproductive biology of the school shark, Galeorhinus galeus, off Argentina: support for a single southwestern Atlantic population with synchronized migratory movements. Environmental Biology of Fishes*, 71, pp. 199-209.

MacDonald, A., Heath, M. R., Greenstreet, S. P. R., & Speirs, D. C. (2019). *Timing of sandeel spawning and hatching off the East Coast of Scotland.* Frontiers in Marine Science, 6(MAR), Article 70. https://doi.org/10.3389/fmars.2019.00070

Maclean, I.M.D., Wright, L.J., Showler, D.A., and Rehfisch, M.M., (2009). *A Review of Assessment Methodologies for Offshore Wind Farms.* [online] Available at: https://www.researchgate.net/publication/256461323_A_Review_of_Assessment_Methodologies_for_Offshore_Wind_Farms [Accessed: 28 August 2025].

Main, R., (2021). *The Marine Scotland North East Scotland Salmon Tracking Array*.

Main, R., Reeve, A., Archer, J., O'Hara Murray, R., Newton, M., Gardiner, R., Buddendorf, B., Armstrong, J., Davies, I., and Hawkins, L., (2023). *North East Scotland Salmon and Sea Trout Tracking Array*. Report for the River Dee Trust and Marine Scotland Science. pp. 130.

Maitland, P.S., Hatton-Ellis, T.W. (2003). *Ecology of the Allis and Twaite Shad. Conserving Natura 2000 Rivers Ecology Series No. 3*. English Nature, Peterborough. Available at: https://publications.naturalengland.org.uk/file/111013 [Accessed: 11 September 2025]

Malcolm, I.A., Godfrey, J. and Youngson, A.F., (2010). *Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables*. Scottish Marine and Freshwater Science, 1(14).

Marine (Scotland) Act 2010. (2010 asp 5). [online] Available at: https://www.legislation.gov.uk/asp/2010/5/contents [Accessed: 27 August 2025].

Marine and Coastal Access Act 2009. (2009 c. 23). [online] Available at: https://www.legislation.gov.uk/ukpga/2009/23/contents [Accessed: 27 August 2025].

Marine and Freshwater Research Institute (2021) *Saithe Pollachius virens.* MFRI Assessment Reports 2021). [online] Available at: https://www.hafogvatn.is/static/extras/images/03-saithe_tr1259382.pdf [Accessed: 27 August 2025].

Marine Data Exchange, (2025). *Fish Ecology Survey Data and Reports*. [online] Available at: https://www.marinedataexchange.co.uk/ [Accessed: 27 August 2025].

Marine Life Information Network (MarLIN), (2025). *North Sea fish data*. [online] Available at: https://www.marlin.ac.uk/ [Accessed: 28 August 2025].

Marine Management Organisation (MMO) (2016). *Marking of fishing gear, retrieval and notification of lost gear.* Available online at: https://www.gov.uk/guidance/marking-of-fishing-gear-retrieval-and-notification-of-lost-gear#retrieval-of-lost-fishing-gear [Accessed: 27 August 2025].

Marine Management Organisation (MMO), (2024). 2011 to 2024. *UK sea fisheries annual statistics reports, covering 2010 to 2023*. [online] Accessed at: https://www.gov.uk/government/collections/uk-sea-fisheries-annual-statistics [Accessed: 9 September 2025].

Marine Scotland, (2022). *Marine Scotland Information for fisheries sensitivity maps, spawning and nursery grounds*. [online] Available at: https://marine.gov.scot/information/fisheries-sensitivity-maps [Accessed: 2022].

Marine Scotland, (2023). *2022 Scottish Sea Fisheries Statistics – Landing Data*. [online] Available at: https://data.marine.gov.scot/dataset/2022-scottish-sea-fisheries-statistics-fishing-effort-and-quantity-and-value-landings-ices-1 [Accessed: 28 August 2025].

MarramWind Limited, (2023). *MarramWind Offshore Wind Farm Environmental Impact Assessment – Scoping Report.* [online] Available at: https://marramwind.co.uk/scoping-report [Accessed: 28 August 2025].

McCully, S. R., Scott, A. P., and Vermeirssen, E. L. M., (1998). *The reproductive biology of the elasmobranchs; a review with a particular emphasis on endocrinological control*. Journal of Fish Biology, 53, pp. 1-28.

McKeown, N.J., Carpi, P., Silva, J.F., Healey, A.J.E., Shaw, P.W., van der Kooij, J., (2020). *Genetic population structure and tools for the management of European sprat (Sprattus sprattus),* ICES Journal of Marine Science, Volume 77, Issue 6, November-December 2020, Pages 2134 2143, [online] Available at: https://doi.org/10.1093/icesjms/fsaa113 [Accessed: 27 August 2025].

Messieh, S. N., Wildish, D. J. and Peterson, R. H., (1981). *Possible impact from dredging and spoil disposal on the Miramichi Bay herring fishery*. Canadian Technical Report of Fisheries and Aquatic Sciences, (1008).

Middlemas, S. J. and Hanson, N. 2025. *The Status of Salmon in Scotland*. Scottish Government, Marine Directorate data. doi: 10.7489/125523-2. Available at: https://data.marine.gov.scot/dataset/status-salmon-scotland

Middlemas, S. J., Stewart, D. C., Mackay, S. and Armstrong, J. D., (2009). *Habitat use and dispersal of post-smolt sea trout Salmo trutta in Scottish sea loch system*. Journal of Fish Biology, 74(3): pp. 639-651.

Miller, M. J., Feunteun, E. and Tsukamoto, K., (2019). *New insights into the spawning biology of anguillid eels: a mini-review*. Aquatic Living Resources, 32, p. 11.

Moorkens, E., Cuttelod, A. and Pollock, C., (2024). *Margaritifera margaritifera*. The IUCN Red List of Threatened Species 2024.

Nachón, D.J., Mota, M., Antunes, C., Servia, M.J. and Cobo, F. (2016). *Marine and continental distribution and dynamic of the early spawning migration of twaite shad (Alosa fallax (Lacépède, 1803)) and allis shad (Alosa alosa (Linnaeus, 1758)) in the north-west of the Iberian Peninsula. Marine and Freshwater Research*, 67(8), pp. 1229-1240.

National Biodiversity Network (NBN), (2025a). *National Biodiversity Network (NBN) Gateway, NBN Atlas, North Sea data*. [online] Available at: https://nbnatlas.org/ [Accessed 10 September 2025].

National Biodiversity Network (NBN) Gateway, (2025b). *Species Records Database*. [online] Available at: https://nbnatlas.org/ [Accessed: 28 August 2025].

National Oceanic and Atmospheric Administration (NOAA), (2025). *Magnetic Field Calculators. National Geophysical Data Centre*. [online] Available at: http://www.ngdc.noaa.gov/geomag-web/#igrfwmm [Accessed 28 July 2025].

Nature Conservation (Scotland) Act 2004. (2004 asp 6). [online] Available at: https://www.legislation.gov.uk/asp/2004/6/contents [Accessed: 27 August 2025].

NatureScot, (2017). *The Scottish Marine Wildlife Watching Code.* [online] Available at: https://www.nature.scot/doc/scottish-marine-wildlife-watching-code-smwwc [Accessed: 10 September 2025].

NatureScot, (2020a). *Priority Marine Features in Scotland's seas – The List.* [online] Available at: https://www.nature.scot/doc/priority-marine-features-scotlands-seas-list [Accessed: 28 August 2025].

NatureScot, (2020b). *Scottish Biodiversity List*. [online] Available at: https://web.archive.org/web/20240422023328/https://www.nature.scot/doc/scottish-biodiversity-list [Accessed: 28 August 2025].

NatureScot, (2020c). *Southern Trench Marine Protected Area*. [online] Available at: https://www.nature.scot/sites/default/files/nature-conservation-mpa/10477/mpa-site-summaryeng-lish.pdf [Accessed: 10 September 2025].

NatureScot, (2023). *Freshwater pearl mussel.* [online] Available at: https://www.nature.scot/plants-animals-and-fungi/invertebrates/freshwater-invertebrates/freshwater-pearl-mussel [Accessed: 10 September 2025].

NatureScot, (2025a). *Marine non-native species*. [online] Available at: https://www.nature.scot/professional-advice/land-and-sea-management/managing-coasts-and-seas/marine-non-native-species [Accessed: 27 August 2025].

NatureScot, (2025b). *Marine Protected Area Reports*. [online] Available at: https://www.nature.scot/professional-advice/protected-areas-and-species/protected-areas/marine-protected-areas-mpas [Accessed: 27 August 2025].

NatureScot, (2025c). *Priority Marine Habitats*. [online] Available at: https://www.nature.scot/doc/priority-marine-features-scotlands-seas-habitats [Accessed: 27 August 2025].

NatureScot, (2025d). *The Habitat map of Scotland*. [online] Available at: https://www.nature.scot/landscapes-and-habitats/habitat-data-and-habitat-map-scotland [Accessed: 10 September 2025].

Neal, K.J. & Pizzolla, P.F 2006. *Dipturus batis Common skate.* In Tyler-Walters H. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available at: https://www.marlin.ac.uk/species/detail/1436 [Accessed: 15 September 2025]

Neal, K.J. and Pizzolla, P.F., (2006). *Dipturus batis Common skate.* In Tyler-Walters H. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. Plymouth: Marine Biological Association of the United Kingdom. [online] Available at: https://www.marlin.ac.uk/species/detail/1436 [Accessed: 17 September 2025].

Normandeau Associates, Inc., Exponent Inc., Tricas, T., Gill, A., (2011). *Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species*. US Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA.

North East Scotland Biological Records Centre (NESBReC), (2025). *Fish species data and observations.* [online] Available at: https://nesbrec.org.uk/ [Accessed: 10 September 2025].

NorthConnect, (2018). *Baseline Characterisation Survey Report*. Survey undertaken in 2016 and 2017. [Accessed: 28 August 2025].

Ocean Biodiversity Information System (OBIS), (2022). *OBIS Mapper*. [online] Available at: https://mapper.obis.org/ [Accessed: 28 August 2025].

Oliveira, N., Henriques, A., Miodonski, J., (2015). *Ghost fishing in the NE Atlantic*. Marine Pollution Bulletin, 91(1), pp. 177-184.

Orpwood, J. E., Armstrong, M. J., Snell, C. D., (2015). *The effect of AC magnetic fields on the behaviour of the European eel (Anguilla anguilla).* Marine and Freshwater Behaviour and Physiology, 48(2), pp. 101-111.

Armstrong, J.D., Hunter, D-C, Fryer, R.J., Rycroft, P. and Orwood, J.E. (2015) *Behavioural Responses of Atlantic Salmon to Mains Frequency Magnetic Fields*. Scottish Marine and Freshwater Science Vol 6 No 9. Edinburgh: Scottish Government, 17pp.

OSPAR Commission, (1992). *Convention for the Protection of the Marine Environment of the North East Atlantic.* [online] Available at: https://www.ospar.org/site/assets/files/1169/ospar_convention.pdf [Accessed: 27 August 2025].

OSPAR Commission, (2008). *Guidance on Environmental Considerations for Offshore Wind Farm Development.* [online] Available at: https://www.ospar.org/work-areas/eiha/offshore-renewables [Accessed: 28 August 2025].

OSPAR Commission, (2009) *Background Document for Sea lamprey Petromyzon marinus. Biodiversity Series.* Available at: https://qsr2010.ospar.org/media/assessments/Species/p00431_Sea_lamprey.pdf [Accessed 11 September 2025].

OSPAR Commission, (2025). *OSPAR list of threatened and declining fish species.* [online] Available at: https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats/fish [Accessed: 28 August 2025].

Paxton, C.G.M., Scott-Hayward, L.A.S. and Rexstad, E., (2014). Statistical approaches to aid the identification of Marine Protected Areas for minke whale, Risso's dolphin, white-beaked dolphin and basking shark. Scottish Natural Heritage Commissioned Report No. 594. [online] Available at: https://www.nature.scot/doc/naturescot-commissioned-report-594-statistical-approaches-aid-identification-marine-protected-areas. [Accessed: 10 September 2025].

Peck, A.M., Baumann, H., Bernreuther, M., Clemmesen, C., Herrmann, J., Haslob, H., Huwer, B., Kanstinger, P., Köster, F.W., Petereit, C., Temming, A., Voss, R., (2012). *The ecophysiology of Sprattus sprattus in the Baltic and North Seas*. Progress in Oceanography, Volume 103, 2012, Pages 42-57. [online] Available at: https://doi.org/10.1016/j.pocean.2012.04.013 [Accessed: 28 August 2025].

Pemberton, R., (1976). *Sea trout in North Argyll sea lochs: population, distribution and movements*. Journal of Fish Biology, 9(2): pp. 157-179.

Petersson, E., (2016). *Homing and timing of reproduction*. Evolutionary Biology of the Atlantic Salmon. London (New York): CRC Press, pp. 44-58.

Poloczanska, E.S., Burrows, M.T., Brown, C.J., García Molinos, J., Halpern, B.S., HoeghGuldberg, O., Kappel, C.V., Moore, P.J., Richardson, A.J., Schoeman, D.S. and Sydeman, W.J., (2016). *Responses of marine organisms to climate change across oceans*. Frontiers in Marine Science, 3, p.180581.

Popper, A.N. and Hawkins, A.D., (2018). *The importance of particle motion to fishes and invertebrates*. The Journal of the Acoustical Society of America, 143(1), pp. 470-488.

Popper, A.N. and Hawkins, A.D., (2019). *An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes*. Journal of fish biology, 94(5), pp. 692-713.

Popper, A.N., Hawkins, A.D. and Thomsen, F., (2019). *Taking the animals' perspective regarding underwater sound.* Trends in ecology & evolution, 34(11), pp. 977-980.

Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D.A, Bartol, S.M., Carlson, T., Coombs, S., Ellison, W.T., Gentry, R.L., Halvorsen, M., Løkkeborg, S., Rogers, P.H., Southall, B., Zeddies, D.G., Tvolga, W.N., (2014). *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report.* [online] Available at: https://www.researchgate.net/publication/279347068_Sound_Exposure_Guidelines [Accessed: 28 August 2025].

PrePARED (2024). PrePARED – *The First Two Years. Report from the PrePARED Annual Knowledge Exchange Meeting 2024 (AKEM24).* PrePARED Report No. 3, April 2024.

Reach, I.S., Latto P., Alexander, D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R., and Seiderer, L.J. (2013). *Screening spatial interactions between marine aggregate application areas and Atlantic herring potential spawning areas. A Method Statement produced for the British Marine Aggregates Producers Association.* Available at: https://www.marinespace.co.uk/wp-content/uploads/2021/06/Herring-Potential-Spawning-Habitat-Method-Statement-v1.1.pdf

Régnier, T., Gibb, F.M. and Wright, P.J., (2019). *Understanding temperature effects on recruitment in the context of trophic mismatch*. Scientific reports, 9(1), p.15179.

Régnier, T., Wright, P. J., Harris, M. P., Gibb, F.M., Newell, M., Eerkes-Medrano, D., Daunt, F., Wanless, S., (2024). *Effect of timing and abundance of lesser sandeel on the breeding success of a North Sea seabird community*. Marine Ecology Progress Series, 727, pp. 1–17.

Régnier, T., Wright, P.J., Harris, M.P., Gibb, F.M., Newell, M., Eerkes-Medrano, D., Daunt, F. and Wanless, S., (2024). *The effect of timing and abundance of lesser sandeel on the breeding success of a North Sea seabird community. Marine Ecology Progress Series*, 727: pp. 1-17.

Reiss, H., Cunze, S., König, K., Neumann, H., Kröncke, I., (2011). *Species distribution modelling of marine benthos: a North Sea case study.* Marine Ecology Progress Series, 442, pp.71-86.

Reubens, J. T., Degraer, S. and Vincx, M. (2013) 'The importance of marine wind farms, as artificial hard substrata, for the ecology of the ichthyofauna in the Belgian part of the North Sea', Hydrobiologia, 727, pp. 113-125.

Righton, D, (2018). *Tuna watching – bluefin are back in UK waters in numbers for the 5th successive year.* [online] Available at: https://marinescience.blog.gov.uk/2018/11/15/tuna-watching-bluefin-are-back-in-uk-waters-in-numbers-for-the-5th-successive-year/ [Accessed: 2 September 2025].

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

Rikardsen, A. H. and Dempson, J. B., (2011). *Dietary life-support: the marine feeding of Atlantic salmon*. Ø. Aas, S. Einum, A. Klemetsen and J. Skurdal, eds. Atlantic salmon ecology. Oxford: Wiley-Blackwell, pp. 115-144.

Rikardsen, A.H., Haugland, M., Bjorn, P.A., and Finstad, B., (2004). *Geographical differences in marine feeding of Atlantic salmon post-smolts in Norwegian fjords*. Journal of Fish Biology, 64(6): pp. 1655-1679.

Risch, D., van Geel, N. C. F., Wilson, B., (2023). *First measurements of operational sound from a floating offshore wind turbine*. The Journal of the Acoustical Society of America, 154(4), pp. 2486-2495.

Rodger, J.R., Lilly, J., Honkanen, H.M., del Villar, D., Kennedy, R., Ó. Maoiléidigh, N., Boylan, P., Rosell, R., Morris, D.J., O'Neill, R., Waters, C., Cotter, D., Wilkie, L., Barkley, A., Green, A., Beck, S.V., Ribbens, J., Henderson, J., Parke, D., Kettle-White, A., Ballantyne, L., Marshall, S., Hopper, P., Gauld, N., Godfrey, J.D., Chapman, L.E., Thorburn, J., Drumm, A., Whoriskey, F., Shields, B., Ramsden, P., Barry, J., Millane, M., Roche, W., Armstrong, J.D., Wells, A., Walton, S., Fletcher, M., Bailey, D.M., Whyte, B., McGill, R., Bilsby, M., Whelan, K., Bean, C.W., and Adams, C.E. (2024). *Inshore and offshore marine migration pathways of Atlantic salmon post-smolts from multiple rivers in Scotland, England, Northern Ireland, and Ireland*. *Journal of Fish Biology.* 106:1422–1439.

Rohtla, M., Daverat, F., Arts, M.T., Browman, H.I., Parzanini, C., Skiftesvik, A.B., Thorstad, E.B., Meeren, T.V., Vøllestad, L.A., and Durif, C.M.F. (2023a). *Habitat use and growth of yellow-stage European eel in coastal and freshwater ecosystems in Norway*. *Canadian Journal of Fisheries and Aquatic Sciences*, 80(1), pp. 14-26.

Rohtla, M., Taal, I., Svirgsden, R., (2023b). *Habitat-and season-specific movements of European eel Anguilla anguilla in a shallow coastal sea.* Marine Ecology Progress Series, 718, pp. 69-82.

Rowley, S. J., (2008). *Lesser sandeel (Ammodytes marinus) and sand goby (Pomatoschistus minutus) information from The Marine Life Information Network.*

RPS, (2019). *Review of cable installation, protection, and decommissioning activities for offshore wind farms*.

RPS, (2022). *Berwick Bank Wind Farm Offshore Environmental Impact Assessment Appendix 9.1: Fish and Shellfish Ecology Technical Report*. [online] Available at: marine.gov.scot/sites/default/files/berwic1_3.pdf. [Accessed: 11 September 2025].

Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003. (2003 asp 15). [online] Available at: https://www.legislation.gov.uk/asp/2003/15/contents [Accessed: 27 August 2025].

Sandlund, N., Tesch, F. W., Vøllestad, L. A., (2017). *Timing and speed of migrating adult European eels Anguilla anguilla in coastal waters*. Marine Ecology Progress Series, 570, pp. 183-194.

Saunders, G., Sotheran, I., and Wilson, B., (2011). *Guidance on survey and monitoring in relation to marine renewables deployments in Scotland*. [online] Available at: https://tethys.pnnl.gov/sites/default/files/publications/SNH-2011-Volume-1.pdf [Accessed: 10 September 2025].

ScotMER, (2024). *ScotMER Diadromous Fish Evidence Map.* [online] Available at: https://www.gov.scot/publications/diadromous-fish-specialist-receptor-group/ [Accessed: 12 September 2025].

Scottish and Southern Energy Renewables (SSER), (2022). *Berwick Bank Offshore Wind Farm EIA Report*. [online] Available at: https://berwickbank-eia.com/ [Accessed: 17 September 2025].

Scottish Government, (2011). *Scotland's Marine Atlas: Information for The National Marine Plan – Sharks and rays.* [online] Available at: https://www.gov.scot/publications/scotlands-marine-atlasin-formation-national-marine-plan/pages/34/ [Accessed 10 September 2025].

Scottish Government, (2013). *Marine Scotland Science: Fish and Shellfish Stocks 2013 addition.* [online] Available at: https://www.gov.scot/publications/fish-shellfish-stocks-2013/pages/10/ [Accessed 07 October 2025].

Scottish Government, (2015a). *Scottish National Marine Plan*. [online] Available at: https://www.gov.scot/publications/scotlands-national-marine-plan/ [Accessed: 28 August 2025].

Scottish Government, (2015b). *Marine Scotland Science: Fish and Shellfish Stocks 2015 addition.* [online] Available at: https://www.gov.scot/publications/fish-shellfish-stocks-2015-edition/pages/16/ [Accessed 07 October 2025].

Scottish Government, (2018). *Offshore wind, wave and tidal energy applications: consenting and licensing manual*. [online] Available at: https://www.gov.scot/publications/marine-scotland-consenting-licensing-manual-offshore-wind-wave-tidal-energy-applications/ / [Accessed: 28 August 2025].

Scottish Government, (2020a). *Sectoral marine plan for offshore wind energy*. [online] Available at: https://www.gov.scot/publications/sectoral-marine-plan-offshore-wind-energy/ [Accessed: 28 August 2025].

Scottish Government, (2020b). *The Environment Strategy for Scotland: vision and outcomes*. [online] Available at: https://www.gov.scot/publications/environment-strategy-scotland-visionout-comes/ [Accessed: 28 August 2025].

Scottish Government, (2020c). *Sectoral marine plan: regional locational guidance*. [online] Available at: https://www.gov.scot/publications/sectoral-marine-plan-regional-locational-guidance/ [Accessed: 28 August 2025].

Scottish Government, (2022). *Scottish Wild Salmon Strategy*. [online] Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2022/01/scottish-wild-salmon-strategy/documents/scottish-wild-salmon-strategy/scottish-wild-salmon-strategy/govscot%3Adocument/scottish-wild-salmon-strategy.pdf [Accessed 10 September 2025].

Scottish Government, (2023a). *National Planning Framework 4*. [online]. Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2023/02/national-planning-framework-4/documents/national-planning-framework-4-revised-draft/national-planning-framework-4-revised-draft/govscot%3Adocument/national-planning-framework-4.pdf [Accessed: 28 August 2025].

Scottish Government, (2023b). *Tackling the Nature Emergency - Scottish biodiversity strategy to 2045*. [online]. Available at: https://www.gov.scot/publications/scottish-biodiversity-strategy-2045-tackling-nature-emergency-scotland-2/ [Accessed: 28 August 2025].

Scottish Government, (2023c). *MarramWind Offshore Wind Farm Environmental Impact Assessment – Scoping Opinion*. [online] Available at: https://marine.gov.scot/node/23928 [Accessed: 22 June 2023].

Scottish Government, (2023d). *Salmon fishing: proposed river gradings for 2024 season* [online] Available at: https://webarchive.nrscotland.gov.uk/20240420084133/http:/www.gov.scot/publications/salmon-fishing-proposed-river-gradings-for-2024-season/ [Accessed 08 October 2025].

Scottish Government, (2024). *Environment Strategy: progress report - March 2024*. [online] Available at: https://www.gov.scot/publications/progress-report-environment-strategy-march-2024/ [Accessed: 28 August 2025].

Scottish Government, (2025a). *Draft Updated Sectoral Marine Plan for Offshore Wind Energy*. [online] Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/consultation-paper/2025/05/draft-updated-sectoral-marine-plan-offshore-wind-energy-2025/documents/draft-updated-sectoral-marine-plan-offshore-wind-energy/draft-updated-sectoral-marine-plan-offshore-wind-energy/govscot%3Adocument/draft-updated-sectoral-marine-plan-offshore-wind-energy.pdf [Accessed: 28 August 2025].

Scottish Government, (2025b). *Marine licensing and consenting: offshore renewable energy projects*. [online] Available at: https://www.gov.scot/publications/marine-licensing-and-consenting-offshore-renewable-energy-projects/ [Accessed: 10 September 2025].

Scottish Government, (2025c). *Sitelink*. [online] Available at: https://feature-activity-sensitivity-tool.scot/ [Accessed 10 September 2025].

Scottish Government, (2025d). *Salmon fishing: final river gradings for the 2025 season* [online] Available at: https://www.gov.scot/publications/salmon-fishing-final-river-gradings/ [Accessed 08 October 2025].

Scottish Government, (2025e). *Salmon fishing: proposed river gradings for the 2026 season* [online] Available at: https://www.gov.scot/publications/salmon-fishing-proposed-river-gradings-for-2026-season [Accessed 08 October 2025].

Sharples, R. J., Arrizabalaga, B. & Hammond, P. S., (2009). *Seals, sandeels and salmon: diet of harbour seals in St Andrews Bay and the Tay Estuary, southeast Scotland*. Marine Ecology Progress Series, 390, pp.265–276.

Simmons, O.M., Silva, A.T., Forseth, T., Andreasson, P., Müller, S., Calles, O., Aldven, D., (2024). *Swimming behaviour of Atlantic salmon kelts migrating past a hydropower plant dam: Effects of hydraulics and dam operations*. Science of The Total Environment Volume 922.

Sims, D.W., Fox, A.M. and Merrett, D.A. (2005). Basking shark occurrence off south-west England in relation to zooplankton abundance. Journal of Fish Biology, 51(2), pp. 436-440.

Sims, D.W., Southall, E.J., Quayle, V.A., and Fox, A.M. (2000). *Annual social behaviour of basking sharks associated with coastal front areas*. Proceedings of the Royal Society of London. Series B: Biological Sciences, 267(1455): 1897-1904.

Sims, D.W., Southall, E.J., Richardson, A.J., Reid, P.C. and Metcalfe, J.D., (2003). Seasonal movements and behaviour of basking sharks from archival tagging: no evidence of winter hibernation. Marine Ecology Progress Series, 248, pp. 187-196.

Singh, G., Sharma, S., (2024). *Heavy metal contamination in fish: sources, mechanisms and consequences.* Aquat Sci 86, 107 (2024). [online] Available at: https://doi.org/10.1007/s00027-024-01121-7 [Accessed: 17 September 2025].

Smith-Vaniz, W.F., Sidibe, A., Nunoo, F., Lindeman, K., Williams, A.B., Quartey, R., Camara, K., Carpenter, K.E., Montiero, V., de Morais, L., Djiman, R., Sylla, M. and Sagna, A., (2015). *Trachurus trachurus. The IUCN Red List of Threatened Species*. [online] available at: https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T198647A43157137.en [Accessed: 17 August 2025].

Solandt, J-L. and Chassin, E., (2013). *Marine Conservation Society Basking Shark Watch Overview of data from 2009 to 2013*. Ross on Wye, UK: Marine Conservation Society, 6 pp.

Sparholt, H., Hawkins, A. and Thomson, A., (2018). *Entry of adult Atlantic salmon into a tributary of the Aberdeenshire Dee, Scotland*. Ecology of Freshwater Fish, 27: pp. 280-295.

Statoil (2015). *Hywind Scotland Pilot Park Project – Environment Statement: Chapter 10 Fish and Shellfish Ecology*. [online] Available at: Statoil-Environmental Statement April 2015 (equinor.com). [Accessed: 11 September 2025]

Stephenson, F. A., Loew, E. R., and Popper, A. N. (2010) 'Amphibious hearing in the American alligator (Alligator mississippiensis)', Journal of Comparative Physiology A, 196, pp. 291-300.

Strøm, J.F., Thorstad, E.B., Hedger, R.D., and Rikardsen, A.H., (2018). *Revealing the full ocean migration of individual Atlantic salmon*. Animal Biotelemetry, 6(2).

Strong, J. T. (1989). *Movement, growth and aspects of the population biology of the thorny skate, Raja radiata Donovan, in the Newfoundland region*.

Sweet, N. A. (2008). *Norway pout (Trisopterus esmarkii) information from The Marine Life Information Network*. [online] Available at: https://www.marlin.ac.uk/species/detail/171 [Accessed: 17 September 2025].

Taormina, B., Bald, J., Want, A., Thouzeua, G., Lejart, M., Desroy, N., and Carlier A., (2018). *A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions.* Renewable and Sustainable Energy Reviews, 96, pp. 380–391. Available online at: https://doi.org/10.1016/j.rser.2018.07.026.

Tesch, F. W., (2003). *The eel*. John Wiley & Sons.

The Conservation (Natural Habitats, &c.) Regulations 1994. (SI 1994 No. 2716). [online] Available at: https://www.legislation.gov.uk/uksi/1994/2716/contents [Accessed: 27 August 2025].

The Conservation of Offshore and Marine Habitats and Species Regulations 2017. (SI 2017 No. 1013). [online] Available at: https://www.legislation.gov.uk/uksi/2017/1013/contents [Accessed: 27 August 2025].

The Environment (EU Exit) (Scotland) (Amendment etc.) Regulations 2019. (SI 2019 No. 26). Part 2. [online] Available at: https://www.legislation.gov.uk/ssi/2019/26/part/2 [Accessed: 27 August 2025].

The Marine Strategy Regulations 2010. (SI 2010 No. 1627). [online] Available at: https://www.legislation.gov.uk/uksi/2010/1627/contents [Accessed: 27 August 2025].

The Water Environment (Controlled Activities) (Scotland) Regulations 2011. (SI 2011 No. 209). [online] Available at: https://www.legislation.gov.uk/ssi/2011/209/contents [Accessed: 27 August 2025].

The River Deveron District Salmon Fishery Board (RDDSFB), (2025). *Annual Report and Accounts 2024/25* [online] Available at: https://www.deveron.org/resources/annual-reports [Accessed: 08 October 2025].

Thorstad, E.B., Økland, F., Finstad, B., and Sivertsgrd, R., (2004). *Migration speeds and orientation of Atlantic salmon and sea trout post-smolts in a Norwegian fjord system*. Environmental Biology of Fishes, 71: pp. 305-311.

Thorstad, E.B., Todd, C.D., Uglem, I., Bjørn, P.A., Gargan, P.G., Wiik Vollset, K., Halttunen, E., Kålås, S., Berg, M., and Finstad, B., (2016). *Marine life of the sea trout*. Marine Biology, Volume 163(47).

Thorstad, E.B., Whoriskey, F., Uglem, I., Moore, A., Rikardsen, A.H., and Finstad, B., (2012). *A critical life stage of the Atlantic salmon Salmo salar: Behaviour and survival during the smolt and initial post-smolt migration*. Journal of Fish Biology, 81: pp. 500-542.

Tyler-Walters, H., (2018). *MarESA-Marine Evidence based Sensitivity Assessment*.

Tyler-Walters, H., (2023). *Sensitivity assessment for Raja clavata*.

Tyler-Walters, H., Tillin, H.M., d'Avack, E.A.S., Perry, F., Stamp, T., (2023). *Marine Evidence-based Sensitivity Assessment (MarESA) – Guidance Manua*l. [online] Available at: https://www.marlin.ac.uk/assets/pdf/MarLIN-MarESA-Manual-Jun2023.pdf [Accessed: 28 August 2025].

U.S. Offshore Wind Synthesis of Environmental Effects Research (SEER) (2022). *Risk to Marine Life from Marine Debris & Floating Offshore Wind Cable Systems.* Report by National Renewable Energy Laboratory and Pacific Northwest National Laboratory for the U.S. Department of Energy, Wind Energy Technologies Office. [online] Available at: https://tethys.pnnl.gov/seer [Accessed: 28 August 2025].

Utne, K.R., Skagseth, Ø., and Wennevik, V., (2022). *Impacts of a changing ecosystem on the feeding and feeding conditions of Atlantic salmon during the first months at sea*. Frontier in Marine Science, 9.

Valenzuela, G.S. and Vargas, C.A., (2002). *Comparative larval growth rate of Sprattus sprattus in relation to physical and biological oceanographic features in the North Sea*. Archive of Fishery and Marine Research, 49(3): 213 230.

Van Deurs, M., Christensen, A., Frisk, C. and Mosegaard, H. (2010). *Overwintering strategy of sandeel ecotypes from an energy/predation trade-off perspective*. Marine Ecology Progress Series, 416, pp.201–214.

Van Deurs, M., van der Sluijs, J. P., and St. John, M., (2012). *A simple model predicting winter activity of sandeel Ammodytes marinus*. Journal of sea research, 74, pp. 21-27.

Verhelst, P., Reubens, J. and Pauwels, I., (2023). *Behavioural complexity of European eel (Anguilla anguilla) in an estuary revealed by acoustic telemetry*. Estuarine, Coastal and Shelf Science, 280, p. 108169.

Wahl, E., and Alheit, J., (1988). *Changes in the distribution and abundance of sprat eggs during spawning season*. ICES CM 1988/H:45. 4 pp.

Walker, T.I., Rigby, C.L., Pacoureau, N., Ellis, J., Kulka, D.W., Chiaramonte, G.E. and Herman, K.,(2020). *Galeorhinus galeus. The IUCN Red List of Threatened Species 2020*: e.T39352A2907336. [online] Available at: https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T39352A2907336.en [Accessed 11 September 2025]

Water Environment and Water Services (Scotland) Act 2003. (2003 asp 3). [online] Available at: https://www.legislation.gov.uk/asp/2003/3/contents [Accessed: 27 August 2025].

Webb, J. H. and McLay, H. A., (1996). *Post-smolt Atlantic salmon (Salmo salar L.) in the River Tay estuary*.

Westerberg, H. and Lagenfelt, I., (2008). *Sub-sea power cables and the migration behaviour of the European eel*. Fisheries management and ecology, 15(5-6), pp. 369-375.

Wheeler, A., (1969). *The fishes of the British Isles and north-west Europe*. London: Macmillan.

Wildlife and Countryside Act 1981. (1981 c. 69). [online] Available at: https://www.legislation.gov.uk/ukpga/1981/69/contents [Accessed: 27 August 2025].

Wildlife and Natural Environment (Scotland) Act 2011. (2011 asp 6). [online] Available at: https://www.legislation.gov.uk/asp/2011/6/contents [Accessed: 27 August 2025].

Wilhelmsson, D., Malm, T., Thompson, R. C., *et al*. (2006) 'The influence of offshore windpower on demersal fish', ICES Journal of Marine Science, 63(5), pp. 775-784.

Wilhelmsson, D., Westerberg, H. and Malm, T., (2010). *Effects of the first offshore wind farm in Sweden*.

Wilson, C.M., Tyler-Walters, H., & Wilding, C.M. (2020). *Cetorhinus maximus Basking shark*. In Tyler-Walters H. *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, Plymouth: Marine Biological Association of the United Kingdom. [online]. Available at: https://www.marlin.ac.uk/species/detail/1438 [Accessed: 10 September 2025].

Winslade, P., (1974). *Behavioural studies on the lesser sandeel Ammodytes marinus (Raitt) I. The effect of food availability on activity and the role of olfaction in food detection*. Journal of fish biology, 6(5), pp. 565-576.

Winslade, P., (1974). *Behavioural studies on the lesser sandeel Ammodytes marinus (Raitt) III. The effect of temperature on activity and the environmental control of the annual cycle of activity.* Journal of Fish Biology, 6(5): pp. 587-599.

Woodruff, D. L., Johnson, G. E. and Pinheiro, I. R., (2013). *An investigation of potential effects of electromagnetic fields on marine organisms in Puget Sound, Washington*.

Wright, P.J., Jensen, H. and Tuck, I., (2000). *The influence of sediment type on the distribution of the lesser sandeel, Ammodytes marinus*. Journal of Experimental Marine Biology and Ecology, 245(1), pp. 1-17.

Wright, R. M., Piper, A. T., Aarestrup, K., (2022). *First direct evidence of adult European eels migrating to their Sargasso Sea spawning area*. Scientific Reports, 12(1), p. 15964.

Wright, R.M., Hutchinson, J.M.C. and Ross, D.G., (2020). *Fish and fisheries in the North Sea', in North Sea Region climate change assessment*. Springer, Cham, pp. 331-379.

Xodus, (2022). *Cenos Offshore Windfarm EIA Report*. [online] Available at: https://cenosoffshorewind.com/documents/ [Accessed: 17 September 2025].

Youngson, A., Jordan, W. and Hay, D., (1994). *Homing of Atlantic salmon (Salmo salar L.) to a tributary spawning stream in a major river catchment*. Aquaculture, 121: pp. 259-267.

13.18 Glossary of terms and abbreviations

13.18.1 Abbreviations

Acronym	Definition
BAP	Biodiversity Action Plan
CMS	Construction Method Statement
DAS	Digital Aerial Surveys
DSFB	District Salmon Fishery Board
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
EMP	Environmental Management Plan
EN	Endangered
FAD	Fish Aggregation Device
FeAST	Feature Activity Sensitivity Tool
HDD	Horizontal directional drilling
Hz	Hertz
HRA	Habitats Regulations Appraisal
HVAC	High Voltage Alternating Current
HVDC	High Voltage Directional Current
IBTSWG	International Bottom Trawl Survey Working Group
ICES	International Council for Exploration of the Sea
iE	induced electric (field)
IHLS	International Herring Larvae Survey
INNS	Invasive Non-Native Species
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
km	kilometre
LAT	Lowest Astronomical Tide
LC	Least Concern

Acronym	Definition
m	metre
MarLIN	Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MD-LOT	Marine Directorate - Licensing Operations Team
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MMMP	Marine Mammal Mitigation Protocol
MPA	Marine Protected Area
MPCP	Marine Pollution Contingency Plan
MSW	Multi-sea-winter
NBN	National Biodiversity Network
NERC	Natural Environment and Rural Communities
nm	nautical mile
NT	Near Threatened
OAA	Option Agreement Area
OEMP	Outline Environmental Management Plan
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
O&M	Operation and maintenance
PMF	Priority Marine Feature
PrePARED	Predators and Prey Around Renewable Energy Developments
PSD	Particle Size Distribution
RIAA	Report to Inform Appropriate Assessment
RCP	Reactive Compensation Platform
ROV	Remotely Operated Vehicles
SAC	Special Area of Conservation
SEL	Sound Exposure Level
SNH	Scottish Natural Heritage
SPL	Sound Pressure Level

Acronym	Definition
SSC	Suspended Sediment Concentration
TAC	Total Allowable Catch
TTS	Temporary Threshold Shift
μT	microtesla
μV	microvolts
μV/m	microvolts per metre
UK	United Kingdom
UXO	Unexploded Ordnance
VU	Vulnerable
WTG	Wind Turbine Generator
ZOI	Zone of Influence

13.18.2 Glossary of terms

Term	Definition
Ambient noise level	The LAeq, T, of the totally encompassing sound in a given situation at a given time, usually from many sources near and far, at the assessment location over a given time interval, T.
Annex I (of the Habitats Directive)	Part of the Habitats Directive 92/43/EEC that identifies habitat types that require conservation through the designation of Special Areas of Conservation (SACs).
Annex II (of the Habitats Directive)	Part of the Habitats Directive 92/43/EEC that identifies habitat types that require conservation through the designation of Special Areas of Conservation (SACs).
Auditory masking	The presence of sound that makes it difficult for the listener to hear or otherwise detect or discriminate sounds they may need or want to hear.
Abiotic	Non-biological, or not derived from living organisms or living matter.
Bedforms	Features on the seabed (e.g. sandwaves or ripples) resulting from the movement and deposition of sediment.
Benthic	Flora or fauna that live on the seabed.
Biodegradation	A natural process whereby organic material is broken down by living organisms such as bacteria.
By-catch	The accidental or unintended capture of biota during fishing activities that are not the target specimens. These include non-target species and target species that are below the minimum size requirements for landing as catch.

Term	Definition
Diadromous	Describing the lifecycle of fish species that migrate between freshwater and saline environments, typically aligned with specific age or development related lifecycle stages and / or for spawning.
Demersal	Organisms and / or activities such as fishing that exist or occur on or close to the seabed.
Digital aerial surveys	Digital photography surveys carried out by aeroplane.
Diel vertical migration	In relation to fish ecology, where biomass moves vertically within the water column on a daily basis, typically towards the sea surface at dusk to feed and to deeper water during the day.
Elasmobranch	Cartilaginous fishes such as sharks, rays and skates.
Epibenthic	Flora or fauna that live within the seabed.
Epipelagic	The uppermost stratum of the ocean where sunlight penetration of the water column is sufficient for photosynthesis to occur.
Fish stock	Any natural population of fish that is an isolated and self-perpetuating group of the same species.
Ghost fishing	The injury and death of marine biota resulting from fishing gear that is lost or abandoned at sea but remains capable of catching organisms.
ICES statistical rectangles	The International Council for the Exploration of the Sea (ICES) standardises the division of sea areas to enable statistical analyses of data. Each ICES statistical rectangle is '30 min latitude by 1 degree longitude' in size (i.e. approximately 30 x 30 nautical miles). A number of rectangles are amalgamated to create ICES statistical areas.
Natal waters	The watercourse in which a diadromous fish is born and which it will typically return to for later lifecycle stages.
Particle motion	The lateral movement of water particles that can be detected by some fish species as a component of underwater sound and used to hear and detect sound.
Pelagic	Relating to the open sea, and specifically within the water column between the surface and the seabed.
Planktonic	Relating to organisms and lifecycle stages such as eggs that float or drift in the ocean, without the ability to free-swim or self-determine their direction or speed.
Secondary entanglement	The snagging of marine debris (including lost fishing gear) on marine infrastructure, that subsequently causes the entanglement of marine biota and typically results in injury or death of the organism.
Smolt	One of the lifecycle stages of salmonid species.
Swim bladder	In fish physiology, this is an air-filled sac used to maintain and control buoyancy and vertical position in the water column.

Term	Definition
Trophic levels	The layers of the food chain that group organisms (e.g. producers, primary consumers, and secondary consumers).

MarramWind